Great Basin Ecological Site Development Project:

State and Transition Models for Major Land Resource Area 26 in Nevada and Portions of California

Nevada Agricultural Experiment Station Research Report 2021-01

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Tamzen K. Stringham, Devon K. Snyder, Patti Novak-Echenique, Kelsey O'Neill, Alexa Lyons, Mattie Johns

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College of Agriculture,
Biotechnology & Natural Resources

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Image on cover by Tamzen K. Stringham.

Executive Summary

This report was completed in March, 2021 in fulfillment of Agreement L16AC00135 with the Bureau of Land Management. It contains state-and-transition models (STMs) for 95 ecological sites within Major Land Resource Area 26 in the states of Nevada and California. STMs were developed in accordance with the National Ecological Site Handbook (USDA 2017) and the Interagency Ecological Site Handbook for Rangelands (Caudle et al. 2013). A team of scientists, professional land managers, and interested stakeholders, led by Dr. Tamzen Stringham, Patti Novak-Echenique, and Devon Snyder, developed these products. The team examined local knowledge, soil mapping data, and published literature relating to soils, plant ecology, plant response to various disturbances, disturbance history of the area, and many other important attributes necessary to document the ecology of MLRA 26 by ecological site. Pre-existing ecological sites were sorted into groups based on their responses to natural or human-induced disturbances. These groups are referred to as Disturbance Response Groups (DRGs). DRGs simplify the landscape into ecologically significant units for management. Twenty-five DRGs were developed and utilized during the STM-building process. DRGs can also be used to map meaningful ecological units. This report is organized by DRG, with one generalized STM narrative for the group, followed by individual STMs for each ecological site within the group. Fieldwork reports including site visit locations and field note reports are included as appendices.

Authors

Tamzen K. Stringham is a Professor with the University of Nevada, Reno

Devon K. Snyder is a Rangeland Ecologist with University of Nevada, Reno

Patti Novak-Echenique is a Rangeland Management Specialist with the Bureau of Land Management, Sparks, Nevada

Kelsey O'Neill was a Rangeland Ecologist with University of Nevada, Reno

Alexa Lyons is a research technician with University of Nevada, Reno

Mattie Johns is a research technician with University of Nevada, Reno

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Introduction

Ecological Site Descriptions (ESD) synthesize information concerning soils, hydrology, ecology, and management into a user-friendly document. A crucial component of an ESD is the state-and-transition model (STM) that identifies the different vegetation states, describes the disturbances that caused vegetation change, and suggests restoration activities needed to restore plant communities. State-and-transition models are powerful tools that utilize professional knowledge, data, and literature to describe the resistance and resilience of an ecological site. The STM then captures various disturbances, triggers leading to ecological thresholds, feedback mechanisms maintaining ecological states, and the restoration techniques required for moving from one ecological state to another (Briske et al. 2008, Stringham et al. 2003).

Many ecological sites are similar in their plant composition and other important physical attributes such as soils, but may differ in total production or landscape setting. Thus, often these similar ecological sites will respond to the same disturbance in a similar manner. The rate of response to disturbance may be different but the endpoint of the change will be very similar. In order to expedite development of STMs, a process developed by Dr. Stringham, referred to as Disturbance Response Grouping was utilized in this project. The Disturbance Response Group process is conducted at the Major Land Resource Area (MLRA) scale, making it a highly efficient method for STM development. The process requires a team of experts with years of experience working in the area of interest.

The core team for this project consisted of:

- Tamzen K. Stringham is a Professor with the University of Nevada, Reno
- Devon K. Snyder is a Rangeland Ecologist with University of Nevada, Reno
- Patti Novak-Echenique is a Rangeland Management Specialist with the Bureau of Land Management, Sparks, Nevada
- Kelsey O'Neill was a Rangeland Ecologist with University of Nevada, Reno
- Alexa Lyons is a research technician with University of Nevada, Reno
- Mattie Johns is a research technician with University of Nevada, Reno

Soil support was provided by:

- Joseph Chiaretti, Soil Scientist, NRCS Nevada (retired)
- Edward Blake, Soil Scientist, NRCS Nevada (retired)
- Matt Cole, NRCS Soil Scientist
- Chris Savastio, NRCS Soil Scientist and MLRA Soil Survey Leader
- John Fisher, Soil Scientist, NRCS Nevada (retired)

Additional support members of the team:

- Martin Oliver, Botanist, BLM Bishop, CA
- Casey Boyd, Rangeland Management Specialist, BLM, Bishop, CA
- Robin Tausch, Professor Emeritus, UNR
- Keith Barker, Fire Ecologist, BLM Carson City, NV

- Rachel Williams, U.S. Fish and Wildlife Service
- Martina Middione, BLM Bishop, CA
- Sarah Johnson
- Alyssa Badertscher
- Sarah Kidd

Initial office meetings were conducted with all Core Team members present to group sites into preliminary Disturbance Response Groups (DRGs) (Stringham et al. 2016). During the DRG office exercise, the Core Team examines characteristics of each existing range site, including but not limited to the following:

- Dominant Vegetation
- Soils: depth, texture, parent material, diagnostic horizons, chemical properties, soil temperature and moisture regimes
- Precipitation
- Slope and Elevation
- Plant productivity
- Response to various disturbances based on all the above characteristics, plus management history

The Core Team spends an extensive amount of time on the topic of response to disturbance. Discussions on different disturbances such as fire, grazing, long-term drought, insects, flooding or ponding, invasive species, and combinations of disturbances are recorded. The Core Team makes a determination as to which DRG each ecological site or range site will be assigned to for modeling purposes. After the initial DRG is finalized, the "modal" ecological site for the DRG is chosen. This ecological site typically represents the site in each DRG with the most mapped acres in the NRCS soil survey. Dr. Stringham then develops a "Tier I" state-and-transition model for the modal ecological site for each DRG. This generalized STM represents each ecological site within the DRG until field validation is complete, and changes to the STM are deemed necessary based on field observations.

Field validation occurs primarily with the Core Team and at times with assistance from others interested in the process. To facilitate the field component, the GIS specialist builds a geodatabase with relevant data. These include NRCS soil survey data (i.e. ecological site type locations, soil map units, ecological site polygons, soil pit sampling locations), historical wildfires dating back at least 30 years, BLM land treatment layers, land ownership, roads, any available vegetation monitoring data, NAIP imagery, and USGS Digital Raster topography. The GIS specialist or the soil scientist utilizes this geodatabase while in the field to inform the team of recent fires, multiple fires, or mechanical treatments performed on the site. The Core Team attempts to visit every ecological site at least once, and visits the modal ecological site for each DRG multiple times in different locations, and in different conditions. At each site visit the following information was recorded:

- GPS coordinates
- Photos
- Elevation

- Slope and aspect
- Landform
- Soil description to 20” depth or to restrictive horizon
- Soil is identified to series if possible
- Known disturbances: fire, drought, insects, management practices, and others
- Plant species composition by weight, estimated ocularly and sometimes clipped
- Shrub and tree cover
- Rangeland Health
- State-and-transition model state and community phase, including any relevant notes on ecological dynamics

Dr. Stringham modifies the STM if needed based on field notes, this then becomes the “Tier II” model. The Core Team reconvenes in the office and reviews the Tier II state-and-transition models. Members of the interested public are invited to the meetings to provide input and critical review. Models are modified if warranted. STMs are built using Microsoft Visio, and a shorthand “key” is written for each Community Pathway and Transition. Dr. Stringham, along with her staff, complete the STMs by developing the “STM narrative,” which explains the ecological dynamics associated with the various States, Community Phases, Community Pathways and Transitions. An extensive literature review is conducted and added to the knowledge gained from the field investigations. The Core Team and interested agency partners peer review and provide critical feedback for the ecological dynamics section and the STM.

This project produced 158 field notes over the course of 3 field seasons and 15 weeks of field work. The Final Report contains the Disturbance Response Group list for MLRA 26, a robust literature review and Ecological Dynamics section for the modal ecological site of each DRG, State-and-Transition Model diagrams for each ecological site contained within a DRG, and supplemental information with field notes for all site visits.

Definitions and Standardized STM Concepts for this Report

This report aims to adhere to the ecological site standards for ecological dynamics outlined in The Interagency Ecological Site Handbook (hereafter "Handbook", Caudle et al. 2013). This section defines concepts and terms used throughout this report, many of which come from the Handbook or associated literature (Stringham et al. 2019).

Definitions:

Disturbance Response Group (DRG):
DRGs are defined as groups of ecological sites that respond similarly to natural or human-caused disturbance, reaching the same state or endpoint, although the rate of adjustment may vary by site.

State:
A state is a suite of community phases and their inherent soil properties that interact with the abiotic and biotic environment to produce persistent functional and structural attributes associated with a characteristic range of variability (Briske et al. 2008, Caudle et al. 2013). Alternative states differ in the operation of one or more primary ecological processes including the hydrologic (water) cycle, nutrient cycle, the process of energy capture and transformation (energy flow). In this report, States are given a number and a title, i.e. Reference State 1.0.

Phase:
A vegetative community within a state, capable of self-repair and resilience in the face of disturbances. In this report, Phases are given a decimal number within their respective State, i.e. Phase 1 in Reference State 1.0 is Phase 1.1.

Community Phase Pathway:
Community pathways describe the causes of shifts between community phases. Community pathways can include the concepts of episodic plant community changes as well as succession and seral stages. Community pathways can represent both linear and non-linear plant community changes. A community pathway is reversible, attributable to succession, natural disturbances, short-term climatic variation, and facilitating practices such as grazing management (Caudle et al. 2013). These pathways generally, though not always, flow in both directions, and are visualized by directional arrows. Arrows are numbered based on the state and phase from which the pathway arrow originates, followed by a lower-case letter (a, b, c, etc.) uniquely identifying the arrow (i.e. 1.1a is the first pathway that originates from Phase 1.1 in State 1.0).

"At-Risk" Phase:
These phases are at risk of transitioning to another state. Careful management is necessary to prevent a transition.

Threshold:
A boundary in space and time at which one or more of the primary ecological processes responsible for maintaining the sustained equilibrium of the state degrades beyond the point of

self-repair. These processes must be actively restored before the return to the previous state is possible.

Transition:
The point in space and/or time at which a vegetative community crosses a threshold. Transitions are not reversible without external inputs of energy or resources to restore to a previous state. These are numbered based on the state from which the transition arrow originates, followed by an upper-case letter (A, B, C, etc.) uniquely identifying the arrow (i.e. T4A is the first Transition that originates from State 4.0).

Restoration Pathway:
Restoration pathways describe the environmental conditions and management practices that are required to recover a state that has undergone a transition. These are numbered based on the state from which the Restoration Pathway arrow originates, followed by an upper-case letter (A, B, C, etc.) uniquely identifying the arrow (i.e. R4A is the first Restoration Pathway that originates from State 4.0).

General descriptions of State concepts used in this report:

Reference state:
The reference state has seen little unnatural disturbances and is thought of as pre-settlement condition. Only native species are present in this state. The reference state and reference community phase (below) formed as a result of interacting environmental gradients, natural disturbance regimes, and physiological characteristics of species comprising the community.

In this report, <u>Phase 1.1</u> is designated as the "reference community phase," which most closely represents the ecological site concept of the modal site for the DRG. The reference community phase may or may not represent a late successional community, because the natural disturbance regime may have maintained early-seral species (i.e. tall grass prairie maintained by frequent wildfire) (Briske et al. 2008, Caudle et al. 2013).

Current potential state:
This state is similar to the Reference state, but with the presence of non-native species. All plant functional groups from the Reference State are still dominant. Non-native species are present in small numbers, but threaten site resilience through competition and by exacerbating effects of disturbances (i.e. increasing fire frequency by creating drier fuels).

<u>Phase 2.4</u> in the Current Potential State does not occur in every DRG. It is primarily used to capture the phenomenon of non-native annual grass flushes after particularly favorable annual weather patterns. Native bunchgrasses and forbs still comprise 50% or more of the understory annual production, however non-native annual grasses are nearly codominant. This phase is temporary, and weather patterns that are unfavorable to annual grasses may reduce the high cover and production of the annual grass component. This phase is considered "At Risk" because fire could lead to perennial bunchgrass mortality, which may shift the site to an Annual State.

Shrub state:

This state is characterized by a loss of deep-rooted native perennial grasses. Shrubs are usually dominant, but after fire the dominant plants are usually Sandberg bluegrass or low-growing, mat-forming forbs. This state is a product of decades of inappropriate grazing management.

Annual state:
In this state, non-native annual species dominate. The species may include cheatgrass, medusahead, Russian thistle, annual mustards. Annual species dominate site resources; soil function and disturbance frequency and severity are altered.

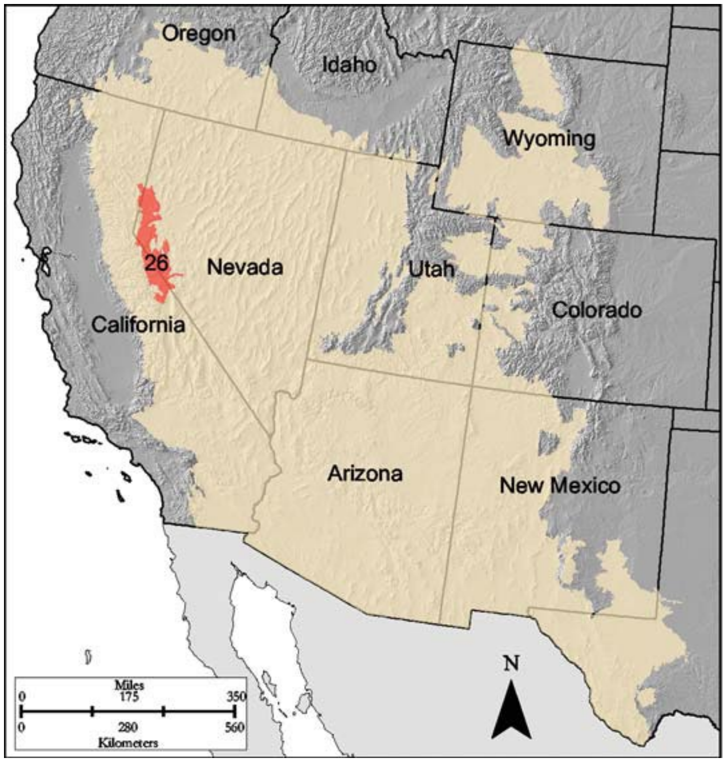
Tree state:
The Tree state is written for shrub-grass ecological sites that currently have Phase II or Phase III trees encroachment (Miller et al. 2008). The shrub-grass understory on these sites has begun to decline in vigor, and significant shrub mortality may be occurring.

Infilled tree state:
The Infilled tree state is like the Tree State, but written for woodland ecological sites. This state has old growth trees present, but because of lack of disturbance, an overabundance of young trees exists. The health of the old growth trees may be impacted, and the risk of stand-replacing crown fire is significantly increased.

Eroded state:
This state is characterized by active soil movement, which inhibits establishment of new plants. This site occurs in late-state conifer encroachment, after severe fires, or after long term inappropriate grazing management resulting in a loss of understory vegetation.

Forb state:
This state is characterized by a dominance of forbs like mule ears. It is a product of long term overgrazing by sheep and usually occurs on clayey soils. This state is less common, but may occur in small areas that have had concentrated use in the past (i.e. sheep bedding grounds)

Major Land Resource Area 26



MLRA 26 (USDA 2006).

Major Land Resource Area 26, known as the Carson Basin and Mountains, is 6,520 square miles (4.2 million acres) in size. Most of MLRA 26 is located in Nevada, with the remainder along the middle of the eastern border of California. Elevation ranges from 3,900 to 6,550 feet in most of the area, with mountains as high as 13,100 feet. This MLRA consists of aggraded desert plains separating north-south trending mountain ranges. Fault blocks with steep side slopes create the mountains, and the Truckee, Carson, and East and West Walker rivers drain most of the valleys in this MLRA. The valleys in the area are filled with alluvium that has been reworked by these rivers. On the west side of the area the Sierra Nevada Mountains consist of granitic rocks, and mostly andesite and basalt in the remaining areas. The soils have been impacted by the historic extent of glacial Lake Lahontan, and there is a level line on high slopes showing evidence of this. The dominant soil orders are Aridisols and Mollisols. The soils are shallow to moderately deep, well drained, and clayey or loamy. The majority of soils in this area are mesic with an aridic or xeric moisture regime.

Average annual precipitation ranges from 5 to 36 inches, increasing with elevation. This area experiences dry summers and receives most of its moisture throughout the fall, winter, and spring. Snow is common in winter. The average annual temperature is 37-54°F, decreasing with elevation. The freeze-free period averages 115 days, but ranges from 40 to 195 days along an elevation gradient.

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Major Land Resource Area 26 Disturbance Response Groups

Ecological Sites and Associated Disturbance Response Groups

DRG Ecological Site Name		*Dominant Species*	*Site ID*
Group 1: Lahontan and low sagebrush and needlegrasses			
Gravelly Clay 10-12"	***Modal Site***	***ARARL3/ACTH7***	***R026XY050NV***
Claypan 8-10"		*ARAR8/ACTH7-POSE/ACWE*	*R026XY025NV*
Gravelly Clay 8-10"		*ARARL3/ACSP12*	*R026XY041NV*
Droughty Claypan		*ARARL3/ACSP12-ACHY*	*R026XY047NV*
Clay Slope 10-12"		*ARARL3/ACTH7*	*R026XY088NV*
Scabland 10-14"		*ARAR8/POSE*	*R026XY090NV*
Sandy Claypan 8-10"		*ARARL3/ACHY*	*R026XY033NV*
Stony Claypan 8-10"	*Correlated CA Site*	*ARAR8/ACSP12*	*026XF066CA*
Group 2: Low sagebrush and thurber's needlegrass			
Claypan 10-12"	***Modal Site***	***ARAR8/ACTH7***	***R026XY023NV***
Claypan 12-14"		*ARAR8/ACTH7*	*R026XY078NV*
Ashy Claypan 12-14"	*Correlated CA Site*	*ARAR8/ACTH7-ACWE3*	*R026XF060CA*
Group 3: Churning clay soils with low or lahontan sagebrush			
Churning Clay 8-10"	***Modal Site***	***ARAR8/ELEL5-POSE***	***R026XY027NV***
Churning Clay 10-12"		*ARTRW8-TEGL/PASM-ELEL5*	*R026XY019NV*
Churning Claypan 10-12"	*ARARL3/POSE*	*R026XY091NV*	
Group 4: Low sagebrush on mountain ridges, low production			
Mountain Ridge	***Modal Site***	***ARAR8/ACPI2-KOMA***	***R026XY028NV***
Claypan 14+		*ARAR8/ACLE9-POA-KOMA*	*R026XY039NV*
Group 5: Silver sagebrush sites, in often-inundated depressions			
Mountain Basin	***Modal Site***	***ARCA13/ACHNA-MURI***	***R026XY049NV***
Clay Basin		*ARCA13/PONE3-LETR5*	*R026XY037NV*
Ashy Mountain Basin	*Correlated CA Site*	*ARTRV-ARCA13/ACOCO*	*026XF062CA*
Group 6: Black sagebrush and needlegrasses			
Shallow Calcareous Loam 8-10"	***Modal Site***	***ARNO4/ACHNA***	***R026XY042NV***
Group 7: Wyoming big sagebrush and needlegrasses			
Loamy 8-10"		***ARTRW8/ACTH7***	***R026XY016NV***
Stony Slope 8-10"		*ARTRW8/ACSP12*	*R026XY022NV*
Droughty Loam 8-10"		*ARTRW8-GRSP/ACHY-ACSP12*	*R026XY024NV*
South Slope 8-10"		*ARTRW8-EPVI/ACSP12*	*R026XY011NV*
Group 8: Steep slopes of alluvial fan remnants			
Eroded Slope 10-12"	***Modal Site***	***ARTRW8/ACHNA-ACHY-ELEL5***	***R026XY029NV***
Eroded Slope 8-10"		*ARARL3/POSE*	*R026XY094NV*

Group 9: Big sagebrush with needlegrass understory

Loamy 10-12"	***Modal Site***	***ARTR2/ACTH7***	***R026XY010NV***
Loamy Hill 10-12"		*ARTRT2-PUTR2/ACTH7-ACSP12*	*R026XY017NV*
Granitic Fan 10-12"		*PUTR-ARTRV/HECO26-ACHY*	*R026XY008NV*
Granitic South Slope 10-12"		*PUTR2-ARTRW8/ACSP12*	*R026XY018NV*
Granitic Slope 10-12"		*ARTRT2-PUTR2/ACTH7-ACSP12*	*R026XY026NV*
Shallow Loam 10-12"		*ARTR2-PUTR2/ACTH7-ACSP12*	*R026XY015NV*
Stony Slope 10-12"		*ARTR2/ACTH7-POFE*	*R026XY100NV*
Granitic Loam 10-12"		*ARTRW8/ACSP12*	*R026XY103NV*
Gravelly Coarse Loamy	*Correlated CA Site*	*ARTRV-PUTR2/ACHY*	*R026XF004CA*
Shallow South Slope 10-14"	*Correlated CA Site*	*ARTRV-PUTR2/ACSP12*	*R026XF070CA*
Shallow Loam 10-14"	*Correlated CA Site*	*ARTRV-PUTR2/ACTH7*	*R026XF069CA*

Group 10: Sandy soils with big sagebrush and a needlegrass understory

Sandy 8-10"	***Modal Site***	***ARTR2/HECO26-ACHY***	***R026XY020NV***
Dune 10-12"		*PUTR2-ARTR2/HECO26-ACHY*	*R026XY014NV*
Sandy Plain		*ARTR2/ACHY-LECI4*	*R026XY096NV*
Deep Ashy	*Correlated CA Site*	*ARTRT-PUTR2/ACHY*	*R026XF005CA*

Group 11: Deep soils with sagebrush, saltbush and a deep rooted perennial bunchgrasses understory

Dry Floodplain	***Modal Site***	***ARTRT/LECI4***	***R026XY012NV***
Deep Sodic Fan		*ATCA2-ATTO/LECI4*	*R026XY032NV*
Wash 8-12"		*ARTRT-PUTR/LECI4*	*R026XY034NV*

Group 12: Mountain big sagebrush and bitterbrush with needlegrass understory

Loamy 12-14"	***Modal Site***	***ARTRV-PUTR2/ACOCO***	***R026XY005NV***
Gravelly Loamy Slope 14-16"		*ARTRV-PUTR2-SYRO/ACOCO-LECI4*	*R026XY105NV*
Granitic Slope 12-14"		*ARTRV-PUTR2/ACTH7-ACOCO*	*R026XY046NV*
Granitic Loam 14+		*ARTRV-PUTR2/ACHNA*	*R026XY006NV*
Loamy Slope 12-14"		*ARTRV-PUTR2/ACTH7-ACOCO*	*R026XY048NV*
Shallow Loam 12-14"		*ARTRV-PUTR2/ACTH7-POA*	*R026XY111NV*
Gravelly Loam 14+		*PUTR2-ARTRV/ACNEN2*	*R026XY040NV*
South Slope 14-16"		*ARTRV-PUTR2/ACHNA*	*R026XY106NV*
South Slope 12-14"		*ARTRV-PUTR/ACTH7-ACSP12*	*R026XY089NV*
Ashy Shallow Loam 14-16"	*Correlated CA Site*	*ARTRV-PUTR2/ACOCO-KOMA*	*R026XF057CA*
Ashy South Slope 12-14"	*Correlated CA Site*	*ARTRV-PUTR2/ACSP12-ACHY*	*R026XF063CA*
Granitic Upland 14-16"	*Correlated CA Site*	*ARTRV-PUTR2/ACSP12-ACHY*	*R026XF064CA*

Group 13: Higher elevations with mountain sagebrush and western needlegrass

Loamy Slope 14+	***Modal Site***	***ARTRV/ACOCO***	***R026XY038NV***
Ashy Slope 14-16"		*ARTRV/ACOCO-LECI4*	*R026XY108NV*
Gravelly Mountain Shoulders 16+	*ARTRV/LEKI2*	*R026XY075NV*	
South Slope 16+		*ARTRV/LEKI2-ACHNA*	*R026XY056NV*
Shallow Loam 16+		*ARTRV-ERMI4/LEKI2-CAREX-KOMA*	*R026XY052NV*
Mountain Shoulders 16+		*ARTRV/ACLE9-CAREX*	*R026XY076NV*
Loamy Slope 16+"		*ARTRV-SYRO/ACOCO-LEKI2*	*R026XY109NV*
Ashy Pocket		*ARTRV/ACOCO-CAREX*	*R026XY112NV*
Gravelly South Slope 16+		*ARTRV-PUTR2/ACOCO*	*R026XY110NV*
Ashy Mountain Shoulders 16-20"	*Correlated CA Site*	*ARTRV/ACOCO*	*R026XF059CA*
Ashy Loamy Slope 16-20"	*Correlated CA Site*	*ARTRV/ACOCO*	*R026XF058CA*

Group 14: Black greasewood alluvial flats and bolsons			
Sodic Flat	***Modal Site***	***SAVE4/LECI4-DISP***	***R026XY021NV***
Sodic Floodplain		*SAVE4/SPAI-DISP-LECI4*	*R026XY013NV*
Saline Bottom		*SAVE4/LECI4*	*R026XY004NV*
Group 15: Mahogany stands with a sagebrush and needlegrass understory			
Mahogany Savanna	***Modal Site***	***CELE3/ARTRV/ACHNA***	***R026XY009NV***
Mahogany Thicket		*CELE3/ACHNA-POA*	*R026XY081NV*
Group 16: Silty soils with winterfat			
Silty 8-10"	***Modal Site***	***KRLA2/ACHY***	***R026XY031NV***
Group 17: Old growth juniper with sagebrush and needlegrass understory			
JUOS WSG: 0S0402	***Modal Site***	***JUOS/ARTRW8/ACHY-HECO26***	***F026XY063NV***
Group 18: Pinyon and juniper with sagebrush and needlegrass understory			
PIMO-JUOS WSG: 0R0502	***Modal Site***	***PIMO-JUOS/ARTRW8/ACTH7***	***F026XY062NV***
PIMO-JUOS WSG: 0D0503		*PIMO-JUOS/ARAR8-PUTR2/ACTH7*	*F026XY064NV*
JUOS WSG: 0X0403		*JUOS/ARAR8/ACTH7-POA*	*F026XY092NV*
PIMO WSG: 0X0603		*PIMO/ARAR8/POFE-ACTH7*	*F026XY093NV*
Group 19: Pinyon with sagebrush and needlegrass understory			
PIMO WSG: 0R0601	***Modal Site***	***PIMO/ARTRV/ACTH7***	***F026XY060NV***
PIMO WSG: 1R0601		*PIMO/ARTRV/POFE-ACTH7*	*F026XY044NV*
PIMO WSG: 0R0602		*PIMO/ARTRV/ACSP12-ACTH7*	*F026XY061NV*
PIMO WSG: 0R0601		*PIMO/ARTRV/POFE*	*F026XY069NV*
PIMO WSG: 1R1		*PIMO/ARTRV/ACSP12*	*F026XY104NV*
PIMO WSG: 1R0601		*PIMO/ARTRV/POFE*	*F026XY071NV*
Group 20: Quaking aspen			
POTRT WSG: 1A1707	***Modal Site***	***POTRT/ARTRV/BRMA4-ELTR7***	***F026XY086NV***
POTRT WSG: 2W1710		*POTRT/PONE3-ELTR7-CAREX*	*F026XY068NV*
POTR5 WSG: 1R1707		*POTRT/SYOR2/BRMA4-ELTR7*	*F026XY066NV*
Aspen Thicket	*Correlated CA Site*	*POTRT/ACHNA-ELTR7*	*R026XF056CA*
Group 22: Deep soil wet basins with silver sagebrush, rushes and sedges			
Wet Clay Basin	***Modal Site***	***IVAX-AAFF***	***R026XY036NV***
Wet Ashy Basin	*Correlated CA Site*	*CATA2*	*R026XF068CA*
Group 23: High elevations with pines, sagebrush, currant and grass understory			
PIFL2 WSG: 0R1001	***Modal Site***	***PIFL2/ARTRV/LEKI2-KOMA-CAREX***	***F026XY067NV***
Group 24: Ponderosa pine and altered andesite buckwheat			
PIPO WSG:2R1207	***Modal Site***	***PIPO/ERLOR/CAREX***	***F026XY065NV***
Group 25: Grassy dry meadows			
Dry Meadow	***Modal Site***	***PONE3***	***R026XY055NV***
Ashy Sodic Basin	*Correlated CA Site*	*PULE-CADO2*	*R026XF065CA*
Group 26: Inset fans and stream terraces with basin wildrye			
Loamy Bottom 8-12"	***Modal Site***	***ARTRT/LECI4***	***R026XY030NV***
Loamy Bottom 14+		*ARTRV/LECI4*	*R026XY057NV*

Ecological Sites Omitted from This Report

The following list of ecological sites were omitted from this final report for various reasons. Some ecological sites have been removed from the soil survey after being deemed redundant, so they no longer have any acres mapped in the USDA Soil Survey database (SSURGO). Other sites are minor inclusions in the MLRA and may only occur on a few hundred acres, and riparian sites were outside the scope of this project. For our purposes, we focused on providing ecological information for Ecological Sites that were extensive enough to be meaningful for management. A tentative Disturbance Response Group (DRG) number is given for some sites, in the event that mapping is updated in the future to include them on a larger scale.

Site Name	***Reason***	***Site Vegetation***	***Site ID***	***(DRG)***
Granitic Claypan 8-12"	*Zero acres mapped*	*ARARL3/ACSP12*	*R026XY095NV*	*1*
Sandy Loam 8-10"	*Zero acres mapped*	*ARARL3/ACSP12*	*R026XY101NV*	*1*
Churning Claypan 8-10"	*Zero acres mapped*	*ARARL3-ATCO/ACSP12*	*R026XY097NV*	*3*
Gravelly Loam 8-10"	*Zero acres mapped*	*ARTRW8/ACTH7*	*R026XY098NV*	*7*
Coarse Loamy 8-10"	*Zero acres mapped*	*ARTRW8/ACTH7-ACHY*	*R026XY099NV*	*7*
Gravelly Clay Loam 8-10"	*Zero acres mapped*	*ARTRW8/ACTH7-ACSP12*	*R026XY102NV*	*7*
Dune 8-10"	*Zero acres mapped*	*ARTRT-GRSP-ATCA2/ACHY-LECI4*	*R026XY051NV*	*10*
Granitic Fan 12-14"	*Zero acres mapped*	*PUTR2-ARTRV/ACOCO*	*R026XY085NV*	*12*
Steep North Slope 14+" P.Z.	*Zero acres mapped*	*ARTRV/FEID*	*R026XY007NV*	*13*
Loamy 16+" P.Z.	*Zero acres mapped*	*ARTRV/BRMA4-ACHNA*	*R026XY053NV*	*13*
Granitic South Slope 14"+ P.Z.	*Zero acres mapped*	*ARTRV/ACOCO-ACLE9*	*R026XY079NV*	*13*
Mountain Loam 16+	*Zero acres mapped*	*ARTRV/ACLE9-ACPI2-KOMA*	*R026XY082NV*	*13*
Deep Loamy 14+	*Zero acres mapped*	*ARTRV/ACOCO-PONE3*	*R026XY084NV*	*13*
Stony Mahogany Savanna	*Zero acres mapped*	*CELE3/ARTRV/ACHNA-LEKI2*	*R026XY080NV*	*15*
JUOS-PIMO WSG: 0R0502	*Zero acres mapped*	*JUOS-PIMO/ARTRW8/ACSP12*	*F026XY043NV*	*18*
JUOS WSG: 0D0402	*Zero acres mapped*	*JUOS/ARTRW8/ACSP12*	*F026XY045NV*	*18*
PIMO-JUOS WSG: 1R0502	*Zero acres mapped*	*PIMO-JUOS/ARTRW8/ACTH7*	*F026XY070NV*	*18*
PIMO WSG: 0X0601	*Zero acres mapped*	*PIMO/ARTRV/POFE-ACTH7*	*F026XY072NV*	*18*
Snow Pocket	*Small acreage*	*ERSU13/ACOCO/LUCA*	*R026XY077NV*	*21**
Alpine Ridge	*Zero acres mapped*	*HAMA2-LEPU-RICE/POA-KOMA*	*F026XY058NV*	*23*
POFR2 WSG: 4W1510	*Small ac/riparian*	*POFR2/LEYMU-PSAM*	*F026XY059NV*	*N/A*
POBAT WSG: 6W1610	*Small ac/riparian*	*POBAT/ARTRV-ROWO/DECE-ELTR7*	*F026XY074NV*	*N/A*
POTRT WSG: 0R1707	*Zero acres mapped*	*POTRT/ARTRV-ROWO*	*F026XY087NV*	*N/A*
Moist Floodplain	*Riparian*	*LETR5-LECI4*	*R026XY001NV*	*N/A*
Wet Sodic Bottom	*Riparian*	*DISP*	*R026XY002NV*	*N/A*
Wet Meadow 10-14" P.Z.	*Riparian*	*PONE3-CAREX*	*R026XY003NV*	*N/A*
Wet Meadow 14+" P.Z.	*Riparian*	*DECE*	*R026XY054NV*	*N/A*
Streambank	*Riparian*	*SALU2-SHAR/LETR5-PONE3*	*R026XY073NV*	*N/A*

**The Snowpocket (R026XY077NV) site was removed from the modeling effort toward the end of the process. Because the numbering scheme was already complete at this time, the numers were kept the same for groups 22 through 26. There is no DRG 21 in this report.*

MLRA 26 Group 1: Lahontan and low sagebrush and needlegrasses

Description of MRLA 26 Disturbance Response Group 1

Disturbance Response Group (DRG) 1 consists of eight ecological sites. The precipitation zone for these sites ranges from 7 to 14 inches. The elevation range of this group is 4,300 to 7,000 feet. Slopes range from 0 to 50 percent, however, 4 to 30 percent are typical. Soils on these sites range from shallow to deep with available water capacity ranging from low to high. Soils exhibit root restrictive layers such as dense clays within the subsoil which limit plant growth on these sites. The argillic horizon within the profile limits deep soil water percolation often leading to saturated near surface soil conditions in the spring and droughty soils in the summer. Due to slow percolation these soils can experience surface water loss through runoff. Annual production in a normal year ranges from 175 to 600 lbs/acre for the group. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by low (*Artemisia arbuscula*) or Lahontan sagebrush (*A. arbuscula ssp. longicaulis*). Spiny hopsage (*Grayia spinosa*) and fourwing saltbush (*Atriplex canescens*) are also important shrub species. The understory is dominated by deep rooted perennial bunchgrasses primarily Thurber's needlegrass (*Achnatherum thurberianum*) or desert needlegrass (*Achnatherum speciosum*) and Sandberg bluegrass (*Poa secunda*). Other important grasses include Indian ricegrass (*Achnatherum hymenoides*), bottlebrush squirreltail (*Elymus elymoides*) and Webber needlegrass (*Achnatherum webberi*). Old growth Utah juniper (*Juniperus osteosperma*) and/or singleleaf pinyon (*Pinus monophylla*) may also be present but is a minor component.

Many of the ecological sites in this group are described as having low sagebrush as the dominant shrub. During our visits to these sites, we used the black light test (Winward and Tisdale 1969, Rosentreter 2005) to verify sagebrush species. Almost all sites visited, including some NRCS Type Locations, had Lahontan sagebrush as the dominant shrub. Lahontan sagebrush was only recently identified as a unique species of sagebrush (Winward and McArthur 1995), so it may not have been apparent at the time some of these ecological sites were established. Due to the differences in palatability between low sage and Lahontan, as well as potential soil differences, we recommend a reevaluation of the low sagebrush ecological sites in MLRA 26, with particular attention given to the Claypan 8-10" site.

Disturbance Response Group 1 Ecological Sites:

Gravelly Clay 10-12" — Modal Site	R026XY050NV
Claypan 8-10"	R026XY025NV
Gravelly Clay 8-10"	R026XY041NV
Droughty Claypan	R026XY047NV
Clay Slope 10-12"	R026XY088NV
Scabland 10-14"	R026XY090NV
Sandy Claypan 8-10"	R026XY033NV
Stony Claypan 8-10"	R026XF066CA

Modal Site:

The Gravelly Clay 10-12” ecological site is the modal for this group as it has the most acres mapped. This site occurs on summits and sideslopes of plateaus and low mountains. Slope generally ranges from 2 to 50 percent. Elevations are 5000 to 6000 feet. Average annual precipitation is 10 to 12 inches. The soils of this site are typically shallow, well drained and moderately permeable. The available water capacity is low. Infiltration is restricted once soils are wetted and water is lost by runoff or evaporation The surface of these soils commonly contain over 60% gravels, cobbles and stones and therefore provide a stabilizing effect to help prevent surface erosion.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site’s resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by deep-rooted cool season, perennial bunchgrasses, a diversity of perennial forbs, and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, but are limited on this site due to depth to a restrictive layer (duripan, bedrock) (Dobrowolski et al. 1990) and less than a 1.0 m for low sagebrush community types (Jensen 1990). These shrubs have a flexible generalized root system with development of both taproots and laterals near the surface (Comstock and Ehleringer 1992).

The perennial bunchgrasses that are dominant include Thurber’s needlegrass and desert needlegrass. Both grasses are caespitose, deep-rooted perennial grasses. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Periodic drought regularly influences sagebrush ecosystems, and drought duration and severity has increased throughout the 20th century in much of the Intermountain West (USGCRP 2017, Schlaepfer et al. 2017, Snyder et al. 2019). Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

Low sagebrush is fairly drought tolerant, but also tolerates periodic wetness during some portions of the growing season (Fosberg and Hironaka 1964, Blackburn et al. 1968a and b, 1969). It grows on soils that have a strongly-structured B2t (argillic) horizon close to the soil surface, limiting available rooting depth (Winward 1980, Fosberg and Hironaka 1964, Zamora and Tueller 1973). Low sagebrush is also susceptible to the sagebrush defoliator, Aroga moth. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975), but the research is inconclusive of the damage sustained by low sagebrush populations.

Lahontan sagebrush was only recently identified as a unique species of sagebrush (Winward and McArthur 1995). Lahontan sagebrush is a cross between low sagebrush and Wyoming sagebrush (*Artemisia tridentata ssp. wyomingensis)* and is typically found near the old shorelines of Lake Lahontan from the Pleistocene epoch. This subspecies grows on soils similar to low sagebrush with shallow depths and low water holding capacity (Winward and McArthur 1995).

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons (MacMahon 1980). Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing, extended drought) that have resulted in fluctuations in resources (Beckstead and Augspurger 2004, Chambers et al. 2007, Johnson et al. 2011). Disturbance changes resource uptake and increases nutrient availability, often to the benefit of non-native species. Native species are often damaged by disturbance and their ability to use resources is depressed for a time, even though resource pools may increase following disturbance from depressed used by plants and/or the decomposition of dead plant material (Whisenant 1999, Miller et al. 2013).

The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency and eventually lead to an annual state. Conversely, as fire frequency decreases, sagebrush will increase and with inappropriate grazing management the perennial bunchgrasses and forbs may be reduced. Infilling by singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma)* may also occur with an extended fire return interval. This will occur on sites that are proximate to existing stands of pinyon or juniper. In the absence of disturbance, singleleaf pinyon and Utah juniper will dominate the site and mountain big sagebrush will be severely reduced along with the herbaceous understory. Bluegrasses may remain underneath trees on north-facing slopes. The potential for soil erosion increases as the Utah juniper woodland matures and the understory plant community cover declines.

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Long-term disturbance response may be influenced by small differences in landscape topography. Concave areas receive run-in from adjacent landscapes and consequently retain more moisture to support the growth of deep-rooted perennial grasses (i.e. Thurber's or desert needlegrass) whereas convex areas where runoff occurs are slightly less resilient and may have more shallow-rooted perennial grasses (i.e. squirreltail). North slopes are also more resilient than south slopes because lower soil surface temperatures operate to keep moisture content higher on northern exposures. Five possible stable states have been identified for this DRG.

Annual Invasive Grasses:

The species most likely to invade these sites are cheatgrass and medusahead. Both species are cool season annual grasses that maintain an advantage over native plants in part because they are prolific seed producers, able to germinate in the autumn or spring, tolerant of grazing and increase with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Medusahead and cheatgrass originated from Eurasia and both were first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead. By 2003, medusahead occupied approximately 2.3 million acres in 17 western states (Rice 2005). In the Intermountain West, the exponential increase in dominance by medusahead has largely been at the expense of cheatgrass (Harris 1967, Hironaka 1994).

Medusahead matures 2-3 weeks later than cheatgrass (Harris 1967) and recently, James et al. (2008) measured leaf biomass over the growing season and found that medusahead maintained vegetative growth later in the growing season than cheatgrass. Mangla et al. (2011) also found medusahead had a longer period of growth and more total biomass than cheatgrass and hypothesized this difference in relative growth rate may be due to the ability of medusahead to maintain water uptake as upper soils dry compared to co-occurring species, especially cheatgrass. Medusahead litter has a slow decomposition rate, because of high silica content, allowing it to accumulate over time and suppress competing vegetation (Bovey et al. 1961, Davies and Johnson 2008). Harris (1967) reported medusahead roots have thicker cell walls compared to those of cheatgrass, allowing it to more effectively conduct water, even in very dry conditions. Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. Collectively, the body of research suggests that the continued invasion and dominance of medusahead onto native grasslands and cheatgrass infested grasslands will continue to increase in severity because conditions that favor native bunchgrasses or cheatgrass over medusahead are rare (Mangla et al. 2011). Medusahead replaces native vegetation and cheatgrass directly by competition and suppression and native vegetation indirectly by increasing fire frequency.

Methods to control medusahead and cheatgrass include herbicide, fire, grazing, and seeding of primarily non-native wheatgrasses. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. A study by Davies et al. (2013), found an increase in medusahead cover near roads. Cover was higher near animal trails than random transects but the difference was less evident. This implies that vehicles and animals aid the spread of the weed; however, vehicles are the major vector of movement. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating medusahead and cheatgrass than spraying alone (Sheley et al. 2012). Where native bunchgrasses are missing from the site, revegetation of medusahead or cheatgrass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron and sulfometuron + Chlorsulfuron) only treatments for suppression of cheatgrass, medusahead and ventenata (North Africa grass, Ventenata dubia) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011), however caution in using these results is advised, as only one year of data was reported. Prescribed fire has also been utilized in combination with the application of pre-emergent herbicide to control medusahead and cheatgrass (Vollmer and Vollmer 2008). Mature medusahead or cheatgrass is very flammable and fire can be used to remove the thatch layer, consume standing vegetation, and even reduce seed levels. Furbush (1953) reported that timing a burn while the seeds were in the milk stage effectively reduced medusahead the following year. He further reported that adjacent unburned areas became a seed source for reinvasion the following year.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic and the same rates with methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz/ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Low sagebrush is killed by fire and does not sprout (Tisdale and Hironaka 1981). Fire risk is greatest following a wet, productive year when there is greater production of fine fuels (Beardall and Sylvester 1976). Fire return intervals are not well understood because these ecosystems rarely coincide with fire-scarred conifers, however, a wide range of 20 to well over 100 years has been estimated (Miller and Rose 1995, Miller and Rose 1999, Baker 2006, Knick et al. 2005). Historically, fires were probably patchy due to the low productivity of these sites (Beardall and Sylvester 1976, Ralphs and Busby 1979, Wright et al. 1979, Smith and Busby 1981). Fine fuel loads generally average 100 to 400 pounds per acre (110-450 kg/ha) but are occasionally as high as 600 pounds per acre (680 kg/ha) in low sagebrush habitat types (Bradley et al. 1992). Reestablishment occurs from off-site wind-dispersed seed (Young 1981). Recovery time of low sagebrush following fire is variable (Young 1981). Without sufficient seed source nearby, it may take decades for sagebrush to reestablish on a site. Little research has focused on low sagebrush recovery post-fire, but we have observed 25+ year old fire scars in this DRG with little to no recruitment. Slow regeneration may subsequently worsen erosion (Blaisdell et al. 1982). We were unable to find any substantial research on success of seeding low sagebrush after fire. To date, we have not been able to find specific research on the fire response of Lahontan sagebrush but field observations indicate this species is killed by fire and does not resprout.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. Thurber's needlegrass is very susceptible to fire-caused mortality. Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk et al. 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber's needlegrass (Britton et al. 1990). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influences the response and mortality of Thurber's needlegrass, smaller bunch sizes are less likely to be damaged by fire (Wright and Klemmedson 1965). However, Thurber's needlegrass often survives fire and will continue growth when conditions are favorable (Koniak 1985). Thus, the initial condition of the bunchgrasses within the site, along with seasonality and intensity of the fire, all factor into the individual species response. Sandberg bluegrass has been found to increase following fire, likely due to its low stature and productivity (Daubenmire 1975) and may retard reestablishment of deeper-rooted bunchgrasses.

Bottlebrush squirreltail (*Elymus elymoides*) is a short-lived perennial grass adapted to a very broad suite of environmental conditions. It is found in plant communities ranging from salt desert to alpine meadows, from 2,000 feet to 11,500 feet in elevation, from Mexico to British Columbia (Monsen et al.

2004). Bottlebrush squirreltail is considered one of the most fire resistant bunchgrasses due to its small size, coarse stems, and sparse leafy material (Britton et al. 1990, Wright 1971, Wright and Klemmedson 1965). Post-fire regeneration occurs from surviving root crowns and from on- and off-site seed sources (Bradley et al. 1992). Bottlebrush squirreltail has the ability to produce large numbers of highly germinable seeds, with relatively rapid germination (Young and Evans 1977) when exposed to the correct environmental cues. Squirreltail is capable of facultative fall or spring germination, develops extensive roots at low temperatures, and produces seed early in the season (Hironaka 1994, Reynolds and Fraley 1989, Monsen et al. 2004). Recent research indicates that squirreltail is capable of relatively rapid natural selection to improve survival in low-water, competitive environments (Kulpa and Leger 2013). These traits and others make squirreltail competitive with cheatgrass and medusahead (Hironaka and Sindelar 1975, Hironaka 1994). Squirreltail reproduces primarily through seed. The long awns of the fruit allow for wind dispersal up to 130 ft (40 m) away from the parent plant (Hironaka and Tisdale 1963, Marlett and Anderson 1986).

The grasses likely to invade this site are cheatgrass and medusahead. These invasive grasses displace desirable perennial grasses, reduce livestock forage, and accumulate large fuel loads that foster frequent fires (Davies and Svejcar 2008). Invasion by annual grasses can alter the fire cycle by increasing fire size, fire season length, rate of spread, numbers of individual fires, and likelihood of fires spreading into native or managed ecosystems (D'Antonio and Vitousek 1992, Brooks et al. 2004). While historical fire return intervals are estimated at 15 to 100 years, areas dominated with cheatgrass are estimated to have a fire return interval of 3-5 years (Whisenant 1990). The mechanisms by which invasive annual grasses alter fire regimes likely interact with climate. For example, cheatgrass cover and biomass vary with climate (Chambers et al. 2007) and are promoted by wet and warm conditions during the fall and spring. Invasive annual species have been shown able to take advantage of high N availability following fire through higher growth rates and increased seedling established relative to native perennial grasses (Monaco et al. 2003).

Livestock/Wildlife Grazing Interpretations:

Domestic sheep and, to a much lesser degree, cattle consume low sagebrush, particularly during the spring, fall, and winter (Sheehy and Winward 1981). Heavy dormant season grazing by sheep will reduce sagebrush cover and increase grass production (Laycock 1967). Severe trampling damage to supersaturated soils could occur if sites are used in early spring when there is abundant snowmelt. Trampling damage, particularly from cattle or horses, in low sagebrush habitat types is greatest when high clay content soils are wet. In drier areas with more gravelly soils, no serious trampling damage occurs, even when the soils are wet (Hironaka et al. 1983). Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton et al. (1990) observed the effects of clipping date on basal area of 5 bunchgrasses in eastern Oregon, and found grazing from August to October (after seed set) has the least impact. Heavy grazing (> 60% utilization) during the growing season, for multiple years in a row, will reduce perennial bunchgrasses and increase sagebrush (Laycock 1967). Abusive grazing by cattle, sheep or horses will likely increase low sagebrush, rabbitbrush and some forbs such as arrowleaf balsamroot (*Balsamorhiza sagittata*). Annual non-native weedy species such as cheatgrass and mustards, and potentially medusahead (*Taeniatherum caput-medusae*), may invade.

Throughout two years of site visits for this report, Lahontan sagebrush was observed in a heavily browsed state on ecological sites within this DRG. This recently differentiated subspecies of low sagebrush (Winward and McArthur 1995) is moderately to highly palatable to browse species (McArthur 2005, Rosentreter 2001). Dwarf sagebrush species such as Lahontan sagebrush, low sagebrush, and black sagebrush are preferred by mule deer for browse among the sagebrush species. Due to its palatability, it can often be hedged from grazing pressure (McArthur 2005).

Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber's needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. "Heavy" was not defined in this study. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass, thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988). Thurber's needlegrass may increase in crude protein content after grazing (Ganskopp et al. 2007).

Bottlebrush squirreltail generally increases in abundance when moderately grazed or protected (Hutchings and Stewart 1953). It is considered to be fair to good forage for cattle, horses and sheep in the spring prior to seed development, and in the late fall after seed shatter. In addition, moderate trampling by livestock in big sagebrush rangelands of central Nevada enhanced bottlebrush squirreltail seedling emergence compared to untrampled conditions. Heavy trampling however was found to significantly reduce germination sites (Eckert et al. 1987). Squirreltail is more tolerant of grazing than Indian ricegrass but all bunchgrasses are sensitive to over utilization within the growing season.

Reduced bunchgrass vigor or density may provide an opportunity for squirreltail or Sandberg bluegrass expansion. With further degradation, cheatgrass and other invasive species may occupy interspaces. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass or other weedy species. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer and site conditions, squirreltail, Sandberg bluegrass, or cheatgrass may become the dominant understory with inappropriate grazing management. In most instances of this DRG, bare ground increased significantly with loss of perennial bunchgrasses.

Low sagebrush sites are often used for strutting grounds for Greater sage-grouse (*Centrocercus urophasianus*) because the low cover allows for high visibility of strutting males (McAdoo and Back 2001). Sage-grouse also use these sites during the winter where sagebrush provides food and cover (Braun, Connelly and Schroeder 2005).

State and Transition Model Narrative for Group 1

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 1.

Reference State 1.0:

The Reference State 1.0 is a representative of the natural range of variability under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
This community is dominated by Lahontan sagebrush, Thurber's needlegrass and Sandberg bluegrass. Forbs and other grasses make up smaller components. Pinyon and/or juniper may be present.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring may be more severe and reduce sagebrush cover to trace amounts.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.3:
Time and lack of disturbance such as fire allows for sagebrush to increase and become decadent. Long-term drought, herbivory, or combinations of these will cause a decline in perennial bunchgrasses and fine fuels leading to a reduced fire frequency and allowing sagebrush to dominate the site.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early/mid-seral community. Thurber's needlegrass, squirreltail, and other perennial bunchgrasses dominate. Depending on fire severity patches of intact sagebrush may remain. Rabbitbrush and other sprouting shrubs may be sprouting. Perennial forbs may be a significant component for a number of years following fire.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Time and lack of disturbance will allow sagebrush to increase.

Community Phase 1.3:
Sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or from herbivory.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
A low severity fire, herbivory or combinations will reduce the sagebrush overstory and create a sagebrush/grass mosaic.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community.

T1A: Transition from the Reference State 1.0 to Current Potential State 2.0

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, mustards, redstem stork's bill (*Erodium cicutarium*), or bur buttercup (*Ceratocephala testiculata*).

Slow variables: Over time the annual non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has four general community phases. These non-native species can be highly flammable, and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. Sagebrush, Thurber's needlegrass and Sandberg bluegrass dominate the site. Forbs and other shrubs and grasses make up smaller components of this site.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Fire reduces the shrub overstory and allows for perennial bunchgrasses to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. Annual non-native species are likely to increase after fire.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Time and lack of disturbance allows for sagebrush to increase and become decadent. Long-term drought reduces fine fuels and leads to a reduced fire frequency, allowing sagebrush to dominate the site. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely Sandberg bluegrass may increase in the understory depending on grazing management.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community where annual non-native species are present. Sagebrush is present in trace amounts; perennial bunchgrasses and perennial forbs dominate the site. Depending on fire severity patches of intact sagebrush may remain. Rabbitbrush may be sprouting or dominant in the community.

Perennial forbs may be a significant component for a number of years following fire. Annual non-native species are stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of low sagebrush can take many years.

Community Phase Pathway 2.2b, from Phase 2.2 to 2.4:
Higher than normal spring precipitation favors annual non-native species such as cheatgrass. Non-native annual species will increase in production and density throughout the site. Perennial bunchgrasses may also increase in production.

Community Phase 2.3 (At Risk):
This community is at risk of crossing a threshold to another state. Sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs or from inappropriate grazing, or from both. Rabbitbrush may be a significant component. Squirreltail or Sandberg bluegrass may increase and become dominant. Annual non-native species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, drought, and fire.

Gravelly Clay 10-12" (R026XY050NV) Phase 2.3 P. Novak-Echenique, May 2015

Gravelly Clay 8-10" (R026XY041NV) Phase 2.3 T.K. Stringham, April 2016

Gravelly Clay 8-10" (R026XY041NV) Phase 2.3 P. Novak-Echenique, July 2017

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
A change in grazing management that reduces shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall or winter grazing may cause mechanical damage and subsequent death to sagebrush, facilitating an increase in the herbaceous understory. Low and Lahontan sagebrush are palatable shrub species and can decrease with increased grazing pressure. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. A low severity fire would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Due to low fuel loads in this state, fires will likely be small creating a mosaic pattern. Annual non-native species are present and may increase in the community.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire eliminates/reduces the overstory of sagebrush and allows for the understory perennial grasses to increase. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community. Annual non-native species respond well to fire and may increase post burn.

Community Phase Pathway 2.3c, from Phase 2.3 to 2.4:
Fall, winter, and spring precipitation and temperatures mediate the ability for annual grasses and perennial grasses to germinate and/or survive. Higher than normal spring precipitation creates high annual production of annual grasses (Bradley et al. 2016). Higher than normal spring precipitation favors annual non-native species such as cheatgrass. Non-native annual species increase in production and density throughout the site. Perennial bunchgrasses may also increase in production.

Community Phase 2.4 (At Risk):
This community is at risk of crossing into an annual state. Native bunchgrasses dominate; however, annual non-native species such as cheatgrass may be sub or co-dominant in the understory. Annual production and abundance of these annuals may increase drastically in years with heavy spring precipitation. Seeded species may be present. Sagebrush is a minor component. This site is susceptible to further degradation from grazing, drought, and fire.

Gravelly Clay 10-12" (R026XY050NV) Phase 2.4 P. Novak-Echenique, May 2015

Community Phase Pathway 2.4a, from Phase 2.4 to 2.2:
Fall, winter, and spring precipitation and temperatures mediate the ability for annual grasses and perennial grasses to germinate and/or survive. Depending on temperatures and precipitation in winter and spring, annual grass production may be reduced in favor of perennial bunchgrasses.

Community Phase Pathway 2.4b, from Phase 2.4 to 2.3:
Rainfall patterns favoring perennial bunchgrasses. Less than normal spring precipitation followed by higher than normal summer precipitation will increase perennial bunchgrass production.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: To Community Phase 3.1: Inappropriate grazing will decrease or eliminate deep rooted perennial bunchgrasses and increase bare ground and shallow-rooted grazing-tolerant grasses. Shrub growth and establishment is favored under these conditions. To Community Phase 3.2: Severe fire in Community Phase 2.3 will remove sagebrush overstory, decrease perennial bunchgrasses and enhance annual and perennial forb growth. Squirreltail and/or Sandberg bluegrass may increase. Annual non-native species are present.

Slow variables: Long term decrease in deep-rooted perennial grass density.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Fire or soil disturbing treatment would transition to Community Phase 4.1.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes temporal and spatial nutrient capture and cycling within the community. Increased, continuous fine fuels modify the fire regime by increasing frequency, size and spatial variability of fires.

Shrub State 3.0:

This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Squirreltail and/or Sandberg bluegrass increase with a reduction in deep rooted perennial bunchgrass competition and become the dominant grasses. Bare ground increases significantly. Annual forbs may be a significant or dominant component of the understory, resulting in bare ground after they senesce in the summer. Sagebrush dominates the overstory and rabbitbrush may be a significant component. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and bluegrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1 (At Risk):
Decadent sagebrush dominates the overstory. Rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses are present in trace amounts and may be absent from the community. Squirreltail, bluegrass species, and/or annual forbs dominate the understory. Bare ground may be significant. Pinyon and/or juniper may be encroaching but are not yet affecting understory vegetation.

Gravelly Clay 10-12” (R026XY050NV) Phase 3.1, D. Snyder, August 2016

Gravelly Clay 8-10” (R026XY041NV) Phase 3.1, P. Novak-Echenique, April 2015

Gravelly Clay 10-12” (R026XY050NV) Phase 3.1, T.K. Stringham, June 2016

Stony Claypan 8-10” (R026XF066CA) Phase 3.1, D. Snyder, September 2017

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire, heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, will greatly reduce the overstory shrubs to trace amounts and allow for Sandberg bluegrass to dominate the site.

Community Phase 3.2:
Annual and perennial forbs dominate the site (i.e. redstem stork’s bill (*Erodium cicutarium*), Hooker’s balsamroot (*Balsamorhiza hookeri*) and tapertip hawksbeard (*Crepis acuminata*)). Squirreltail and/or Sandberg bluegrass may increase and be co-dominant with forbs. Deep-rooted perennial bunchgrasses are a minor component or missing. Annual non-native species may be present but are not dominant. Trace amounts of sagebrush or rabbitbrush may be present.

Gravelly Clay 8-10" (R026XY041NV) Forb Phase 3.2 T. K. Stringham, April 2016

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of low and/or Lahontan sagebrush can take many years.

T3A: Transition from Shrub State 3.0 to Annual State 4.0:

Trigger: Fire and/or treatments that disturb the soil and existing plant community.

Slow variables: Increased seed production (following a wet spring) and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing frequency, intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the temporal and spatial aspects of nutrient cycling and distribution.

T3B: Transition from Shrub State 3.0 to Tree State 5.0:

Trigger: Absence of disturbance over time allows Utah juniper and/or singleleaf pinyon dominance.

Feedbacks and ecological processes: Trees increasingly dominate use of soil water, contributing to reductions in soil water availability to grasses and shrubs. Overtime, grasses and shrubs are outcompeted. Reduced herbaceous and shrub production slows soil organic matter inputs and increases soil erodibility through loss of cover and root structure.

Slow variables: Long-term increase in pinyon pine and/or Utah juniper density.

Threshold: Trees overtop sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs in number. There is minimal recruitment of new shrub cohorts.

Annual State 4.0:

An abiotic threshold has been crossed and state dynamics are driven by fire and time. The herbaceous understory is dominated by annual non-native species such as cheatgrass and mustards. Resiliency has declined and further degradation from fire facilitates a cheatgrass and sprouting shrub plant community. Fire return interval has shortened due to the dominance of cheatgrass in the understory and is a driver in site dynamics.

Community Phase 4.1:
Annuals nonnative species dominate. Sagebrush and perennial bunchgrasses may still be present in trace amounts. Surface erosion may increase with summer convection storms and would be verified through increased pedestalling of plants, rill formation or extensive water flow paths.

Gravelly Clay 10-12” (R026XY050NV) Annual State 4.1, P. Novak-Echenique, May 2015

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Time and lack of disturbance allows rabbitbrush and/or other sprouting shrubs to recover after fire. Probability of sagebrush establishment is extremely low.

Community Phase 4.2:
Rabbitbrush is typically the dominant overstory shrub. Sagebrush is a minor component or missing. Annual non-native species dominate the understory.

Community Phase Pathway 4.2a, from Phase 4.2 to 4.1:
Fire reduces/eliminates overstory brush component and allows for annual non-native species to dominate the site.

Tree State 5.0:

This state is characterized by a dominance of Utah juniper and/or singleleaf pinyon in the overstory. Big sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients and soil organic matter distribution and cycling have been spatially and temporally altered.

Community Phase 5.1:
Utah juniper and/or singleleaf pinyon dominates the overstory and site resources. Trees are actively growing with noticeable leader growth. Trace amounts of bunchgrasses may be found under tree canopies with trace amounts of Sandberg bluegrass and forbs in the interspaces. Sagebrush is stressed and dying. Annual non-native species are present under tree canopies. Bare ground interspaces are large and connected.

Gravelly Clay 10-12” (R26XY050NV) Tree State 5.1 P. Novak-Echenique, May 2015

Community Phase Pathway 5.1a, from Phase 5.1 to 5.2:
Time and lack of disturbance or management action allows Utah juniper and/or singleleaf pinyon to further mature and dominate site resources.

Community Phase 5.2:
Utah juniper and/or singleleaf pinyon dominates the site and tree leader growth is minimal; annual non-native species may be the dominant understory species and will typically be found under the tree canopies. Trace amounts of sagebrush may be present, however, dead skeletons will be more numerous than living sagebrush. Bunchgrass may or may not be present. Sandberg bluegrass or mat forming forbs may be present in trace amounts. Bare ground interspaces are large and connected. Soil redistribution is evident.

Gravelly Clay 10-12” (R026XY050NV) Tree State 5.2 P. Novak-Echenique, May 2015

Community Phase Pathway 5.2a, from Phase 5.2 to 5.1:
Tree thinning treatment, typically done for fuels management.

T5A: Transition from Tree State 5.0 to Annual State 4.0:

Trigger: Catastrophic fire causing a stand replacement event will transition Annual State 4.0. Inappropriate tree removal practices with soil disturbance will cause a transition to the Annual State 4.

Slow variables: Increased production and cover of non-native annual species under tree canopies.

Threshold: Closed tree canopy with non-native annual species dominant in the understory changes the intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact nutrient cycling and distribution.

Potential Resilience Differences with other Ecological Sites:

Claypan 8-10” (R026XY025NV):

This site is very similar to the modal site but had low sagebrush listed as the dominant shrub at the time of site concept development. This site is most likely dominated by Lahontan sagebrush, since all Claypan 8-10” sites visited were dominated by Lahontan sagebrush. It occurs on piedmont slopes, is slightly less productive with 300 lbs/acre in a normal year and has less precipitation at 8-10 inches per year. The soils are moderately deep to deep and are well drained. The water capacity is moderate to high but a dense clay subsoil layer limits the development of this plant community. This site is similar to the modal site with 5 stable states.

Gravelly Clay 8-10" (R026XY041NV):

This site is very similar to the modal site but has desert needlegrass (*Achnatherum speciosum*) as the dominant grass and less precipitation at 8-10 inches per year. This site is slightly less productive than the modal with an average of 350 lb/ac in normal years. The soil surface is medium in texture with over 60% gravels, cobbles and stones that provide a stabilizing affect to surface erosion. This site is similar to the modal site with 5 stable states.

Droughty Claypan (R026XY047NV):

This site has desert needlegrass and Indian ricegrass as dominant grasses. It is less productive than the modal site with only 200 lb/ac in a normal year. This site receives an average of 7 inches of precipitation per year. It occurs on lower elevations than the modal site at 4,300 to 5,200 feet. Shadscale may be a minor component of the site, but this site does not have Utah juniper in the Reference State. This site is similar to the modal site with 5 stable states.

Clay Slope 10-12” (R026XY088NV):

This site is more productive than the modal site with an average of 500 lb/ac in normal years. Nevada greasebush (*Glossopetalon spinescens*) and bitterbrush may be minor components. This site is similar to the modal site with 5 stable states.

Scabland 10-14" (R026XY090NV):

This site is not a common ecological site and was not seen during field work for this project. Although this site receives more annual precipitation, it is much less productive than the modal site with 175 lbs/ac in a normal year. This site has very shallow soils, and dominant plants are those with shallow root systems. Sandberg bluegrass is the dominant grass on this site with Thurber’s needlegrass as a subdominant. Low sagebrush is the dominant shrub. As it is similar to the Scabland 10-14” found in MLRA 23, this site is unlikely to go to a tree state. It is susceptible to annual grass invasion. This site has four stable states.

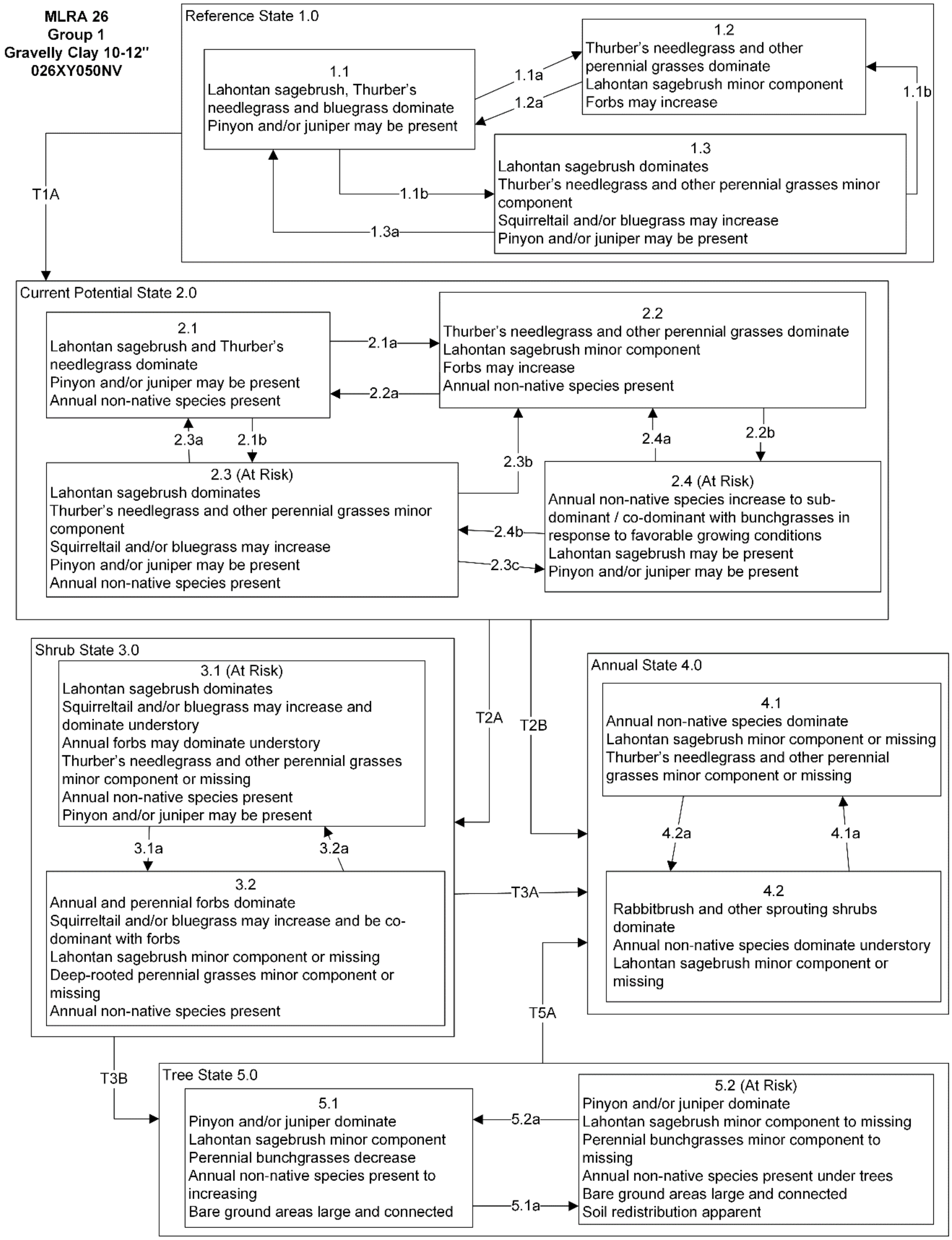
Sandy Claypan 8-10" (R026XY033NV):

This site is not a common ecological site and was not seen during field work for this project. This site is characterized by a sandy soil surface horizon up to 20" thick. Indian ricegrass is the dominant grass. Fourwing saltbush may be a subdominant shrub. There is no pinyon or juniper in the Reference state for this site. This site is similar to the modal site with 5 stable states, however this model may be altered if this site is found in the field.

Stony Claypan 8-10" (R026XF066CA):

This site is not a common ecological site and was only seen once during site visits. This California ecological site is dominated by desert needlegrass (*Achnatherum speciosum*) and low sagebrush. It is slightly less productive than the modal site with 300 lb/ac in normal years. This site is similar to the modal site with 5 stable states.

Modal State and Transition Model for Group 1 in MRLA 26:



MLRA 26
Group 1
Gravelly Clay 10-12"
026XY050NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (to 3.1).
Transition T2B: Fire or brush management causing severe soil disturbance.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance (unlikely/may take many years).

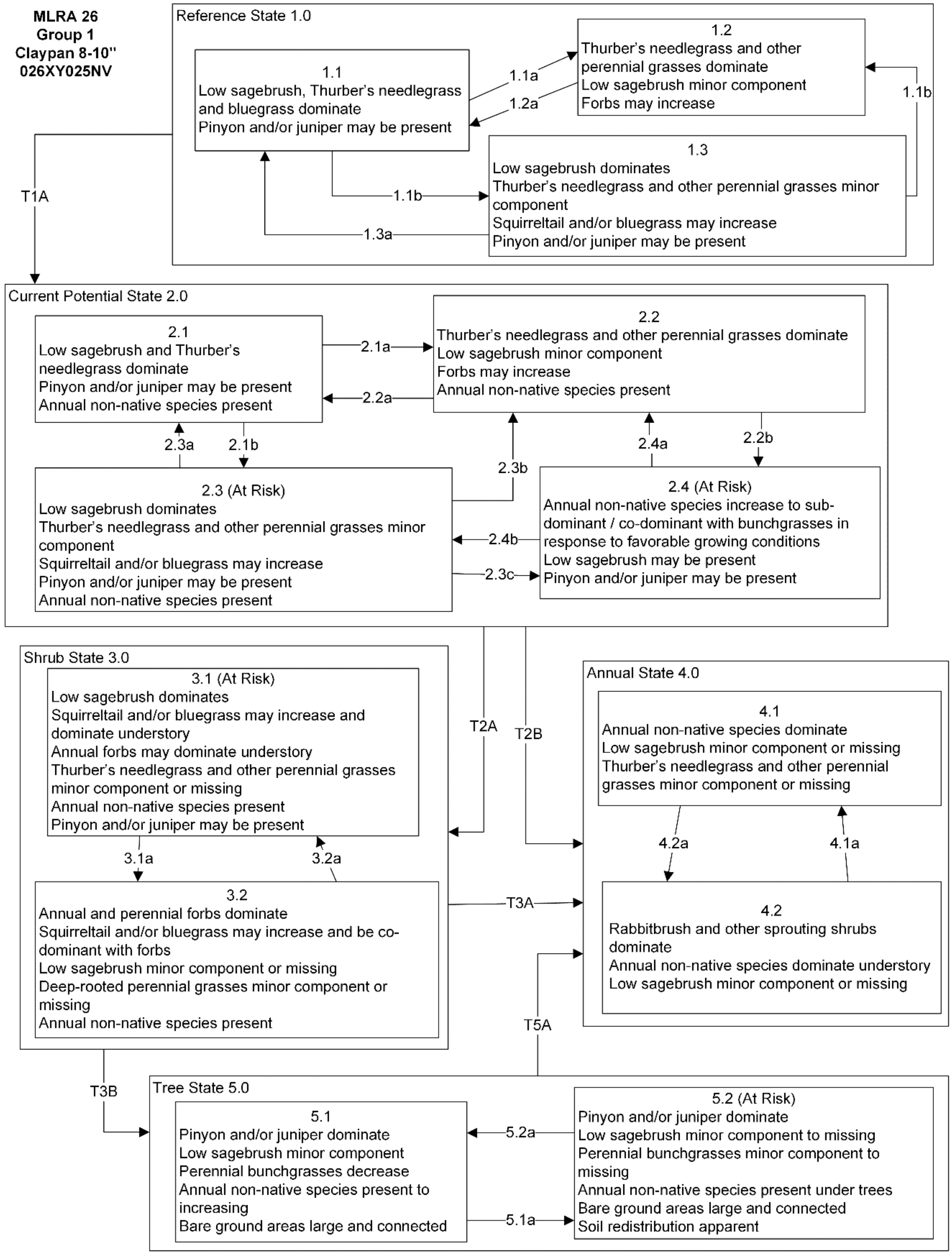
Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows for maturation of the tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Additional State and Transition Models for Group 1 in MLRA 26:



MLRA 26
Group 1
Claypan 8-10"
026XY025NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (to 3.1).
Transition T2B: Fire or brush management causing severe soil disturbance.

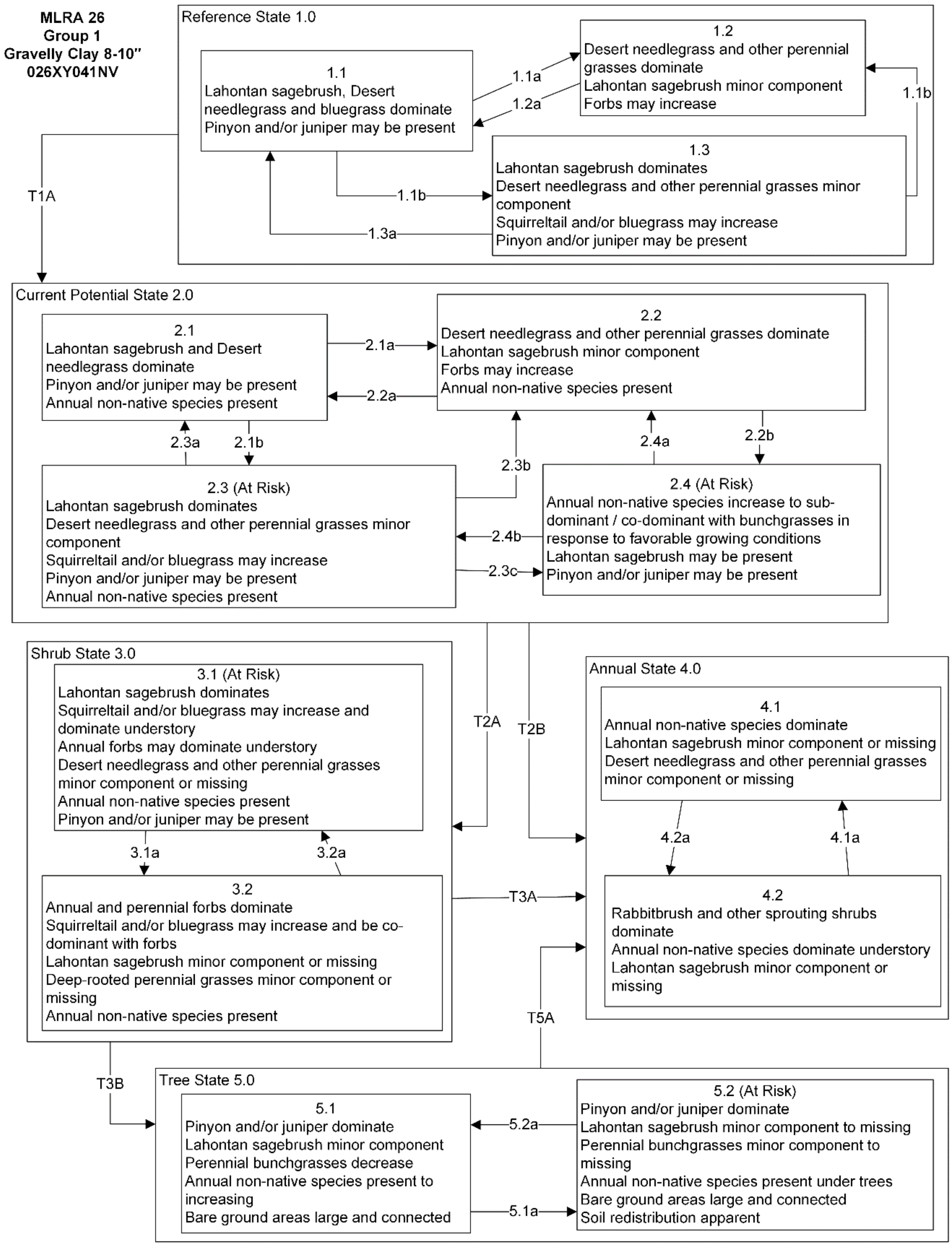
Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows for maturation of the tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.


MLRA 26
Group 1
Gravelly Clay 8-10"
026XY041NV
Reference State 1.0
1.1
Lahontan sagebrush, Desert needlegrass and bluegrass dominate
Pinyon and/or juniper may be present
1.2
Desert needlegrass and other perennial grasses dominate
Lahontan sagebrush minor component
Forbs may increase
1.3
Lahontan sagebrush dominates
Desert needlegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
Pinyon and/or juniper may be present
1.1a
1.2a
1.1b
1.1b
1.3a
T1A
Current Potential State 2.0
2.1
Lahontan sagebrush and Desert needlegrass dominate
Pinyon and/or juniper may be present
Annual non-native species present
2.2
Desert needlegrass and other perennial grasses dominate
Lahontan sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Lahontan sagebrush dominates
Desert needlegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Lahontan sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.3a
2.1b
2.3b
2.4a
2.2b
2.4b
2.3c
Shrub State 3.0
3.1 (At Risk)
Lahontan sagebrush dominates
Squirreltail and/or bluegrass may increase and dominate understory
Annual forbs may dominate understory
Desert needlegrass and other perennial grasses minor component or missing
Annual non-native species present
Pinyon and/or juniper may be present
3.2
Annual and perennial forbs dominate
Squirreltail and/or bluegrass may increase and be co-dominant with forbs
Lahontan sagebrush minor component or missing
Deep-rooted perennial grasses minor component or missing
Annual non-native species present
3.1a
3.2a
T2A
T2B
Annual State 4.0
4.1
Annual non-native species dominate
Lahontan sagebrush minor component or missing
Desert needlegrass and other perennial grasses minor component or missing
4.2
Rabbitbrush and other sprouting shrubs dominate
Annual non-native species dominate understory
Lahontan sagebrush minor component or missing
4.2a
4.1a
T3A
T5A
T3B
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Lahontan sagebrush minor component
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.2 (At Risk)
Pinyon and/or juniper dominate
Lahontan sagebrush minor component to missing
Perennial bunchgrasses minor component to missing
Annual non-native species present under trees
Bare ground areas large and connected
Soil redistribution apparent
5.2a
5.1a

MLRA 26
Group 1
Gravelly Clay 8-10"
026XY041NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (to 3.1).
Transition T2B: Fire or brush management causing severe soil disturbance.

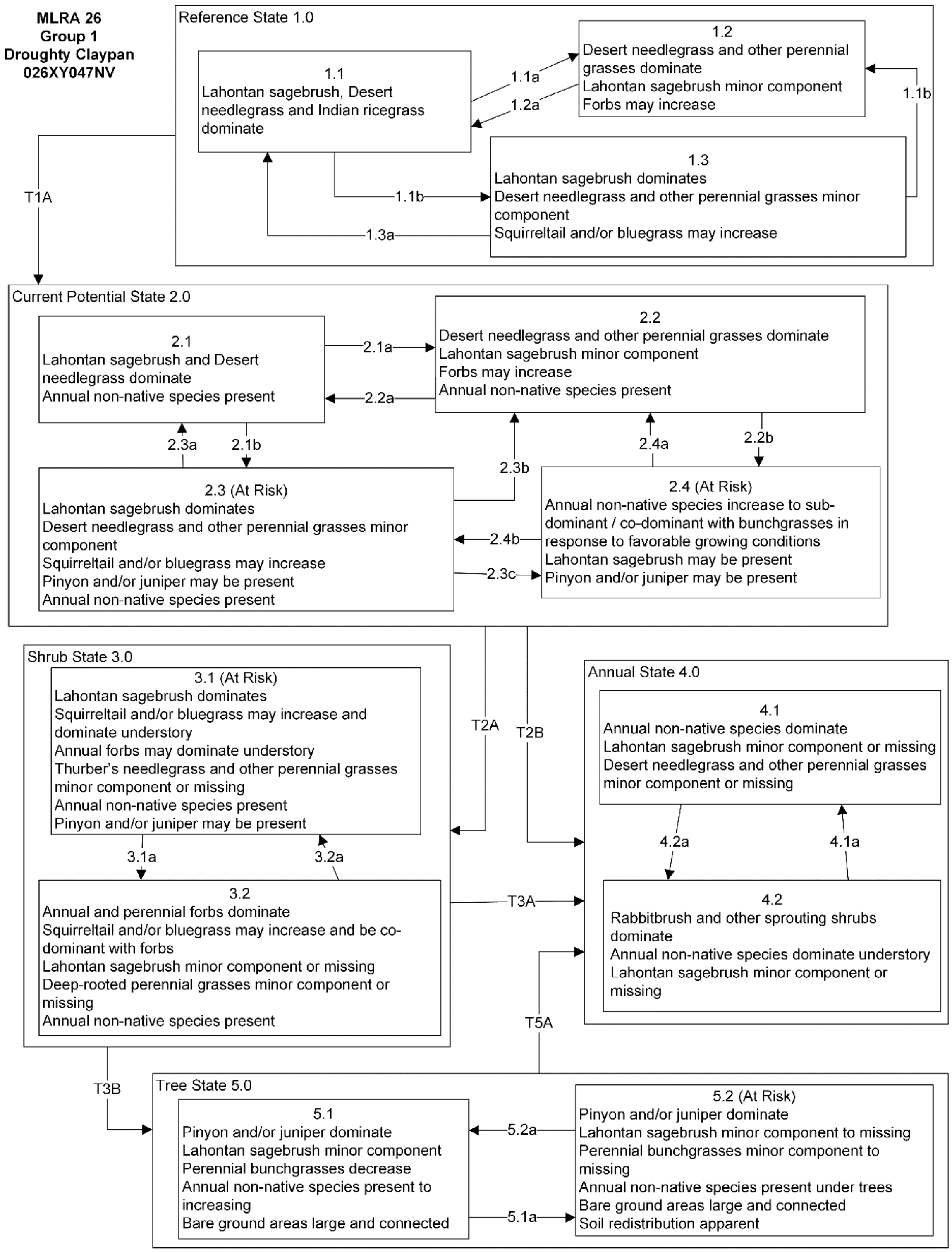
Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows for maturation of the tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.


MLRA 26
Group 1
Droughty Claypan
026XY047NV
Reference State 1.0
1.1
Lahontan sagebrush, Desert needlegrass and Indian ricegrass dominate
1.2
Desert needlegrass and other perennial grasses dominate
Lahontan sagebrush minor component
Forbs may increase
1.3
Lahontan sagebrush dominates
Desert needlegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
1.1a
1.2a
1.1b
1.1b
1.3a
T1A
Current Potential State 2.0
2.1
Lahontan sagebrush and Desert needlegrass dominate
Annual non-native species present
2.2
Desert needlegrass and other perennial grasses dominate
Lahontan sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Lahontan sagebrush dominates
Desert needlegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Lahontan sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.3a
2.1b
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Lahontan sagebrush dominates
Squirreltail and/or bluegrass may increase and dominate understory
Annual forbs may dominate understory
Thurber's needlegrass and other perennial grasses minor component or missing
Annual non-native species present
Pinyon and/or juniper may be present
3.1a
3.2a
3.2
Annual and perennial forbs dominate
Squirreltail and/or bluegrass may increase and be co-dominant with forbs
Lahontan sagebrush minor component or missing
Deep-rooted perennial grasses minor component or missing
Annual non-native species present
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Lahontan sagebrush minor component or missing
Desert needlegrass and other perennial grasses minor component or missing
4.2a
4.1a
4.2
Rabbitbrush and other sprouting shrubs dominate
Annual non-native species dominate understory
Lahontan sagebrush minor component or missing
T5A
T3B
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Lahontan sagebrush minor component
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.2 (At Risk)
Pinyon and/or juniper dominate
Lahontan sagebrush minor component to missing
Perennial bunchgrasses minor component to missing
Annual non-native species present under trees
Bare ground areas large and connected
Soil redistribution apparent
5.2a
5.1a

MLRA 26
Group 1
Droughty Claypan
026XY047NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (to 3.1).
Transition T2B: Fire or brush management causing severe soil disturbance.

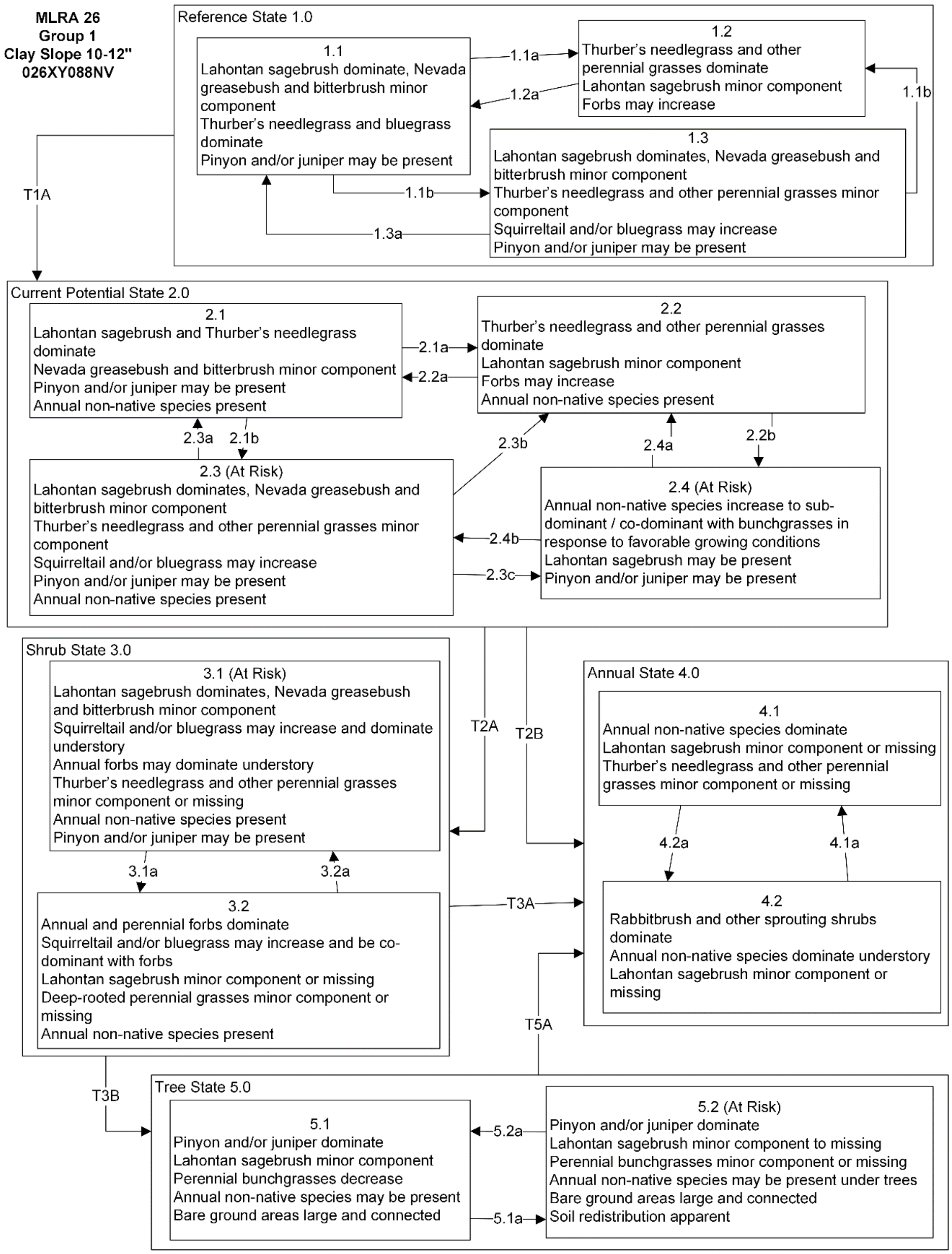
Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows for maturation of the tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.


MLRA 26
Group 1
Clay Slope 10-12"
026XY088NV
Reference State 1.0
1.1
Lahontan sagebrush dominate, Nevada greasebush and bitterbrush minor component
Thurber's needlegrass and bluegrass dominate
Pinyon and/or juniper may be present
1.1a
1.2a
1.2
Thurber's needlegrass and other perennial grasses dominate
Lahontan sagebrush minor component
Forbs may increase
1.1b
1.3
Lahontan sagebrush dominates, Nevada greasebush and bitterbrush minor component
Thurber's needlegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
Pinyon and/or juniper may be present
1.1b
1.3a
T1A
Current Potential State 2.0
2.1
Lahontan sagebrush and Thurber's needlegrass dominate
Nevada greasebush and bitterbrush minor component
Pinyon and/or juniper may be present
Annual non-native species present
2.1a
2.2a
2.2
Thurber's needlegrass and other perennial grasses dominate
Lahontan sagebrush minor component
Forbs may increase
Annual non-native species present
2.3a
2.1b
2.3b
2.4a
2.2b
2.3 (At Risk)
Lahontan sagebrush dominates, Nevada greasebush and bitterbrush minor component
Thurber's needlegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4b
2.3c
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Lahontan sagebrush may be present
Pinyon and/or juniper may be present
Shrub State 3.0
3.1 (At Risk)
Lahontan sagebrush dominates, Nevada greasebush and bitterbrush minor component
Squirreltail and/or bluegrass may increase and dominate understory
Annual forbs may dominate understory
Thurber's needlegrass and other perennial grasses minor component or missing
Annual non-native species present
Pinyon and/or juniper may be present
T2A
T2B
3.1a
3.2a
3.2
Annual and perennial forbs dominate
Squirreltail and/or bluegrass may increase and be co-dominant with forbs
Lahontan sagebrush minor component or missing
Deep-rooted perennial grasses minor component or missing
Annual non-native species present
Annual State 4.0
4.1
Annual non-native species dominate
Lahontan sagebrush minor component or missing
Thurber's needlegrass and other perennial grasses minor component or missing
4.2a
4.1a
4.2
Rabbitbrush and other sprouting shrubs dominate
Annual non-native species dominate understory
Lahontan sagebrush minor component or missing
T3A
T5A
T3B
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Lahontan sagebrush minor component
Perennial bunchgrasses decrease
Annual non-native species may be present
Bare ground areas large and connected
5.2a
5.1a
5.2 (At Risk)
Pinyon and/or juniper dominate
Lahontan sagebrush minor component to missing
Perennial bunchgrasses minor component or missing
Annual non-native species may be present under trees
Bare ground areas large and connected
Soil redistribution apparent

MLRA 26
Group 1
Clay Slope 10-12"
026XY088NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (to 3.1).
Transition T2B: Fire or brush management causing severe soil disturbance.

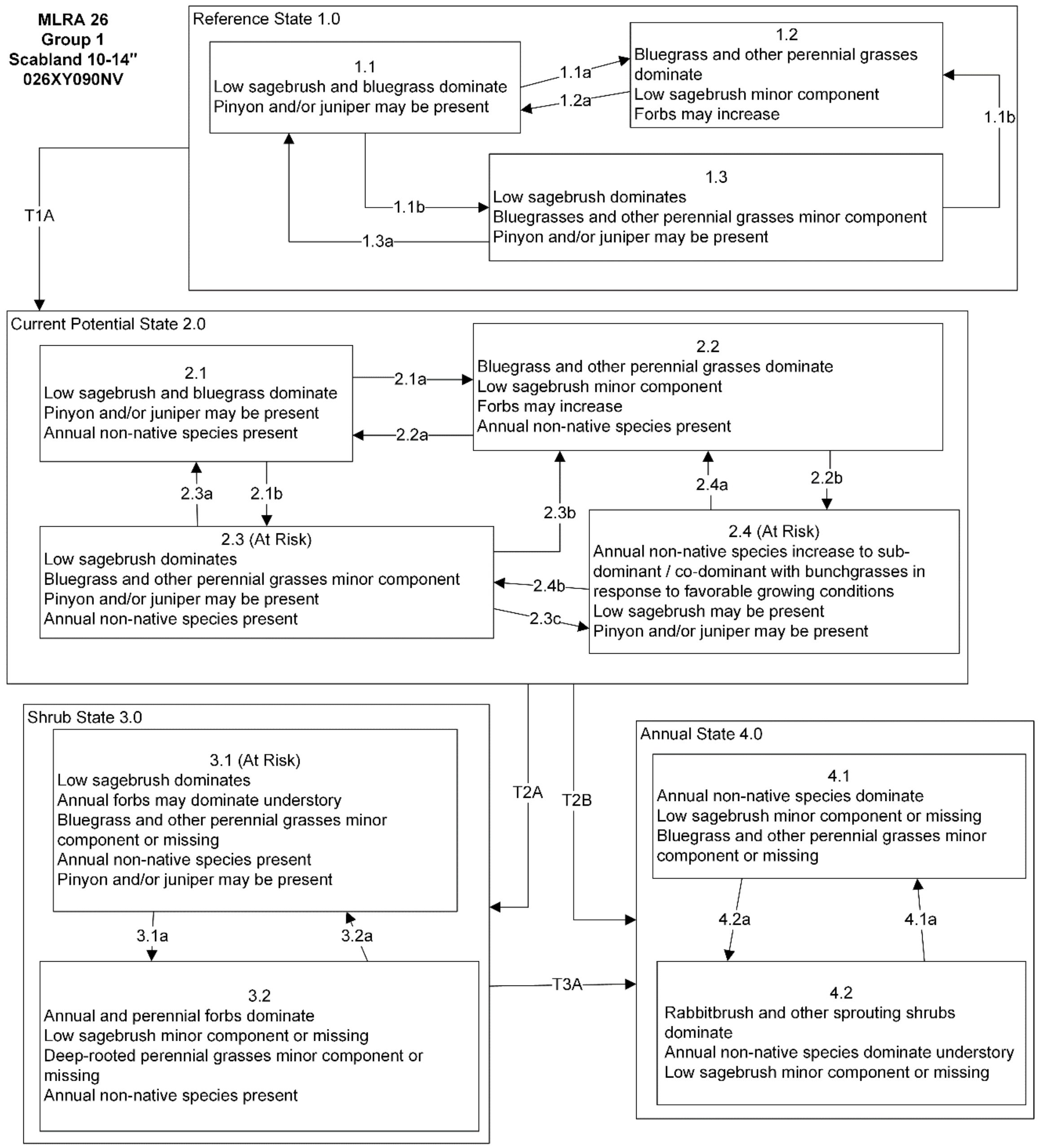
Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows for maturation of the tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.


MLRA 26
Group 1
Scabland 10-14"
026XY090NV
Reference State 1.0
1.1
Low sagebrush and bluegrass dominate
Pinyon and/or juniper may be present
1.2
Bluegrass and other perennial grasses dominate
Low sagebrush minor component
Forbs may increase
1.3
Low sagebrush dominates
Bluegrasses and other perennial grasses minor component
Pinyon and/or juniper may be present
1.1a
1.2a
1.1b
1.3a
T1A
Current Potential State 2.0
2.1
Low sagebrush and bluegrass dominate
Pinyon and/or juniper may be present
Annual non-native species present
2.2
Bluegrass and other perennial grasses dominate
Low sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Low sagebrush dominates
Bluegrass and other perennial grasses minor component
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Low sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.3a
2.1b
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Low sagebrush dominates
Annual forbs may dominate understory
Bluegrass and other perennial grasses minor component or missing
Annual non-native species present
Pinyon and/or juniper may be present
3.2
Annual and perennial forbs dominate
Low sagebrush minor component or missing
Deep-rooted perennial grasses minor component or missing
Annual non-native species present
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Low sagebrush minor component or missing
Bluegrass and other perennial grasses minor component or missing
4.2
Rabbitbrush and other sprouting shrubs dominate
Annual non-native species dominate understory
Low sagebrush minor component or missing
4.2a
4.1a

MLRA 26
Group 1
Scabland 10-14"
026XY090NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

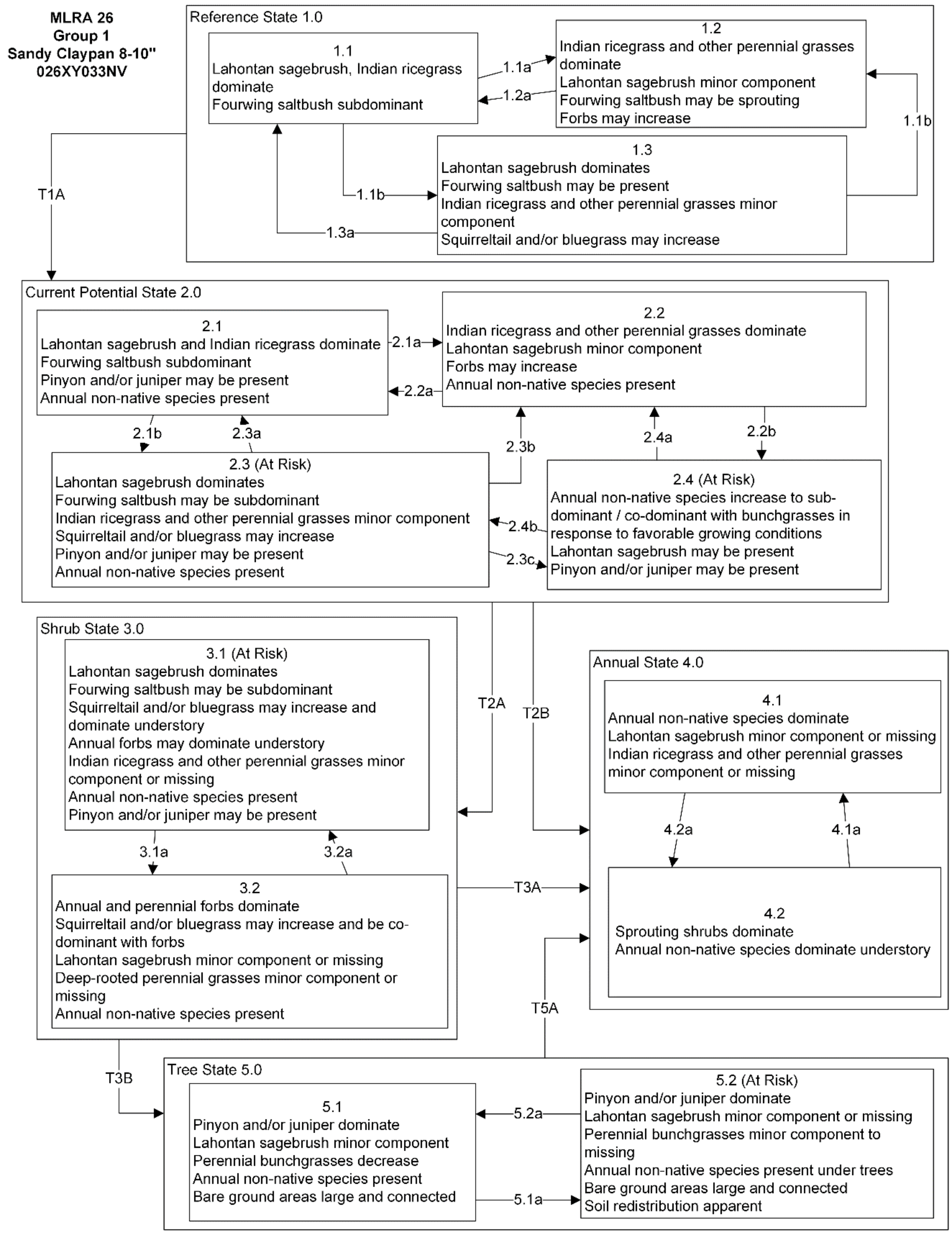
Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (to 3.1).
Transition T2B: Fire or brush management causing severe soil disturbance.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows for maturation of the tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.


MLRA 26
Group 1
Sandy Claypan 8-10"
026XY033NV
Reference State 1.0
1.1
Lahontan sagebrush, Indian ricegrass dominate
Fourwing saltbush subdominant
1.2
Indian ricegrass and other perennial grasses dominate
Lahontan sagebrush minor component
Fourwing saltbush may be sprouting
Forbs may increase
1.3
Lahontan sagebrush dominates
Fourwing saltbush may be present
Indian ricegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
1.1a
1.2a
1.1b
1.1b
1.3a
T1A
Current Potential State 2.0
2.1
Lahontan sagebrush and Indian ricegrass dominate
Fourwing saltbush subdominant
Pinyon and/or juniper may be present
Annual non-native species present
2.2
Indian ricegrass and other perennial grasses dominate
Lahontan sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Lahontan sagebrush dominates
Fourwing saltbush may be subdominant
Indian ricegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Lahontan sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Lahontan sagebrush dominates
Fourwing saltbush may be subdominant
Squirreltail and/or bluegrass may increase and dominate understory
Annual forbs may dominate understory
Indian ricegrass and other perennial grasses minor component or missing
Annual non-native species present
Pinyon and/or juniper may be present
3.2
Annual and perennial forbs dominate
Squirreltail and/or bluegrass may increase and be co-dominant with forbs
Lahontan sagebrush minor component or missing
Deep-rooted perennial grasses minor component or missing
Annual non-native species present
3.1a
3.2a
T3A
T3B
Annual State 4.0
4.1
Annual non-native species dominate
Lahontan sagebrush minor component or missing
Indian ricegrass and other perennial grasses minor component or missing
4.2
Sprouting shrubs dominate
Annual non-native species dominate understory
4.2a
4.1a
T5A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Lahontan sagebrush minor component
Perennial bunchgrasses decrease
Annual non-native species present
Bare ground areas large and connected
5.2 (At Risk)
Pinyon and/or juniper dominate
Lahontan sagebrush minor component or missing
Perennial bunchgrasses minor component to missing
Annual non-native species present under trees
Bare ground areas large and connected
Soil redistribution apparent
5.2a
5.1a

MLRA 26
Group 1
Sandy Claypan 8-10"
026XY033NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (to 3.1).
Transition T2B: Fire or brush management causing severe soil disturbance.

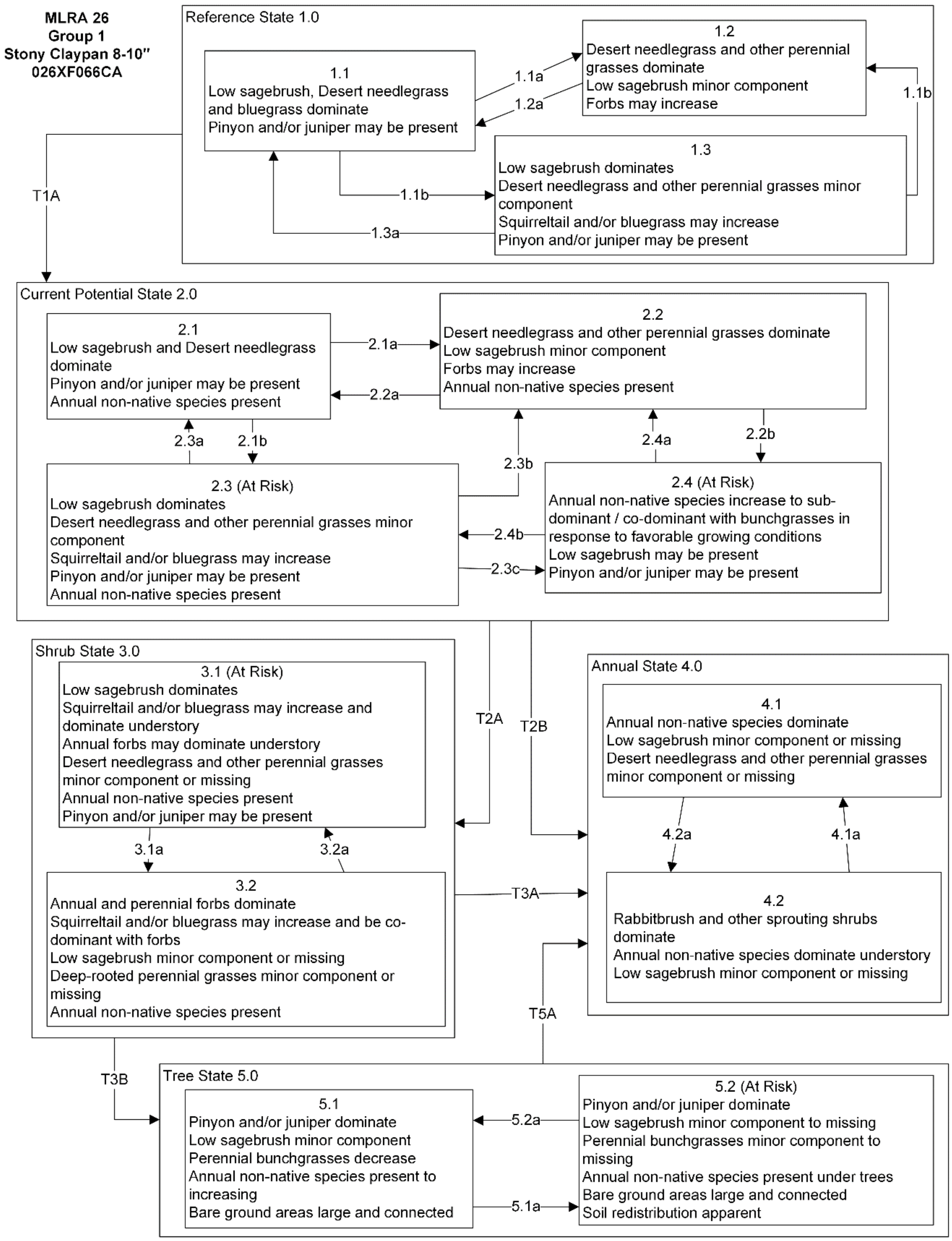
Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows for maturation of the tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.


MLRA 26
Group 1
Stony Claypan 8-10"
026XF066CA
Reference State 1.0
1.1
Low sagebrush, Desert needlegrass and bluegrass dominate
Pinyon and/or juniper may be present
1.2
Desert needlegrass and other perennial grasses dominate
Low sagebrush minor component
Forbs may increase
1.3
Low sagebrush dominates
Desert needlegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
Pinyon and/or juniper may be present
1.1a
1.2a
1.1b
1.1b
1.3a
T1A
Current Potential State 2.0
2.1
Low sagebrush and Desert needlegrass dominate
Pinyon and/or juniper may be present
Annual non-native species present
2.2
Desert needlegrass and other perennial grasses dominate
Low sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Low sagebrush dominates
Desert needlegrass and other perennial grasses minor component
Squirreltail and/or bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Low sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.3a
2.1b
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Low sagebrush dominates
Squirreltail and/or bluegrass may increase and dominate understory
Annual forbs may dominate understory
Desert needlegrass and other perennial grasses minor component or missing
Annual non-native species present
Pinyon and/or juniper may be present
3.2
Annual and perennial forbs dominate
Squirreltail and/or bluegrass may increase and be co-dominant with forbs
Low sagebrush minor component or missing
Deep-rooted perennial grasses minor component or missing
Annual non-native species present
3.1a
3.2a
T3A
T3B
Annual State 4.0
4.1
Annual non-native species dominate
Low sagebrush minor component or missing
Desert needlegrass and other perennial grasses minor component or missing
4.2
Rabbitbrush and other sprouting shrubs dominate
Annual non-native species dominate understory
Low sagebrush minor component or missing
4.2a
4.1a
T5A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Low sagebrush minor component
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.2 (At Risk)
Pinyon and/or juniper dominate
Low sagebrush minor component to missing
Perennial bunchgrasses minor component to missing
Annual non-native species present under trees
Bare ground areas large and connected
Soil redistribution apparent
5.2a
5.1a

MLRA 26
Group 1
Stony Claypan 8-10"
026XF066CA
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (to 3.1).
Transition T2B: Fire or brush management causing severe soil disturbance.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows for maturation of the tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

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MLRA 26 Group 2: Low sagebrush and Thurber's needlegrass

Description of MLRA 26 Disturbance Response Group 2

Disturbance Response Group (DRG) 2 consists of 3 ecological sites. The precipitation zone for these sites ranges from 10 to 14 inches. The elevation range of this group is 6,000 to 8,800 feet. Slopes range from 0 to 30 percent however, 4 to 15 percent are typical. Soils on these sites range from very shallow to moderately deep to a restrictive layer. Available water capacity ranges from low to moderate. These soils exhibit root restrictive layers or dense clays within the subsoil which limit plant growth on these sites. With the high clay content these soils can have limited infiltration when wetted and are subject to water loss by runoff. Annual production in a normal year ranges from 400 to 500 lbs/acre for the group. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by low sagebrush (*Artemisia arbuscula*). Antelope bitterbrush (*Purshia tridentata*), Douglas' rabbitbrush (*Chrysothamnus viscidiflorus*), and green ephedra (*Ephedra viridis*) are also important shrub species. The understory is dominated by deep rooted perennial bunchgrasses, primarily Thurber's needlegrass (*Achnatherum thurberianum*) or desert needlegrass (*Achnatherum speciosum*), bluegrasses (*Poa* spp.), and prairie junegrass (*Koeleria macrantha*). Other important grasses include Indian ricegrass (*Achnatherum hymenoides*), bottlebrush squirreltail (*Elymus elymoides*), basin wildrye (*Leymus cinereus*), needleandthread (*Hesperostipa comata*), and Sandberg bluegrass (*Poa secunda*).

The ecological sites in this group are described as having low sagebrush as the dominant shrub. During our visits to these sites, we used the black light test (Winward and Tisdale 1969, Rosentreter 2005) to verify sagebrush species. On some sites, including some NRCS Type Locations, Lahontan sagebrush (*Artemisia arbuscula ssp. longicaulis*) was the dominant shrub. Lahontan sagebrush was only recently identified as a unique species of sagebrush (Winward and McArthur 1995), so it may not have been apparent at the time some of these ecological sites were established. Due to the differences in palatability between low sage and Lahontan, as well as potential soil differences, we recommend a reevaluation of the low sagebrush ecological sites in MLRA 26.

Disturbance Response Group 2 Ecological Sites:

Claypan 10-12" – Modal site	R026XY023NV
Claypan 12-14"	R026XY078NV
Ashy Claypan 12-14"	R026XF060CA

Modal Site:

Claypan 10-12" ecological site is the modal site for this group as it has the most acres mapped. This site occurs on summits and sideslopes of hills, upper piedmont slopes, and lower mountains on all aspects. Slopes range from 2 to 50 percent, but slope gradients of 4 to 15 percent are most typical. Elevations are 6,000 to 7,000 feet. The soils in this site are shallow to moderately deep and well drained. The available water capacity is low to moderate. The presence of heavy textured subsoil restricts deep rooting by most plants. Very fine and fine roots penetrate the clay subsoil along ped faces while medium and coarse roots are confined in the surface layer above the clay. The plant community is dominated by

Thurber’s needlegrass and low sagebrush. Antelope bitterbrush and bluegrasses are other important species associated with this site. Total annual production ranges from 350 to 700 lbs/ac.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site’s resilience to disturbance and resistance to invasives. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by deep-rooted cool season, perennial bunchgrasses, a diversity of perennial forbs, and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m (Dobrowolski et al. 1990). However, community types with low sagebrush as the dominant shrub may only have available rooting depths of 71 to 81 cm (Jensen 1990). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The perennial bunchgrasses that are dominant include Thurber’s needlegrass and desert needlegrass. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Low sagebrush is fairly drought tolerant but also tolerates periodic wetness during some portion of the growing season (Fosberg and Hironaka 1964, Blackburn et al. 1968a and b, 1969). It grows on soils that have a strongly structured B2t (argillic) horizon close to the soil surface (Winward 1980, Fosberg and Hironaka 1964, Zamora and Tueller 1973). Low sagebrush is also susceptible to the sagebrush defoliator, Aroga moth. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975), but research is inconclusive of the damage sustained by low sagebrush populations.

Lahontan sagebrush was only recently identified as a unique species of sagebrush (Winward and McArthur 1995). Lahontan sagebrush is a cross between low sagebrush and Wyoming sagebrush (*Artemisia tridentata ssp. wyomingensis*) and is typically found near the old shorelines of Lake Lahontan from the Pleistocene epoch. This subspecies grows on soils similar to low sagebrush with shallow depths and low water holding capabilities (Winward and McArthur 1995). It often occurs in pure stands but can also occur with Wyoming big sagebrush, low sagebrush, and black sagebrush species as well as salt desert shrub species at lower elevations (Winward and McArthur 1995).

Early sagebrush (also known as alkali sagebrush, *A. arbuscula* ssp. *longiloba*) is a unique subspecies of low sagebrush that is differentiated because it blooms in mid-June to July. While originally named alkali sagebrush because it was found on alkaline limestone soils (Beetle 1960), a body of research has challenged this claim across the species' range (Passey and Hughie 1962, Robertson et al. 1966, Zamora and Tueller 1973). It is found on soils similar to low sagebrush, with a restrictive horizon close to the soil surface (Robertson et al. 1966, Zamora and Tueller 1973).

Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons (MacMahon 1980). Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance changes resource uptake and increases nutrient availability, often to the benefit of non-native species; native species are often damaged and their ability to use resources is depressed for a time, but resource pools may increase from lack of use and/or the decomposition of dead plant material following disturbance (Whisenant 1999, Miller et al. 2013). The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Beckstead and Augspurger 2004, Chambers et al. 2007, Johnson et al. 2011).

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Four possible stable states have been identified for this DRG.

Fire Ecology:

Low sagebrush is killed by fire and does not sprout (Tisdale and Hironaka 1981). Fire risk is greatest following a wet, productive year when there is greater production of fine fuels (Beardall and Sylvester 1976). Fire return intervals are not well understood because these ecosystems rarely coincide with fire-scarred conifers, however a wide range of 20 to well over 100 years has been estimated (Miller and Rose 1995, Miller and Rose 1999, Baker 2006, Knick et al. 2005). Historically, fires were probably patchy due to the low productivity of these sites (Beardall and Sylvester 1976, Ralphs and Busby 1979, Wright et al. 1979, Smith and Busby 1981). Fine fuel loads generally average 100 to 400 pounds per acre (110- 450 kg/ha) but are occasionally as high as 600 pounds per acre (680 kg/ha) in low sagebrush habitat types (Bradley et al. 1992). Reestablishment occurs from off-site wind-dispersed seed (Young 1981). Recovery time of low sagebrush following fire is variable (Young 1981). After fire, if regeneration conditions are favorable, low sagebrush recovers in 2 to 5 years, however on harsh sites where cover is low to begin with and/or erosion occurs after fire, recovery may require more than 10 years (Young 1981). Slow regeneration may subsequently worsen erosion (Blaisdell et al. 1982). We were unable to find any substantial research on success of seeding low sagebrush after fire. To date, we have not been able to find specific research on the fire response of Lahontan sagebrush, but field observations indicate that it is killed by fire and does not resprout

Antelope bitterbrush, a minor component on these sites, is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires and springtime fires may allow bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983, Busse et al. 2000, Kerns et al. 2006).). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956).If cheatgrass is present, bitterbrush seedling success is much lower; the factor that most limits establishment of bitterbrush seedlings is competition for water resources with the invasive species cheatgrass (Clements and Young 2002).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. Thurber's needlegrass is very susceptible to fire caused mortality. Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk et al. 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber's needlegrass (Britton et al. 1990). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influences the response and mortality of Thurber's needlegrass, smaller bunch sizes are less likely to be damaged by fire (Wright and Klemmedson 1965). However, Thurber's needlegrass often survives fire and will continue growth when conditions are favorable (Koniak 1985). Thus, the initial condition of the bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response.

Sandberg bluegrass, a minor component of this ecological site, has been found to increase following fire likely due to its low stature and productivity (Daubenmire 1975) and may retard reestablishment of deeper-rooted bunchgrasses.

The grasses that are likely to invade this site are cheatgrass and medusahead. These invasive grasses displace desirable perennial grasses, reduce livestock forage, and accumulate large fuel loads that foster frequent fires (Davies and Svejcar 2008). Invasion by annual grasses can alter the fire cycle by increasing fire size, fire season length, rate of spread, numbers of individual fires, and likelihood of fires spreading into native or managed ecosystems (D'Antonio and Vitousek 1992, Brooks et al. 2004). While historical fire return intervals are estimated at 15 to 100 years, areas dominated with cheatgrass are estimated to have a fire return interval of 3-5 years (Whisenant 1990). The mechanisms by which invasive annual grasses alter fire regimes likely interact with climate. For example, cheatgrass cover and biomass vary with climate (Chambers et al. 2007) and are promoted by wet and warm conditions during the fall and spring. Invasive annual species have been shown able to take advantage of high N availability following fire through higher growth rates and increased seedling established relative to native perennial grasses (Monaco et al. 2003).

Wildlife/Livestock Grazing Interpretations:

Domestic sheep and, to a much lesser degree, cattle consume low sagebrush, particularly during the spring, fall, and winter (Sheehy and Winward 1981). Heavy dormant season grazing by sheep will reduce sagebrush cover and increase grass production (Laycock 1967). Trampling damage, particularly from cattle or horses, in low sagebrush habitat types is greatest in areas with high clay content soils during spring snowmelt when surface soils are saturated. In drier areas with more gravelly soils, trampling is less of a problem (Hironaka et al. 1983). Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton et al. (1990) observed the effects of clipping date on basal area of five bunchgrasses in eastern Oregon and found grazing from August to October (after seed set) has the least impact. Heavy grazing during the growing season will reduce perennial bunchgrasses and increase sagebrush (Laycock 1967). Abusive grazing by cattle or horses allows unpalatable plants like low sagebrush, rabbitbrush and some forbs such as arrowleaf balsamroot to become dominant on the site. Sandberg bluegrass is also grazing tolerant due to its short stature. Annual non-native weedy species such as cheatgrass, mustards, and medusahead may invade.

Throughout two years of site visits for this report, Lahontan sagebrush was observed in a heavily browsed state on ecological sites within this DRG. This recently differentiated subspecies of low sagebrush (Winward and McArthur 1995) is moderately to highly palatable to browse species (McArthur 2005, Rosentreter 2001). Dwarf sagebrush species such as Lahontan sagebrush, low sagebrush, and black sagebrush are preferred by mule deer for browse among the sagebrush species. Due to its palatability, it can often be hedged from grazing pressure (McArthur 2005).

Antelope bitterbrush a minor component on this site is a critical browse species for mule deer, antelope and elk and is often utilized heavily by domestic livestock (Wood et al. 1995). Grazing tolerance is dependent on-site conditions (Garrison 1953) and the shrub can be severely hedged during the dormant season for grasses and forbs.

Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber's needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988).

Needleandthread, a minor grass on some sites in this group, is most commonly found on warm/dry soils (Miller et al. 2013). It is not grazing tolerant and will be one of the first grasses to decrease under heavy grazing pressure (Smoliak et al. 1972, Tueller and Blackburn 1974). Heavy grazing is likely to reduce basal area of these plants (Smoliak et al. 1972). With the reduction in competition from deep rooted perennial bunchgrasses, shallower rooted grasses forbs may increase (Smoliak et al. 1972).

Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass expansion and/or cheatgrass and other invasive species to occupy interspaces. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass or other weedy species. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

Inappropriate grazing practices can be tied to the success of medusahead, however, eliminating grazing will not eradicate medusahead if it is already present (Wagner et al. 2001). Sheley and Svejcar (2009) reported that even moderate defoliation of bluebunch wheatgrass resulted in increased medusahead density. They suggested that disturbances such as plant defoliation limit soil resource capture, which creates an opportunity for exploitation by medusahead. Avoidance of medusahead by grazing animals allows medusahead populations to expand. This creates seed reserves that can infest adjoining areas and cause changes to the fire regime. Medusahead replaces native vegetation and cheatgrass directly by competition and suppression and native vegetation indirectly by an increase in fire frequency. Medusahead litter has a slow decomposition rate, because of high silica content, allowing it to accumulate over time and suppress competing vegetation (Bovey et al. 1961, Davies and Johnson 2008).

Low sagebrush sites are often used for strutting grounds for sage grouse (*Centrocercus urophasianus*) because the low cover allows for high visibility of strutting males (McAdoo and Back 2001). Sage grouse also use these sites during the winter where sagebrush provides food and cover (Braun, Connelly and Schroeder 2005).

State and Transition Model Narrative for Group 2

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 2.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase, and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
This community is dominated by Lahontan/low sagebrush, bluegrasses and Thurber's needlegrass. A diversity of perennial forbs and other grasses make up smaller components. Singleleaf pinyon (*Pinus monophyla*) and juniper (*Juniperus osterosperma* or *J. occidentalis)* may or may not be present.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Fire will decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Fires will typically be low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring may be more severe and reduce sagebrush cover to trace amounts.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.3:
Time and lack of disturbance such as fire allows for sagebrush to increase and become decadent. Long-term drought, herbivory, or combinations of these will cause a decline in perennial bunchgrasses and fine fuels leading to a reduced fire frequency and allowing sagebrush to dominate the site.

Community Phase 1.2:

This community phase is characteristic of a post-disturbance, early/mid-seral community. Thurber's needlegrass, bluegrasses, and other perennial bunchgrasses dominate. Depending on fire severity, patches of intact sagebrush may remain. Rabbitbrush and other sprouting shrubs may be sprouting. Perennial forbs may be a significant component for several years following fire.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Time and lack of disturbance will allow sagebrush to increase.

Community Phase 1.3:
Sagebrush increases in the absence of disturbance. Mature and/or decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory become minor component either from competition with shrubs and/or from herbivory. Sandberg bluegrass may become co-dominant with deep rooted bunchgrasses. Pinyon and juniper may be present.

Ashy Claypan 12-14" (R026XY060CA) Phase 1.3, P.Novak-Echenique, July 2017

Claypan 12-14" (R026XY078NV) Phase 1.3, P.Novak-Echenique, July 2017

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
A low severity fire, herbivory or combinations will reduce the sagebrush overstory and create a sagebrush/grass mosaic.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire will decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community.

T1A: Transition from the Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, medusahead, mustards, and bur buttercup.

Slow variables: Over time, the annual non-native plants will increase within the community. The change in dominance from perennial grasses to annual grasses reduces organic matter inputs from root turn-over, resulting in reductions in soil water availability.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

T1B: Transition from the Reference State 1.0 to Shrub State 3.0:

Trigger: To Community Phase 3.1: Long term lack of fire and/or inappropriate grazing will decrease or eliminate deep-rooted perennial bunchgrasses, increase Sandberg bluegrass and favor shrub growth and establishment. To Community Phase 3.2: Severe fire in community phase 2.3 will remove sagebrush overstory, decrease perennial bunchgrasses and enhance Sandberg bluegrass.

Slow variables: Long-term decrease in deep-rooted perennial grass density.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed; however, the resiliency of the state has been reduced by the presence of invasive weeds. This state has four general community phases. These non-native species can be highly flammable and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. Lahontan/low sagebrush, bluegrasses, and Thurber's needlegrass dominate the site. Perennial forbs and other shrubs and grasses make up smaller components of this site.

Ashy Claypan 12-14" (R026XY060CA) Phase 2.1. T.K. Stringham, July 2015

Gravelly Clay-like 10-12" (New Site) Phase 2.1. T.K. Stringham, June 2016

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Fire reduces the shrub overstory and allows for perennial bunchgrasses and perennial forbs to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. Annual non-native species are likely to increase after fire.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Time and lack of disturbance allows for sagebrush to increase and become decadent. Long-term drought reduces fine fuels and leads to a reduced fire frequency, allowing Lahontan/low sagebrush to dominate the site. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely Sandberg bluegrass may increase in the understory depending on grazing management.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community where annual non-native species are present. Sagebrush is present in trace amounts; perennial bunchgrasses dominate the site. Depending on fire severity, patches of intact sagebrush may remain. Rabbitbrush may be sprouting or dominant in the community. Perennial forbs may be a significant component for a number of years following fire. Annual non-native species are stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of sagebrush can take many years.

Community Phase 2.3 (At Risk):
This community is at risk of crossing a threshold to another state. Sagebrush dominates the overstory and perennial bunchgrasses in the understory are minor components, either from competition with shrubs or from inappropriate grazing, or from both. Rabbitbrush may be a significant component. Sandberg bluegrass may become co-dominant with deep rooted

bunchgrasses. Annual non-natives species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, drought, and fire.

Ashy Claypan 12-14" (R026XF060CA) Phase 2.3. T.K. Stringham, July 2017

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
A change in grazing management that reduces shrubs will allow the perennial bunchgrasses in the understory to dominate. Heavy late-fall or winter grazing may cause mechanical damage and subsequent death to sagebrush, facilitating an increase in the herbaceous understory. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. A low severity fire would decrease the overstory of sagebrush or leave patches of shrubs and would allow the understory perennial grasses to dominate. Annual non-native species are present and may increase in the community.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire eliminates/reduces the overstory of sagebrush and allows the understory perennial grasses to dominate. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community. Annual non-native species respond well to fire and may increase post burn.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0

Trigger: To Community Phase 3.1: Inappropriate grazing will decrease or eliminate deep-rooted perennial bunchgrasses, increase Sandberg bluegrass and favor shrub growth and establishment. To Community Phase 3.2: Severe fire in community phase 2.3 will remove sagebrush overstory, decrease perennial bunchgrasses and enhance Sandberg bluegrass. Annual non-native species will increase.

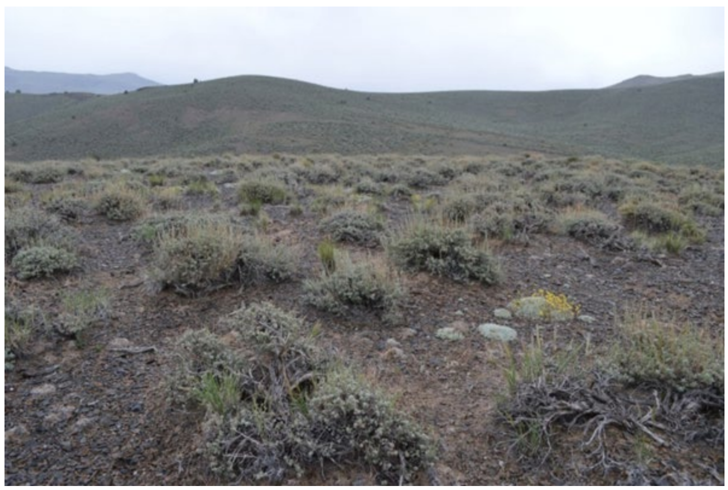
Slow variables: Long term decrease in deep-rooted perennial grass density.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

Shrub State 3.0:

This state is a product of long-term lack of fire and/or many years of heavy grazing during time periods harmful to perennial bunchgrasses. Sandberg bluegrass may increase with a reduction in deep rooted perennial bunchgrass competition and become the dominant grass. Sagebrush dominates the overstory and rabbitbrush may be a significant component. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and bluegrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1 (At Risk):
Lahontan/low sagebrush dominates the overstory and may be decadent. Rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Sandberg bluegrass and annual non-native species increase. Bare ground is significant. Pinyon and juniper may be present.



Ashy Claypan 12-14" (R026XF060CA) Phase 3.1. T.K. Stringham, July 2015

Gravelly Clay 10-12" (R026XY50NV) Phase 3.1. D. Snyder, September 2017

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire, heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, will greatly reduce the overstory shrubs to trace amounts and allow Sandberg bluegrass to dominate the site.

Community Phase 3.2:
Bluegrass dominates the site; annual non-native species may be present but are not dominant. Sprouting shrubs may increase. Trace amounts of sagebrush may be present with Thurber's needlegrass and other perennial grasses a minor component or missing altogether.

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of Lahontan/low sagebrush can take many years.

T3A: Transition from Shrub State 3.0 to Tree State 4.0:

Trigger: Absence of disturbance over time allows for Utah juniper or western juniper dominance.

Feedbacks and ecological processes: Trees increasingly dominate use of soil water, contributing to reductions in soil water availability to grasses and shrubs. Overtime, grasses and shrubs are outcompeted. Reduced herbaceous and shrub production slows soil organic matter inputs and increases soil erodibility through loss of cover and root structure.

Slow variables: Long-term increase in Utah juniper and/or western juniper density.

Threshold: Trees overtop Lahontan/low sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs in number. There is minimal recruitment of new shrub cohorts.

Tree State 4.0:

This state is characterized by a dominance of pinyon and juniper in the overstory. Lahontan sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients and soil organic matter distribution and cycling have been spatially and temporally altered.

Community Phase 4.1:
Pinyon and juniper dominate the overstory and site resources. Trees are actively growing with noticeable leader growth. Trace amounts of bunchgrass may be found under tree canopies with trace amounts of Sandberg bluegrass and forbs in the interspaces. Sagebrush is stressed and dying. Annual non-native species are present under tree canopies. Bare ground interspaces are large and connected.

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Time and lack of disturbance or management action allows for tree cover and density to further increase and trees to out-compete the herbaceous understory species for sunlight and water.

Community Phase 4.2:
Pinyon and juniper dominate the overstory. Lahontan/low sagebrush is decadent and dying with numerous skeletons present or sagebrush may be missing from the system. Bunchgrasses are present in trace amounts and annual non-native species may dominate understory. Herbaceous species may be located primarily under the canopy or near the drip line of trees. Bare ground interspaces are large and connected. Soil movement may be apparent.

Potential Resilience Differences with other Ecological Sites

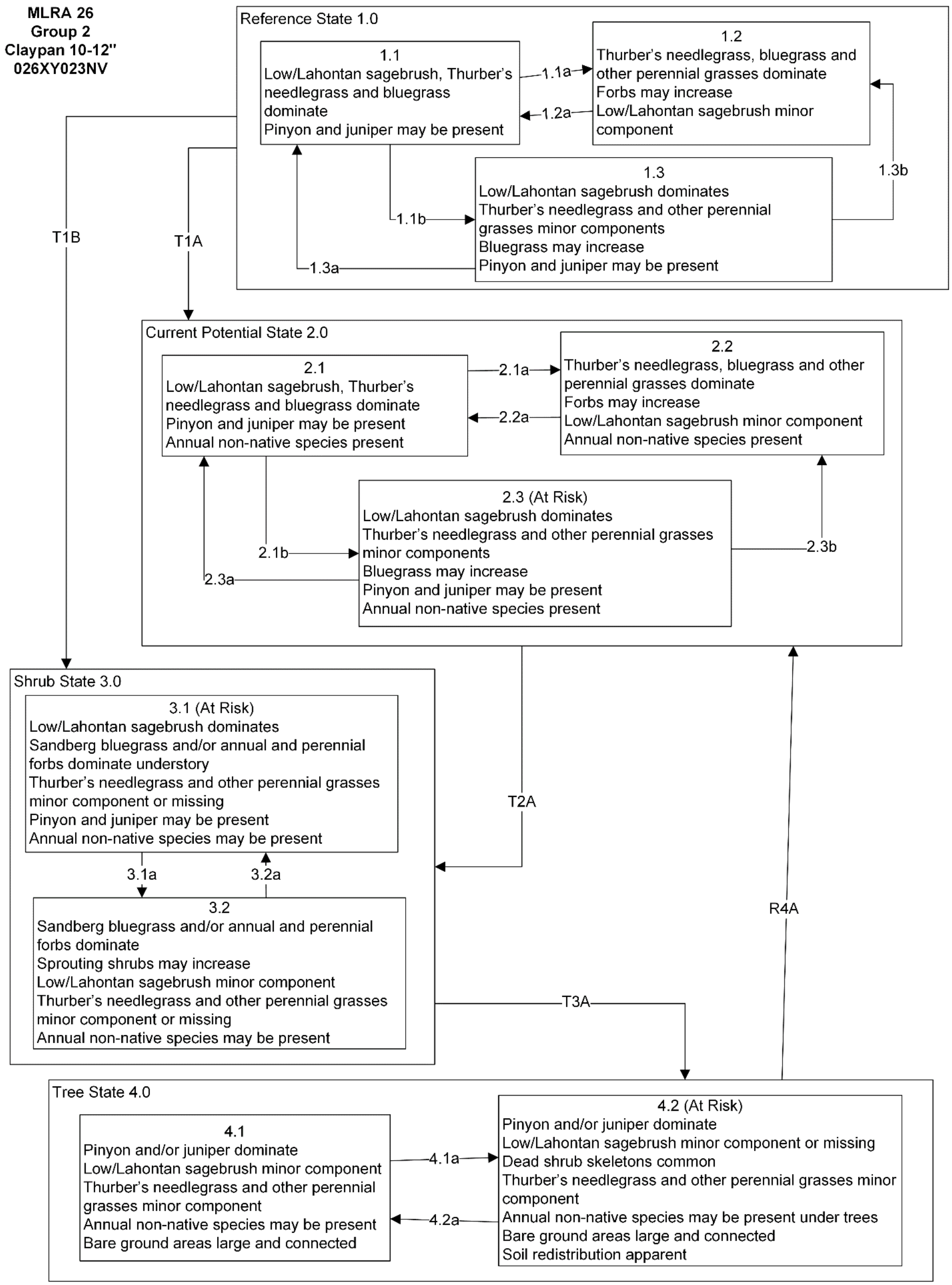
Claypan 12-14" P.Z. (026XY078NV):

This site occurs at higher elevations (6,700-8,800 feet) and at generally greater slope gradients (4-30% typical). Dominant shrubs and grasses are similar to MLRA 26 modal site for this group with the exception of a possible increase in prairie junegrass density. Production is lower at 400 lbs/ac in normal years.

Ashy Claypan 12-14 P.Z. (R026XF060CA):

This site is at significantly higher elevations (7,200-9,000 feet) and soils have a high ash component which increases water holding capacity. Average growing period ranges between 30 and 100 days. Vegetation is similar to MLRA 26 modal site for this group with the possible inclusion of Webber's needlegrass (*Achnatherum webberi).*

Modal State and Transition Model for Group 2 MLRA 26:



MLRA 26
Group 2
Claypan 10-12"
026XY023NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Lack of fire may be combined with historic inappropriate grazing. Not associated with introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).

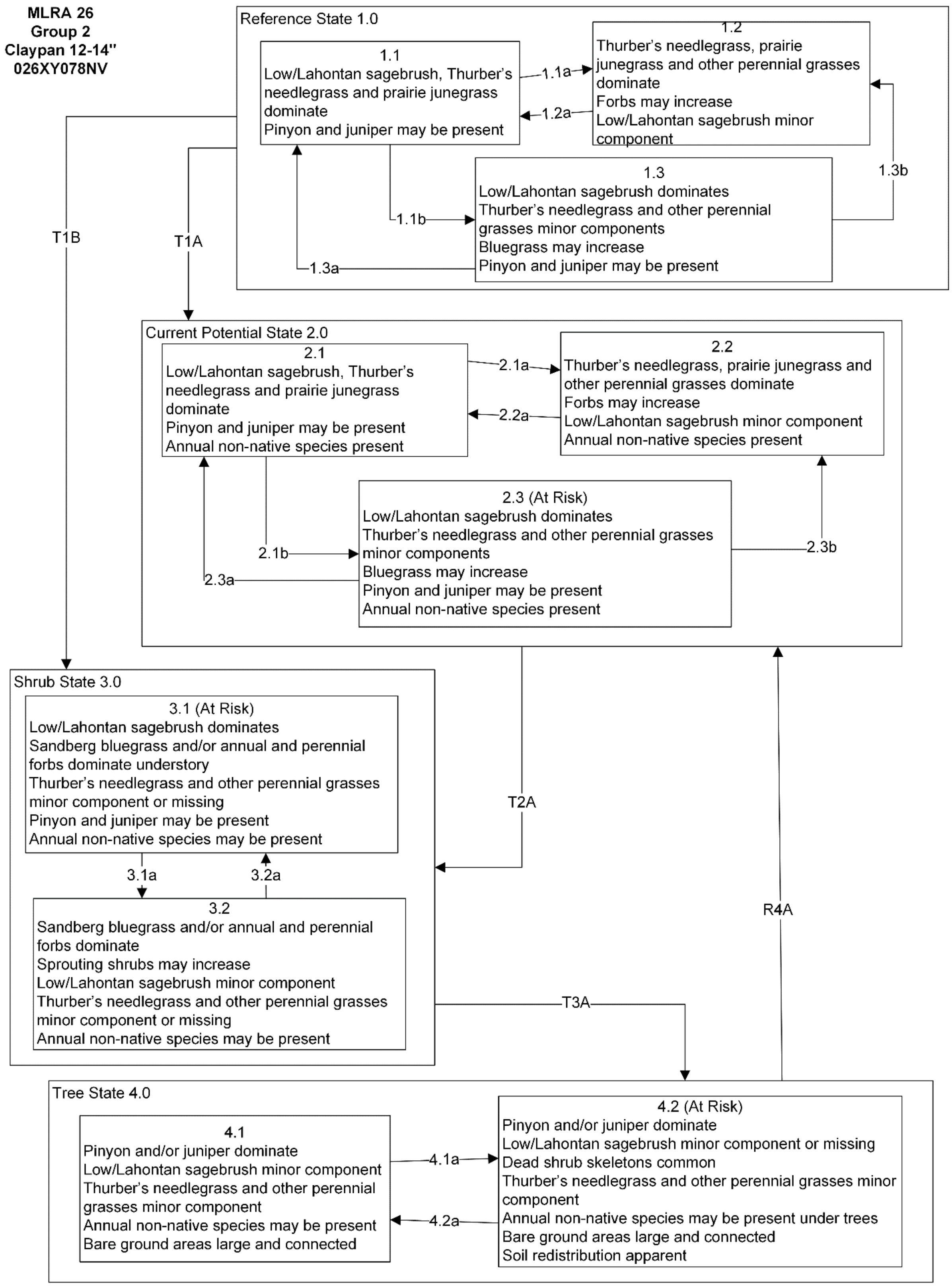
Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire.
3.2a: Time and lack of disturbance.

Transition T3A: Time and lack of disturbance allows for maturation of the tree community.

Tree State 4.0.
4.1a: Time and lack of disturbance allows for maturation of tree community.
4.2a: Tree thinning treatment (typically for fuels management).

Restoration Pathway R4A: Tree removal.

Additional State and Transition Models for Group 2 MLRA 26:



MLRA 26
Group 2
Claypan 12-14"
026XY078NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Lack of fire may be combined with historic inappropriate grazing. Not associated with introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.

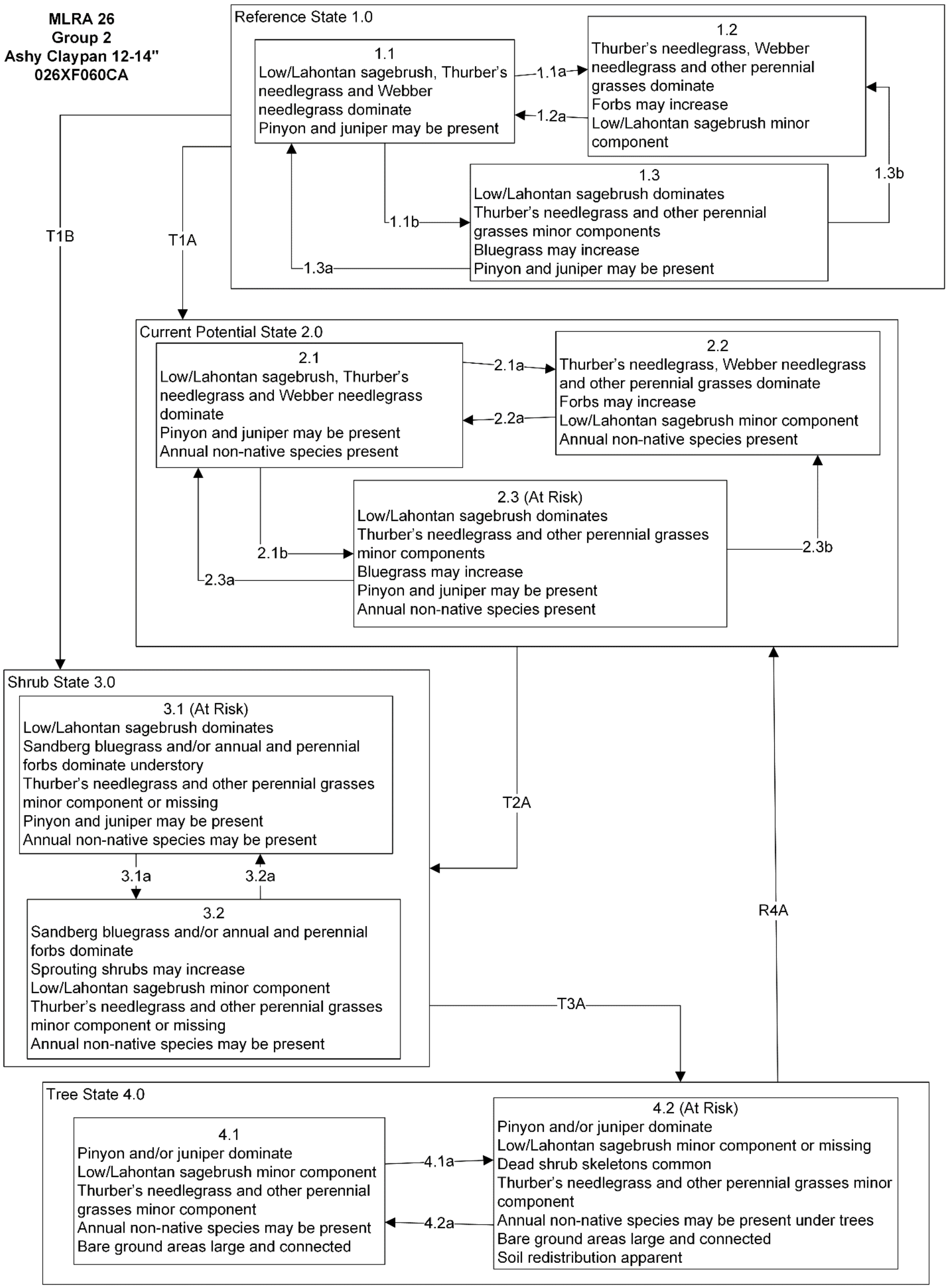
Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire.
3.2a: Time and lack of disturbance.

Transition T3A: Time and lack of disturbance allows for maturation of the tree community.

Tree State 4.0.
4.1a: Time and lack of disturbance allows for maturation of tree community.
4.2a: Tree thinning treatment (typically for fuels management).

Restoration Pathway R4A: Tree removal.


MLRA 26
Group 2
Ashy Claypan 12-14"
026XF060CA
Reference State 1.0
1.1
Low/Lahontan sagebrush, Thurber's needlegrass and Webber needlegrass dominate
Pinyon and juniper may be present
1.2
Thurber's needlegrass, Webber needlegrass and other perennial grasses dominate
Forbs may increase
Low/Lahontan sagebrush minor component
1.3
Low/Lahontan sagebrush dominates
Thurber's needlegrass and other perennial grasses minor components
Bluegrass may increase
Pinyon and juniper may be present
1.1a
1.2a
1.1b
1.3a
1.3b
T1B
T1A
Current Potential State 2.0
2.1
Low/Lahontan sagebrush, Thurber's needlegrass and Webber needlegrass dominate
Pinyon and juniper may be present
Annual non-native species present
2.2
Thurber's needlegrass, Webber needlegrass and other perennial grasses dominate
Forbs may increase
Low/Lahontan sagebrush minor component
Annual non-native species present
2.3 (At Risk)
Low/Lahontan sagebrush dominates
Thurber's needlegrass and other perennial grasses minor components
Bluegrass may increase
Pinyon and juniper may be present
Annual non-native species present
2.1a
2.2a
2.1b
2.3a
2.3b
Shrub State 3.0
3.1 (At Risk)
Low/Lahontan sagebrush dominates
Sandberg bluegrass and/or annual and perennial forbs dominate understory
Thurber's needlegrass and other perennial grasses minor component or missing
Pinyon and juniper may be present
Annual non-native species may be present
3.1a
3.2a
3.2
Sandberg bluegrass and/or annual and perennial forbs dominate
Sprouting shrubs may increase
Low/Lahontan sagebrush minor component
Thurber's needlegrass and other perennial grasses minor component or missing
Annual non-native species may be present
T2A
R4A
T3A
Tree State 4.0
4.1
Pinyon and/or juniper dominate
Low/Lahontan sagebrush minor component
Thurber's needlegrass and other perennial grasses minor component
Annual non-native species may be present
Bare ground areas large and connected
4.2 (At Risk)
Pinyon and/or juniper dominate
Low/Lahontan sagebrush minor component or missing
Dead shrub skeletons common
Thurber's needlegrass and other perennial grasses minor component
Annual non-native species may be present under trees
Bare ground areas large and connected
Soil redistribution apparent
4.1a
4.2a

MLRA 26
Group 2
Ashy Claypan 12-14"
026XF060CA
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Lack of fire may be combined with historic inappropriate grazing. Not associated with introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire.
3.2a: Time and lack of disturbance.

Transition T3A: Time and lack of disturbance allows for maturation of the tree community.

Tree State 4.0.
4.1a: Time and lack of disturbance allows for maturation of tree community.
4.2a: Tree thinning treatment (typically for fuels management).

Restoration Pathway R4A: Tree removal.

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MLRA 26 Group 3: Churning clay soils with low, Lahontan, and/or Wyoming big sagebrush

Description of MLRA 26 Disturbance Response Group 3

Disturbance Response Group (DRG) 3, consists of three ecological sites. The precipitation for these sites ranges from 8 to 12 inches. The elevation range for this group is 4,500 to 6,500 feet. Slopes range from 2 to 30 percent, however, 2 to 8 percent is typical. The soils in this group are deep and well drained. The water holding capacity ranges from low to moderate. The soils are heavy textured throughout and are subject to extreme shrink and swell action as they fluctuate from wet to dry. The vertical and horizontal soil movement from alternate wetting and drying shears fine and very fine roots and the establishment of plants with extensive lateral root systems is restricted. Annual production in a normal year ranges from 300 to 600 lbs/ac for the group. The potential native plant community varies depending on precipitation, elevation and landform. The shrub component is dominated by low sagebrush (*Artemisia arbuscula*), Lahontan sagebrush (*Artemisia arbuscula* ssp. *longicaulis*), or Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Other shrubs include spiny hopsage (*Grayia spinosa*), shadscale (*Atriplex confertifolia*), and littleleaf horsebrush (*Tetradymia glabrata*). The understory is dominated by perennial bunchgrasses, primarily bottlebrush squirreltail (*Elymus elymoides*), Sandberg bluegrass (*Poa secunda*) and western wheatgrass (*Pascopyrum smithii*).

Ecological sites in this group have multiple sagebrush species listed as the dominant shrub on the sites. During our visits to these sites, we used the black light test (Winward and Tisdale 1969, Rosentreter 2005) to verify sagebrush species. We identified Lahontan sagebrush as the dominant shrub during one site visit, and Wyoming big sagebrush as the dominant on others. On one occasion they occurred together on the modal site. The concepts for the three sites in this group may need reevaluation. Lahontan sagebrush was only recently identified as a unique subspecies of low sagebrush (Winward and McArthur 1995), so it may not have been apparent at the time some of these ecological sites were established. Additionally, these sites are mapped in highly disturbed areas, so site concepts may have been created on alternate states. Due to the differences in palatability between low sagebrush and Lahontan sagebrush, as well as potential soil differences, we recommend a reevaluation of the low sagebrush ecological sites in MLRA 26.

Disturbance Response Group 3 Ecological Sites:

Churning Clay 8-10" — Modal Site	R026XY027NV
Churning Clay 10-12"	R026XY019NV
Churning Claypan 10-12"	R026XY091NV

Modal Site:

The Churning Clay 8-10” ecological site is the modal site for this group as it has the most acres mapped. This site occurs on nearly level to slightly sloping piedmont slopes. Slopes range from 2 to 30 percent. Elevations are 4,500 to 6,000 feet. Average annual precipitation is 8 to 10 inches. The soils of this site are deep and well drained. The available water capacity is moderate. On partial drying, deep wide cracks develop in these heavy textured soils, which may extend to a depth of 40 inches or more. These openings in the soil result in rapid loss of soil moisture by exposing the subsoil to the atmosphere. The vertical and horizontal movement of the soil from alternative wetting and drying, shears fine and very fine roots and the establishment of plants with an extensive lateral root system is restricted. The combination of rapid moisture loss and root shear adversely affects root development. Disturbance of the soil surface by cracking and sloughing of the surface layer into the cracks favors plants capable of rapid regeneration through production of highly viable seed or rhizomatous growth habit. The potential native plant community is dominated by bottlebrush squirreltail and low sagebrush.

Ecological Dynamics and Disturbance Response

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by moderately deep-rooted cool season perennial bunchgrasses and/or rhizomatous grasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m (Dobrowolski et al. 1990). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). However, community types with low sagebrush as the dominant shrub were found to have soil depths, and thus available rooting depths, of 71 to 81 cm in a study in northeast Nevada (Jensen 1990).These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The perennial bunchgrasses that are dominant include bottlebrush squirreltail, Sandberg's bluegrass and western wheatgrass. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Periodic drought regularly influences sagebrush ecosystems, and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity (Snyder et al. 2019). Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

Low sagebrush is fairly drought tolerant but also tolerates periodic wetness during some portion of the growing season. Low sagebrush is also susceptible to the sagebrush defoliator, Aroga moth. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975), but the research is inconclusive of the damage sustained by low sagebrush populations.

Lahontan sagebrush was only recently identified as a unique subspecies of low sagebrush (Winward and McArthur 1995). Lahontan sagebrush is a cross between low sagebrush and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). It is typically found near the old shorelines of Lake Lahontan from the Pleistocene epoch, but has been recorded throughout MLRA 26. This subspecies grows on soils similar to low sagebrush with shallow depths and low water holding capabilities (Winward and McArthur 1995).

Wyoming big sagebrush is the most drought tolerant of the big sagebrushes. It is generally long-lived, therefore it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment are the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The moisture resource supporting the greatest amount of plant growth is usually the water stored in the soil profile during the winter. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition or can increase resource pools by the decomposition of dead plant material following disturbance. The invasion of sagebrush communities by cheatgrass has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007). Dobrowolski et al. (1990) cite multiple authors on the extent of the soil profile exploited by the competitive exotic annual cheatgrass. In competitive environments cheatgrass roots were found to penetrate only 15 cm whereas isolated plants and pure stands were found to root at least 1 meter in depth with some plants rooting as deep as 1.5 to 1.7 meters.

Bottlebrush squirreltail and western wheatgrass are dominant grass species in this group. These species generally have shallower root systems than the shrubs. Root densities are often as high as or higher than those of shrubs in the upper 0.5 m of soil (Dobrolowski et al. 1990, Reynolds and Fraley 1989). Squirreltail is a bunchgrass that has moderately deep roots. Squirreltail persists on these shrink-swell soils because its seeds are able to remain near the surface of deep soil cracks; the long awns keep the seeds from falling too deep. Western wheatgrass is adapted to soil movement in a different way; as a rhizomatous grass it is capable of spreading vegetatively and thrives in disturbed soil (Cronquist et al. 1994). Differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems.

The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency and eventually lead to an annual state. Conversely, as fire frequency decreases, sagebrush will increase and with inappropriate grazing management the perennial bunchgrasses and forbs may be reduced. Infilling by singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma)* may also occur with an extended fire return interval. This will occur on sites that are proximate to existing stands of pinyon or juniper. This group was only seen in Phase I tree encroachment, so it is unknown if a tree state exists.

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation, and increased nutrient availability. Four possible alternative stable states have been identified for this DRG.

Annual Invasive Grasses:

The species most likely to invade these sites are cheatgrass and medusahead. Both species are cool-season annual grasses that maintain an advantage over native plants in part because they are prolific seed producers, able to germinate in the autumn or spring, tolerant of grazing and increase with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Medusahead and cheatgrass originated from Eurasia and both were first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead. By 2003, medusahead occupied approximately 2.3 million acres in 17 western states (Rice 2005). In the Intermountain West, the exponential increase in dominance by medusahead has largely been at the expense of cheatgrass (Harris 1967, Hironaka 1994). Medusahead matures 2-3 weeks later than cheatgrass (Harris 1967) and recently, James et al. (2008) measured leaf biomass over the growing season and found that medusahead maintained vegetative growth later in the growing season than cheatgrass. Mangla et al. (2011) also found medusahead had a longer period of growth and more total biomass than cheatgrass and hypothesized this difference in relative growth rate may be due to the ability of medusahead to maintain water uptake as upper soils dry compared to co-occurring species, especially cheatgrass. Medusahead litter has a slow decomposition rate, because of high silica content, allowing it to accumulate over time and suppress competing vegetation (Bovey et al. 1961, Davies and Johnson 2008). Harris (1967) reported medusahead roots have thicker cell walls compared to those of cheatgrass, allowing it to more effectively conduct water, even in very dry conditions.

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. Collectively, the body of research suggests that the continued invasion and dominance of medusahead onto native grasslands and cheatgrass infested grasslands will continue to increase in severity because conditions that favor native bunchgrasses or cheatgrass over medusahead are rare (Mangla et al. 2011). Medusahead replaces native vegetation and cheatgrass directly by competition and suppression and native vegetation indirectly by increasing fire frequency.

Methods to control medusahead and cheatgrass include herbicide, fire, grazing, and seeding of primarily non-native wheatgrasses. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. A study by Davies et al. (2013), found an increase in medusahead cover near roads. Cover was higher near animal trails than random transects but the difference was less evident. This implies that vehicles and animals aid the spread of the weed; however, vehicles are the major vector of movement. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating medusahead and cheatgrass than spraying alone (Sheley et al. 2012). Where native bunchgrasses are missing from the site, revegetation of medusahead or cheatgrass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (*Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011), however caution in using these results is advised, as only one year of data was reported.

Prescribed fire has also been utilized in combination with the application of pre-emergent herbicide to control medusahead and cheatgrass (Vollmer and Vollmer 2008). Mature medusahead or cheatgrass is very flammable and fire can be used to remove the thatch layer, consume standing vegetation, and even reduce seed levels. Furbush (1953) reported that timing a burn while the seeds were in the milk stage effectively reduced medusahead the following year. He further reported that adjacent unburned areas became a seed source for reinvasion the following year.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic and the same rates with methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz/ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Low sagebrush is killed by fire and does not sprout (Tisdale and Hironaka 1981). Fire risk is greatest following a wet, productive year when there is greater production of fine fuels (Beardall and Sylvester 1976). Fire return intervals are not well understood because these ecosystems rarely coincide with fire-scarred conifers, however, a wide range of 20 to well over 100 years has been estimated (Miller and Rose 1995, Miller and Rose 1999, Baker 2006, Knick et al. 2005). Historically, fires were probably patchy due to the low productivity of these sites (Beardall and Sylvester 1976, Ralphs and Busby 1979, Wright et al. 1979, Smith and Busby 1981). Fine fuel loads generally average 100 to 400 pounds per acre (110-450 kg/ha) but are occasionally as high as 600 pounds per acre (680 kg/ha) in low sagebrush habitat types (Bradley et al. 1992). Reestablishment occurs from off-site wind-dispersed seed (Young 1983). Recovery time of low sagebrush following fire is variable (Young 1983). Without sufficient seed source nearby, it may take decades for sagebrush to reestablish on a site. Little research has focused on low sagebrush recovery post-fire, but we have observed 25+ year old fire scars in this DRG with little to no recruitment. Slow regeneration may subsequently worsen erosion (Blaisdell et al. 1982). We were unable to find any substantial research on success of seeding low sagebrush after fire. To date, we have not been able to find specific research on the fire response of Lahontan sagebrush.

Wyoming big sagebrush communities historically had low fuel loads. Patchy fires that burned in a mosaic pattern were common at 10 to70 year return intervals (Young et al. 1979, West and Hassan 1985, Bunting et al. 1987), however more recent research suggests longer return intervals. Davies et al. (2006) suggest fire return intervals in Wyoming big sagebrush communities were around 50 to100 years. More recently, Baker (2011) estimates fire rotation to be 200 to350 years in Wyoming big sagebrush communities. Wyoming big sagebrush is killed by fire and only regenerates from seed. Recovery time for Wyoming big sagebrush may require 50 to120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities.

Bottlebrush squirreltail is considered more fire tolerant than Indian ricegrass (*Achnatherum hymenoides*) due to its small size, coarse stems, and sparse leafy material (Britton et al. 1990). Post-fire regeneration occurs from surviving root crowns and from on- and off-site seed sources. Bottlebrush squirreltail has the ability to produce large numbers of highly germinable seeds, with relatively rapid germination (Young and Evans 1977) when exposed to the correct environmental cues. Early spring growth and ability to grow at low temperatures contribute to the persistence of bottlebrush squirreltail among cheatgrass dominated ranges (Hironaka and Tisdale 1973).

The rhizomatous growth form of western wheatgrass makes it capable of surviving fire and may increase vegetative growth afterward (Bushey 1987, Wasser 1982). Sandberg bluegrass has been found to increase following fire, likely due to its low stature and productivity (Daubenmire 1975). Sandberg bluegrass may retard reestablishment of deeper-rooted bunchgrass.

The grasses likely to invade this site are cheatgrass and medusahead. These invasive grasses displace desirable perennial grasses, reduce livestock forage, and accumulate large fuel loads that foster frequent fires (Davies and Svejcar 2008). Invasion by annual grasses can alter the fire cycle by increasing fire size, fire season length, rate of spread, numbers of individual fires, and likelihood of fires spreading into native or managed ecosystems (D'Antonio and Vitousek 1992, Brooks et al. 2004). While historical fire return intervals are estimated at 15 to 100 years, areas dominated with cheatgrass are estimated to have a fire return interval of 3 to5 years (Whisenant 1990). The mechanisms by which invasive annual grasses alter fire regimes likely interact with climate. For example, cheatgrass cover and biomass vary with climate (Chambers et al. 2007) and are promoted by wet and warm conditions during the fall and spring. Invasive annual species have been shown able to take advantage of high N availability following fire through higher growth rates and increased seedling established relative to native perennial grasses (Monaco et al. 2003).

Livestock/Wildlife Grazing Interpretations:

Domestic sheep and cattle to a much lesser degree - consume low sagebrush, particularly during the spring, fall, and winter (Sheehy and Winward 1981). Heavy dormant season grazing by sheep will reduce sagebrush cover and increase grass production (Laycock 1967). Severe trampling damage to supersaturated soils could occur if sites are used in early spring when there is abundant snowmelt. Trampling damage, particularly from cattle or horses, in low sagebrush habitat types is greatest when high clay content soils are wet. In drier areas with more gravelly soils, no serious trampling damage occurs, even when the soils are wet (Hironaka et al. 1983). Bunchgrasses, in general, will tolerate light grazing after seed formation. Britton et al. (1990) observed the effects of clipping date on basal area of 5 bunchgrasses in eastern Oregon, and found grazing from August to October (after seed set) has the least impact. Heavy grazing during the growing season will reduce perennial bunchgrasses and increase sagebrush (Laycock 1967). Abusive grazing by cattle or horses will likely increase low sagebrush, rabbitbrush and some forbs such as arrowleaf balsamroot (*Balsamorhiza sagittata*). Annual non-native weedy species such as cheatgrass and mustards, and potentially medusahead (*Taeniatherum caput-medusae*), may invade.

Throughout two years of site visits for this report, Lahontan sagebrush was observed in a heavily browsed state on ecological sites within this DRG. This recently differentiated subspecies of low sagebrush (Winward and McArthur 1995) is moderately to highly palatable to browse species (McArthur 2005, Rosentreter 2001). Dwarf sagebrush species such as Lahontan sagebrush, low sagebrush, and black sagebrush are preferred by mule deer for browse among the sagebrush species. Due to its palatability, it can often be hedged from grazing pressure (McArthur 2005).

Bottlebrush squirreltail generally increases in abundance when moderately grazed or protected (Hutchings and Stewart 1953). In addition, moderate trampling by livestock in big sagebrush rangelands of central Nevada enhanced bottlebrush squirreltail seedling emergence compared to untrampled conditions. Heavy trampling, however, was found to significantly reduce germination sites (Eckert and Spencer 1987). Squirreltail is more tolerant of grazing than other perennial bunchgrasses, but all bunchgrasses are sensitive to over utilization within the growing season.

Western wheatgrass is a preferred feed for livestock and wildlife, but is not a very productive plant (Enevoldsen and Lewis 1978, Hafenrichter et al. 1968). It is short in stature and has sparse growth in low-water conditions. Compared to native bunchgrasses, western wheatgrass is not as palatable (Hafenrichter et al. 1968).

Inappropriate grazing practices can be tied to the success of medusahead, however, eliminating grazing will not eradicate medusahead if it is already present (Wagner et al. 2001). Sheley and Svejcar (2009) reported that even moderate defoliation of bluebunch wheatgrass resulted in increased medusahead density. They suggested that disturbances such as plant defoliation limit soil resource capture, which creates an opportunity for exploitation by medusahead. Avoidance of medusahead by grazing animals allows medusahead populations to expand. This creates seed reserves that can infest adjoining areas and cause changes to the fire regime. Medusahead replaces native vegetation and cheatgrass directly by competition and suppression and native vegetation indirectly by an increase in fire frequency. Medusahead litter has a slow decomposition rate, because of high silica content, allowing it to accumulate over time and suppress competing vegetation (Bovey et al. 1961, Davies and Johnson 2008).

State and Transition Model Narrative for Group 3

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 3.

Reference State 1.0:

The Reference State 1.0 is representative of the natural range of variability under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:

This community is dominated by low sagebrush, bottlebrush squirreltail and Sandberg bluegrass. Forbs and other grasses make up smaller components.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring may be more severe and reduce sagebrush cover to trace amounts.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.3:
Time and lack of disturbance such as fire allows for sagebrush to increase and become decadent. Long-term drought, herbivory, or combinations of these will cause a decline in perennial bunchgrasses and fine fuels leading to a reduced fire frequency and allowing sagebrush to dominate the site.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early/mid-seral community. Bottlebrush squirreltail, Sandberg bluegrass and other perennial bunchgrasses dominate. Depending on fire severity patches of intact sagebrush may remain. Rabbitbrush and other sprouting shrubs may be sprouting. Perennial forbs may be a significant component for a number of years following fire.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Time and lack of disturbance will allow sagebrush to increase.

Community Phase 1.3:
Sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or from herbivory.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.2:
Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community.

T1A: Transition from the Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, mustards, and bur buttercup (*Ceratocephala testiculata*).

Slow variables: Over time the annual non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however, the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. These non-native species can be highly flammable, and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. Sagebrush, bottlebrush squirreltail and Sandberg bluegrass dominate the site. Forbs and other shrubs and grasses make up smaller components of this site.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Fire reduces the shrub overstory and allows for perennial bunchgrasses to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. Annual non-native species are likely to increase after fire.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Time and lack of disturbance allows for sagebrush to increase and become decadent. Long-term drought reduces fine fuels and leads to a reduced fire frequency, allowing sagebrush to dominate the site. Inappropriate grazing management reduces the perennial grass understory.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community where annual non-native species are present. Sagebrush is present in trace amounts; bottlebrush squirreltail, Sandberg bluegrass and other perennial bunchgrasses dominate the site. Depending on fire severity patches of intact sagebrush may remain. Rabbitbrush may be sprouting or dominant in the community. Perennial forbs may be a significant component for a number of years following fire. Annual non-native species are stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of low sagebrush can take many years.

Community Phase 2.3 (At Risk):
This community is at risk of crossing a threshold to another state. Sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs, from inappropriate grazing, or from both. Rabbitbrush may be a significant component. Bare ground increases. Annual non-native species may be stable or increasing due

to lack of competition with perennial bunchgrasses. Pinyon and/or juniper may be present. This site is susceptible to further degradation from grazing, drought, and fire.

Churning Clay 10-12" (R026XY019NV) Phase 2.3, P. Novak-Echenique May 2014

Community Phase Pathway 2.3a, from Phase 2.3 to 2.2:
Fire eliminates/reduces the overstory of sagebrush and allows for the understory perennial grasses to increase. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community. Annual non-native species respond well to fire and may increase post burn.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: To Community Phase 3.1: Inappropriate grazing will decrease or eliminate deep rooted perennial bunchgrasses, increase Sandberg bluegrass and favor shrub growth and establishment. To Community Phase 3.2: Severe fire in Community Phase 2.3 will remove sagebrush overstory. Annual non-native species will increase.

Slow variables: Long term decrease in deep-rooted perennial grass density.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Fire or soil disturbing treatment would transition to Community Phase 4.1.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes temporal and spatial nutrient capture and cycling within the community. Increased, continuous fine fuels modify the fire regime by increasing frequency, size and spatial variability of fires.

Shrub State 3.0:

This state has two community phases, a shrub-dominated phase and a grass-dominated phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Sagebrush dominates the overstory and rabbitbrush may be a significant component. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and bottlebrush squirreltail or western wheatgrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1 (At Risk):
Decadent sagebrush dominates the overstory. Rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Western wheatgrass and annual non-native species increase. Bare ground is significant. Pinyon and/or juniper may be present.

Churning Clay 10-12" (R026XY019NV), Phase 3.1, P. Novak-Echenique, May 2015

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire, heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, will greatly reduce the overstory shrubs to trace amounts and allow grasses to dominate the site.

Community Phase 3.2:
Bottlebrush squirreltail and/or western wheatgrass dominate the site; annual non-native species may be present but are not dominant. Trace amounts of sagebrush or rabbitbrush may be present. Bare ground may be significant.

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of low sagebrush can take many years.

T3A: Transition from Shrub State 3.0 to Annual State 4.0:

Trigger: Fire and/or treatments that disturb the soil and existing plant community.

Slow variables: Increased seed production (following a wet spring) and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing frequency, intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the temporal and spatial aspects of nutrient cycling and distribution.

Annual State 4.0:

This state has one community phase dominated by annual plants. An abiotic threshold has been crossed and state dynamics are driven by fire and time. The herbaceous understory is dominated by annual non-native species such as cheatgrass, medusahead, Russian thistle, and mustards. Resiliency has declined and further degradation from fire facilitates a cheatgrass and sprouting shrub plant community. Fire return interval has shortened due to the dominance of annual grasses in the understory and is a driver in site dynamics.

Community Phase 4.1:
Annual plants like cheatgrass, medusahead, and Russian thistle dominate. Bottlebrush squirreltail and perennial forbs may still be present in trace amounts. Surface erosion may increase with summer convection storms and would be evidenced by increased pedestalling of plants, rill formation, or extensive water flow paths.

Churning Clay 8-10" (R026XY027NV) Annual State 4.1, P. Novak-Echenique, May 2015

Churning Clay 10-12" (R026XY027NV) Phase 4.1, P. Novak-Echenique 1/7/21

Potential Resilience Differences with Other Ecological Sites:

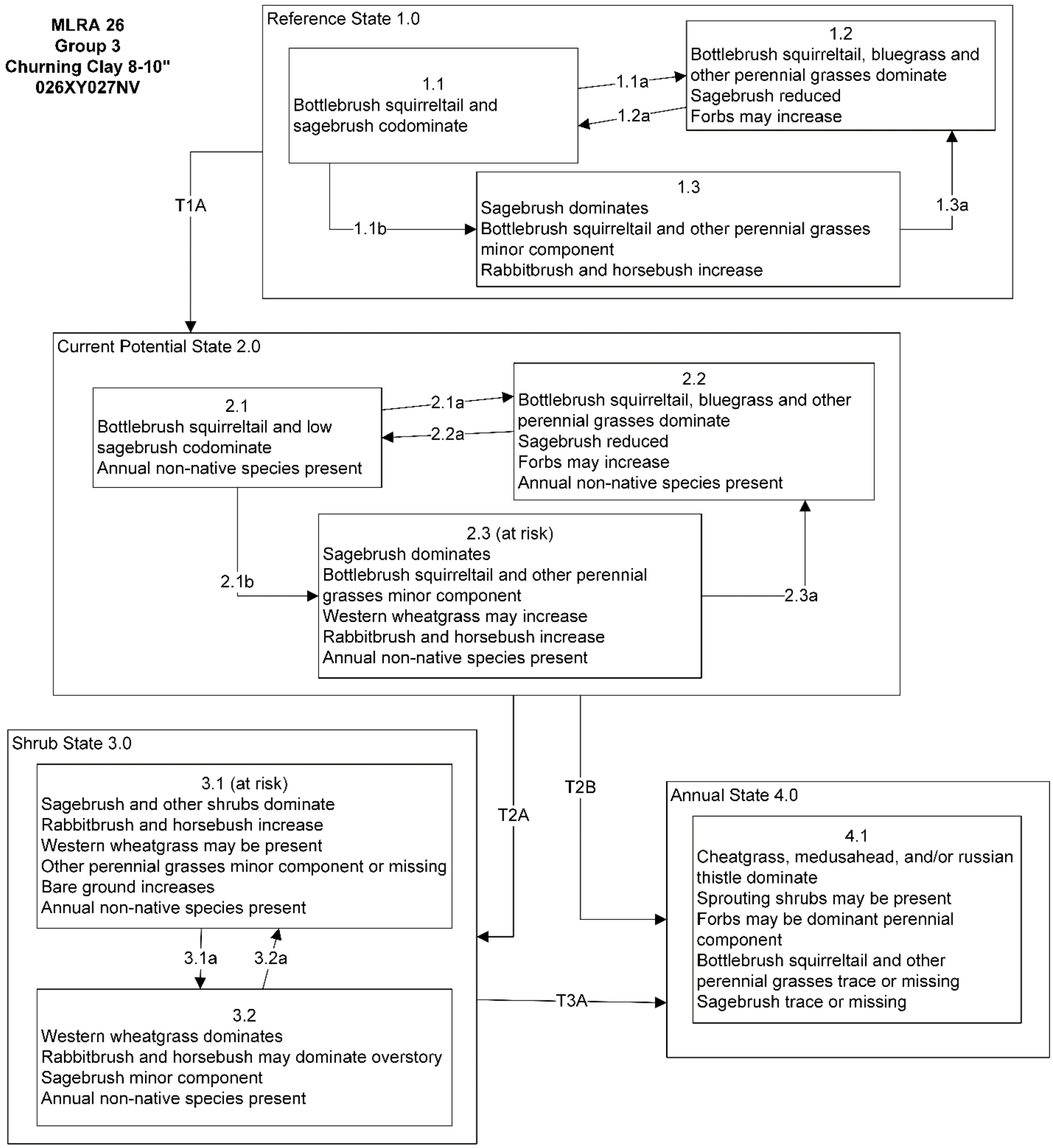
Churning Clay 10-12" (R026XY019NV):

This site occurs on similar landforms and at similar elevations as the modal site, but has a much different plant community that is dominated by western wheatgrass and Wyoming big sagebrush. This site is also much more productive than the modal site with 600 lb/ac in a normal year. The soils are deep, well drained and have moderate available water capacity. Root development is restricted due to shearing and soil moisture loss from shrink and swell action of the soil. Therefore, plants that rapidly regenerate through seed or have rhizomatous growth habits are favored.

Churning Claypan 10-12" (R026XY091NV):

This site is slightly more productive that the modal site at 400 lb/ac in a normal year. Sandberg bluegrass is listed as the dominant grass in the site description, but this site was not found during field work for this project to verify. The soil surface typically has more than 50% of cobbles and stones. Shrink and swell action in these soils impact root development causing extensive lateral root systems to be restricted. It is unlikely that this site would support pinyon or juniper with this cobbly soil type.

Modal State and Transition Model for Group 3 in MRLA 26:



MLRA 26
Group 3
Churning Clay 8-10"
026XY027NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.

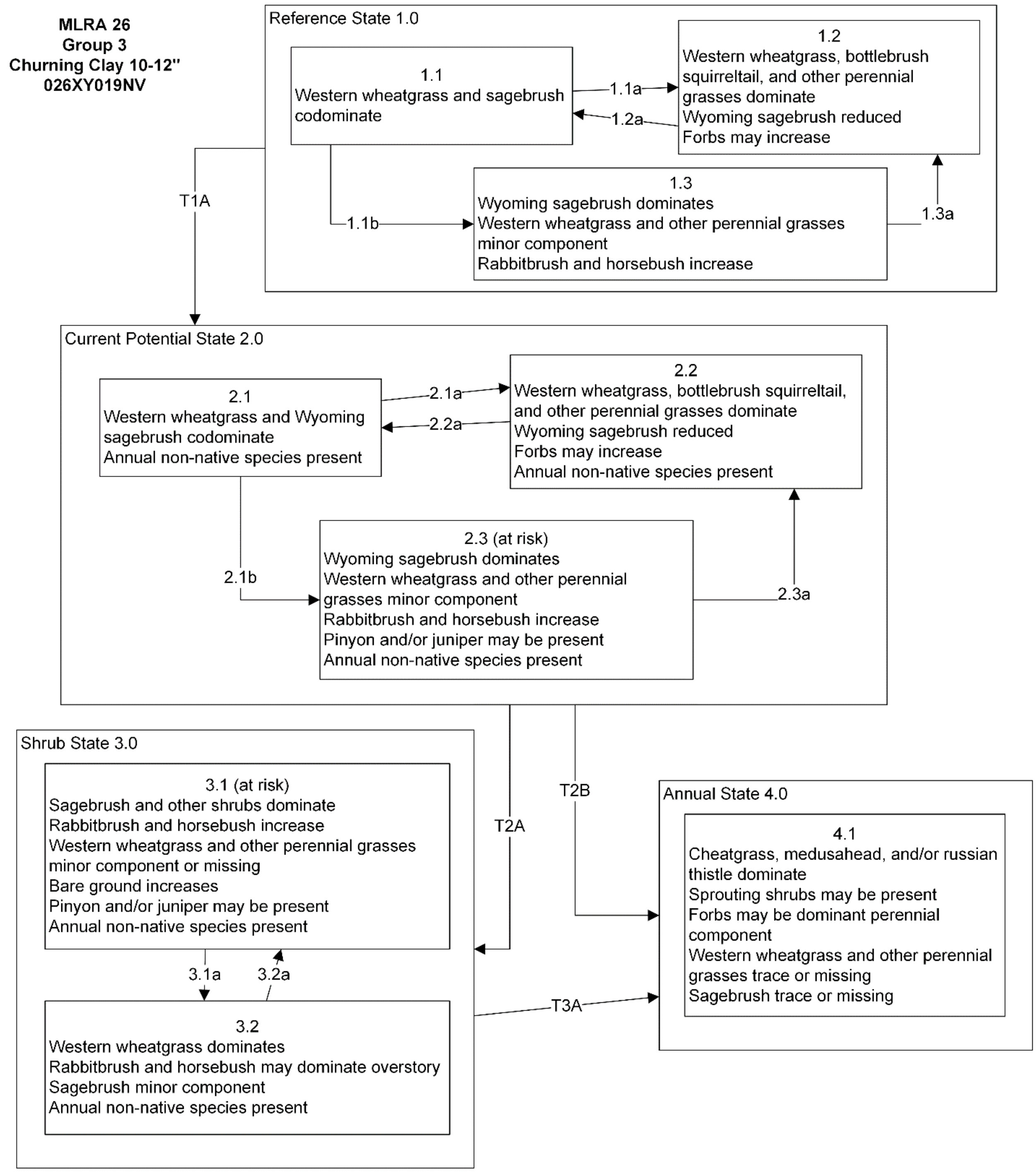
Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.

Annual State 4.0 Community Phase Pathways
None.

Additional State and Transition Models for Group 3 in MLRA 26:



MLRA 26
Group 3
Churning Clay 10-12"
026XY019NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

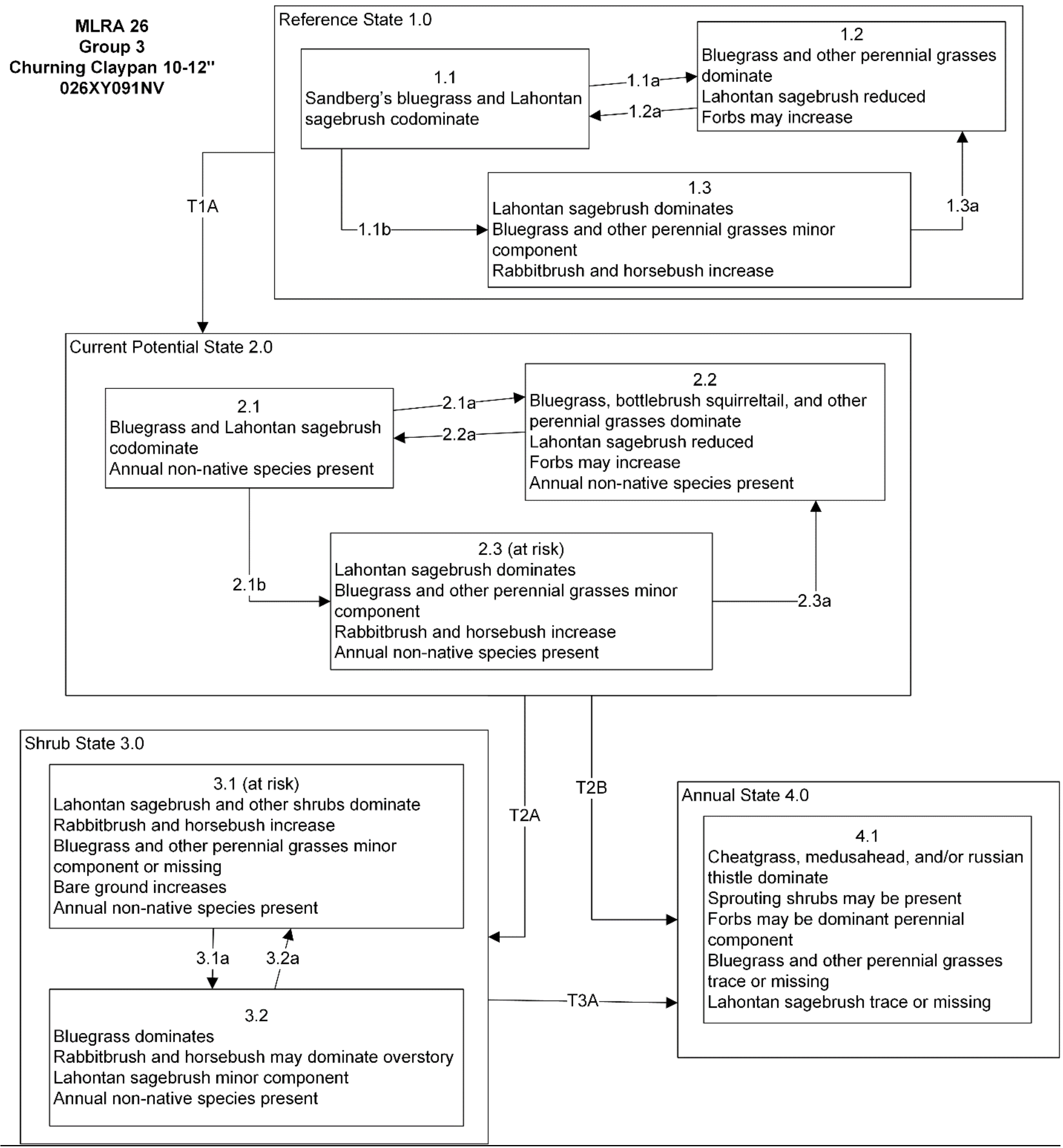
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.

Annual State 4.0 Community Phase Pathways
None.


MLRA 26
Group 3
Churning Claypan 10-12"
026XY091NV
Reference State 1.0
1.1
Sandberg's bluegrass and Lahontan sagebrush codominate
1.1a
1.2a
1.2
Bluegrass and other perennial grasses dominate
Lahontan sagebrush reduced
Forbs may increase
1.1b
1.3
Lahontan sagebrush dominates
Bluegrass and other perennial grasses minor component
Rabbitbrush and horsebush increase
1.3a
T1A
Current Potential State 2.0
2.1
Bluegrass and Lahontan sagebrush codominate
Annual non-native species present
2.1a
2.2a
2.2
Bluegrass, bottlebrush squirreltail, and other perennial grasses dominate
Lahontan sagebrush reduced
Forbs may increase
Annual non-native species present
2.1b
2.3 (at risk)
Lahontan sagebrush dominates
Bluegrass and other perennial grasses minor component
Rabbitbrush and horsebush increase
Annual non-native species present
2.3a
T2A
T2B
Shrub State 3.0
3.1 (at risk)
Lahontan sagebrush and other shrubs dominate
Rabbitbrush and horsebush increase
Bluegrass and other perennial grasses minor component or missing
Bare ground increases
Annual non-native species present
3.1a
3.2a
3.2
Bluegrass dominates
Rabbitbrush and horsebush may dominate overstory
Lahontan sagebrush minor component
Annual non-native species present
T3A
Annual State 4.0
4.1
Cheatgrass, medusahead, and/or russian thistle dominate
Sprouting shrubs may be present
Forbs may be dominant perennial component
Bluegrass and other perennial grasses trace or missing
Lahontan sagebrush trace or missing

MLRA 26
Group 3
Churning Clay 8-10"
026XY027NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.

Annual State 4.0 Community Phase Pathways
None.

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MLRA 26 Group 4: Low sagebrush on mountain ridges, low productivity

Description of MLRA 26 Disturbance Response Group 4

Disturbance Response Group (DRG) 4 consists of two ecological sites. The annual precipitation for these sites ranges from 14 to over 20 inches. Elevations range from 8,000 to 10,000 feet. Slopes range from 2 to over 50 percent, however, slopes of 4 to 30 percent are typical. Soils for these sites range from very shallow to moderately deep, and they typically exhibit a clay layer that can restrict root growth. The potential native plant community of these sites is dominated by low sagebrush (*Artemisia arbuscula*), pine needlegrass (*Achnatherum pinetorum*), and Letterman's needlegrass (*Achnatherum lettermanii).* Bluegrasses (*Poa* spp.) and prairie junegrass (*Koeleria macrantha*) are typically significant components of these sites. Production for a normal year ranges from 150 to 300 lbs/ac.

Disturbance Response Group 4 Ecological Sites:

Mountain Ridge - Modal	R026XY028NV
Claypan 14+	R026XY039NV

Modal Site:

The Mountain Ridge (R026XY028NV) ecological site is the modal site for this group, as it has the most acres mapped. This site occurs on summits, shoulders and upper backslopes of mountains. Slopes range from 2 to over 50 percent, but slope gradients of 4 to 30 percent are most typical. Elevations are 8,500 to over 10,000 feet. Average annual precipitation is about 14 to over 20 inches. Production in a normal year is 150 lbs/ac. The soils in this site are typically very shallow and formed in a residuum from extrusive igneous rocks. Many soils have only a thin, clayey horizon just above bedrock. Lack of soil depth and high volumes of coarse fragments in the soil profile result in very low available water capacity. The soils commonly have over 70 percent gravels, cobbles and stones on the surface which provide a stabilizing effect on surface erosion conditions.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by shallow and deep-rooted cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m (Dobrowolski et al. 1990). However, community types with low sagebrush as the dominant shrub were found to have soil depths and thus available rooting depths of 71 to 81 cm in a study in northeast

Nevada (Jensen 1990). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992). The ecological sites in this group have very shallow soil depths, resulting in low available water holding capacity and therefore low productivity. Additionally, these sites occur on harsh windswept ridgeline positions that favor low-stature vegetation.

The perennial bunchgrasses that are dominant include pine needlegrass and Letterman's needlegrass. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Periodic drought regularly influences sagebrush ecosystems, and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability with the soil profile (Bates et al. 2006).

Low sagebrush is fairly drought tolerant but also tolerates periodic wetness during the early growing season. Low sagebrush is also susceptible to the sagebrush defoliator, Aroga moth. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975), but the research is inconclusive of the damage sustained by low sagebrush populations.

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition or can increase resource pools by the decomposition of dead plant material following disturbance. The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007).

At the time of publication of this document, no literature could be found about the ecological dynamics of pine needlegrass (*Achnatherum pinetorum*), but it likely responds similarly to Letterman's needlegrass (*Achnatherum lettermanii*), another densely tufted needlegrass which reproduces by seed and tillering.

The ecological sites in this DRG have moderate to high resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Three possible alternative stable states have been identified for this DRG.

Fire Ecology:

Fire is not a major ecological component of these community types (Winward 2001), and would be patchy and infrequent when they occur due to the low productivity of the sites. Fire return intervals have been estimated at 100 to 200 years (Kitchen and McArthur 2007). Low sagebrush is killed by fire and does not resprout (Tisdale and Hironaka 1981). Establishment after fire is from seed, generally blown in and not from the seed bank (Bradley et al. 1992). Fire risk is greatest following a wet, productive year when there is greater production of fine fuels (Beardall and Sylvester 1976). Fine fuel loads generally average 100 to 400 pounds per acre (110- 450 kg/ha) but are occasionally as high as 600 pounds per acre (680 kg/ha) in low sagebrush habitat types (Bradley et al. 1992). Recovery time of low sagebrush following fire is variable (Young 1983). After fire, if regeneration conditions are favorable, low sagebrush recovers in 2 to 5 years, however, on harsh sites where cover is low to begin with and/or erosion occurs after fire, recovery may require more than 10 years (Young 1983). Slow regeneration may subsequently worsen erosion (Blaisdell et al. 1982).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. Sandberg bluegrass, a minor component of this ecological site, has been found to increase following fire likely due to its low stature and productivity (Daubenmire 1975) and may retard reestablishment of deeper-rooted bunchgrasses.

Prairie junegrass can be a significant component on these sites. It is a short-statured cool season perennial bunchgrass that is relatively shallow rooted (Albertson and Weaver 1944) but is found throughout the western United States and can vary morphologically. Prairie junegrass is moderately resistant to fire, likely due to its low stature and loosely tufted growth form (Young 1983). It is typically not a dominant grass in the Great Basin but is found in early-seral and climax communities and occurs on sites with coarse to medium textured soils (Friesen 2002). Prairie junegrass is widely documented as a drought tolerant species that is often used for reclamation but one study found that its drought tolerance significantly decreased in populations at higher elevations (Zhang et al. 2011).

Needlegrasses are slightly to moderately damaged by fire depending on season of burn. They tend to be more susceptible when burned during mid-summer (Wright and Klemmedson 1965).

Livestock/Wildlife Grazing Interpretations:

Domestic sheep and, to a much lesser degree, cattle consume low sagebrush, particularly during the spring, fall, and winter (Sheehy and Winward 1981). Heavy dormant season grazing by sheep will reduce sagebrush cover and increase grass production (Laycock 1967). Severe trampling damage to supersaturated soils could occur if sites are used in early spring when there is abundant snowmelt. Trampling damage, particularly from cattle or horses, in low sagebrush habitat types is greatest when high clay content soils are wet. In drier areas with more gravelly soils, no serious trampling damage occurs, even when the soils are wet (Hironaka et al. 1983). Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton et al. (1990) observed the effects of clipping date on basal area of 5 bunchgrasses in eastern Oregon, and found grazing from August to October (after seed set) has the least impact. Heavy grazing during the growing season will reduce perennial bunchgrasses and increase sagebrush (Laycock 1967). Abusive grazing by cattle or horses will likely increase low sagebrush, rabbitbrush and some forbs such as arrowleaf balsamroot (*Balsamorhiza sagittata*). Annual non-native weedy species such as cheatgrass and mustards, and potentially medusahead (*Taeniatherum caput-medusae*), may invade.

Needlegrasses are widely distributed throughout the U.S. but are most common in the Great Basin and Southwest. They have a high forage value specifically in the western ranges. When mature the foliage can become coarse and reduce the palatability of these grasses, however, they remain green longer than other grasses and mature well, making them valuable forage for late fall and winter. The seeds of these grasses are mechanically injurious to grazing animals and can sometimes work into the tissues of the mouth, tongue, ears, and nose of livestock and game animals (USDA 1988).

Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass expansion and/or cheatgrass and other invasive species to occupy interspaces. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass or other weedy species.

Prairie junegrass is palatable to all livestock and many wildlife species including deer, antelope, elk, bighorn sheep, small mammals and upland birds. It is valuable forage in the early spring as it develops earlier than most species and flowers in April to June. Palatability decreases during seed development but then returns in the fall after curing. It is tolerant to grazing as long as adequate soil moisture is available (Fernandez-Gimenez and Allen-Diaz 2001).

Low sagebrush sites are often used for strutting grounds for sage grouse (*Centrocercus urophasianus*) because the low cover allows for high visibility of strutting males (McAdoo and Back 2001). Sage grouse also use these high wind-swept sites during the winter where sagebrush provides food and cover (Braun, Connelly and Schroeder 2005).

State and Transition Model Narrative for Group 4

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 4.

Reference State 1.0:

The Reference State 1.0 is a representative of the natural range of variability under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:

This community is dominated by low sagebrush, pine needlegrass (*Achnatherum pinetorum*), prairie junegrass and bluegrasses. Rabbitbrush and antelope bitterbrush are also common. A diversity of forbs and other grasses make up smaller components.

Mountain Ridge (R026XY028NV) Phase 1.1 T. K. Stringham, June 2016

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Fire reduces the shrub overstory and allows for perennial bunchgrasses to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.3:
Long-term drought, herbivory, or combinations of these will cause a decline in perennial bunchgrasses and fine fuels leading to a reduced fire frequency and allowing sagebrush to dominate the site.

Community Phase 1.2:
Sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or from herbivory.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Release from drought allows the perennial bunchgrasses to increase.

Community Phase 1.3:
This community is at risk of crossing a threshold to another state. Sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs or from inappropriate grazing, or from both. Rabbitbrush may be a significant component. Bluegrasses may increase and become dominant. Annual non-native species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, drought, and fire.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
A change in grazing management that reduces shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall or winter grazing may cause mechanical damage and subsequent death to sagebrush, facilitating an increase in the herbaceous understory. Low sagebrush are palatable shrub species and can decrease with increased grazing pressure. Brush

treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. A low severity fire would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Due to low fuel loads in this state, fires will likely be small, creating a mosaic pattern.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire eliminates/reduces the overstory of sagebrush and allows for the understory perennial grasses to increase. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community. Annual non-native species respond well to fire and may increase post burn.

Claypan 14+ (026XY039NV) Phase 1.3 T.K. Stringham, July 2015

T1A: Transition from the Reference State 1.0 to Current Potential State 2.0

Trigger: This transition is caused by the introduction of non-native annual plants.

Slow variables: Over time the annual non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however, the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. These non-native species can be highly flammable, and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1

This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. Sagebrush, pine needlegrass and prairie junegrass dominate the site. A diversity of forbs and other shrubs and grasses make up smaller components of this site.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:

Fire reduces the shrub overstory and allows for perennial bunchgrasses and perennial forbs to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. Annual non-native species are likely to increase after fire.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:

Time and lack of disturbance allows for sagebrush to increase and become decadent. Long-term drought reduces fine fuels and leads to a reduced fire frequency, allowing sagebrush to dominate the site. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely bluegrasses may increase in the understory depending on grazing management.

Community Phase 2.2:

This community phase is characteristic of a post-disturbance, early to mid-seral community where annual non-native species are present. Sagebrush is present in trace amounts; perennial bunchgrasses and forbs dominate the site. Depending on fire severity, patches of intact sagebrush may remain. Rabbitbrush may be sprouting or dominant in the community. Perennial forbs may be a significant component for a number of years following fire. Annual non-native species are stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:

Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of low sagebrush can take many years.

Community Phase 2.3 (At Risk):

This community is at risk of crossing a threshold to another state. Sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs or from inappropriate grazing, or from both. Rabbitbrush may be a significant component. Bluegrasses may increase and become dominant. Annual non-native species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, drought, and fire.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:

A change in grazing management that reduces shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall or winter grazing may cause mechanical damage and subsequent death to sagebrush, facilitating an increase in the herbaceous understory. Low sagebrush are palatable shrub species and can decrease with increased grazing pressure. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. A low severity fire would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Due to low fuel loads in this state, fires will likely be small, creating a mosaic pattern. Annual non-native species are present and may increase in the community.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire eliminates/reduces the overstory of sagebrush and allows for the understory perennial grasses to increase. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community. Annual non-native species respond well to fire and may increase post burn.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0

Trigger: To Community Phase 3.1: Inappropriate grazing will decrease or eliminate deep-rooted perennial bunchgrasses, increase bluegrasses and favor shrub growth and establishment. To Community Phase 3.2: Severe fire in Community Phase 2.3 will remove sagebrush overstory, decrease perennial bunchgrasses and enhance bluegrasses. Annual non-native species will increase.

Slow variables: Long term decrease in deep-rooted perennial grass density.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

Shrub State 3.0:

This state has 2 community phases, a shrub dominated phase and a bluegrass/annual grass dominated phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Bluegrasses will increase with a reduction in deep-rooted perennial bunchgrass competition and become the dominant grass. Sagebrush dominates the overstory and rabbitbrush may be a significant component. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and bluegrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1 (At Risk):
Decadent sagebrush dominates the overstory with perennial forbs dominant in the understory. Rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Bluegrasses and annual non-native species increase. Bare ground is significant.

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire, heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, will greatly reduce the overstory shrubs to trace amounts and allow for bluegrasses to dominate the site.

Community Phase 3.2:
Bluegrass dominates the site; annual non-native species may be present but are not dominant. Trace amounts of sagebrush or rabbitbrush may be present.

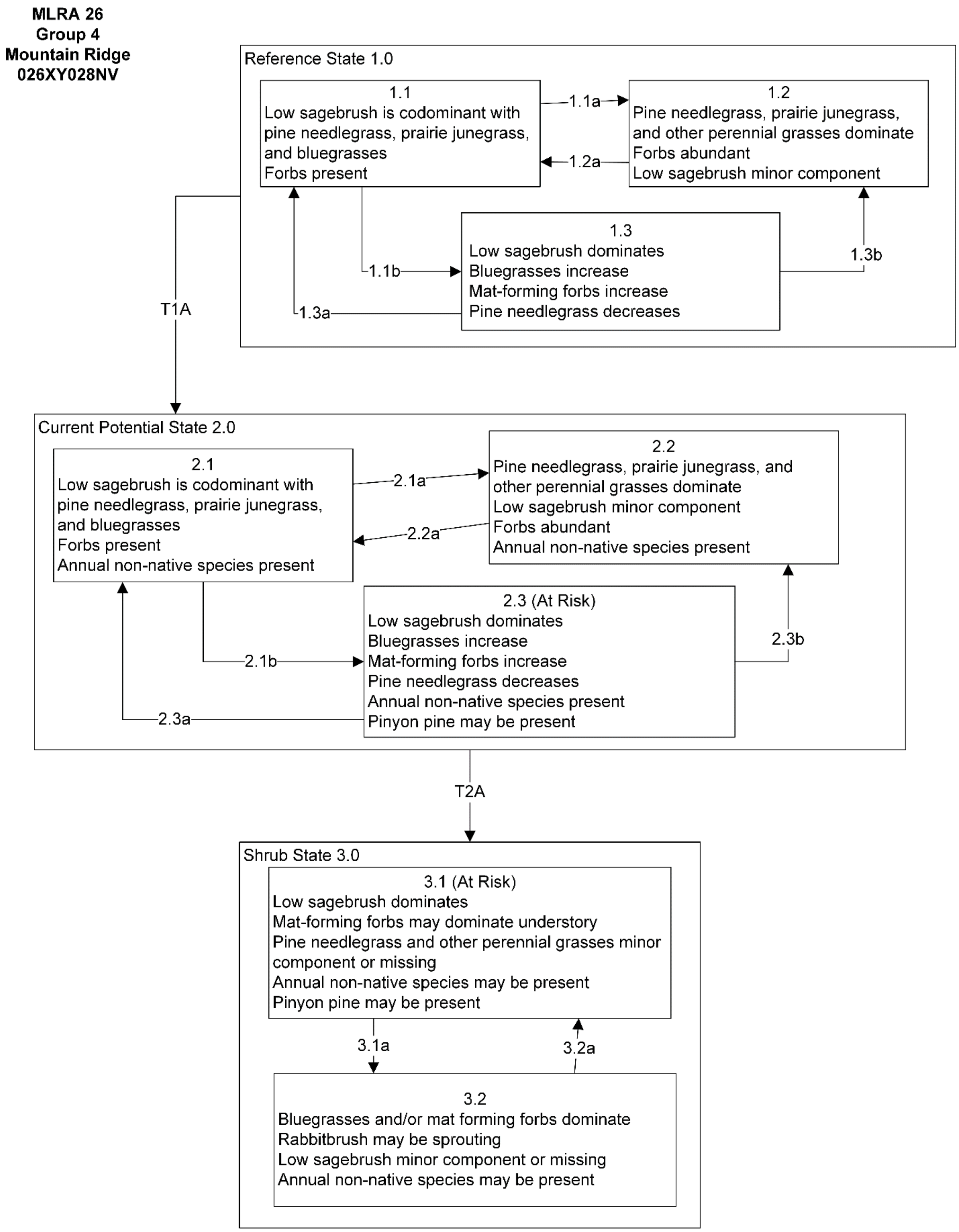
Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of low sagebrush can take many years.

Potential Resilience Differences with Other Ecological Sites

Claypan 14+ (R026XY039NV):

This site is more productive than the modal site at 300 lb/ac in a normal year. It has a similar vegetation community as the modal site but with Letterman's needlegrass (*Achnatherum lettermanii*) as the dominant grass. The soils are similar to the modal site with shallow depths, low available water capacity, and over 70 percent cobbles and stones at the soil surface. This site occurs on mountain summits and sideslopes at elevations of 8,000 to over 9,500 feet.

Modal State and Transition Model for Group 4 MLRA 26:



MLRA 26
Group 4
Mountain Ridge
026XY028NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory would also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, drought, or other disturbance reduces sagebrush cover.
1.3b: Fire significantly reduces sagebrush.

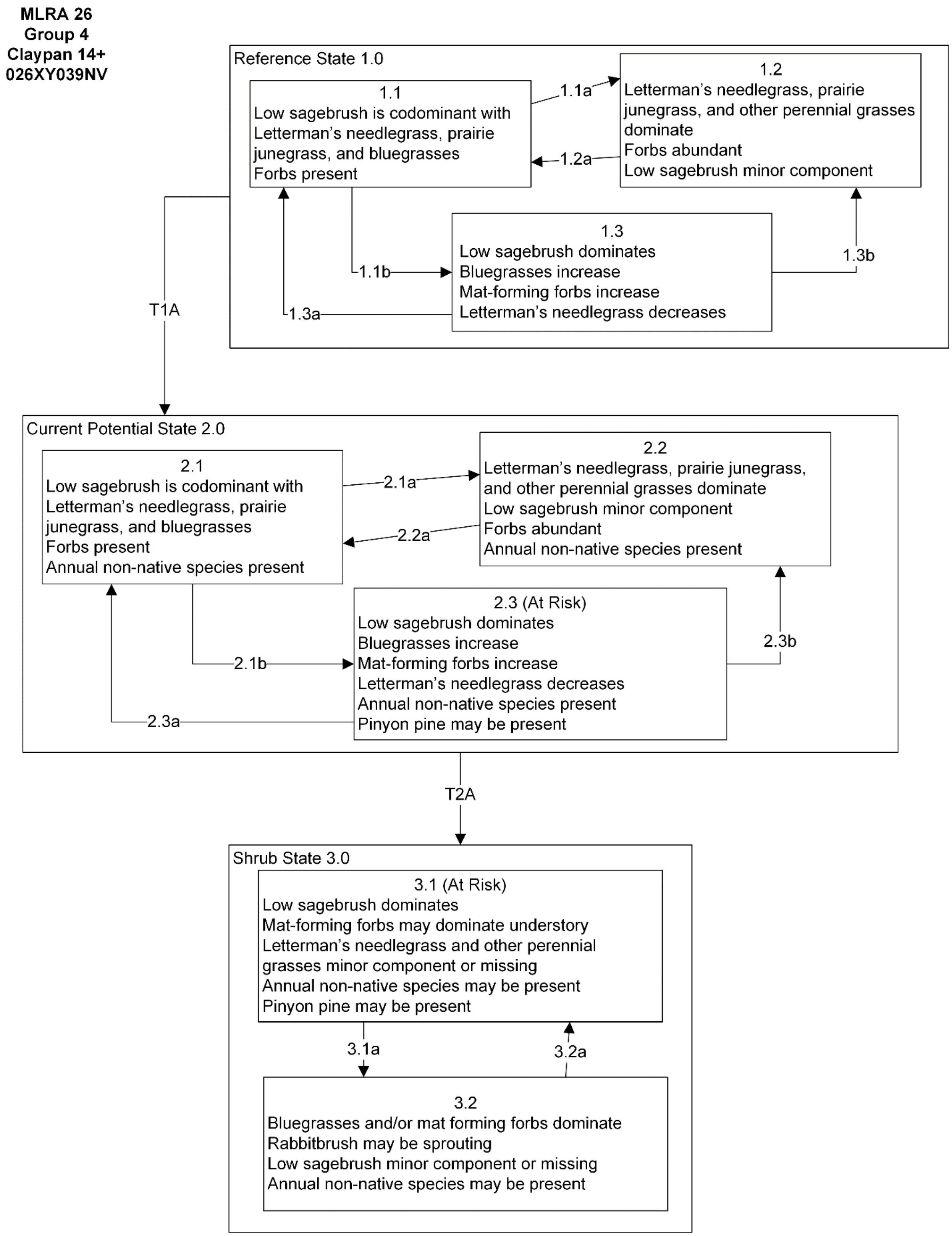
Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
1.3a: Low severity fire, drought, or other disturbance reduces sagebrush cover.
1.3b: Fire significantly reduces sagebrush.

Transition T2A: Inappropriate grazing management (3.1), or fire (3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

Additional State and Transition Models for Group 4 in MRLA 26:



MLRA 26
Group 4
Claypan 14+
026XY039NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory would also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, drought, or other disturbance reduces sagebrush cover.
1.3b: Fire significantly reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
1.3a: Low severity fire, drought, or other disturbance reduces sagebrush cover.
1.3b: Fire significantly reduces sagebrush.

Transition T2A: Inappropriate grazing management (3.1), or fire (3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

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MRLA 26 Group 5: Silver sagebrush sites, in often-inundated depressions

Description of MLRA 26 Disturbance Response Group 5

Disturbance Response Group (DRG) 5 consists of three ecological sites. The precipitation for these sites ranges from 8 to 16 inches. Slopes range from 0 to 8 percent with 2 to 4 percent being typical. Sites are found in depressional areas within intermountain valleys, accumulating water from higher landforms. Elevations range from 5,000 to 9,200 feet. The potential native plant community is dominated by silver sagebrush (*Artemisia cana*) with an understory of needlegrass (*Achnatherum* spp**.**), bluegrasses (*Poa* spp.) and wheatgrasses (*Agropyron* spp.). Mat muhly (*Muhlenbergia richardsonis*), basin wildrye (*Leymus cinereus*), sedges (*Carex* spp.) and rushes (*Juncus* spp.) are also found on these sites. Other shrubs include snowberry (*Symphoricarpos rotundifolius*) and rubber rabbitbrush (*Ericameria nauseosa*). The production for a normal year ranges from 600 to 800 lb/ac. The Clay Basin (026XY037NV) site has not been correlated to a specific soil or soil mapping unit and may require revisiting as a site concept. The Ashy Mountain Basin is found on summits of plateaus, typically with significant additions of volcanic ash in the soil profile

Disturbance Response Group 5 Ecological Sites:

Mountain Basin – Modal Site	R026XY049NV
Clay Basin	R026XY037NV
Ashy Mountain Basin	R026XF062CA

Modal Site:

The Mountain Basin (R026XY049NV) ecological site is the modal site for this group as it has the most acres mapped. This site occurs on depressional areas within intermountain valleys. Slopes range from 0 to 8 percent but slope gradients of 2 to 4 percent are typical. Elevations range from 7,000 to 9,200 feet. Average annual precipitation is 12 to 16 inches. The soils in this site are very deep and formed in alluvium. They have a very high available water capacity. Flooding commonly occurs in areas along intermittent drainages. Overland flow is common as run-on from high landforms. Runoff is moderate and the potential for sheet and rill erosion is moderate. Degraded vegetative conditions lead to active gully erosion in drainages. The plant community is dominated by silver sagebrush, Letterman's (*Achnatherum lettermanii*) and/or California needlegrass, mat muhly and western wheatgrass (*Pascopyrum smithii*). Annual production ranges from 400 to 800 lbs/acre.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire,

herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The sites in this group are driven primarily by hydrology. Various states or phases may exist at once, if some areas are ponded and some remain dry depending on annual precipitation. Within a state, these patterns should be considered natural and not necessarily a product of degradation.

The ecological sites in this DRG are dominated by deep-rooted cool season, perennial bunchgrasses, a diversity of perennial forbs, and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, but are limited on this site due to depth to a restrictive layer (duripan, bedrock) (Dobrowolski et al. 1990) and less than a 1.0 m for low sagebrush community types (Jensen 1990). These shrubs have a flexible generalized root system with development of both taproots and laterals near the surface (Comstock and Ehleringer 1992).

The perennial bunchgrasses that are dominant include of needlegrass, bluegrasses, and wheatgrasses. These grasses are caespitose, deep-rooted perennial grasses. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity (Snyder et al. 2019). Species composition and productivity can be altered by the timing of precipitation and water availability with the soil profile (Bates et al. 2006).

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation, both among years and within growing seasons. The Mountain Basin ecological site is subject to both periodic drought and flooding, which influence the vegetative community from year to year. Many of these sites have been altered since settlement times through changes in the hydrologic function of the basin. Ditches or flow path development within the site can lower water table, potentially decreasing the silver sagebrush community and transitioning the site to a drier, Wyoming big sagebrush plant community.

Silver sagebrush is often found on deep, poorly drained, often flooded, alluvial soils high in clay with a seasonally high water table. Silver sagebrush is an evergreen shrub that often forms colonies from a system of extensive rhizomes (Stubbendieck et al. 1992). The root system of silver sagebrush consists of a taproot with lateral roots and rhizomes, usually located within a few inches of the soil surface. Silver sagebrush is the most vigorous sprouter of all sagebrush (Wright et al. 1979); it is able to sprout from roots, rhizomes, and the root crown after disturbance (Ellison and Woolfolk 1937, Whitson et al. 1991, Blaisdell et al. 1982). It has been known to readily layer, meaning it can generate adventitious roots from branches touching soil (Blaisdell et al. 1982). Silver sagebrush is also capable of reproducing by seeds (Whitson 1991).

Silver sagebrush is susceptible to the herbicides 2, 4-D and 2,4,5-T, which have been used to reduce silver sagebrush cover in order to increase native grass production (Cornelius and Graham 1958, Hormay et al. 1962, Kachergis et al. 2014). Kachergis et al. (2014) found silver sagebrush returned to pre-spray levels within 50 years after spraying. They also found an initial increase in palatable native perennial grasses shortly after herbicide spraying combined with reduced stocking rates.

Silver sagebrush is a host species for the sagebrush defoliator, Aroga moth (*Aroga websteri*) (Henry 1961, Gates 1964, Hall 1965), but it remains unclear whether the moth causes significant damage or mortality to individual or entire stands of plants. Severe drought has been known to kill the crowns of entire stands of silver sagebrush, however after release from drought it can rapidly regrow due to its vigorous sprouting ability (Ellison and Woolfolk 1937).

Letterman needlegrass is an erect, densely-tufted perennial bunchgrass that forms large clumps. It is found on dry to moist soils in a variety of vegetation communities, including high elevation meadows, subalpine grasslands, the understory of aspen stands, and in sagebrush communities. It grows best on loamy soils with greater than 20 cm depth (Dittberner and Olson 1983).

Western wheatgrass is a rhizomatous grass that is capable of spreading vegetatively and thrives in disturbed soil (Cronquist et al. 1994). Mat muhly, a warm-season strongly rhizomatous perennial grass is also highly resistant to disturbance and usually grows in loose clumps or mats (USDA 1988, Penskar and Higman 1999, Schultz 2002). Mat muhly reproduces by seed or rhizomes. Mat muhly can be found on dry to moist sites and often persists in an area for many years after hydrological modifications lower the water table (USDA 1988).

This ecological site has moderate resilience to disturbance and resistance to invasion. Significant year-to-year variation in ponding and depth to water table are primary drivers for above-ground biomass production. Surface alteration, prolonged drought, or prolonged flooding decreases resilience and increases the probability of annual or perennial weed invasion. Three possible stable states have been identified for this DRG.

Fire Ecology:

Silver sagebrush is an evergreen shrub that often forms colonies from a system of extensive rhizomes (Stubbendieck et al. 1992). Silver sagebrush has been found to be less sensitive to fire than other sagebrush species due to its ability to sprout. The root system of silver sagebrush consists of a taproot with lateral roots and rhizomes, usually located within a few inches of the soil surface. Rhizome length of plains silver sagebrush in Montana averaged 1.1 m (3.4 ft). Silver sagebrush is a vigorous sprouter (Wright et al. 1979). It is able to sprout from roots, rhizomes, and the root crown after disturbance (Ellison and Woolfolk 1937, Whitson et al. 1991, Blaisdell et al. 1982). Silver sagebrush has spreading rhizomes underground and sprouts after fire (Cronquist et al. 1994, Blaisdell 1982). Silver sagebrush is also capable of reproducing by seed (Whitson et al. 1991). Seedling establishment can occur in the years after fire if the growing season is favorably wet (Wambolt et al. 1989). Survival and resprouting ability of silver sagebrush is considerably greater in the spring versus the fall (White and Currie 1983). As burn intensity increases, regrowth of silver sagebrush plants decreases (White and Currie 1983). Fall burning resulted in mortality of 40 to >70% of the silver sagebrush plants, suggesting summer wildfires could cause substantial stand death. Post-fire recovery and resilience is primarily influenced by pre-fire site conditions, fire severity, and post-fire weather and land use that relate to vegetation recovery. Sites with low abundances of native perennial grasses and forbs typically have reduced resiliency following disturbance and are less resistant to invasion or increases in cheatgrass or other weedy species (Miller et al. 2013).

Fire return intervals for silver sagebrush largely depend on the fire intervals of surrounding vegetation communities. Usually this silver sagebrush ecological site is a smaller pocket in a large landscape of Wyoming big sagebrush. Thus, fire return intervals for Ashy Mountain Basin are probably similar to those estimated for Wyoming big sagebrush. Wyoming big sagebrush communities historically had low fuel loads, and patchy fires that burned in a mosaic pattern were common at 10-70 year return intervals (Young and Evans 1978, West and Hassan 1985, Bunting et al. 1987). Davies et al. (2006) suggest fire return intervals in Wyoming big sagebrush communities were around 50-100 years.

The non-modal site, Ashy Mountain Basin (R026XF062CA), is typically found in a larger setting of mountain big sagebrush (*Artemisia tridentata var. vaseyana*). Mountain big sagebrush systems are estimated to have burned more often than lower-elevation Wyoming big sagebrush sites. Pre-settlement fire return intervals in mountain big sagebrush communities varied from 15 to 25 years (Burkhardt and Tisdale 1969, Houston 1973, Miller and Tausch 2000).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983).

The rhizomatous growth form of western wheatgrass makes it capable of surviving fire and may increase vegetative growth afterward (Bushey 1987, Wasser 1982). Mat muhly is resistant to damage from fire because the rhizome buds are insulated by soil (Benedict 1984). A few studies have observed that fire in the spring has stimulated flowering (Anderson and Bailey 1980, Pemble et al. 1981), however there is little other documentation of this plant's fire response.

Livestock/Wildlife Grazing Interpretations:

Silver sagebrush, as with other sagebrush species, has been known to increase with grazing (Kachergis et al. 2014). The reduction of the herbaceous understory allows this shrub to increase and dominate these sites. Silver sagebrush can provide an important source of browse and is used by livestock and big game when other food sources are scarce (Kufeld et al. 1973, Wasser 1982, Cronquist et al. 1994). In fall and winter feeding trials, silver sagebrush was among the most preferred sagebrush species for mule deer and sheep (Sheehy and Winward 1981). However, silver sagebrush is an aggressive colonizer and can occupy areas at high densities, due to its ability to resprout from the crown and to spread by rhizomes (Monsen et al. 2004). Therefore, silver sagebrush can increase significantly under inappropriate grazing management on this site.

Needlegrasses are widely distributed throughout the U.S. but are most common in the Great Basin and Southwest. They have a high forage value specifically in the western ranges. When mature the foliage can become coarse and reduce the palatability of these grasses, however they remain green longer than other grasses and mature well, making them valuable forage for late fall and winter. The seeds of these grasses are mechanically injurious to grazing animals and can sometimes work into the tissues of the mouth, tongue, ears and nose of livestock and game animals (USDA 1988). Letterman's needlegrass increases under grazing by sheep and decreases with cattle grazing (Ellison 1954, Ellison and Aldous 1952, Bowns and Bagley 1986).

Letterman's needlegrass provides valuable forage for both livestock and wildlife (Taylor 2000). It begins growth early in the year and is available to be utilized when other grasses are not yet palatable, and is especially important fall forage for big game. (Monsen et al. 2004). Letterman's needlegrass has been shown to increase under grazing by sheep and decreases under light grazing by cattle and horses (Bowns and Bagley 1986). It also declines when grazing is excluded for a long time (Turner 1969).

Western wheatgrass is a preferred feed for livestock and wildlife, but is not a very productive plant (Enevoldsen and Lewis 1978, Hafenrichter et al. 1968). It is short in stature and has sparse growth in low-water conditions. Compared to native bunchgrasses, western wheatgrass is not as palatable (Hafenrichter et al. 1968).

Mat muhly withstands heavy grazing because of its sod-forming growth form (USDA 1988). It is a short-statured plant with stems typically 3 to 8 inches long and many basal and stem leaves between one-half and two or more inches long (USDA 1988).

In general, inappropriate grazing by domestic livestock or feral horses can cause needlegrasses to decrease and mat muhly or western wheatgrass to initially increase. Continued deterioration may lead to a decrease in all deep-rooted grasses and an increase silver sagebrush.

State and Transition Model Narrative for Group 5

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 5.

Reference State 1.0:

The reference state 1.0 is a representative of the natural range of variability under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns, hydrology and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
This community is dominated by silver sagebrush and needlegrasses. Mat muhly and western wheatgrass can be significant components. Forbs and other grasses make up smaller components.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Fire will top-kill silver sagebrush and allow for the perennial bunchgrasses and mat-forming grasses to increase. Fire severity is dependent on amount of fine fuels in the understory.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.3:
Ponding reduces plant productivity and may allow rabbitbrush to dominate.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early- to mid-seral community. Needlegrasses and other perennial grasses dominate. Silver sagebrush is reduced within the community after fire, but will be sprouting. Rabbitbrush and other sprouting shrubs may increase. Perennial forbs may be a significant component for a number of years following fire. If coming from a Phase 1.3 (post-flood), silver sagebrush will reestablish by seed.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Time and lack of disturbance will allow sagebrush to increase.

Community Phase Pathway 1.2b, from Phase 1.2 to 1.3:
Prolonged ponding reduces plant productivity, causes silver sagebrush stress, and may allow rabbitbrush to dominate once the site dries

Community Phase 1.3:
Rubber rabbitbrush becomes dominant after a wet year or years that result in ponded conditions. Bare ground increases and may dominate the visual aspect. Silver sagebrush and grasses are reduced.

Ashy Mountain Basin (R026XF062CA) Phase 1.3 D. Snyder, September 2017

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
Release from ponded conditions allows silver sagebrush to dominate.

T1A: Transition from the Reference State 1.0 to Current Potential State 2.0

Trigger: This transition is caused by the introduction of non-native annual plants.

Slow variables: Over time the annual non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

T1B: Transition from the Reference State 1.0 to Sagebrush State 3.0

Trigger: Long term drought, incision, or other significant hydrological change that lowers the water table. May be coupled with lack of fire and inappropriate grazing management. Transition not associated with introduction of annual non-native species.

Slow Variables: Silver sagebrush is not capable of surviving with a low water table. Over time, plants die off and are not capable of reproducing in the drier soil conditions. Wyoming big sagebrush is able to populate the area. If coupled with inappropriate grazing management, needlegrasses are lost from excessive long-term use.

Threshold: Permanent lowering of the water table beyond the reach of silver sagebrush that results in mortality of adult plants.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has four general community phases: a shrub-grass dominant phase, a perennial grass dominant phase, a shrub dominant phase and a sprouting shrub dominant phase. These non-native species can be highly flammable and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. Silver sagebrush, needlegrasses and mat muhly dominate the site. Forbs and other shrubs and grasses make up smaller components of this site.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Fire will top kill silver sagebrush and allow for the herbaceous community to increase. Fire severity is dependent on amount of fine fuels in the understory. Annual non-native species are likely to increase after fire.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Ponding reduces plant productivity and may allow rabbitbrush to dominate.

Community Phase Pathway 2.1c, from Phase 2.1 to 2.4:
Time without disturbance such as fire. May be coupled with inappropriate grazing management.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early/mid-seral community. Needlegrasses and other perennial bunchgrasses dominate. Silver sagebrush is reduced within the community post-fire, but will resprout. Rabbitbrush and other sprouting shrubs may increase. Perennial forbs may be a significant component for a number of years following fire. If coming from a Phase 2.3 (post-flood), silver sagebrush will reestablish by seed. Annual non-native species are stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. Silver sagebrush sprouts and will be able to return to pre-burn levels quickly.

Community Phase Pathway 2.2b, from Phase 2.2 to 2.3:
Prolonged ponding reduces plant productivity, causes silver sagebrush stress, and may allow rabbitbrush to dominate once the site dries.

Community Phase 2.3:
Rubber rabbitbrush becomes dominant after a wet year or years that result in ponded conditions. Bare ground increases and may dominate the visual aspect. Silver sagebrush and bunchgrasses are reduced.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
Release from ponded conditions allows silver sagebrush to dominate.

Community Phase 2.4:
Sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs or from inappropriate grazing, or from both. Rabbitbrush may be a significant component. Mat muhly may increase. This site is susceptible to further degradation from grazing, drought, and fire.

Community Phase Pathway 2.4a, from Phase 2.4 to 2.2:
Fire will top kill silver sagebrush and allow for the herbaceous community to increase. Fire severity is dependent on amount of fine fuels in the understory.

T2A: Transition from Current Potential State 2.0 to Sagebrush State 3.0

Trigger: Long term drought, incision, or other significant hydrological change that lowers the water table. May be coupled with lack of fire and inappropriate grazing management. Transition not associated with introduction of annual non-native species.

Slow Variables: Silver sagebrush is not capable of surviving with a water table below the rooting zone during spring growing season. Over time, plants die off and are not capable of reproducing in the drier soil conditions. Big sagebrush (*Artemisia tridentata)* is able to populate the area. If coupled with inappropriate grazing management, needlegrasses are lost from excessive long-term use. Rhizomatous grasses or dryland sedge may become the dominant understory.

Threshold: Permanent lowering of the water table beyond the reach of silver sagebrush that results in mortality of adult plants.

Shrub State 3.0:

This state has two community phases, a silver sagebrush-dominated phase and a post-fire phase. Long-term inappropriate grazing management reduces or eliminates grazing-intolerant grasses like needlegrasses and basin wildrye. Repeated heavy utilization in the spring or season-long use is damaging to the bunchgrass community on this site. Shrubs and grazing-tolerant grasses and grass-likes become dominant. The loss of deep-rooted grasses reduces the amount and depth of organic matter that is cycled in the soil. Shrub cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and rhizomatous grass and/or sedge understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1:
Decadent silver sagebrush dominates the overstory. Deep-rooted perennial bunchgrasses are present in only trace amounts or are absent from the community. Mat muhly, western wheatgrass, and dryland sedges increase. Bare ground may be significant. Annual non-native species may be present.

Mountain Basin (R026XY049NV) Shrub State T.K. Stringham, June 2016

Mountain Basin (R026XY049NV) Shrub State T.K. Stringham, June 2016

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire reduces cover and production of silver sagebrush. Rabbitbrush sprouts after fire and becomes the dominant shrub. Mat muhly, western wheatgrass, and sedges survive fire and increase in the understory.

Community Phase 3.2:
Mat muhly, western wheatgrass, and/or Douglas sedge dominate. Rubber rabbitbrush may be a significant component. Basin wildrye and needlegrasses are missing. Silver sagebrush may be sprouting.

Mountain Basin (R026XY049NV) Shrub State T.K. Stringham, June 2016

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Time without disturbance allows silver sagebrush to again become dominant.

Potential Resilience Differences with Other Ecological Sites

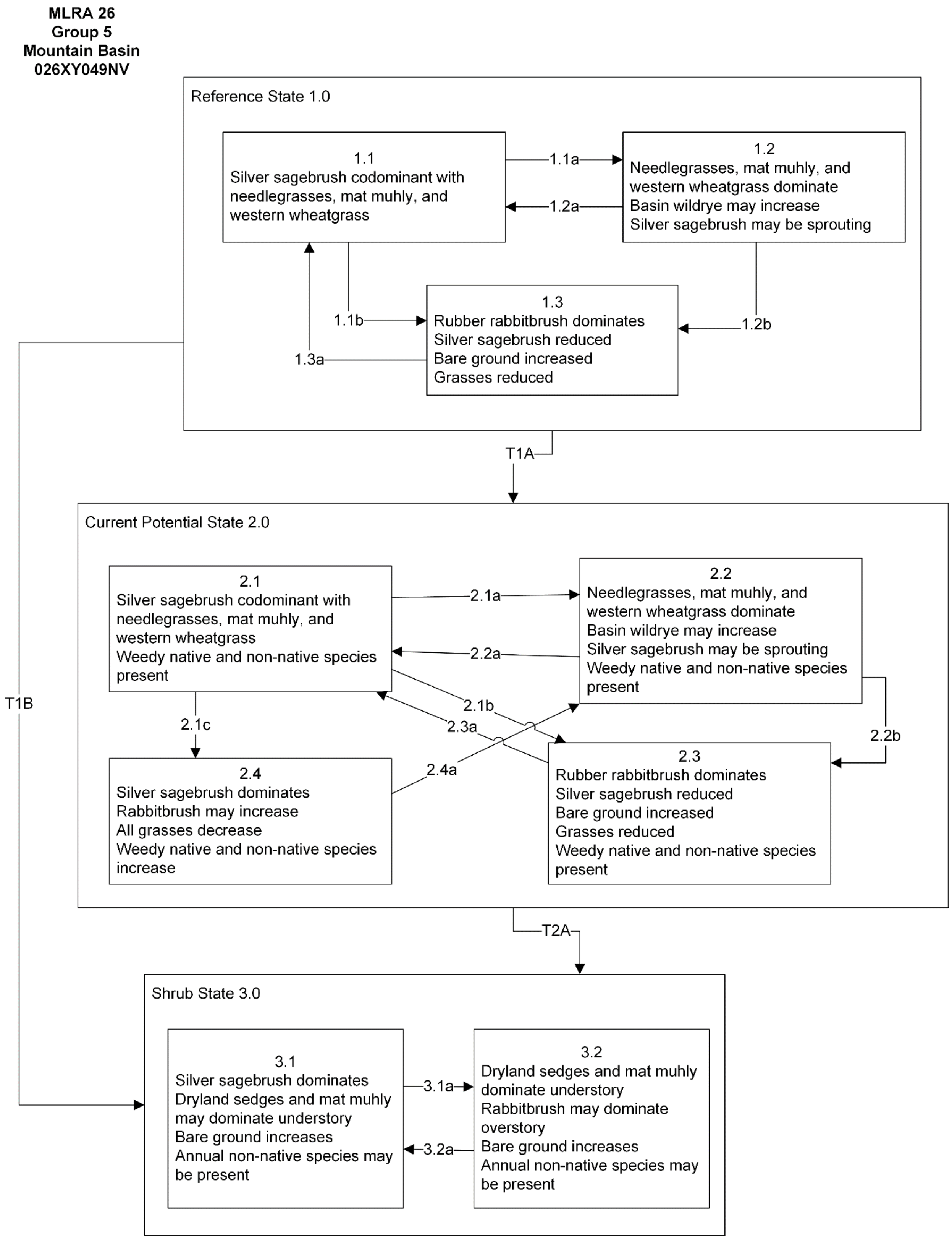
Clay Basin (R026XY037NV)

This site occurs on intermountain basins with slopes from 0 to 2 percent and at elevations of 5,000 to 7,000 feet. Like the modal site, silver sagebrush is the dominant shrub but the dominant grasses are Nevada bluegrass (*Poa nevadensis*) and creeping wildrye (*Leymus triticoides*). Production is greater than the modal site with 800 lbs/acre in a normal year. The soils on this site are moderately well to somewhat poorly drained. This site has not been correlated to a specific soil or soil mapping unit at this time.

Ashy Mountain Basin (R026XF062CA)

This site is more productive than the modal site with a range of approximately 600 to 100 lb/ac depending on moisture levels in a given year. This site is found in the southern portion of MLRA 26 where there are significant deposits of aeolian volcanic ash. Ash increases soil water holding capacity, improving site productivity. Western needlegrass (*Achnatherum occidentale)* may be a dominant species on this site. This site exists in small pockets of a larger landscape of mountain big sagebrush, making it less prone to fire and invasive weed invasions in comparison to the lower-elevation sites amongst Wyoming big sagebrush.

Modal State and Transition Model for Group 5 in MRLA 26:



MLRA 26
Group 5
Mountain Basin
026XY049NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Fire.
1.1b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory results in a reduction in grasses.
1.2a: Time without disturbance.
1.2b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory results in a reduction in grasses.
1.3a: Release from ponded conditions allows silver sagebrush to dominate.

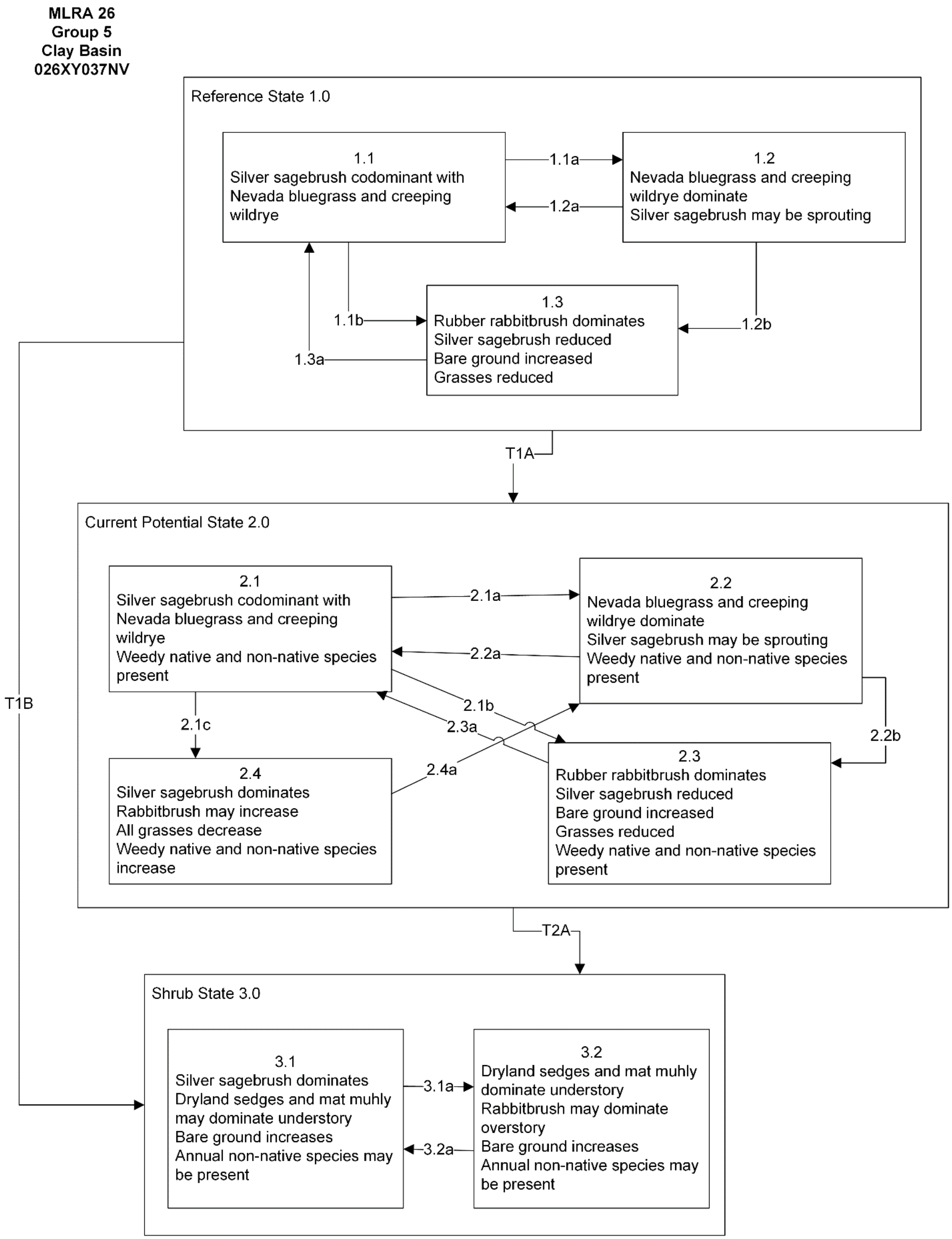
Transition T1A: Introduction of non-native annual species.
Transition T1B: Long term drought, incision, or other significant hydrological change that lowers the water table. May be coupled with lack of fire and inappropriate grazing management. Transition not associated with introduction of annual non-native species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Fire.
2.1b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory or inappropriate grazing management results in a reduction in grasses.
2.2a: Time without disturbance.
2.2b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory or inappropriate grazing management results in a reduction in grasses.
2.3a: Release from ponded conditions allows silver sagebrush to dominate.
2.1c: Time without disturbance such as fire. May be coupled with inappropriate grazing management.
2.4a: Fire.

Transition T2A: Long term drought, incision, or other significant hydrological change that lowers the water table. May be coupled with lack of fire and inappropriate grazing management.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time without disturbance allows silver sagebrush to reestablish.

Additional State and Transition Models for Group 5 MLRA 26:



MLRA 26
Group 5
Clay Basin
026XY037NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Fire.
1.1b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory results in a reduction in grasses.
1.2a: Time without disturbance.
1.2b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory results in a reduction in grasses.
1.3a: Release from ponded conditions allows silver sagebrush to dominate.

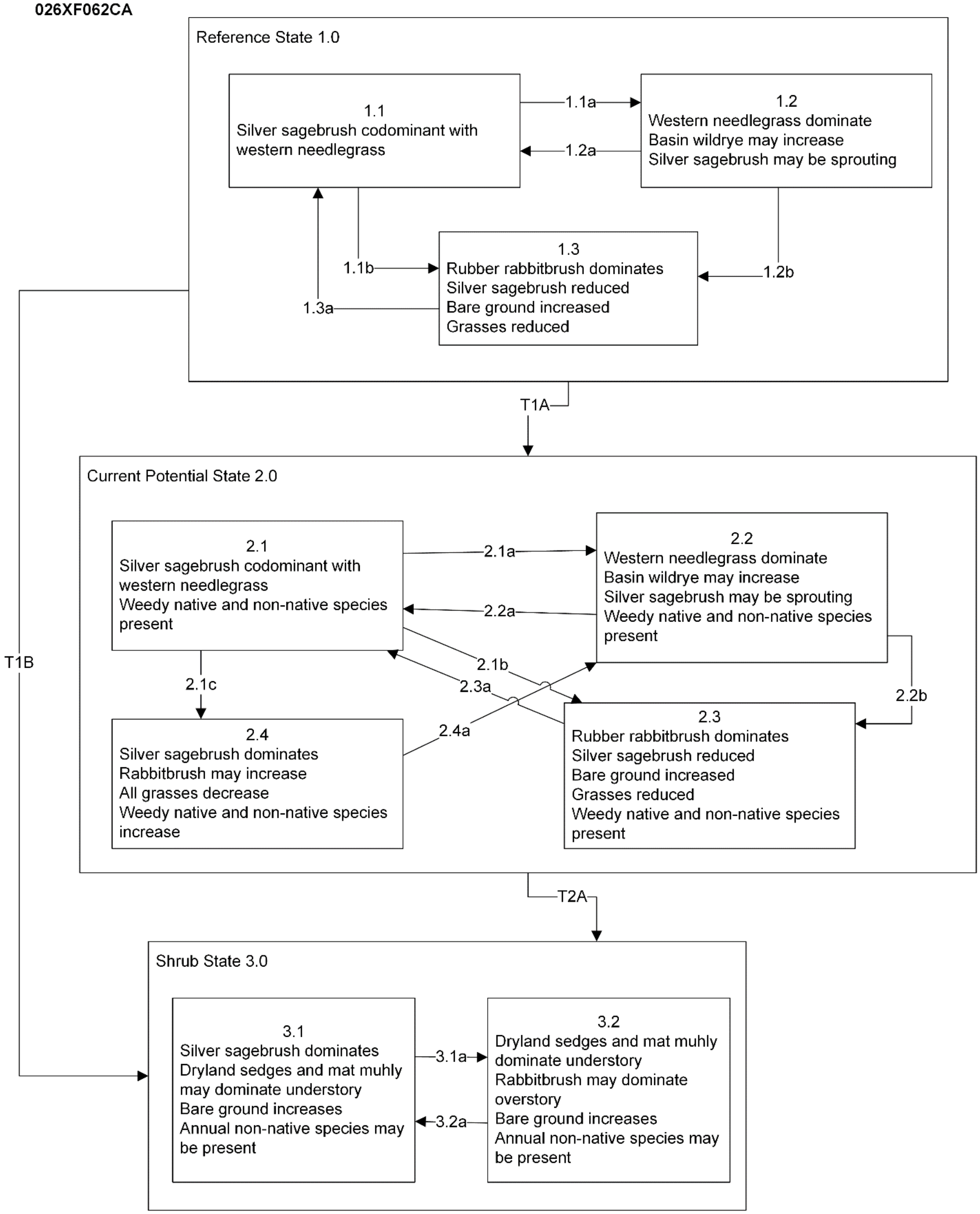
Transition T1A: Introduction of non-native annual species.
Transition T1B: Long term drought, incision, or other significant hydrological change that lowers the water table. May be coupled with lack of fire and inappropriate grazing management. Transition not associated with introduction of annual non-native species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Fire.
2.1b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory or inappropriate grazing management results in a reduction in grasses.
2.2a: Time without disturbance.
2.2b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory or inappropriate grazing management results in a reduction in grasses.
2.3a: Release from ponded conditions allows silver sagebrush to dominate.
2.1c: Time without disturbance such as fire. May be coupled with inappropriate grazing management.
2.4a: Fire.

Transition T2A: Long term drought, incision, or other significant hydrological change that lowers the water table. May be coupled with lack of fire and inappropriate grazing management.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time without disturbance allows silver sagebrush to reestablish.

MLRA 26
Group 5
Ashy Mountain Basin
026XF062CA



MLRA 26
Group 5
Ashy Mountain Basin
026XF062CA
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Fire.
1.1b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory results in a reduction in grasses.
1.2a: Time without disturbance.
1.2b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory results in a reduction in grasses.
1.3a: Release from ponded conditions allows silver sagebrush to dominate.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Long term drought, incision, or other significant hydrological change that lowers the water table. May be coupled with lack of fire and inappropriate grazing management. Transition not associated with introduction of annual non-native species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Fire.
2.1b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory or inappropriate grazing management results in a reduction in grasses.
2.2a: Time without disturbance.
2.2b: Ponding reduces plant productivity and may allow rabbitbrush to dominate after site dries. Excessive herbivory or inappropriate grazing management results in a reduction in grasses.
2.3a: Release from ponded conditions allows silver sagebrush to dominate.
2.1c: Time without disturbance such as fire. May be coupled with inappropriate grazing management.
2.4a: Fire.

Transition T2A: Long term drought, incision, or other significant hydrological change that lowers the water table. May be coupled with lack of fire and inappropriate grazing management.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time without disturbance allows silver sagebrush to reestablish.

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MLRA 26 Group 6: Black sagebrush and needlegrasses

Description of MLRA 26 Disturbance Response Group 6:

Disturbance Response Group (DRG) 6 consists of one ecological site: Shallow Calcareous Loam 8-10" (R026XY042NV). This site occurs on piedmont slopes and foothills with slopes ranging from 2 to 30 percent and elevations ranging from 4,800 to 5,400 feet. The soils on this site are deep to moderately deep and well drained. They are formed in alluvium, derived from mixed sources of rocks. The shrub component of this plant community is dominated by black sagebrush (*Artemisia nova*) with Thurber's needlegrass (*Achnatherum thurberianum*) dominating the understory. Desert needlegrass (*Achnatherum speciosum*), Sandberg bluegrass (*Poa secunda*), and bud sagebrush (*Picrothamnus desertorum*) are also present in the community. The annual production on this site ranges from 200 to 400 lbs/ac, with 300 lbs/ac in a normal year.

This site was not seen during fieldwork for this project. It is limited in extent in MLRA 26 with only 1,000 acres mapped between 3 map units. We failed to find the site in one of these units (MU 72 in survey NV629). It may be that this site was a Lahontan sagebrush site incorrectly identified as black sagebrush. Lahontan sagebrush was only recently identified as a unique species of sagebrush (Winward and McArthur 1995), so it may not have been apparent at the time some of these ecological sites were established. For this reason, much of this report is adapted from a similar ecological sites in MLRA 28A and 28B. If further field work is able to verify the existence of this site, edits may be warranted.

Disturbance Response Group 6 Ecological Sites:

Shallow Calcareous Loam 8-10"	R026XY042NV

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by deep-rooted cool season, perennial bunchgrasses, a diversity of perennial forbs, and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, but are limited on this site due to depth to a restrictive layer (duripan, bedrock) (Dobrowolski et al. 1990) and less than a 1.0 m for low sagebrush community types (Jensen 1990). These shrubs have a flexible generalized root system with development of both taproots and laterals near the surface (Comstock and Ehleringer 1992).

The dominant perennial bunchgrass is Thurber's needlegrass. This species generally has a somewhat shallower root system than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

In the Great Basin, the majority of annual precipitation is received during the winter and early spring. This continental semiarid climate regime favors growth and development of deep-rooted shrubs and herbaceous cool season plants using the C3 photosynthetic pathway (Comstock and Ehleringer 1992). Winter precipitation and slow melting of snow results in deeper percolation of moisture into the soil profile. Herbaceous plants, more shallow-rooted than shrubs, grow earlier in the growing season and thrive on spring rains. The deeper-rooted shrubs lag in phenological development because they draw from deeply infiltrating moisture from snowmelt that arrives later in the season. Periodic drought regularly influences sagebrush ecosystems, and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historic precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation, both among years and within growing seasons (MacMahon 1980). Nutrient availability is typically low, but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species, and depressed competition can increase resource pools by the decomposition of dead plant material following disturbance (Whisenant 1999, Miller et al. 2013). The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Beckstead and Augspurger 2004, Chambers et al. 2007, Johnson et al. 2011).

Black sagebrush is found primarily on shallow soils that are well drained, gravelly and often calcareous (Thatcher 1959, Hironaka 1963, Zamora and Tueller 1973). Black sagebrush is generally long-lived; therefore it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks, especially the sagebrush defoliator, Aroga moth (*Aroga websteri*). Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and have been ongoing in Nevada since 2004 (Bentz et al. 2008). Thousands of acres of sagebrush have been impacted, including black sagebrush (Henry 1961), with partial to complete die-off observed (Gates 1964, Hall 1965). Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975).

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Five possible alternative stable states have been identified for this DRG.

Annual Invasive Grasses:

The species most likely to invade these sites is cheatgrass. Cheatgrass is a cool season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead.

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass "die-off" provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but there is ongoing work to try to predict where they occur, in the hopes of aiding conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, as only one year of data was reported.

In considering pre-emergent herbicide for invasive annual grass control, it is important to assess the soil for characteristics that may reduce effectiveness. Imazapic, for example, is less effective in soils with high contents of sand; on the other hand, clay soils allow for excessive leaching (Inoue et al. 2009). Imazapic may be minimally effective on calcareous soils because the chemical binds to particles of organic matter more readily at high pH (Inoue et al. 2009, Tu et al. 2001). Effects on non-target plants should also be considered. Imazapic is readily adsorbed through foliage and roots (Tu et al. 2001) and can have negative effects on desirable plants, however most established perennial grasses remain unaffected (Applestein et al. 2018). Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated. Grasses drill-seeded after imazapic application displayed improved establishment rates, indicating that careful seeding can lead to restoration success, at least for the species studied (Morris et al. 2009).

After a wildfire, there is opportunity to intervene with seeding to establish perennial plants that will compete with cheatgrass. To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, are able to suppress cheatgrass growth when mature (Blank et al. 2020). Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al. 2015).

Fire Ecology:

Fire is not a major ecological component of these community types (Winward 2001), and will be infrequent. Fire return intervals have been estimated at 100 to 200 years (Kitchen and McArthur 2007); however, fires were probably patchy and very infrequent due to the low productivity of these sites. Black sagebrush plants have no morphological adaptations for surviving fire and must reestablish from seed (Wright et al. 1979). The ability of black sagebrush to establish after fire is mostly dependent on the amount of seed deposited in the seed bank the year before the fire. Seeds typically do not persist in the soil for more than 1 growing season (Beetle 1960), however, a few seeds may remain viable in soil for 2 years (Meyer 2008). Even in dry storage, black sagebrush seed viability has been found to drop rapidly over time, from 81% to 1% viability after 2 and 10 years of storage, respectively (Stevens et al. 1981). Thus, repeated frequent fires can eliminate black sagebrush from a site, however, black sagebrush in zones receiving 12 to 16 inches of annual precipitation have been found to have greater fire survival (Boltz 1994). In lower precipitation zones rabbitbrush may become the dominant shrub species following fire, often with an understory of Sandberg bluegrass and/or cheatgrass and other weedy species.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site, along with seasonality and intensity of the fire, all factor into the individual species response. For most forbs and grasses, the growing points are located at or below the soil surface, providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat, which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983).

Burning has been found to decrease the vegetative and reproductive vigor of Thurber’s needlegrass (Uresk et al. 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber’s needlegrass (Britton et al. 1990). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influenced the response and mortality of Thurber’s needlegrass, smaller bunch sizes were less likely to be damaged by fire (Wright and Klemmedson 1965). Thurber’s needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Koniak 1985, Britton et al. 1990). Reestablishment on burned sites has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and may preclude reestablishment (Evans and Young 1978).

Desert needlegrass has persistent dead leaf bases, making this species susceptible to burning. Fire removes this accumulation and a rapid, cool fire will not result in death of the plants (Humphrey 1984).

Field observations indicate that this grass survives and increases after most wildfires (Abella 2009, Thatcher and Hart 1974). Desert needlegrass does not germinate well in the presence of non-native annual species such as cheatgrass (Rafferty and Young 2000).

Invasive grasses, such as cheatgrass, displace desirable perennial grasses, reduce livestock forage, and accumulate large fuel loads that foster frequent fires (Davies and Svejcar 2008). Invasion by annual grasses can alter the fire cycle by increasing fire size, fire season length, rate of spread, numbers of individual fires, and likelihood of fires spreading into native or managed ecosystems (D'Antonio and Vitousek 1992, Brooks et al. 2004). While historical fire return intervals are estimated at 15 to 100 years, areas dominated with cheatgrass are estimated to have a fire return interval of 3-5 years (Whisenant 1990). The mechanisms by which invasive annual grasses alter fire regimes likely interact with climate. For example, cheatgrass cover and biomass vary with climate (Chambers et al. 2007) and are promoted by wet and warm conditions during the fall and spring. Invasive annual species have shown the ability to take advantage of high N availability following fire through higher growth rates and increased seedling establishment relative to native perennial grasses (Monaco et al. 2003).

The range and density of Utah juniper (*Juniperus osteosperma*) and singleleaf pinyon (*Pinus monophylla)* have increased since the middle of the nineteenth century (Tausch 1999, Miller and Tausch 2000). Causes for expansion of pinyon and juniper into sagebrush ecosystems include wildfire suppression, historic livestock grazing, and climate change (Bunting 1994). Mean fire return intervals prior to European settlement in black sagebrush ecosystems were greater than 100 years, however frequent enough to inhibit the encroachment of trees into these low productive sagebrush cover types (Kitchen and McArthur 2007). Thus, trees were isolated to fire-safe areas such as rocky outcroppings and areas with low-productivity. An increase in crown density causes a decrease in understory perennial vegetation and an increase in bare ground. This allows for the invasion of non-native annual species such as cheatgrass. With annual species in the understory, wildfire can become more frequent and increase in intensity. With frequent wildfires these plant communities can convert to annual species with a sprouting shrub overstory.

Livestock/Wildlife Grazing Interpretations:

Black sagebrush palatability has been rated as moderate to high depending on the ungulate and the season of use (Horton 1989, Wambolt 1996). The palatability of black sagebrush increases the potential negative impacts on remaining black sagebrush plants from grazing or browsing pressure following fire (Wambolt 1996). Pronghorn utilize black sagebrush heavily (Beale and Smith 1970). On the Desert Experiment Range, black sagebrush was found to comprise 68% of pronghorn diet even though it was only the 3rd most common plant. Fawns were found to prefer black sagebrush utilizing it more than all other forage species combined (Beale and Smith 1970). Domestic livestock will also utilize black sagebrush. The domestic sheep industry that emerged in the Great Basin in the early 1900s was largely based on wintering domestic sheep in black sagebrush communities (Mozingo 1987). Domestic sheep will browse black sagebrush during all seasons of the year depending on the availability of other forage species with greater amounts being consumed in fall and winter. Black sagebrush is generally less palatable to cattle than to domestic sheep and wild ungulates (McArthur et al. 1979); however, cattle use of black sagebrush has also been shown to be greatest in fall and winter (Schultz and McAdoo 2002), with only trace amounts being consumed in summer (Van Vuren 1984).

Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1986). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber's needlegrass (Eckert and Spencer 1986), suggesting that both seasonality and utilization are important factors in management of this plant. "Heavy" was not defined in this study. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass, thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988). Thurber's needlegrass may increase in crude protein content after grazing (Ganskopp et al. 2007). Desert needlegrass is a preferred forage for sheep (Phillips et al. 1996). It tolerates light grazing, but can be eliminated with overgrazing or inappropriate management. Mature seeds may be injurious to grazing animals.

Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass expansion and/or cheatgrass and other invasive species to occupy interspaces, leading to increased fire frequency and potentially an annual plant community. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

Halogeton (*Halogeton glomeratus*) is a non-competitive plant that tends to invade areas that are susceptible to repeated disturbance such as: livestock trails, roadsides, trampled areas near watering holes, or corrals and rangeland areas stripped of the natural vegetation by excessive grazing or other soil disturbing activities (Young 2002). It was first introduced into the western U.S. during the 20th century with the first collection being made near Wells, Nevada in 1934. Halogeton is highly toxic to sheep and has been responsible for thousands of sheep deaths throughout the western U.S., which triggered a massive effort to eradicate the introduced species (Young 2002).

Long-term disturbance response may be influenced by small differences in landscape topography. Concave areas hold more moisture and may retain deep-rooted perennial grasses, whereas convex areas are slightly less resilient and may have more Sandberg bluegrass present.

State and Transition Model Narrative for Group 6:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for MLRA 26 Disturbance Response Group 6.

Reference State 1.0:

The Reference State 1.0 is a representative of the natural range of variability under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
This community is dominated by black sagebrush, Thurber's needlegrass and desert needlegrass. Forbs and other grasses make up smaller components.

Shallow Calcareous Loam 8-10 (028BY011NV) Phase 1.1 T.K. Stringham, July 2014
This is a similar site found in MLRA 28B.

Community Phase Pathway 1.1a, from phase 1.1 to 1.2:
Fire will decrease or eliminate the overstory of sagebrush and allows the perennial bunchgrasses to dominate the site. Fires will typically be low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring may be more severe and reduce sagebrush cover to trace amounts.

Community Phase Pathway 1.1b, from phase 1.1 to 1.3:
Time and lack of disturbance such as fire allows black sagebrush to increase and become decadent. Long-term drought, herbivory, or combinations of these will cause a decline in perennial bunchgrasses and fine fuels leading to a reduced fire frequency and allowing sagebrush to dominate the site.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early/mid-seral community. Thurber's needlegrass and desert needlegrass dominate. Depending on fire severity patches of intact black sagebrush may remain. Rabbitbrush and other sprouting shrubs may increase. Perennial forbs may be a significant component for a number of years following fire.

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Time and lack of disturbance will allow black sagebrush to increase.

Community Phase 1.3:
Black sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced, either

from competition with shrubs or from herbivory. Sandberg's bluegrass will likely increase in the understory and may be the dominant grass on the site.

Community Phase Pathway 1.3a, from phase 1.3 to 1.1:
A low severity fire, herbivory, or combinations of these can reduce the black sagebrush overstory and create a sagebrush/grass mosaic.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be high intensity due to the dominance of sagebrush resulting in removal of the overstory shrub community.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, mustard (*Descurainia spp.),* and bur buttercup (*Ceratocephala testiculata*).

Slow variables: Over time the annual non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however, the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. These non-native species can be highly flammable, and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. Black sagebrush is codominant with Thurber's needlegrass and desert needlegrass. Forbs and other shrubs and grasses make up smaller components of this site.

Community Phase Pathway 2.1a, from phase 2.1 to 2.2:
Fire reduces the shrub overstory and allows perennial bunchgrasses to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. Annual non-native species are likely to increase after fire.

Community Phase Pathway 2.1b, from phase 2.1 to 2.3:
Time and lack of disturbance allows black sagebrush to increase and become decadent. Long-term drought reduces fine fuels and leads to a reduced fire frequency, allowing sagebrush to dominate the site. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely Sandberg bluegrass may increase in the understory depending on grazing management.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early/mid-seral community. Thurber's needlegrass and desert needlegrass dominate. Depending on fire severity patches of intact black sagebrush may remain. Rabbitbrush and other sprouting shrubs may increase. Perennial forbs may be a significant component for a number of years following fire. Annual non-native species are stable or increasing within the community.

Shallow Calcareous Loam 8-10" (028BY011NV) Phase 2.2. T.K. Stringham, August 2014. This is a similar site found in MLRA 28B.

Community Phase Pathway 2.2a, from phase 2.2 to 2.1:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush allows the shrub component to recover. The establishment of black sagebrush can take many years.

Community Phase 2.3 (At Risk):
This community is at risk of crossing a threshold to another state. Black sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced, either from competition with shrubs or from herbivory. Sandberg's bluegrass will likely increase in the understory and may be the dominant grass on the site. Pinyon and/or juniper may be present. Annual non-native species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, drought, and fire.

Shallow Clay Loam 10-12" (028BY089NV) Phase 2.3. T.K. Stringham, September 2013.
This is a similar site in MLRA 28B.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
Grazing management that reduces shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall/winter grazing may cause mechanical damage to sagebrush promoting the perennial bunchgrass understory. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. Annual non-native species are present and may increase in the community. A low severity fire would decrease the overstory of sagebrush and allow for the understory perennial grasses to increase. Due to low fuel loads in this State, fires will likely be small creating a mosaic pattern.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires will typically be high intensity due to the dominance of sagebrush resulting in removal of the overstory shrub community. Annual non-native species respond well to fire and may increase post-burn.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0

Trigger: To Community Phase 3.1: Inappropriate cattle/horse grazing will decrease or eliminate deep rooted perennial bunchgrasses, increase Sandberg bluegrass and favor shrub growth and establishment. To Community Phase 3.2: Severe fire will remove sagebrush overstory, decrease perennial bunchgrasses and enhance Sandberg bluegrass. Soil disturbing brush treatments and/or inappropriate sheep grazing will reduce sagebrush and potentially increase sprouting shrubs and Sandberg's bluegrass.

Slow variables: Long term decrease in deep-rooted perennial grass density and/or black sagebrush.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter. Loss of long-lived, black sagebrush changes the temporal and depending on the replacement shrub, the spatial distribution of nutrient cycling.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0

Trigger: Catastrophic fire or soil surface disturbance.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes energy and nutrient capture and cycling both temporally and spatially within the community. Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires.

T2C: Transition from Current Potential State 2.0 to Tree State 5.0:

Trigger: Absence of disturbance over time allows for Utah juniper dominance.

Feedbacks and ecological processes: Trees increasingly dominate use of soil water resulting in decreasing herbaceous and shrub production and decreasing organic matter inputs, contributing to reductions in soil water availability to grasses and shrubs and increased soil erodibility.

Slow variables: Long term increase in juniper density.

Threshold: Trees overtop black sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs in number. There is minimal recruitment of new shrub cohorts. Litter builds up underneath trees while bare ground increases in interspaces; this changes nutrient cycling and levels of organic matter in the soil. Redistribution of soil, organic matter and nutrients may occur with water and wind erosion.

Shrub State 3.0:

This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. This state is characterized by black sagebrush or a sprouting shrub overstory with a Sandberg's bluegrass understory. The site has crossed a biotic threshold and site processes are being controlled by shrubs. Bare ground has increased and pedestalling of grasses may be excessive. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and bluegrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1 (At Risk):
Black sagebrush dominates overstory while Sandberg bluegrass dominates the understory. Deep-rooted perennial bunchgrasses have significantly declined. Annual non-native species may be present. Bare ground and soil redistribution may be increasing. If present on the site, pinyon and/or juniper are increasing. The community phase may be at risk of transitioning into a Tree State or Annual State.

Shallow Calcareous Slope 8-10" (028BY016NV) Phase 3.1. T.K. Stringham, September 2013. This is a similar site in MLRA 28B.

Community Phase Pathway 3.1a, from phase 3.1 to 3.2:
Fire reduces black sagebrush to trace amounts and allows for sprouting shrubs such as rabbitbrush to dominate. Shadscale may also establish post-fire and become dominate. Inappropriate or excessive sheep grazing could also reduce cover of sagebrush and allow sprouting shrubs to dominate the community. Brush treatments with minimal soil disturbance would facilitate sprouting shrubs and Sandberg's bluegrass.

Community Phase 3.2:
Bluegrass dominates the site. Rabbitbrush may dominate the overstory. Annual non-native species may be increasing and bare ground is significant. This site is at risk for an increase in invasive annual weeds.

Shallow Calcareous Loam 8-10" PZ (028BY011NV) Phase 3.2. T.K. Stringham, July 2014. This is a similar site in MLRA 28B.

T3A: Transition from Shrub State 3.0 to Annual State 4.0

Trigger: Fire or treatments that disturb the soil and existing plant community (ex: failed restoration attempts).

Slow variables: Increased seed production and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

T3B: Transition from Shrub State 3.0 to Tree State 5.0

Trigger: Absence of disturbance over time allows for Utah juniper dominance.

Feedbacks and ecological processes: Trees increasingly dominate use of soil water resulting in decreasing herbaceous and shrub production and decreasing organic matter inputs, contributing to reductions in soil water availability to grasses and shrubs and increased soil erodibility.

Slow variables: Long term increase in Utah juniper density.

Threshold: Trees overtop black sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs in number. There is minimal recruitment of new shrub cohorts. Litter builds up underneath trees while bare ground increases in interspaces; this changes nutrient cycling and levels of organic matter in the soil.

Annual State 4.0:

In this state, a biotic threshold has been crossed and state dynamics are driven by the dominance and persistence of the annual grass community which is perpetuated by a shortened fire return interval fire. The herbaceous understory is dominated by annual non-native species such as cheatgrass, halogeton, and mustards. Resiliency has declined and further degradation from fire facilitates a cheatgrass and/or halogeton and sprouting shrub plant community. Fire return interval has shortened due to the dominance of cheatgrass in the understory and is a driver in site dynamics.

Community Phase 4.1:
Cheatgrass, mustards, halogeton and other annuals dominate the site. Halogeton more readily invades this site on calcareous soils. Sprouting shrubs may be present. Erosion may be significant. Sandberg bluegrass and perennial forbs may still be present in trace amounts.

Shallow Calcareous Loam 8-10" (028BY011NV) Phase 5.1. T.K. Stringham, September 2013.
This is a similar site in MLRA 28B.

Tree State 5.0:

This state is characterized by a dominance of pinyon and/or juniper in the overstory. Black sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients and soil organic matter distribution and cycling have been spatially and temporally altered.

Community Phase 5.1:
Utah juniper trees dominate overstory, sagebrush is decadent and dying, deep rooted perennial bunchgrasses are decreasing. Recruitment of sagebrush cohorts is minimal. Annual non-natives may be present or increasing. Bare ground in interspaces are large and connected.

Community Phase Pathway 5.1a, from Phase 5.1 to 5.2:
Time and lack of disturbance or management action allows for tree cover and density to further increase and trees to out-compete the herbaceous understory species for sunlight and water.

Community Phase 5.2:
Pinyon and/or juniper trees dominate overstory. Black sagebrush is decadent and dying, with numerous skeletons present. Bunchgrasses present in trace amounts and annual non-native species may dominate understory. Herbaceous species may be located primarily under the canopy or near the drip line of trees. Bare ground interspaces are large and connected. Soil redistribution may be apparent.

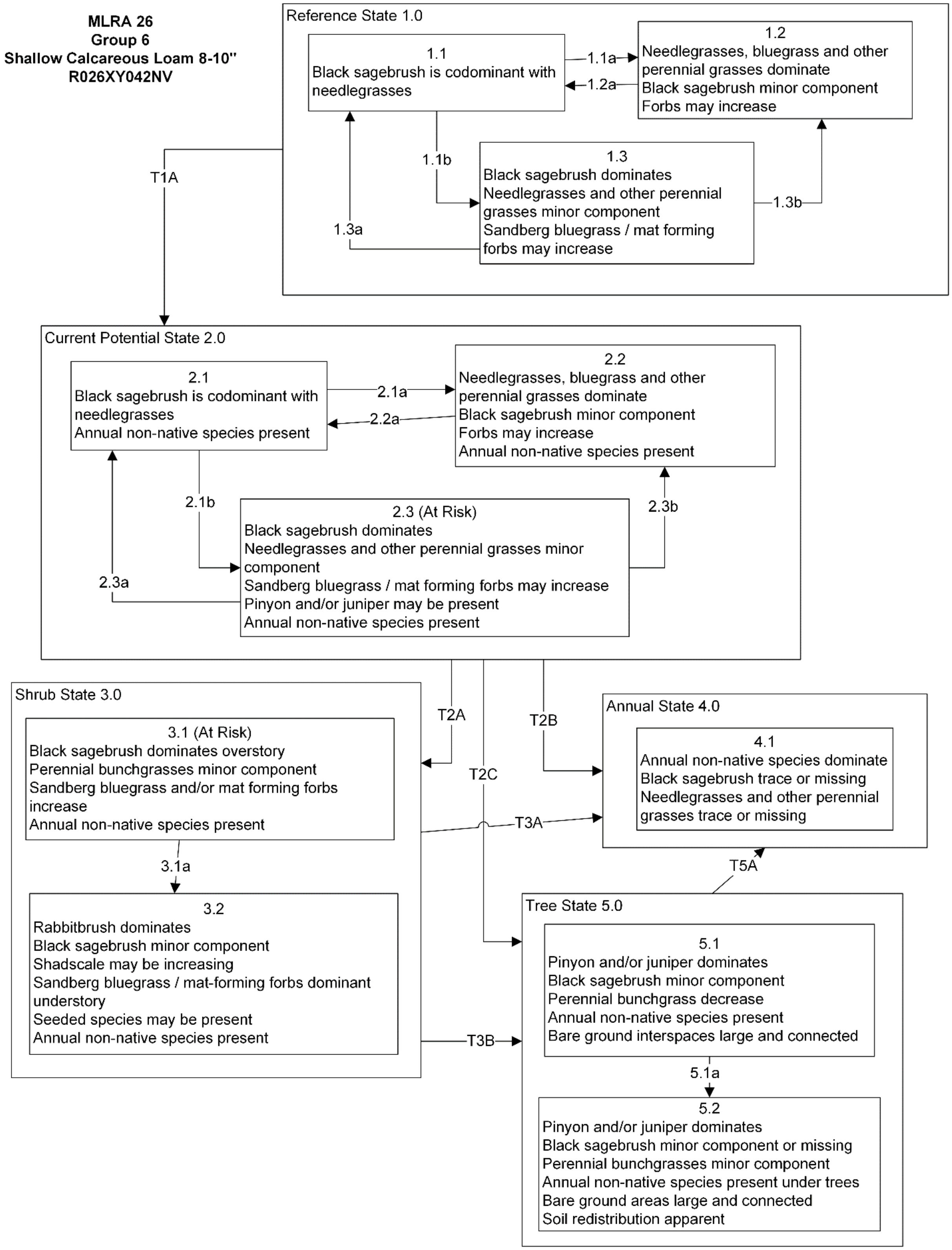
T5A: Transition from Tree State 5.0 to Annual State 4.0:

Trigger: Catastrophic fire causing a stand replacement event. Inappropriate tree removal practices with soil disturbance will also cause a transition to Annual State 5.

Slow variables: Increased production and cover of non-native annual species under tree canopies.

Threshold: Closed tree canopy with non-native annual species dominant in the understory changes the intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impacts nutrient cycling and distribution.

State and Transition Model for Group 6 in MLRA 26



MLRA 26
Group 6
Shallow Calcareous Loam 8-10"
026XY042NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time and lack of disturbance allows for maturation of the tree community.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows for maturation of the tree community. Inappropriate grazing will expedite this transition.

Annual State 4.0 Community Phase Pathways
None.

Tree State 5.0 Community Pathways
5.1a: Time and lack of disturbance allows for maturation of the tree community.

Transition T5A: Catastrophic fire that significantly reduces or eliminates tree and any remaining shrub overstory. Inappropriate tree removal practices may also contribute to this transition.

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MLRA 26 Group 7: Wyoming big sagebrush and needlegrasses

Description of MRLA 26 Disturbance Response Group 7

Disturbance Response Group (DRG) 7 consists of four ecological sites. The precipitation zone for these sites ranges from 6 to 12 inches. The elevation range for this group is 4,400 to 7,200 feet. Slopes range from 2 to 75 percent; however, 2 to 50 percent are typical. The soils on these sites range from shallow to deep but are typically moderately deep and well drained. Available water holding capacity for these sites is low. Many of these sites exhibit a high volume of rock fragments which help to increase infiltration but can take up plant growing space. These sites are dominated by an overstory of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and an understory of Thurber's needlegrass (*Achnatherum thurberianum*) or desert needlegrass (*Achnatherum speciosum*). Green ephedra (*Ephedra viridis*) and Indian ricegrass (*Achnatherum hymenoides*) are also common on these sites. Average annual production for a normal year ranges from 450-800 lbs/ac.

Disturbance Response Group 7 Ecological Sites

Loamy 8-10" – Modal Site	R026XY016NV
Stony Slope 8-10"	R026XY022NV
Droughty Loam 8-10"	R026XY024NV
South Slope 8-10"	R026XY011NV

Modal Site:

The Loamy 8-10" (026XY016NV) ecological site is the modal site for this group as it has the most acres mapped. This site occurs on piedmont slopes, rock pediments and low hills. Slopes range from 2 to 30 percent, but slope gradients of 4 to 15 percent are most typical. Elevations range from 4,400 to 5,800 feet. Mean annual precipitation is from 8 to 10 inches. The soils on this site are typically moderately deep to deep and well drained. These soils often have a sub-surface layer that is restrictive to root development within 20 inches of the soil surface. Surface soils are moderately coarse to medium textured. Subsoils are medium to fine textured and the soil profile may be modified with 35 to over 50 percent rock fragments, by volume. Infiltration is moderate to rapid and permeability to a restrictive layer is moderate to moderately rapid. The available water capacity is low to moderate. Runoff is slow to medium and the potential for sheet and rill erosion is slight to moderate depending on slope gradient. The plant community is dominated by Thurber's needlegrass and Wyoming big sagebrush. Indian ricegrass (*Achnatherum hymenoides*), needleandthread (*Hesperostipa comata*), ephedra, desert peach (*Prunus andersonii*) and spiny hopsage (*Grayia spinosa*) are also common on these sites. Average annual production ranges from 400 to 800 lbs/ac.

Ecological Dynamics and Disturbance Response

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasives. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by deep-rooted cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m (Dobrowolski et al. 1990). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The perennial bunchgrasses that are dominant include Thurber's needlegrass and Indian ricegrass. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historic precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability with the soil profile (Bates et al. 2006).

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition or can increase resource pools by the decomposition of dead plant material following disturbance. The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007).

Variability in plant community composition and production depends on soil surface texture and depth. Thurber's needlegrass will increase on gravelly soils, whereas Indian ricegrass will increase with sandy soil surfaces, and bottlebrush squirreltail (*Elymus elymoides*) will increase with silty soil surfaces. Production generally increases with soil depth. The amount of sagebrush in the plant community is dependent upon disturbances like fire, Aroga moth infestations, and grazing.

Wyoming big sagebrush is the most drought tolerant of the big sagebrushes and is generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks especially a sagebrush defoliator, Aroga moth (*Aroga websteri*). Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and have been ongoing in Nevada since 2004 (Bentz et al. 2008). Thousands of acres of big sagebrush have been impacted, with partial to complete die-off observed. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975).

Green ephedra is a dioecious sprouting shrub. Male individuals tend to be found on steep hillsides, and female plants are sometimes found occupying concave sites where conditions may be more favorable to successful cone production (Freeman et al. 1976). Ephedra does not compete well with cheatgrass, and may exhibit reduced shoot growth when growing in areas dominated by cheatgrass (Pendleton et al. 2007).

Desert peach is found exclusively in eastern California and western Nevada, primarily on granitic soils of the eastern Sierra Nevada mountains (Mason 1913). Desert peach is the most drought tolerant of the North American *Prunus* species (Rieger and Duemmel 1992), and occurs as large clones with large clumps of plants connected through their root system (Mozingo 1987) Taproots reach depths of 1-2 m, similar to other Great Basin shrubs (Mason 1913). Once established, it is capable of layering and producing adventitious roots where stems may become buried in soil (Sharrer 2019).

At the upper range of this group's precipitation range, there is potential for infilling by Utah juniper (*Juniperus osteosperma*) and/or singleleaf pinyon (*Pinus monophylla*). Infilling may also occur if the site is adjacent to woodland sites or other ecological sites with juniper present. Without disturbance in these areas, Utah juniper will eventually dominate the site and out-compete sagebrush for water and sunlight severely reducing both the shrub and herbaceous understory (Miller and Tausch 2001, Lett and Knapp 2005). The potential for soil erosion increases as the woodland matures and the understory plant community cover declines (Pierson et al. 2010).

Millions of acres in the arid and semi-arid West were brush-beaten and planted with crested wheatgrass in the mid 1900's for the purpose of competing with weed species and increasing grass production on rangelands. Success and longevity of these seeding projects have been mixed (Williams et al. 2017). Crested wheatgrass is a cool-season, medium height, exotic perennial bunchgrass native to Asia. Sites within this DRG may exhibit an understory of crested wheatgrass in areas where historical seedings have been allowed to return to sagebrush.

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Six possible alternative stable states have been identified for this DRG.

Annual Invasive Grasses:

The species most likely to invade these sites are cheatgrass and medusahead. While medusahead was not seen on this site during field work, it exists in close proximity to ecological sites in this group and is of regional concern. Both species are cool season annual grasses that maintain an advantage over native plants in part because they are prolific seed producers, able to germinate in the autumn or spring, tolerant of grazing and increase with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Medusahead and cheatgrass originated from Eurasia and both were first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead. By 2003, medusahead occupied approximately 2.3 million acres in 17 western states (Rice 2005). In the Intermountain West, the exponential increase in dominance by medusahead has largely been at the expense of cheatgrass (Harris 1967, Hironaka 1994).

Medusahead matures 2-3 weeks later than cheatgrass (Harris 1967) and recently, James et al. (2008) measured leaf biomass over the growing season and found that medusahead maintained vegetative growth later in the growing season than cheatgrass. Mangla et al. (2011) also found medusahead had a longer period of growth and more total biomass than cheatgrass and hypothesized this difference in relative growth rate may be due to the ability of medusahead to maintain water uptake as upper soils dry compared to co-occurring species, especially cheatgrass. Medusahead litter has a slow 23 decomposition rate, because of high silica content, allowing it to accumulate over time and suppress competing vegetation (Bovey et al. 1961, Davies and Johnson 2008). Harris (1967) reported medusahead roots have thicker cell walls compared to those of cheatgrass, allowing it to more effectively conduct water, even in very dry conditions.

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. Collectively, the body of research suggests that the continued invasion and dominance of medusahead onto native grasslands and cheatgrass infested grasslands will continue to increase in severity because conditions that favor native bunchgrasses or cheatgrass over medusahead are rare (Mangla et al. 2011). Medusahead replaces native vegetation and cheatgrass directly by competition and suppression and native vegetation indirectly by increasing fire frequency.

Methods to control medusahead and cheatgrass include herbicide, fire, grazing, and seeding of primarily non-native wheatgrasses. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. A study by Davies et al. (2013), found an increase in medusahead cover near roads. Cover was higher near animal trails than random transects but the difference was less evident. This implies that vehicles and animals aid the spread of the weed; however, vehicles are the major vector of movement. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating medusahead and cheatgrass than spraying alone (Sheley et al. 2012). Where native bunchgrasses are missing from the site, revegetation of medusahead or cheatgrass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron and sulfometuron + Chlorsulfuron) only treatments for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011), however caution in using these results is advised, as only one year of data was reported. Prescribed fire has also been utilized in combination with the application of pre-emergent herbicide to control medusahead and cheatgrass (Vollmer and Vollmer 2008). Mature medusahead or cheatgrass is very flammable and fire can be used to remove the thatch layer, consume standing vegetation, and even reduce seed levels. Furbush (1953) reported that timing a burn while the seeds were in the milk stage effectively reduced medusahead the following year. He further reported that adjacent unburned areas became a seed source for reinvasion the following year.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic and the same rates with methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz./ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not 24 reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Wyoming big sagebrush communities historically had low fuel loads, and patchy fires that burned in a mosaic pattern were common at 10 to 70 year return intervals (Young and Evans 1978, West and Hassan 1985, Bunting et al. 1987). Davies et al. (2006) suggest fire return intervals in Wyoming big sagebrush communities were around 50 to 100 years. Wyoming big sagebrush is killed by fire and only regenerates from seed. Recovery time for Wyoming big sagebrush may require 50 to 120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities.

Ephedra vigorously sprouts after fire from extensive woody crowns (Young and Evans 1978, Koniak 1985). Sprouting after fire may vary by season of burn and fire severity, however. Spiny hopsage is a sprouting shrub (Daubenmire 1970) that is fairly tolerant of fire due its dormancy during the summer months (Rickard and McShane 1984). After fire, these sprouting shrubs can produce significant new growth if there is enough moisture available (Shaw 1992). Other environmental conditions also determine the level of re-establishment that occurs, such as the salinity and temperature of soil. In order to germinate, seeds need moist conditions (Monsen et al. 2004). They do not compete well with annual invasives (Monsen et al. 2004).

Desert peach sprouts reliably after fire, from lignotubers and an extensive network of underground stems (Young and Evans 1978). Desert peach relies on hoarding by rodents for seed dispersal and recruitment, and up to 75% of seeds may be carried away by various rodent species (Beck and Van Der Wall 2010). Germination and survival rates of seedlings are significantly higher for seeds buried 1-5 cm in rodent caches (Beck and Van Der Wall 2010). Germination and emergence increased with burial depth. Seedling survival through the first growing season may be 8% or less (Beck and Van Der Wall 2010). Its ability to sprout allows it to be easily propagated from hardwood or softwood stem cuttings (Everett et al. 1978) and containerized transplants have high survival rates (Everett 1980).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983).

Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk et al. 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber's needlegrass (Britton et al. 1990). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influenced the response and mortality of Thurber's needlegrass, smaller bunch sizes were less likely to be damaged by fire (Wright and Klemmedson 1965). Thurber's needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Koniak 1985, Britton et al. 1990). Thurber's needlegrass was shown to decrease in density following a spring fire, but it produced more reproductive culms the year after a fall fire (Ellsworth & Kauffman, 2010). Reestablishment on burned sites has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and may preclude reestablishment (Young and Evans 1978).

Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below-ground root crowns. Vallentine (1989) cites several studies in the sagebrush zone that classified Indian ricegrass as being slightly damaged from late summer burning. Indian ricegrass has also been found to reestablish on burned sites through seed dispersed from adjacent unburned areas (Young 1983, West 1994). Thus the presence of surviving, seed producing plants facilitates the reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

Desert needlegrass has persistent dead leaf bases making this species susceptible to burning. Fire removes this accumulation and a rapid, cool fire will not result in death of the plants (Humphrey 1984). Field observations indicate that desert needlegrass survives and increases after most wildfires.

Wildlife/Livestock Grazing Interpretations:

This site is suitable for grazing. Grazing management considerations include timing, duration and intensity of grazing. Overgrazing leads to an increase in mountain big sagebrush and a decline in deep-rooted perennial bunchgrasses. Shallow-rooted bluegrasses will increase with further degradation. Reduced bunchgrass vigor or density provides an opportunity for expansion of bluegrass species in interspaces. Sandberg bluegrass and similar low-growing grasses increase under grazing pressure (Tisdale and Hironaka 1981). A combination of overgrazing and prolonged drought may lead to soil redistribution, increased bare ground and a loss in plant production.

Generally, Wyoming sagebrush is the least palatable of the big sagebrush taxa (Bray et al. 1991, Sheehy and Winward 1981) however it may receive light or moderate use depending upon the amount of understory herbaceous cover (Tweit and Houston 1980). Personius et al. (1987) found Wyoming big sagebrush and basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) to be intermediately palatable to mule deer when compared to mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) (most palatable) and black sagebrush (*Artemisia nova*) (least palatable). Wyoming big sagebrush sites provide nesting, fall and winter habitat for sage grouse (*Centrocercus urophasianus*) (McAdoo and Back 2001). Sage grouse require sagebrush for food and cover during each stage of their life cycle.

Green ephedra is used as winter forage by wild ungulates and livestock (Jameson et al. 1962, Kufeld et al. 1973). Keeler 1989 found green ephedra to be toxic to cattle and sheep, but not to calves and lambs. Ephedra is an important component of bighorn sheep diets in the eastern Sierra Nevada (McCullough and Schneegas 1966).

Desert peach sprouts reliably after fire, from lignotubers and an extensive network of underground stems (Young and Evans 1978). Desert peach relies on hoarding by rodents for seed dispersal and recruitment, and up to 75% of seeds may be carried away by various rodent species (Beck and Van Der Wall 2010). Germination and survival rates of seedlings are significantly higher for seeds buried 1-5 cm in rodent caches (Beck and Van Der Wall 2010). Germination and emergence increased with burial depth. Seedling survival through the first growing season may be 8% or less (Beck and Van Der Wall 2010). Its ability to sprout allows it to be easily propagated from hardwood or softwood stem cuttings (Everett et al. 1978) and containerized transplants have high survival rates (Everett 1980).

Spiny hopsage is palatable to livestock, especially sheep, during the spring and early summer (Phillips et al. 1996, Simmons and Rickard 2003). However, the shrub goes to seed and loses its leaves in July and August so its usefulness in the fall and winter is limited (Sanderson and Stutz 1994). Two studies showed little to no utilization by sheep during the winter (Harrison and Thatcher 1970, Green et al. 1951). Some scientists are concerned about the longevity of the species. One study showed no change in cover or density when excluded from livestock and wildlife grazing for 10+ years (Rice and Westoby 1978), while another seldom observed seedling establishment (Daubenmire 1970). With poor recruitment rates, some are concerned that with repeated fires and overgrazing, local populations of spiny hopsage may be lost (Simmons and Rickard 2003).

Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber’s needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988). Thurber’s needlegrass may increase in crude protein content after grazing (Ganskopp et al. 2007).

Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971) however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1965). Cook and Child (1971) found significant reduction in plant cover after 7 years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended.

State and Transition Model Narrative for Group 7

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 7.

Reference State 1.0:

The Reference State 1.0 is a representative of the natural range of variability under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
Wyoming big sagebrush and Thurber's needlegrass dominate the site. Ephedra, Indian ricegrass and bottlebrush squirreltail (*Elymus elymoides*) are also common. Utah juniper is described in the site concept and may be present in minor amounts.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.3:
Long-term drought, time and/or herbivory favor an increase in Wyoming big sagebrush over deep-rooted perennial bunchgrasses. Combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses. Bottlebrush squirreltail may increase in density depending on the grazing management.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community phase. Thurber's needlegrass can experience high mortality from fire and may be reduced in the community for several years. With low fire severity, Thurber's needlegrass may dominate the site post-fire. Sprouting shrubs such as ephedra, desert peach, spiny hopsage and rabbitbrush are dominant. Indian ricegrass and other perennial grasses are common. Wyoming big sagebrush is killed by fire, therefore decreasing within the burned community. Sagebrush could still be present in unburned patches.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Time and lack of disturbance allows for sagebrush to reestablish.

Community Phase 1.3:

Wyoming big sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from herbivory. Bottlebrush squirreltail will likely increase in the understory and may be the dominant grass on the site.

Loamy 8-10" (R026XY016NV) Phase 1.3, T.K. Stringham, April 2016

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
Aroga moth infestation and/or release from growing season herbivory may reduce sagebrush dominance and allow recovery of the perennial bunchgrass understory.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0

Trigger: This transition is caused by the introduction of non-native annual weeds; such as cheatgrass, Russian thistle (*Salsola tragus*), medusahead, or stork's bill (*Erodium spp*.) dominate the understory.

Slow variables: Over time the annual non-native plants will increase within the community decreasing organic matter inputs from deep-rooted perennial bunchgrasses resulting in reductions in soil water availability for perennial bunchgrasses.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate and adaptations for seed dispersal. Additionally, the presence of highly flammable, non-native species reduces state resilience because these species can promote fire where historically fire has been infrequent leading to positive feedbacks that further the degradation of the system.

Community Phase 2.1:
Wyoming big sagebrush and Thurber's needlegrass dominate the site. Ephedra, Indian ricegrass and bottlebrush squirreltail are also common on this site. Utah juniper may be present. Non-native annual species are present in minor amounts.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Time, long-term drought, grazing management that favors shrubs or combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses. However, Sandberg bluegrass and/or squirreltail may increase in the understory depending on the grazing management. Heavy spring grazing will favor an increase in sagebrush. Annual non-native species may be stable or increasing within the understory.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early seral community phase. Thurber's needlegrass, Indian ricegrass, and other perennial bunchgrasses dominate the site. Sprouting shrubs such as rabbitbrush, ephedra, desert peach, and spiny hopsage may increase. Wyoming big sagebrush is killed by fire, therefore decreasing within the burned community. Sagebrush could still be present in unburned patches. Perennial forbs may increase or dominate after fire for several years. Thurber's needlegrass can experience high mortality from fire and may be reduced in the community for several years. Annual non-native species generally respond well after fire and may be stable or increasing within the community. Rabbitbrush may dominate the aspect for a number of years following wildfire.

Stony Slope 8-10" (026XY022NV) Phase 2.2, P. Novak-Echenique, April 2015

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Absence of disturbance over time allows for the sagebrush to recover may be combined with grazing management that favors shrubs.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.4:
Higher than normal spring precipitation favors annual non-native species such as cheatgrass. Non-native annual species will increase in production and density throughout the site. Perennial bunchgrasses may also increase in production.

Community Phase 2.3:
Wyoming big sagebrush increases and the perennial understory is reduced. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from inappropriate grazing management. Bottlebrush squirreltail will likely increase in the understory and may be the dominant grass on the site. Utah juniper may be present. Annual non-native species present.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Other disturbances/practices include brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

Community Phase Pathway 2.3c, from Phase 2.3 to 2.4:
Fall, winter, and spring precipitation and temperatures mediate the ability for annual grasses and perennial grasses to germinate and/or survive. Higher than normal spring precipitation creates high annual production of annual grasses (Bradley et al. 2016). Non-native annual species increase in production and density throughout the site. Perennial bunchgrasses may also increase in production.

Community Phase 2.4:
This community is at risk of crossing into an annual state. Native bunchgrasses dominate; however, annual non-native species such as cheatgrass may be sub or co-dominant in the understory. Annual production and abundance of these annuals may increase drastically in years with heavy spring precipitation. Seeded species may be present. Sagebrush may be present if coming from phase 2.3. This site is susceptible to further degradation from grazing, drought, and fire.

Community Phase Pathway 2.4a, from Phase 2.4 to 2.2:
Fall, winter, and spring precipitation and temperatures mediate the ability for annual grasses and perennial grasses to germinate and/or survive. Depending on temperatures and precipitation in winter and spring, annual grass production may be reduced in favor of perennial bunchgrasses.

Community Phase Pathway 2.4b, from Phase 2.4 to 2.3:
Rainfall patterns favoring perennial bunchgrasses. Less than normal spring precipitation followed by higher than normal summer precipitation will increase perennial bunchgrass production.

South Slope 8-10" (R026XY011NV) Phase 2.4, P. Novak-Echenique May 2016

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during growing season would favor shrubs and initiate transition to Community Phase 3.1. Fire would cause a transition to Community Phase 3.2.

Slow variables: Long term decrease in deep-rooted perennial grass density resulting in a decrease in organic matter inputs and subsequent soil water decline.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and redistribution, and reduces soil organic matter.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Fire or a failed range seeding leads to plant community phase 4.1. Inappropriate grazing management that favors shrubs in the presence of non-native annual species leads to community phase 4.2.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Cheatgrass or other non-native annuals dominate the understory.

Shrub State 3.0:

This state has two community phases; a Wyoming big sagebrush dominated phase and a bottlebrush squirreltail dominated phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Bottlebrush squirreltail will increase with a reduction in deep-rooted perennial bunchgrass competition and become the dominant grass. Sagebrush dominates the overstory and rabbitbrush may be a significant component. Sagebrush canopy cover is high and sagebrush may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and bottlebrush squirreltail understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1:
Wyoming big sagebrush dominates the overstory. Bottlebrush squirreltail dominates the understory. Utah juniper may be present or increasing. Annual non-native species may be present. Understory may be sparse, with bare ground increasing. Pinyon and/or juniper may be present or increasing.

Loamy 8-10" (026XY016NV) Phase 3.1 P. Novak-Echenique, April 2015

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire would decrease or eliminate the overstory of sagebrush. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the bottlebrush squirreltail, forbs and sprouting shrubs. Heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, would greatly reduce the overstory shrubs and allow for Sandberg bluegrass to dominate the site.

Community Phase 3.2:
Bottlebrush squirreltail dominates the understory; annual non-natives are present but are not dominant. Trace amounts of sagebrush may be present. Sprouting shrubs may dominate for a number of years following fire.

Loamy 8-10" (RO26XY016NV) Phase 3.2, T.K. Stringham, May 2015.

Droughty Loam 8-10” (026XY024NV) Phase 3.2, T.K. Stringham, April 2017

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Absence of disturbance over time would allow for sagebrush and other shrubs to recover.

T3A: Transition from Shrub State 3.0 to Annual State 4.0:

Trigger: Fire or inappropriate grazing management can eliminate the bottlebrush squirreltail understory and transition to community phase 4.1 or 4.2.

Slow variable: Increased seed production and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

T3B: Transition from Shrub State 3.0 to Tree State 5.0:

Trigger: Lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management that reduces fine fuels.

Slow variables: Increased establishment and cover of juniper trees, reduction in organic matter inputs.

Threshold: Trees overtop Wyoming big sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

R3A: Restoration from Shrub State 3.0 to Seeded State 5.0:

Brush management, herbicide, and seeding of crested wheatgrass (*Agropyron cristatum*) and/or other desired species.

Annual State 4.0:

This state has two community phases; one dominated by annual non-native species and the other is a shrub dominated state. This state is characterized by the dominance of annual non-native species such as cheatgrass, Russian thistle, medusahead, and/or stork's bill (*Erodium spp*.) in the understory. Sagebrush and/or rabbitbrush may dominate the overstory.

Community Phase 4.1:
Annual non-native plants dominate the site. This phase may have seeded species present if resulting from a failed seeding attempt.

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Time and lack of disturbance allows for shrubs to reestablish. Sprouting shrubs such as ephedra, desert peach and rabbitbrush will be the first to reappear after fire. Probability of sagebrush establishment is extremely low.

Community Phase 4.2:
Wyoming big sagebrush remains in the overstory with annual non-native species dominating the understory. Trace amounts of desirable bunchgrasses may be present.

Loamy 8-10" (R026XY016NV) Phase 4.2, T.K. Stringham, April 2016

Community Phase Pathway 4.2a, from Phase 4.2 to 4.1:
Fire allows for annual non-native species to dominate site.

Tree State 5.0:

This state has two community phases that are characterized by the dominance of Utah juniper and/or singleleaf pinyon in the overstory. Wyoming big sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients, soil organic matter distribution and nutrient cycling have been spatially and temporally altered.

Community Phase 5.1:

Utah juniper and/or singleleaf pinyon dominate overstory, sagebrush is decadent and dying, and cover of deep-rooted perennial bunchgrasses is decreasing. Recruitment of sagebrush cohorts is minimal. Annual non-natives may be present or increasing.

Community Phase Pathway 5.1a, from Phase 5.1 to 5.2:
Absence of disturbance over time allows for tree cover and density to further increase and out-compete the herbaceous understory species.

Community Phase 5.2:
Utah juniper and/or singleleaf pinyon dominates the site and tree leader growth is minimal; annual non-native species may be the dominant understory species and will typically be found under the tree canopies. Trace amounts of sagebrush may be present however dead skeletons will be more numerous than living sagebrush. Bunchgrasses may or may not be present. Bottlebrush squirreltail or mat forming forbs may be present in trace amounts. Bare ground interspaces are large and connected. Soil redistribution is evident.

South Slope 8-10" (R026XY011NV) Tree State D. Snyder, September 2017

Community Phase Pathway 5.2a, from Phase 5.2 to 5.1:
Manual or mechanical thinning of trees allows understory regrowth due to less competition for resources. This treatment is typically done for fuel management.

T5A: Transition from Tree State 5.0 to Annual State 4.0:

Trigger: Catastrophic crown fire would reduce or eliminate trees to transition the site to 4.1. Tree removal when annual non-natives such as cheatgrass are present would also transition the site to state 4.0.

Slow variable: Increased seed production and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

R5A: Restoration from Tree State 5.0 to Shrub State 3.0:

Tree removal or fire when bottlebrush squirreltail is dominant in the understory will transition to community phase 3.2.

R5B: Restoration from Tree State 5.0 to Seeded State 6.0:

Tree removal and seeding of desired species. Tree removal practices that minimize soil disturbance are recommended. Probability of success declines with increased presence of nonnative annual species.

Seeded State 6.0:

This state has two community phases: a grass-dominated phase, and a shrub-dominated phase. This state is characterized by the dominance of seeded introduced wheatgrass species in the understory. Wyoming big sagebrush, native forbs, and non-native forbs may be present.

Community Phase 6.1:
Seeded wheatgrass and/or other seeded species dominate the community. Non-native annual species are present. Trace amounts of Wyoming big sagebrush may be present, especially if seeded.

Community Phase Pathway 6.1a, from Phase 6.1 to 6.2:
Time and lack of disturbance allow shrubs to increase. Pathway may be coupled with inappropriate grazing management.

Community Phase 6.2:
Wyoming big sagebrush increases and becomes dominant in the overstory. Seeded wheatgrass species dominate understory. Annual non-native species may be present in trace amounts.

Loamy 8-10” (RO26XY016NV) Seeded State T.K. Stringham, May 2015

Community Phase Pathway 6.2a, from Phase 6.2 to 6.1:
Fire, brush management and/or Aroga moth infestation reduces sagebrush overstory and allows for seeded wheatgrasses or other seeded grasses to increase.

T6A: Transition from Seeded State 6.0 Shrub State 3.0:

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during growing season would favor shrubs and initiate transition to Community Phase 3.1. Fire would cause a transition to Community Phase 3.2.

Slow variables: Long term decrease in deep-rooted perennial grass density, resulting in a decrease in organic matter inputs and subsequent soil water decline.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter.

Potential Resilience Differences with other Ecological Sites:

Stony Slope 8-10 (R026XY022NV):

The vegetation community of this site is similar to the modal site but has desert needlegrass as a dominant grass species. Production is lower than the modal site with 450 lbs/ac in normal years. This site occurs on convex sideslopes of plateaus and hills with slopes that range from 2 to 75 percent. Soils are shallow to moderately deep with boulders, stones, and cobbles on the soil surface. The available water capacity is very low and the soils have an argillic horizon.

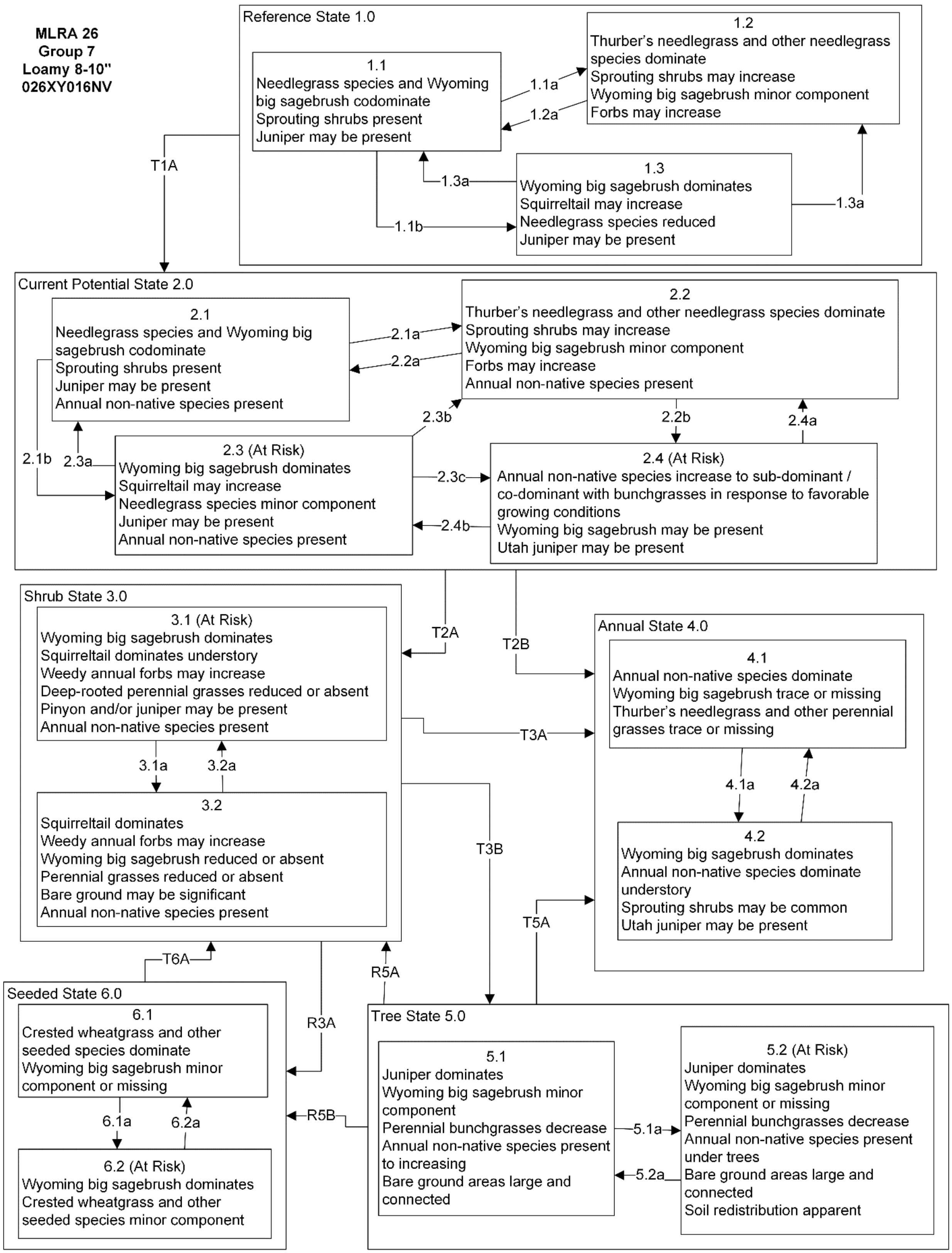
Droughty Loam 8-10 (R026XY024NV):

The vegetation community is similar to the modal site but has Indian ricegrass and desert needlegrass as the dominant grasses. Production is similar to the modal site. This site occurs on alluvial flats and lower piedmont slopes on slopes from 2 to 15 percent. The soils are moderately deep and well to somewhat excessively drained with very low available water capacity.

South Slope 8-10 (R026XY011NV):

This site occurs on southerly-facing sideslopes of mountains, hills, plateaus, rock pediments and fan piedmonts with slopes that range from 30 to 75 percent. Elevations are higher than the modal site at 6000 to 7200 feet and average annual precipitation of 8 to 12 inches. The vegetation community is similar to the modal site but with desert needlegrass as the dominant grass species. The production is higher than the modal site with 800 lbs/ac in a normal year. The soils of this site a typically shallow to soft bedrock and well drained. The available water capacity is low. In addition to the high temperature of a southerly exposure, the soil factors limit productivity and diversity of native plants on this site.

Modal State and Transition Model for Group 7 in MLRA 26:



MLRA 26
Group 7
Loamy 8-10"
026XY016NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic; non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing and/or drought will reduce perennial bunchgrasses.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management (aerial herbicide application), late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (to 3.2).
Transition T2B: Fire or brush management causing severe soil disturbance. Annuals like cheatgrass can become dominant under an existing shrub canopy (to 4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: High severity fire; brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community (to 4.1). Annuals like cheatgrass can become dominant under an existing shrub canopy (to 4.2).
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance to allow sagebrush to increase (pathway unlikely).
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

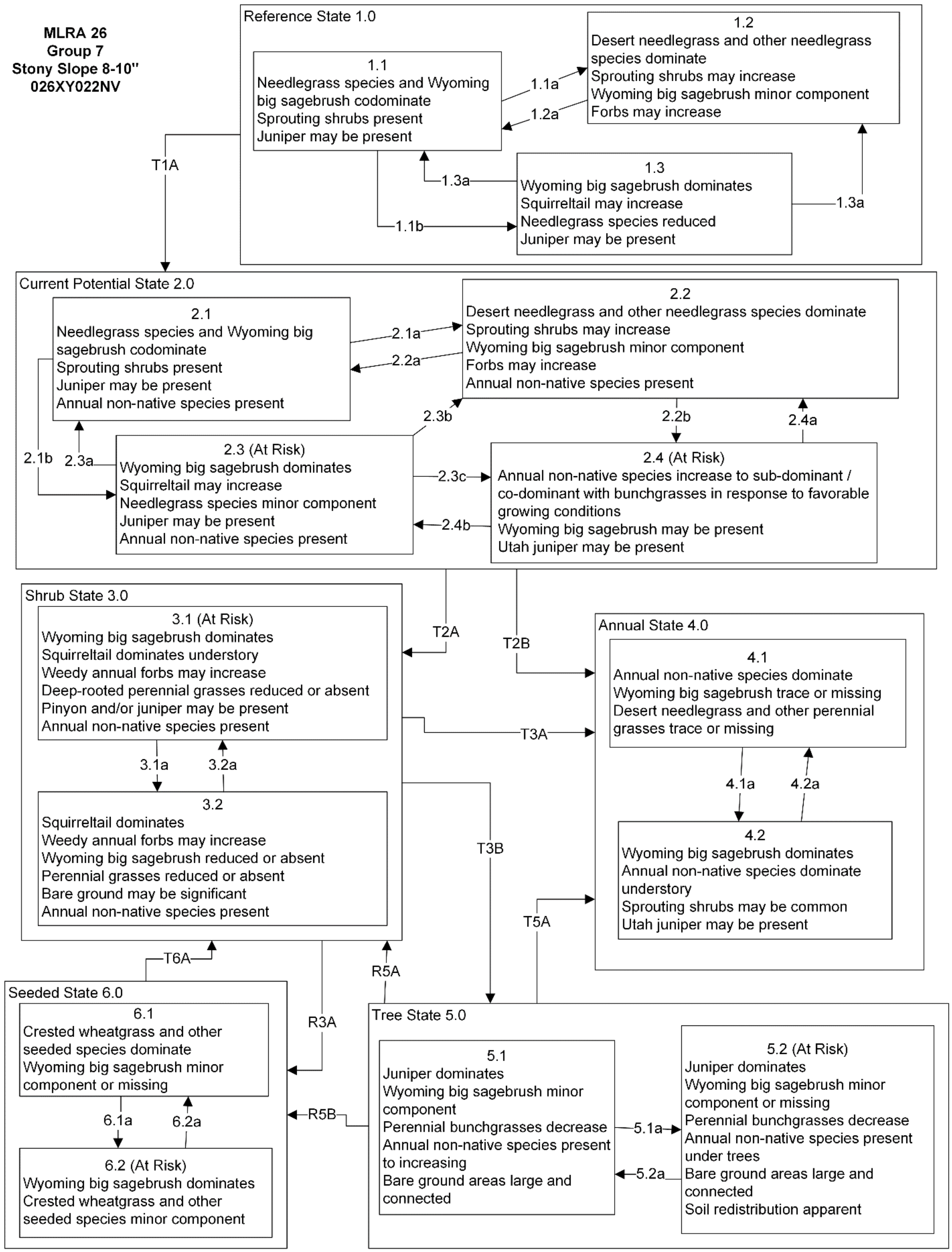
Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree removal with minimal soil disturbance with native grasses present and seeding of wheatgrass species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Inappropriate grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments and/or fire will lead to phase 3.2.

Additional State and Transition Models for Group 7 in MLRA 26



MLRA 26
Group 7
Stony Slope 8-10"
026XY022NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic; non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing and/or drought will reduce perennial bunchgrasses.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management (aerial herbicide application), late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (to 3.2).
Transition T2B: Fire or brush management causing severe soil disturbance. Annuals like cheatgrass can become dominant under an existing shrub canopy (to 4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: High severity fire; brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community (to 4.1). Annuals like cheatgrass can become dominant under an existing shrub canopy (to 4.2).
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance to allow sagebrush to increase (pathway unlikely).
4.2a: Fire.

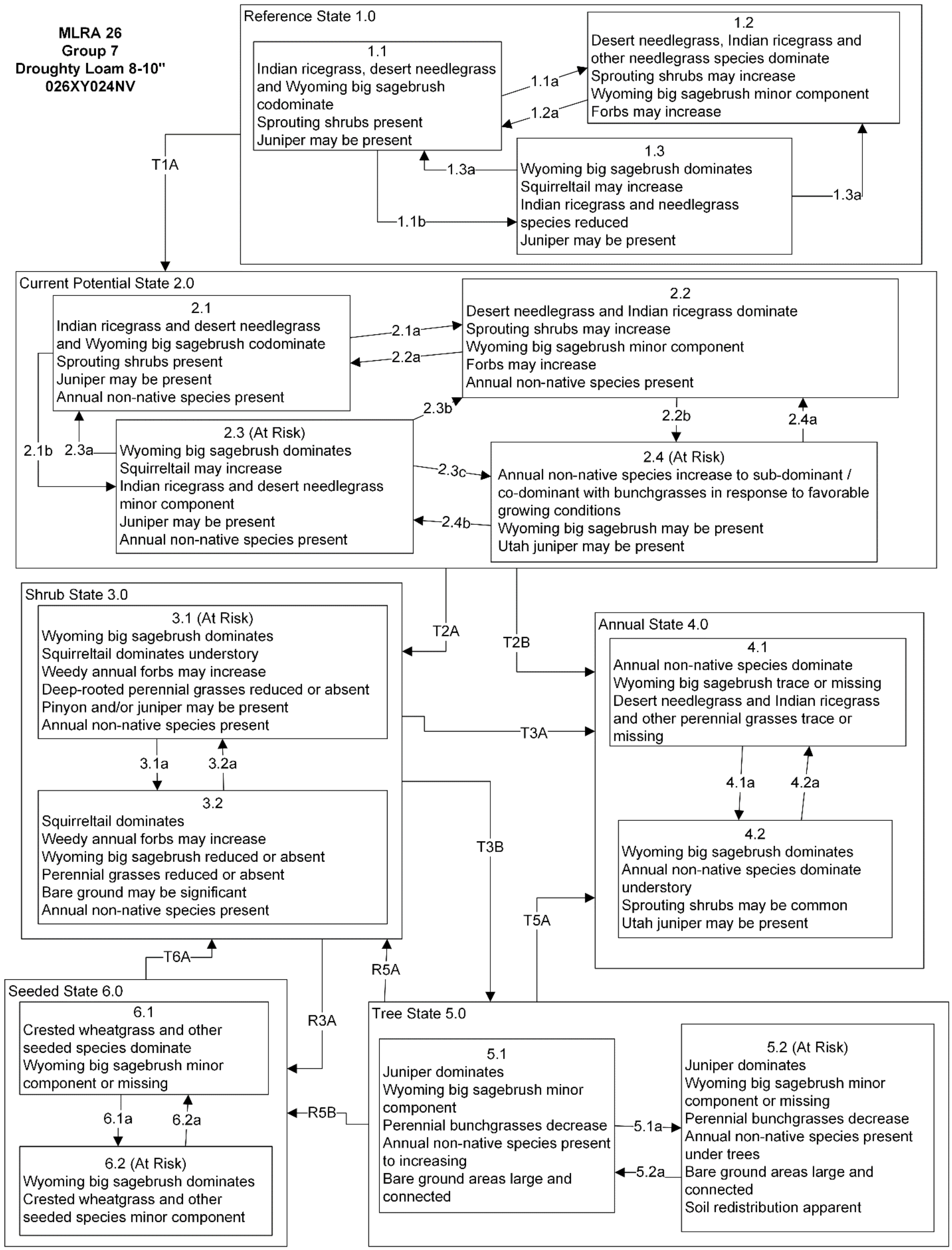
Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree removal with minimal soil disturbance with native grasses present and seeding of wheatgrass species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Inappropriate grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments and/or fire will lead to phase 3.2.


MLRA 26
Group 7
Droughty Loam 8-10"
026XY024NV
Reference State 1.0
1.1
Indian ricegrass, desert needlegrass and Wyoming big sagebrush codominate
Sprouting shrubs present
Juniper may be present
1.2
Desert needlegrass, Indian ricegrass and other needlegrass species dominate
Sprouting shrubs may increase
Wyoming big sagebrush minor component
Forbs may increase
1.3
Wyoming big sagebrush dominates
Squirreltail may increase
Indian ricegrass and needlegrass species reduced
Juniper may be present
1.1a
1.2a
1.3a
1.1b
1.3a
T1A
Current Potential State 2.0
2.1
Indian ricegrass and desert needlegrass and Wyoming big sagebrush codominate
Sprouting shrubs present
Juniper may be present
Annual non-native species present
2.2
Desert needlegrass and Indian ricegrass dominate
Sprouting shrubs may increase
Wyoming big sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Wyoming big sagebrush dominates
Squirreltail may increase
Indian ricegrass and desert needlegrass minor component
Juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Wyoming big sagebrush may be present
Utah juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.2b
2.4a
2.3c
2.4b
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush dominates
Squirreltail dominates understory
Weedy annual forbs may increase
Deep-rooted perennial grasses reduced or absent
Pinyon and/or juniper may be present
Annual non-native species present
3.1a
3.2a
3.2
Squirreltail dominates
Weedy annual forbs may increase
Wyoming big sagebrush reduced or absent
Perennial grasses reduced or absent
Bare ground may be significant
Annual non-native species present
T3A
T3B
Annual State 4.0
4.1
Annual non-native species dominate
Wyoming big sagebrush trace or missing
Desert needlegrass and Indian ricegrass and other perennial grasses trace or missing
4.1a
4.2a
4.2
Wyoming big sagebrush dominates
Annual non-native species dominate understory
Sprouting shrubs may be common
Utah juniper may be present
T5A
T6A
R5A
R3A
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Wyoming big sagebrush minor component or missing
6.1a
6.2a
6.2 (At Risk)
Wyoming big sagebrush dominates
Crested wheatgrass and other seeded species minor component
R5B
Tree State 5.0
5.1
Juniper dominates
Wyoming big sagebrush minor component
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.1a
5.2a
5.2 (At Risk)
Juniper dominates
Wyoming big sagebrush minor component or missing
Perennial bunchgrasses decrease
Annual non-native species present under trees
Bare ground areas large and connected
Soil redistribution apparent

MLRA 26
Group 7
Droughty Loam 8-10"
026XY024NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic; non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing and/or drought will reduce perennial bunchgrasses.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management (aerial herbicide application), late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (to 3.2).
Transition T2B: Fire or brush management causing severe soil disturbance. Annuals like cheatgrass can become dominant under an existing shrub canopy (to 4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: High severity fire; brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community (to 4.1). Annuals like cheatgrass can become dominant under an existing shrub canopy (to 4.2).
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance to allow sagebrush to increase (pathway unlikely).
4.2a: Fire.

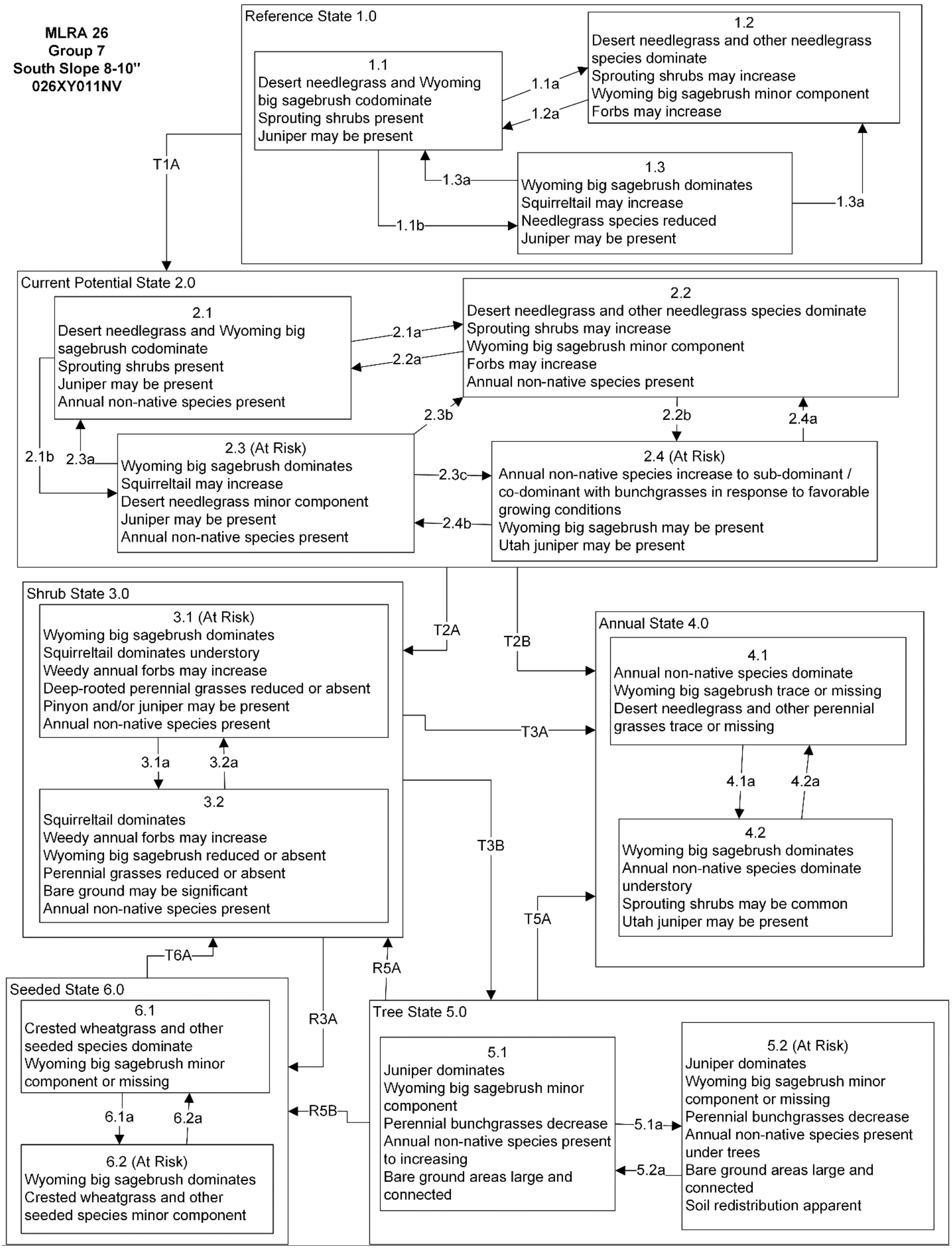
Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree removal with minimal soil disturbance with native grasses present and seeding of wheatgrass species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Inappropriate grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments and/or fire will lead to phase 3.2.


MLRA 26
Group 7
South Slope 8-10"
026XY011NV
Reference State 1.0
1.1
Desert needlegrass and Wyoming big sagebrush codominate
Sprouting shrubs present
Juniper may be present
1.2
Desert needlegrass and other needlegrass species dominate
Sprouting shrubs may increase
Wyoming big sagebrush minor component
Forbs may increase
1.3
Wyoming big sagebrush dominates
Squirreltail may increase
Needlegrass species reduced
Juniper may be present
1.1a
1.2a
1.3a
1.1b
1.3a
T1A
Current Potential State 2.0
2.1
Desert needlegrass and Wyoming big sagebrush codominate
Sprouting shrubs present
Juniper may be present
Annual non-native species present
2.2
Desert needlegrass and other needlegrass species dominate
Sprouting shrubs may increase
Wyoming big sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Wyoming big sagebrush dominates
Squirreltail may increase
Desert needlegrass minor component
Juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Wyoming big sagebrush may be present
Utah juniper may be present
2.1a
2.2a
2.3b
2.2b
2.4a
2.1b
2.3a
2.3c
2.4b
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush dominates
Squirreltail dominates understory
Weedy annual forbs may increase
Deep-rooted perennial grasses reduced or absent
Pinyon and/or juniper may be present
Annual non-native species present
3.2
Squirreltail dominates
Weedy annual forbs may increase
Wyoming big sagebrush reduced or absent
Perennial grasses reduced or absent
Bare ground may be significant
Annual non-native species present
3.1a
3.2a
T3A
T3B
Annual State 4.0
4.1
Annual non-native species dominate
Wyoming big sagebrush trace or missing
Desert needlegrass and other perennial grasses trace or missing
4.2
Wyoming big sagebrush dominates
Annual non-native species dominate understory
Sprouting shrubs may be common
Utah juniper may be present
4.1a
4.2a
T5A
T6A
R5A
R3A
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Wyoming big sagebrush minor component or missing
6.2 (At Risk)
Wyoming big sagebrush dominates
Crested wheatgrass and other seeded species minor component
6.1a
6.2a
R5B
Tree State 5.0
5.1
Juniper dominates
Wyoming big sagebrush minor component
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.2 (At Risk)
Juniper dominates
Wyoming big sagebrush minor component or missing
Perennial bunchgrasses decrease
Annual non-native species present under trees
Bare ground areas large and connected
Soil redistribution apparent
5.1a
5.2a

MLRA 26
Group 7
South Slope 8-10"
026XY011NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic; non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing and/or drought will reduce perennial bunchgrasses.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management (aerial herbicide application), late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (to 3.2).
Transition T2B: Fire or brush management causing severe soil disturbance. Annuals like cheatgrass can become dominant under an existing shrub canopy (to 4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: High severity fire; brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (may take many years).

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community (to 4.1). Annuals like cheatgrass can become dominant under an existing shrub canopy (to 4.2).
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance to allow sagebrush to increase (pathway unlikely).
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree removal with minimal soil disturbance with native grasses present and seeding of wheatgrass species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Inappropriate grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments and/or fire will lead to phase 3.2.

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MRLA 26 Group 8: Steep slopes of alluvial fan remnants

Description of MLRA 26 Disturbance Response Group 8:

Disturbance Response Group (DRG) 8 has two ecological sites. These sites range in precipitation from 8 to 12 inches. Slopes range from 15 to 50 percent. The elevation range is from 5,000 to 6,000 feet. These sites occur on side slopes of dissected fan remnants. The soils on these sites are well drained and range in depth from very shallow to shallow. They have low available water capacity. The overstory is dominated by Wyoming (*Artemisia tridentata* ssp. *wyomingensis*) and/or Lahontan sagebrush (*Artemisia arbuscula* Nutt. ssp. *longicaulis*) with an understory of desert needlegrass (*Achnatherum speciosum*) and/or Thurber's needlegrass (*Achnatherum thurberianum*.) Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), littleleaf horsebrush (*Tetradymia glabrata*), purple sage (*Salvia dorrii*) and antelope bitterbrush (*Purshia tridentata*) are common. Other grasses include squirreltail (*Elymus elymoides*), and Indian ricegrass (*Achnatherum hymenoides*). Forbs such as rockcress (*Arabis* spp.), hawksbeard (*Crepis acuminata*) and phlox (*Phlox* spp.) make up minor components. Average production for a normal year for both sites is 150 lbs/ac.

Disturbance Response Group 8 Ecological Sites:

Eroded Slope 10-12" – Modal Site	R026XY029NV
Eroded Slope 8-10"	R026XY094NV

Modal Site:

This site occurs on side slopes of dissected piedmont slopes. Slopes range from 15 to 50 percent. Elevations are 5,000 to 6,000 feet. Average annual precipitation is 8 to 12 inches. The soils on this site are very shallow to shallow and well drained. The available water capacity is very low. Loss of the soil surface layer through erosion is a severely limiting factor to plant establishment and development. A thin surface layer or exposed subsoil restricts infiltration of moisture. Because of the low infiltration rate and steepness of slope, runoff is high. The plant community is dominated by Wyoming big sagebrush, desert and/or Thurber's needlegrass, Indian ricegrass and bottlebrush squirreltail. Total annual production ranges from 100 to 200 lbs/ac.

Ecological Dynamics and Disturbance Response

An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that influence a site's resilience to disturbance, and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by deep-rooted cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. Deep-rooted, cool season, perennial bunchgrasses, and long-lived shrubs (50+ years) with high root to shoot ratios dominate the ecological sites in this DRG. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which on this site is limited by depth to bedrock (Dobrowolski et al. 1990). Root length of mature sagebrush plants was measured to a depth of 2 meters on deep alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The perennial bunchgrasses generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Periodic drought regularly influences sagebrush ecosystems, and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by, the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition, or can increase resource pools by the decomposition of dead plant material following disturbance. The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007).

Variability in plant community composition and production depends on soil surface texture and depth. Thurber's needlegrass will increase on gravelly soils, whereas Indian ricegrass will increase with sandy soil surfaces, and bottlebrush squirreltail will increase with silty soil surfaces. A weak argillic horizon will promote production of bluebunch wheatgrass (*Pseudoroegneria spicata*). Production generally increases with soil depth. The amount of sagebrush in the plant community is dependent upon disturbances like fire, Aroga moth infestations, and grazing.

The sites on this DRG occur on steep slopes and have low productivity with around 150 lb/ac in a normal year. High amounts of bare ground are typical for these sites and can be over 50 percent. Due to these factors, rills and water flow patterns are typical. If the surface layer of the soil is lost from disturbance, runoff and subsequent erosion increase due to the lack of infiltration into the soil profile. Lack of infiltration is the most limiting factor of these sites and can severely affect plant community development.

Wyoming big sagebrush is the most drought-tolerant of the big sagebrushes and is generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

Lahontan sagebrush was only recently identified as a unique species of sagebrush (Winward and McArthur 1995). Lahontan sagebrush is a cross between low sagebrush and Wyoming sagebrush (Artemisia tridentata ssp. wyomingensis) and is typically found near the old shorelines of Lake Lahontan from the Pleistocene epoch. This subspecies grows on soils similar to low sagebrush with shallow depths and low water holding capabilities (Winward and McArthur 1995).

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks, especially the sagebrush defoliator, Aroga moth (*Aroga websteri*). Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and have been ongoing in Nevada since 2004 (Bentz et al. 2008). Thousands of acres of big sagebrush have been impacted, with partial to complete die-off observed. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975).

Purple sage may be a significant component of these sites. This shrub is aromatic and blooms from May to July. It reproduces through seed but has also shown to successfully establish roots in a propagation study using stem cutting of the plant (Everett et al 1978). Purple sage has moderate drought tolerance and high fire tolerance.

There is potential for infilling by Utah juniper (*Juniperus osteosperma*) and/or singleleaf pinyon (*Pinus monophylla*) on these sites. Infilling may also occur if the site is adjacent to woodland sites or other ecological sites with juniper present. Without disturbance in these areas, Utah juniper will eventually dominate the site and out-compete sagebrush for water and sunlight, severely reducing both the shrub and herbaceous understory (Miller and Tausch 2000, Lett and Knapp 2005). The potential for soil erosion increases as the woodland matures and the understory plant community cover declines (Pierson et al. 2010).

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Five possible alternative stable states have been identified for this DRG.

Annual Invasive Grasses:

The species most likely to invade these sites is cheatgrass. Cheatgrass is a cool season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, able to germinate in the autumn or spring, tolerant of grazing and increase with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead. Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses.

Methods to control cheatgrass include herbicide, fire, grazing, and seeding of primarily non-native wheatgrasses. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass has been found to be more successful at combating medusahead and cheatgrass than spraying alone (Sheley et al. 2012). Where native bunchgrasses are missing from the site, revegetation of medusahead or cheatgrass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron and sulfometuron + Chlorsulfuron) only treatments for suppression of cheatgrass, medusahead and ventenata (North Africa grass, Ventenata dubia) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011), however caution in using these results is advised, as only one year of data was reported. Prescribed fire has also been utilized in combination with the application of pre-emergent herbicide to control medusahead and cheatgrass (Vollmer and Vollmer 2008). Mature cheatgrass is very flammable and fire can be used to remove the thatch layer, consume standing vegetation, and even reduce seed levels.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (Cercocarpus montanus), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic and the same rates with methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz./ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Wyoming big sagebrush communities historically had low fuel loads, and patchy fires that burned in a mosaic pattern were common at 10-70 year return intervals (Young et al. 1979, West and Hassan 1985, Bunting et al. 1987). Davies et al. (2006) suggest fire return intervals in Wyoming big sagebrush communities were around 50-100 years. Wyoming big sagebrush is killed by fire and only regenerates from seed. Recovery time for Wyoming big sagebrush may require 50-120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities.

To date, we have not been able to find specific research on the fire response of Lahontan sagebrush, however it likely behaves similarly to low sagebrush, which is killed by fire and does not sprout (Tisdale and Hironaka 1981). Fire risk is greatest following a wet, productive year when there is greater production of fine fuels (Beardall and Sylvester 1976). Fire return intervals are not well understood because these ecosystems rarely coincide with fire-scarred conifers, however a ride range of 20 to well over 100 years has been estimated (Miller and Rose 1995, Miller and Rose 1999, Baker 2006, Knick et al. 2005). Historically, fires were probably patchy due to the low productivity of these sites (Beardall and

Sylvester 1976, Ralphs and Busby 1979, Wright et al. 1979, Smith and Busby 1981). Fine fuel loads generally average 100 to 400 pounds per acre (110- 450 kg/ha) but are occasionally as high as 600 pounds per acre (680 kg/ha) in low sagebrush habitat types (Bradley et al. 1992). Reestablishment occurs from off-site wind-dispersed seed (Young 1983). Recovery time of low sagebrush following fire is variable (Young 1983). After fire, if regeneration conditions are favorable, low sagebrush recovers in 2 to 5 years, however on harsh sites where cover is low to begin with and/or erosion occurs after fire, recovery may require more than 10 years (Young 1983). Slow regeneration may subsequently worsen erosion (Blaisdell et al. 1982). We were unable to find any substantial research on success of seeding low sagebrush after fire.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site, along with seasonality and intensity of the fire, all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances, which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat, which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983).

Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk et al. 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber's needlegrass (Britton et al. 1990). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influenced the response and mortality of Thurber's needlegrass, smaller bunch sizes were less likely to be damaged by fire (Wright and Klemmedson 1965). Thurber's needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Koniak 1985, Britton et al. 1990). Reestablishment on burned sites has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and may preclude reestablishment (Evans and Young 1978).

Desert needlegrass may increase after burning. In a summation of 13 studies Abella (2010) found that desert needlegrass increased in abundance (derived from cover, density, or frequency depending on the source of publication) on burned to unburned sites. Thatcher and Hart (1974) observed an increase in desert needlegrass in areas which appeared to have burned on a relict site, however, they attributed this to soil type rather than species response. Webb and Wilshire (1980) found desert needlegrass exhibited 2-4 times more cover on streets of a Nevada ghost town, which had been abandoned 51 years prior. For desert needlegrass to establish by seed some form of cheatgrass control is required. In a greenhouse study by Rafferty and Young (2002) reducing the cheatgrass density to 25% of that in the field still did not allow for desert needlegrass seedlings to establish.

Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below-ground root crowns. Vallentine (1989) cites several studies in the sagebrush zone that classified Indian ricegrass as being slightly damaged from late summer burning. Indian ricegrass has also been found to reestablish on burned sites through seed dispersed from adjacent unburned areas (Young 1983, West 1994). Following fire, grazing management should be adjusted to promote seed production and establishment of seedlings.

Wildlife/Livestock Grazing Interpretations:

Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber's needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass, thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988). Desert needlegrass is a compact bunchgrass with considerable basal leafage. The young herbage is palatable to all classes of livestock. When mature the fine basal leaves, intermingled with the coarse stems and flowering stalks, are grazed some by cattle and horses, but little by sheep (Sampson et al. 1951). Desert needlegrass is palatable to wildlife such as bighorn sheep and feral burros when young. Desert needlegrass tolerates light grazing but overgrazing may eliminate it from an ecological site. It is best to graze it before seed develops because the seed has a sharp callus that can injure the eyes and mouths of grazing animals (Perkins and Ogle 2008).

Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971) however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1965). Cook and Child (1971) found significant reduction in plant cover after 7 years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1965, Cook and Child 1971); however, utilization of less than 60% is recommended.

The literature is unclear as to the palatability of Wyoming big sagebrush. Generally, Wyoming sagebrush is the least palatable of the big sagebrush taxa (Bray et al. 1991, Sheehy and Winward 1981). However, it may receive light or moderate use depending upon the amount of understory herbaceous cover (Tweit and Houston 1980). Personius et al. (1987) found Wyoming big sagebrush and basin big sagebrush to be intermediately palatable to mule deer when compared to mountain big sagebrush (most palatable) and black sagebrush (least palatable).

Purple sage is an undesirable forage for livestock and wildlife (Pavek 2010), though it may support a variety of pollinator species.

State and Transition Model Narrative for Group 8

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 8.

Reference State 1.0:

The Reference State 1.0 is a representative of the natural range of variability under pristine conditions. The reference state has three general community phases; a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
Wyoming big sagebrush, Thurber's needlegrass, desert needlegrass, bottlebrush squirreltail and Indian ricegrass dominate the site. Douglas rabbitbrush, purple sage and antelope bitterbrush are also common on this site. Utah juniper and singleleaf pinyon are described in the site concept and may be present in minor amounts.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

Community Phase Pathway 1.1b, Phase 1.1 to 1.3:
Long-term drought, time and/or herbivory favor an increase in Wyoming big sagebrush over deep-rooted perennial bunchgrasses. Combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community phase. Thurber's needlegrass, desert needlegrass, bottlebrush squirreltail, Indian ricegrass and other perennial grasses are common. Sprouting shrubs are present. Wyoming big sagebrush is killed by fire, therefore decreasing within the burned community. Sagebrush could still be present in unburned patches. Needlegrasses can experience high mortality from fire and may be reduced in the community for several years.

Community Phase Pathway 1.2a, Phase 1.2 to 1.1:
Time and lack of disturbance allows for sagebrush to reestablish.

Community Phase 1.3:
Wyoming big sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from herbivory. Squirreltail will likely increase in the understory and may be the dominant grass on the site.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass and mustards.

Slow variables: Over time the annual non-native plants will increase within the community decreasing organic matter inputs from deep-rooted perennial bunchgrasses resulting in reductions in soil water availability for perennial bunchgrasses.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross-pollinate and adaptations for seed dispersal. Additionally, the presence of highly flammable, non-native species reduces state resilience because these species can promote fire where historically fire has been infrequent leading to positive feedbacks that further the degradation of the system.

Community Phase 2.1:
Wyoming big sagebrush, desert needlegrass and Thurber’s needlegrass dominate the site. Bottlebrush squirreltail, Indian ricegrass, Douglas rabbitbrush, purple sage and antelope bitterbrush are also common on this site. Utah juniper and singleleaf pinyon may be present. Non-native annual species are present in minor amounts.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial

grasses and forbs. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Time, long-term drought, grazing management that favors shrubs or combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses. However, squirreltail may increase in the understory depending on the grazing management. Heavy spring grazing will favor an increase in sagebrush. Annual non-native species may be stable or increasing within the understory.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early seral community phase. Thurber's needlegrass, desert needlegrass, bottlebrush squirreltail, Indian ricegrass and other perennial grasses are common. Sprouting shrubs are present. Wyoming big sagebrush is killed by fire, therefore decreasing within the burned community. Sagebrush could still be present in unburned patches. Perennial forbs may increase or dominate after fire for several years. Thurber's needlegrass can experience high mortality from fire and may be reduced in the community for several years. Annual non-native species generally respond well after fire and may be stable or increasing within the community. Rabbitbrush may dominate the aspect for a number of years following wildfire.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Absence of disturbance over time allows for the sagebrush to recover. This transition may be combined with grazing management that favors shrubs.

Community Phase 2.3 (At-Risk):
Wyoming big sagebrush increases and the perennial understory is reduced. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from inappropriate grazing management. Squirreltail will likely increase in the understory and may be the dominant grass on the site. Utah juniper and singleleaf pinyon may be present. Annual non-native species present.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.2:
Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Other disturbances/practices include brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during growing season would favor shrubs and initiate transition to Community Phase 3.1. Fire would cause a transition to Community Phase 3.2.

Slow variables: Long term decrease in deep-rooted perennial grass density resulting in a decrease in organic matter inputs and subsequent soil water decline.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Fire leads to Community Phase 4.1. Inappropriate grazing management that favors shrubs in the presence of non-native annual species leads to Community Phase 4.2.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Cheatgrass or other non-native annuals dominate understory.

Shrub State 3.0:

This state has two community phases; a Wyoming big sagebrush dominated phase and a sprouting shrub dominated phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Squirreltail will increase with a reduction in deep-rooted perennial bunchgrass competition and become the dominant grass. Sagebrush dominates the overstory and rabbitbrush may be a significant component. Sagebrush canopy cover is high and sagebrush may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and squirreltail understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1:
Wyoming big sagebrush dominates overstory and sprouting shrubs may be a significant component. Squirreltail dominates the understory and may also be a significant component of the plant community. Utah juniper and singleleaf pinyon may be present or increasing. Annual non-native species are present to increasing. Understory may be sparse, with bare ground increasing.

Eroded Slope 10-12" (026XY029NV) Phase 3.1 P. Novak-Echenique, April 2015

Eroded Slope 10-12” (R026XY029NV) Shrub State T.K. Stringham, April 2016

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire would decrease or eliminate the overstory of sagebrush. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to sprouting shrubs. Heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, would greatly reduce the overstory shrubs and allow for squirreltail to dominate the site.

Community Phase 3.2:
Sprouting shrubs such as Douglas rabbitbrush, littleleaf horsebrush, desert peach and antelope bitterbrush dominate the understory; annual non-natives are present but are not dominant. Trace amounts of sagebrush may be present.

Eroded Slope 8-10” (026XY094NV) Shrub State T.K. Stringham, April 2017

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Absence of disturbance over time would allow for sagebrush and other shrubs to recover.

T3A: Transition from Shrub State 3.0 to Annual State 4.0:

Trigger: Fire or inappropriate grazing management can eliminate the squirreltail understory and transition to community Phase 4.1 or 4.2.

Slow variable: Increased seed production and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

T3B: Transition from Shrub State 3.0 to Tree State 5.0:

Trigger: Lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management that reduces fine fuels.

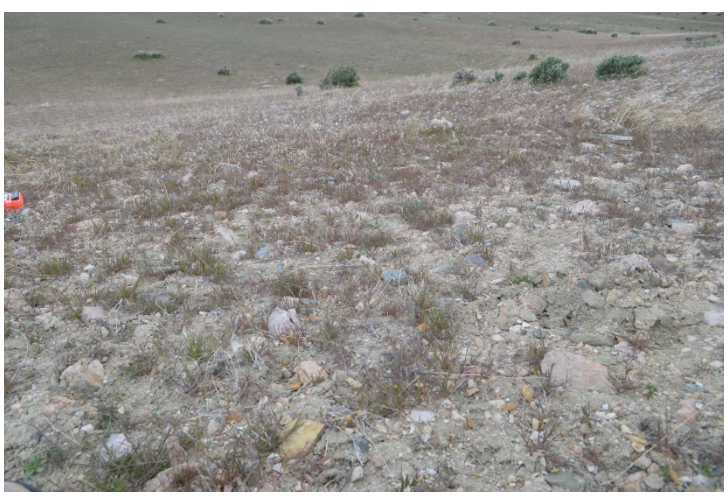
Slow variables: Increased establishment and cover of juniper/pinyon trees, reduction in organic matter inputs.

Threshold: Trees overtop Wyoming big sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

Annual State 4.0:

This state has two community phases; one dominated by annual non-native species and the other is a shrub dominated state. This state is characterized by the dominance of annual non-native species such as cheatgrass in the understory. Sagebrush and/or rabbitbrush may dominate the overstory. Annual non-native species dominate the understory.

Community Phase 4.1:
Annual non-native plants dominate the site. Sagebrush and sprouting shrubs may be present.



Eroded Slope 8-10” (026XY094NV) Annual State T.K. Stringham, April 2017

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Time and lack of disturbance allows for shrubs to reestablish. Sprouting shrubs such as rabbitbrush will be the first to reappear after fire. Probability of sagebrush establishment is extremely low.

Community Phase 4.2:
Sprouting shrubs and/or sagebrush remains in the overstory with annual non-native species, likely cheatgrass, dominating the understory. Trace amounts of desirable bunchgrasses may be present.

Community Phase Pathway 4.2a, from Phase 4.2 to 4.1:
Fire allows for annual, non-native species to dominate site.

Tree State 5.0:

This state has two community phases that are characterized by the dominance of Utah juniper and singleleaf pinyon in the overstory. Wyoming big sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients, soil organic matter distribution and nutrient cycling have been spatially and temporally altered.

Community Phase 5.1:
Juniper trees dominate overstory, sagebrush is decadent and dying, deep rooted perennial bunchgrasses are decreasing. Recruitment of sagebrush cohorts is minimal. Annual non-natives may be present or increasing.

Community Phase Pathway 5.1a, from Phase 5.1 to 5.2:
Absence of disturbance over time allows for tree cover and density to further increase and out-compete the herbaceous understory species for sunlight and water.

Community Phase 5.2:
Utah juniper dominates the site and tree leader growth is minimal; annual non-native species may be the dominant understory species and will typically be found under the tree canopies. Trace amounts of sagebrush may be present however dead skeletons will be more numerous than living sagebrush. Bunchgrasses may or may not be present. Squirreltail or mat forming forbs may be present in trace amounts. Bare ground interspaces are large and connected. Soil redistribution is evident.

Community Phase Pathway 5.2a, from Phase 5.2 to 5.1:
Manual or mechanical thinning of trees allows understory regrowth due to less competition for resources.

T5A: Transition from Tree State 5.0 to Annual State 4.0:

Trigger: Catastrophic crown fire would reduce or eliminate trees to transition the site to 4.1. Tree removal when annual non-natives such as cheatgrass are present would also transition the site to state 4.0.

Slow variable: Increased seed production and cover of annual non-native species.

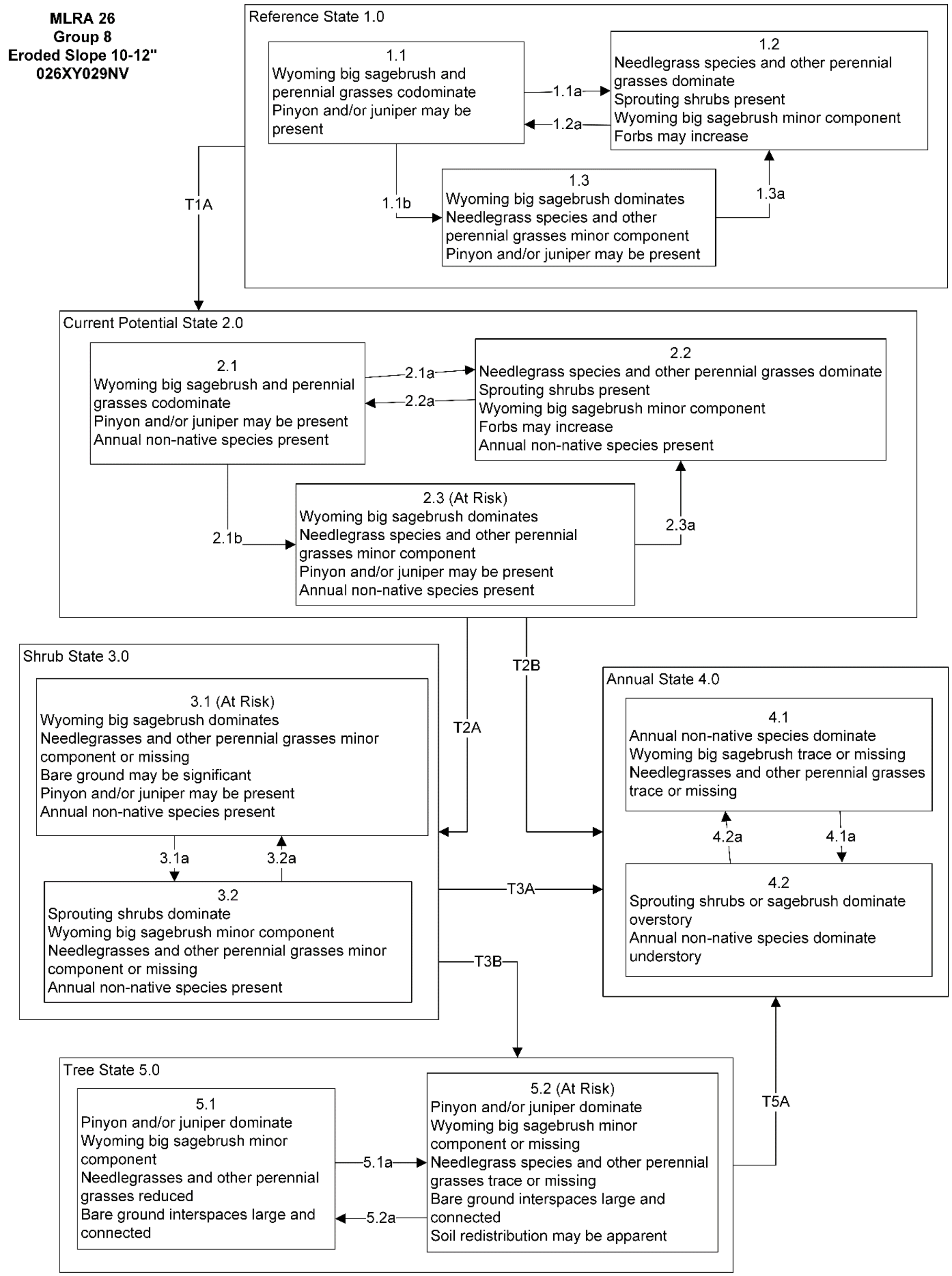
Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

Potential Resilience Differences with Other Ecological Sites

Eroded Slope 8-10" (R026XY094NV):

This site occurs on similar landforms and soil types as the modal site but receives less precipitation with 8-10 inches annually. This site has the same low productivity as the modal site, but with desert needlegrass as the dominant bunchgrass and Lahontan sagebrush as the dominant shrub. Lahontan sagebrush is palatable, particularly to sheep, which may make this site more vulnerable to degradation.

Modal State and Transition Model for Group 8 in MRLA 26:



MLRA 26
Group 8
Eroded Slope 10-12"
026XY029NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire. Annuals may increase under an intact shrub canopy (to 4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire.
3.2a: Time and lack of disturbance.

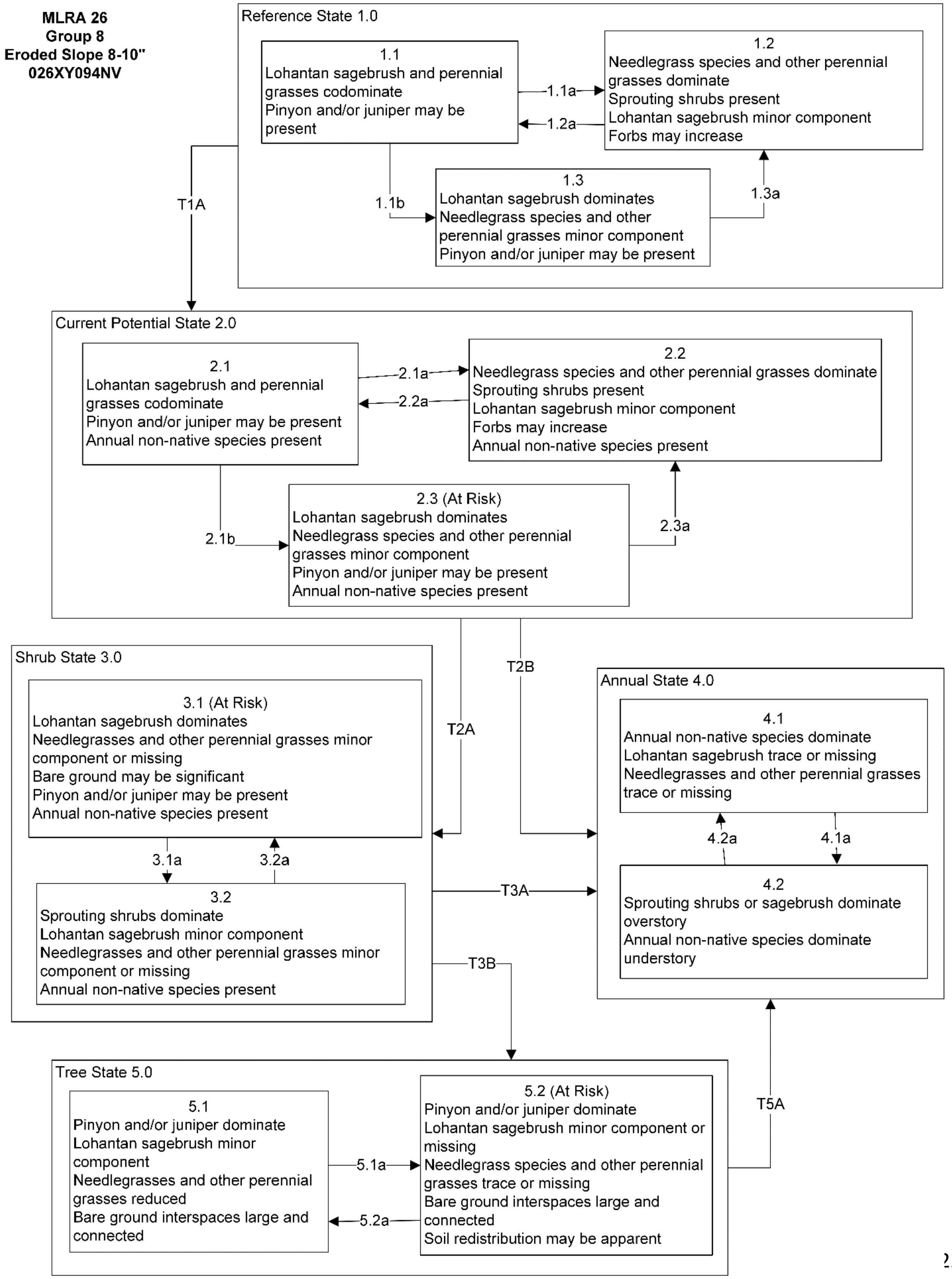
Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community. Annuals may increase under an intact shrub canopy (to 4.2).
Transition T3B: Time and lack of disturbance allows for maturation of tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Additional State and Transition Models for Group 8 in MLRA 26:



MLRA 26
Group 8
Eroded Slope 8-10"
026XY094NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire. Annuals may increase under an intact shrub canopy (to 4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community. Annuals may increase under an intact shrub canopy (to 4.2).
Transition T3B: Time and lack of disturbance allows for maturation of tree community.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

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MLRA 26 Group 9: Mid-elevation big sagebrush with needlegrass understory

Description of MRLA 26 Disturbance Response Group 9:

Disturbance Response Group (DRG) 9 consists of 10 ecological sites. These sites are found primarily on fan piedmonts, foothills, and lower mountain slopes. Precipitation for these sites ranges from 10 to 14 inches. Slopes range from 0 to 75 percent but slopes from 2 to 50 percent are typical. Elevations range from 4,500 to 7,900 feet. Soil on these sites range from shallow to very deep, and are usually modified by high volumes of rock fragments on the soil surface and throughout the profile. These soils are typically well to excessively drained and have low available water capacity. These sites are dominated by big sagebrush (*Artemisia tridentata*) and/or antelope bitterbrush (*Purshia tridentata*) with an understory of needlegrasses (*Achnatherum* spp.) or needleandthread grass (*Hesperostipa comata*). This site exists in the transition zone between the droughty Wyoming big sagebrush and Lahontan sagebrush sites and the productive mountain big sagebrush sites. Three subspecies of big sagebrush may be present on this site: Wyoming (*A. tridentata* ssp. *wyomingensis)*, mountain (*A. tridentata* ssp. *vaseyana)*, and/or basin (*A. tridentata* ssp. *tridentata).* Indian ricegrass (*Achnatherum hymenoides*), bluegrasses (*Poa* spp.) and other perennial grasses are also common. Other shrubs include spiny hopsage (*Grayia spinosa*), ephedra (*Ephedra* spp.) and rabbitbrush (*Chrysothamnus* spp. and *Ericameria* spp.). Average annual production ranges from 450 to 800 lbs/ac.

Disturbance Response Group 9 Ecological Sites:

Loamy 10-12" – Modal Site	R026XY010NV
Loamy Hill 10-12"	R026XY017NV
Granitic Fan 10-12"	R026XY008NV
Granitic South Slope 10-12"	R026XY018NV
Granitic Slope 10-12"	R026XY026NV
Shallow Loam 10-12"	R026XY015NV
Stony Slope 10-12"	R026XY100NV
Granitic Loam 10-12"	R026XY103NV
Gravelly Coarse Loamy	R026XF004CA
Shallow South Slope 10-14"	R026XF070CA
Shallow Loam 10-14"	R026XF069CA

Modal Site:

Loamy 10-12" ecological site (R026XY010NV) is the modal site for this group as it has the most acres mapped. This site occurs on summits and sideslopes of hills and upper fan piedmonts. Slopes range from 2 to 50 percent, but slope gradients of 2 to 15 percent are most typical. Elevations are 5,500 to 6,500 feet. The soils in this site are moderately deep to deep and well drained. Surface soils are coarse to medium textured and normally more than 10 inches thick to the subsoil or underlying material. The available water capacity is low to moderate. Some soils are modified with high volumes of rock fragments through the soil profile. Runoff is slow to moderate and the potential for sheet and rill erosion is medium to high depending on slope. The plant community is dominated by Thurber's needlegrass and a mix of big sagebrush subspecies. Wyoming big sagebrush, basin big sagebrush, and mountain big sagebrush may be found in varying proportions on this site. Antelope bitterbrush and basin wildrye (*Leymus cinereus*) are other important species associated with this site. Total annual production ranges from 600 to 1,000 lbs/ac, with 800 lbs/ac in normal years.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Deep-rooted cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios dominate the ecological sites in this DRG. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m (Dobrowolski et al. 1990). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The perennial bunchgrasses that are dominant include needlegrasses and needleandthread grass. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historic precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance can cause an increase or a reduction in resource pools (Cleary et al. 2010). A reduction in resource uptake may occur when the disturbance results in plant mortality. An increase in resource pools occurs when a disturbance results in decomposition of dead plant material and a subsequent flush of nutrients (Blank et al. 2007). The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007).

Variability in plant community composition and production depends on soil surface texture and depth. Production generally increases with soil depth. The amount of sagebrush in the plant community is dependent upon disturbances like fire, Aroga moth (*Aroga websteri*) infestations, and grazing. Sandberg bluegrass (*Poa secunda*) more easily dominates sites where surface soils are gravelly loams or when there is an increase in ash in the upper soil profile.

Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) is the most drought tolerant of the big sagebrushes and is generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks especially a sagebrush defoliator, Aroga moth. Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and have been ongoing in Nevada since 2004 (Bentz, et al 2008). Thousands of acres of big sagebrush have been impacted, with partial to complete die-off observed. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975).

There is potential for infilling by Utah juniper (*Juniperus osteosperma*) and/or singleleaf pinyon (*Pinus monophylla*) on these sites. Infilling may also occur if the site is adjacent to woodland sites or other ecological sites where pinyon and/or juniper are present. Without disturbance in these areas, pinyon and/or juniper will eventually dominate the site and out-compete sagebrush for water and sunlight severely reducing both the shrub and herbaceous understory (Miller and Tausch 2000, Lett and Knapp 2005). The potential for soil erosion increases as the woodland matures and the understory plant community cover declines (Pierson et al. 2010).

Millions of acres in the arid and semi-arid West were brush-beaten and planted with crested wheatgrass in the mid 1900's for the purpose of competing with weed species and increasing grass production on rangelands. Success and longevity of these seeding projects have been mixed (Williams et al. 2017). Crested wheatgrass is a cool-season, medium height, exotic perennial bunchgrass native to Asia. Sites within this DRG may exhibit an understory of crested wheatgrass in areas where historical seedings have been allowed to return to sagebrush.

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Five possible alternative stable states have been identified for this DRG.

Invasive Annual Grasses:

The species most likely to invade these sites is cheatgrass. Cheatgrass is a cool season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead.

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass "die-off" provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but there is ongoing work to try to predict where they occur, in the hopes of aiding conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, are able to suppress cheatgrass growth when mature (Blank et al. 2020). Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, as only one year of data was reported.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz./ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Wyoming big sagebrush communities historically had low fuel loads, and patchy fires that burned in a mosaic pattern and were common at 10 to70 year return intervals (Young et al. 1983, West and Hassan 1985, Bunting et al. 1987). Davies et al. (2006) suggest fire return intervals in Wyoming big sagebrush communities were around 50 to 100 years. Wyoming big sagebrush is killed by fire and only regenerates from seed. Recovery time for Wyoming big sagebrush may require 50 to 120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities.

Pre-settlement fire return intervals in mountain big sagebrush communities varied from 15 to 25 years (Burkhardt and Tisdale 1969b, Houston 1973, Miller and Tausch 2000a). Mountain big sagebrush

(*Artemisia tridentata* ssp. *vaseyana*) is killed by fire (Neuenschwander 1980, Blaisdell et al. 1982), and does not resprout (Blaisdell 1953). Post fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and may reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). Mountain big sagebrush may return to pre-burn density and cover within 15 to 20 years following fire, but establishment after severe fires may proceed more slowly and can take up to 50 years (Bunting et al. 1987, Ziegenhagen 2003, Miller and Heyerdahl 2008, Ziegenhagen and Miller 2009). The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency and eventually lead to an annual dominated community.

In many basin big sagebrush communities, changes in fire frequency occurred along with fire suppression, livestock grazing and OHV use. Few if any fire history studies have been conducted on basin big sagebrush; however, Sapsis and Kauffman (1991) suggest that fire return intervals in basin big sagebrush are intermediate between mountain big sagebrush (15 to 25 years) and Wyoming big sagebrush (50 to 100 years). Fire severity in big sagebrush communities is described as "variable" depending on weather, fuels, and topography. However, fire in basin big sagebrush communities are typically stand replacing (Sapsis and Kauffman 1991). Basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) does not sprout after fire. Because of the time needed to produce seed, it is eliminated by frequent fires (Bunting et al. 1987). Basin big sagebrush reinvades a site primarily by off-site seed or seed from plants that survive in unburned patches. Approximately 90% of big sagebrush seed is dispersed within 30 feet (9 m) of the parent shrub (Goodrich et al. 1985) with maximum seed dispersal at approximately 108 feet (33 m) from the parent shrub (Shumar and Anderson 1986). Therefore, regeneration of basin big sagebrush after stand replacing fires is difficult and dependent upon proximity of residual mature plants and favorable moisture conditions (Johnson and Payne 1968, Humphrey 1984).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses, the growing points are located at or below the soil surface providing relative protection from disturbances that remove above ground biomass, such as grazing or fire. Thus, grass mortality after fire relates directly to culm density, culm-leaf morphology, size of plant and abundance of old growth because these factors increase duration and intensity of heat at the plant base (Wright 1971, Young 1983).

Burning has been found to decrease the vegetative and reproductive vigor of Thurber’s needlegrass (Uresk et al. 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber’s needlegrass (Britton et al. 1990). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influenced the response and mortality of Thurber’s needlegrass, smaller bunch sizes were less likely to be damaged by fire (Wright and Klemmedson 1965). Thurber’s needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Koniak 1985, Britton et al. 1990). Reestablishment on burned sites has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and may preclude reestablishment (Evans and Young 1978).

Desert needlegrass has persistent dead leaf bases, making this species susceptible to burning. Fire removes this accumulation and a rapid, cool fire will not result in death of the plants (Humphrey 1984).

Field observations indicate that this grass survives and increases after most wildfires (Abella 2009, Thatcher and Hart 1974). Desert needlegrass does not germinate well in the presence of non-native annual species such as cheatgrass (Rafferty and Young 2000).

Basin wildrye is relatively resistant to fire, particularly dormant season fire, as plants sprout from surviving root crowns and rhizomes (Zschaechner 1985). Miller et al. (2013) reported increased total shoot and reproductive shoot densities in the first year following fire, although by year two there was little difference between burned and control treatments.

Needleandthread is a fine-leaf grass and is considered sensitive to fire (Akinsoji 1988, Bradley et al. 1992, Miller et al. 2013). Needleandthread is top-killed by fire but is likely to resprout if fire does not consume above ground stems (Akinsoji 1988, Bradley et al. 1992). In a study by Wright and Klemmedson (1965), season of burn rather than fire intensity seemed to be the crucial factor in mortality for needleandthread grass. Early spring season burning was seen to kill the plants while August burning had no effect. Thus under wildfire scenarios needleandthread is often present in the post-burn community. However, due to its lack of grazing tolerance, grazing after fire should be managed carefully.

Antelope bitterbrush, a minor component on these sites, is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and sprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires and springtime fires may allow bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983, Busse et al. 2000, Kerns et al. 2006).). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956). If cheatgrass is present, bitterbrush seedling success is much lower; the factor that most limits establishment of bitterbrush seedlings is competition for water resources with the invasive species cheatgrass (Clements and Young 2002).

Depending on fire severity, rabbitbrush, desert peach, ephedra, and horsebrush may increase after fire. Rubber rabbitbrush is top-killed by fire, but can resprout after fire and can also establish from seed (Young 1983). Yellow rabbitbrush is top-killed by fire, but sprouts vigorously after fire (Kuntz 1982, Akinsoji 1988). As cheatgrass increases, fire frequencies will also increase. At frequencies between 0.23 and 0.43 times a year, even sprouting shrubs such as rabbitbrush will not survive (Whisenant 1990). Ephedra vigorously sprouts after fire from extensive woody crowns (Young and Evans 1978, Koniak 1985). Sprouting after fire may vary by season of burn and fire severity, however.

The grasses likely to invade this site are cheatgrass and medusahead. These invasive grasses displace desirable perennial grasses, reduce livestock forage, and accumulate large fuel loads that foster frequent fires (Davies and Svejcar 2008). Invasion by annual grasses can alter the fire cycle by increasing fire size, fire season length, rate of spread, numbers of individual fires, and likelihood of fires spreading into native or managed ecosystems (D'Antonio and Vitousek 1992, Brooks et al. 2004). While historical fire return intervals are estimated at 15 to 100 years, areas dominated with cheatgrass are estimated to have a fire return interval of 3-5 years (Whisenant 1990). The mechanisms by which invasive annual grasses alter fire regimes likely interact with climate. For example, cheatgrass cover and biomass vary with climate (Chambers et al. 2007) and are promoted by wet and warm conditions during the fall and spring. Invasive annual species have been shown able to take advantage of high N availability following fire through higher growth rates and increased seedling establishment relative to native perennial grasses (Monaco et al. 2003).

Wildlife/Livestock Grazing Interpretations:

Many wildlife species are dependent on the sagebrush ecosystem including the greater sage grouse, sage sparrow, pygmy rabbit and the sagebrush vole. Dobkin and Sauder (2004) identified 61 animal species, including 24 mammals and 37 birds, associated with the shrub-steppe habitats of the Intermountain West. Big sagebrush sites provide nesting, fall, and winter habitat for sage grouse (Centrocercus urophasianus) (McAdoo and Back 2001). Sage grouse require sagebrush for food and cover during each stage of their life cycle.

The literature is unclear as to the palatability of Wyoming big sagebrush. Generally, Wyoming sagebrush is the least palatable of the big sagebrush taxa (Bray et al. 1991, Sheehy and Winward 1981) however it may receive light or moderate use depending upon the amount of understory herbaceous cover (Tweit and Houston 1980). Personius et al. (1987) found Wyoming big sagebrush and basin big sagebrush to be intermediately palatable to mule deer when compared to mountain big sagebrush (most palatable) and black sagebrush (least palatable).

Antelope bitterbrush a minor component on this site is a critical browse species for mule deer, antelope and elk and is often utilized heavily by domestic livestock (Wood et al. 1995). Grazing tolerance is dependent on site conditions (Garrison 1953) and the shrub can be severely hedged during the dormant season for grasses and forbs. Needlegrasses in general are valuable forage for both livestock and wildlife. They are grazed closely when the leaves are green in early spring but are usually avoided once seed has matured (Sampson et al 1951). Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Heavy grazing during the growing season has been shown to reduce the basal area of Thurber’s needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, can reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988).

Needleandthread is a deep-rooted perennial bunchgrass, which depends upon seed for reproduction therefore, on drier sites where seed production is variable it is easily removed by overgrazing (USDA 1988). It is considered not grazing tolerant and will be one of the first grasses to decrease under heavy grazing pressure (Smoliak et al. 1972, Tueller and Blackburn 1974). Heavy grazing is likely to reduce basal area of these plants (Smoliak et al. 1972).

Overgrazing leads to an increase in sagebrush and a decline in perennial bunchgrasses. Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass expansion and/or cheatgrass and other invasive species such as halogeton (*Halogeton glomeratus*), bur buttercup (*Ceratocephala testiculata*) and annual mustards to occupy interspaces. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

Invasion of annual weedy forbs and cheatgrass could occur with further grazing degradation, leading to a decline in squirreltail and bluegrasses and an increase in bare ground. A combination of overgrazing and prolonged drought leads to soil erosion, increased bare ground and a loss in plant production. Wildfire in sites with cheatgrass present could transition to cheatgrass dominated communities. Without management, cheatgrass and annual forbs are likely to invade and dominate the site, especially after fire. Although trees are part of the site concept, singleleaf pinyon and Utah juniper can increase and eventually dominate this site if fire return intervals are altered.

State and Transition Model Narrative for Group 9

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 23 Disturbance Response Group 1.

Reference State 1.0:

The Reference State 1.0 is a representative of the natural range of variability under pristine conditions. The reference state has three general community phases; a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
Thurber's needlegrass is codominant with big sagebrush. Sagebrush may be a mix of Wyoming big sagebrush, basin big sagebrush, and mountain big sagebrush. Pinyon and/or juniper may be present.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Low severity fire creates a sagebrush/grass mosaic. High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and perennial forbs. In reference condition, fires would typically be small and patchy due to low fuel loads. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.3:
Time and lack of disturbance such as fire or drought allows shrubs to become dominant and may reduce grass production. Excessive herbivory and/or long-term drought may also reduce the perennial understory.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community. Bitterbrush, ephedra, rabbitbrush, and spiny hopsage may be sprouting and may become the dominant shrubs in this phase. Big sagebrush is killed by fire and is reduced within the burned

community, but may be present in unburned patches. Thurber's needlegrass can experience high mortality from fire and may be reduced in the community for several years. With low fire severity, Thurber's needlegrass and basin wildrye may dominate the site post-fire.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Time and lack of disturbance allows for shrubs to reestablish.

Community Phase 1.3:
Big sagebrush increases in the absence of disturbance. Thurber's needlegrass and other perennial grasses reduced. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from herbivory. Squirreltail will likely increase in the understory and may be the dominant grass on the site. Pinyon and/or juniper may be present but constitute less than 2% of production on the site.

Deep Ashy (R026XF005CA) Phase 1.3 P. Novak-Echenique, July 2017

Community Phase Pathway 1.3a, from Phase 1.3 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.1:
Aroga moth infestation and/or release from growing season herbivory may reduce sagebrush dominance and allow recovery of the perennial bunchgrass understory.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass, mustards and Russian thistle (*Salsola tragus*).

Slow variables: Over time the annual non-native plants will increase within the community decreasing organic matter inputs from deep-rooted perennial bunchgrasses resulting in reductions in soil water availability for perennial bunchgrasses.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross-pollinate and adaptations for seed dispersal. Additionally, the presence of highly flammable, non-native species reduces state resilience because these species can promote fire where historically fire has been infrequent leading to positive feedbacks that further the degradation of the system.

Community Phase 2.1:
Thurber's needlegrass is codominant with big sagebrush. Sagebrush may be a mix of Wyoming big sagebrush, basin big sagebrush, and mountain big sagebrush. Pinyon and/or juniper may be present. Non-native annual species are present in minor amounts.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Time, long-term drought, grazing management that favors shrubs or combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses. However, squirreltail may increase in the understory depending on the grazing management. Heavy spring grazing will favor an increase in sagebrush. Annual non-native species may be stable or increasing within the understory.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community. Bitterbrush, ephedra, rabbitbrush, and spiny hopsage may be sprouting and may become the dominant shrubs in this phase. Big sagebrush is killed by fire and is reduced within the burned community, but may be present in unburned patches. Thurber's needlegrass can experience

high mortality from fire and may be reduced in the community for several years. With low fire severity, Thurber's needlegrass and basin wildrye may dominate the site post-fire. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Gravelly Coarse Loamy (R026XF004CA) Phase 2.2 P. Novak-Echenique, July 2017

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Absence of disturbance over time allows for the sagebrush to recover may be combined with grazing management that favors shrubs.

Community Phase Pathway 2.2b, from Phase 2.2 to 2.4:
Higher than normal spring precipitation favors annual non-native species such as cheatgrass. Non-native annual species will increase in production and density throughout the site. Perennial bunchgrasses may also increase in production.

Community Phase 2.3 (At Risk):
Big sagebrush increases in the absence of disturbance. Thurber's needlegrass and other perennial grasses reduced. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from herbivory. Squirreltail will likely increase in the understory and may be the dominant grass on the site. Pinyon and/or juniper may be increasing. Annual non-native species are present. This phase may be at risk of transitioning to the Shrub State 3.0 or the Tree State 5.0.


Shallow Loam 10-12" (026XY015NV) Phase 2.3 P. Novak-Echenique, April 2015


Loamy 10-12" (R026XY010NV) Phase 2.3 T.K. Stringham, August 2015


Granitic Loam 10-12" (R026XY103NV) Phase 2.3 T.K. Stringham, May 2017

Community Phase Pathway 2.3a, from Phase 2.3 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fuel loads. A fire following an unusually wet spring or a change in management may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.1:
Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Other disturbances/practices include brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

Community Phase Pathway 2.3c, from Phase 2.3 to 2.4:
Fall, winter, and spring precipitation and temperatures mediate the ability for annual grasses and perennial grasses to germinate and/or survive. Higher than normal spring precipitation creates high annual production of annual grasses (Bradley et al. 2016). Non-native annual species increase in production and density throughout the site. Perennial bunchgrasses may also increase in production.

Community Phase 2.4 (At Risk):
This community is at risk of crossing into an annual state. Native bunchgrasses dominate; however, annual non-native species such as cheatgrass may be sub or co-dominant in the understory. Annual production and abundance of these annuals may increase drastically in years with heavy spring precipitation. Seeded species may be present. Sagebrush may be present if coming from phase 2.3. This site is susceptible to further degradation from grazing, drought, and fire. Pinyon and/or juniper may be present.

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Shallow Loam 10-12 (R026XY015NV) Phase 2.4 T.K. Stringham, April 2016

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Loamy Hill 10-12" (R026XY017NV) Phase 2.4 D. Snyder, August 2016

Community Phase Pathway 2.4a, from phase 2.4 to 2.3:
Rainfall patterns favoring perennial bunchgrasses. Less than normal spring precipitation followed by higher-than-normal summer precipitation will increase perennial bunchgrass production.

Community Phase Pathway 2.4b, from phase 2.4 to 2.2:
Fall, winter, and spring precipitation and temperatures mediate the ability for annual grasses and perennial grasses to germinate and/or survive. Depending on temperatures and precipitation in winter and spring, annual grass production may be reduced in favor of perennial bunchgrasses.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during growing season would favor shrubs and initiate transition to Community Phase 3.1. Fire would cause a transition to Community Phase 3.2.

Slow variables: Long term decrease in deep-rooted perennial grass density resulting in a decrease in organic matter inputs and subsequent soil water decline.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and redistribution, and reduces soil organic matter.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Fire or a failed range seeding leads to plant community phase 4.1. Inappropriate grazing management that favors shrubs in the presence of non-native annual species leads to community phase 4.2.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Cheatgrass or other non-native annuals dominate understory.

T2C: Transition from Current Potential State 2.0 to Tree State 5.0:

Trigger: Lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management that reduces the perennial grass understory.

Slow variables: Increased establishment and cover of juniper/pinyon trees, reduction in organic matter inputs.

Threshold: Trees overtop big sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

Shrub State 3.0:

This state has two community phases; a big sagebrush dominated phase and a sprouting shrub dominated phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Squirreltail will increase with a reduction in deep rooted perennial bunchgrass competition and become the dominant grass. Sagebrush dominates the overstory and sprouting shrubs may be a significant component. Sagebrush canopy cover is high and sagebrush may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and squirreltail and Sandberg bluegrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1 (At Risk):
Big sagebrush dominates overstory. Thurber's needlegrass and other perennial grasses are reduced, with squirreltail and bluegrass species dominant in the understory. Pinyon and juniper may be present. Annual non-native species may be present. Bare ground may be significant. Seeded species may be present. Pinyon and/or juniper may be present or increasing.

Loamy 10-12" (R026XY010NV) Phase 3.1 T.K. Stringham, April 2016

Deep Ashy (R026XF005CA) Phase 3.1 P. Novak-Echenique, July 2017

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire would decrease or eliminate the overstory of sagebrush. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to squirreltail, bluegrasses, perennial forbs and sprouting shrubs. Heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, would greatly reduce the overstory shrubs and allow for squirreltail and bluegrasses to dominate the site.

Granitic Slope 10-12" (R026XY026NV) Phase 3.1 T.K. Stringham, May 2015

Community Phase 3.2 (At Risk):
Squirreltail and bluegrass species dominate the understory. Sprouting shrubs may be present**.** Perennial grasses trace or missing**.** Annual non-native species dominate understory. Bare ground may be significant. Seeded species may be present.

Granitic Loam 10-12" (R026XY103NV) Phase 3.2, P. Novak-Echenique, August 2016

Granitic Slope 10-12" (R026XY026NV) Phase 3.2, T.K. Stringham, May 2017

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Absence of disturbance over time would allow for sagebrush and other shrubs to recover.

T3A: Transition from Shrub State 3.0 to Annual State 4.0:

Trigger: Fire or inappropriate grazing management can eliminate the squirreltail and Sandberg bluegrass understory and transition to community phase 4.1 or 4.2.

Slow variable: Increased seed production and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

T3B: Transition from Shrub State 3.0 to Tree State 5.0:

Trigger: Lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management that reduces perennial grass understory.

Slow variables: Increased establishment and cover of juniper/pinyon trees, reduction in organic matter inputs.

Threshold: Trees overtop big sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

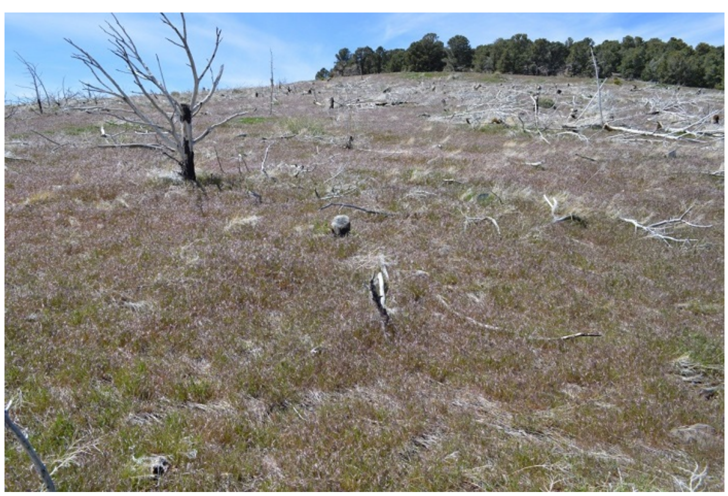
R3A: Restoration from Shrub State 3.0 to Seeded State 6.0:

Brush management, herbicide, and seeding of crested wheatgrass (*Agropyron cristatum*) and/or other desired species.

Annual State 4.0:

This state has two community phases; one dominated by annual non-native species and the other is a shrub dominated state. This state is characterized by the dominance of annual non-native species such as cheatgrass in the understory. Sagebrush and/or sprouting shrubs may dominate the overstory. Ecological dynamics are significantly altered in this state. Annual non-native species create a highly combustible fuel bed that shortens the fire return interval. Nutrient cycling is spatially and temporally truncated as annual plants contribute significantly less to deep soil carbon. Because this is a productive site, some deep-rooted perennial grasses may remain, even in the annual state. Without management, it is unlikely these plants will be able to recruit in the presence of dominant annual grasses.

Community Phase 4.1:
Annual non-native plants such as cheatgrass dominate the site. Perennial plants are a minor component or missing from the site. This phase may have seeded species present if resulting from a failed seeding attempt.



Loamy 10-12" (R026XY010NV) Annual State T.K. Stringham, May 2016

Shallow South Slope 10-14" (R026XF070CA) Annual State P. Novak-Echenique, September 2017

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Time and lack of disturbance allows for shrubs to reestablish. Sprouting shrubs such as ephedra, desert peach and rabbitbrush will be the first to reappear after fire. Probability of sagebrush establishment is extremely low.

Community Phase 4.2:
Annual non-native species dominate understory. Sagebrush or sprouting shrubs dominate the overstory. Perennial bunchgrasses are a minor component. This phase may have seeded species present if resulting from a failed seeding attempt.

Granitic Slope 10-12" (R026XY026NV) Phase 4.2 T.K. Stringham, May 2015


Granitic Slope 10-12" (R026XY026NV) Annual State T.K. Stringham, May 2016


Granitic Loam 10-12" (R026XY103NV) Annual State T.K. Stringham, April 2017

Community Phase Pathway 4.2a, from Phase 4.2 to 4.1:
Fire reduces sprouting shrubs and allows for annual non-native species to dominate the site.

R4A: Restoration from Annual State 4.0 to Seeded State 6.0:

Application of herbicide and seeding of desired species. Probability of success is best immediately following fire.

Tree State 5.0:

This state has two community phases that are characterized by the dominance of Utah juniper and/or singleleaf pinyon in the overstory. Big sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients, soil organic matter distribution and nutrient cycling have been spatially and temporally altered.

Community Phase 5.1:

Utah juniper and/or singleleaf pinyon dominate overstory. Big sagebrush is subdominant and may be decadent. Thurber's needlegrass and other perennial grasses are reduced. Annual non-native may be present. Bare ground areas are large and connected.

Deep Ashy (R026XF005CA) Tree State P. Novak-Echenique, July 2017

Loamy 10-12" (026XY010NV) Tree State P. Novak-Echenique, May 2015

Community Phase Pathway 5.1a, from Phase 5.1 to 5.2:
Absence of disturbance over time allows for tree cover and density to further increase and out-compete the herbaceous understory species.

Community Phase 5.2 (At Risk):
Utah juniper and/or singleleaf pinyon dominates the site and tree leader growth is minimal; annual non-native species may be the dominant understory species and will typically be found under the tree canopies. Trace amounts of sagebrush may be present, but dead shrub skeletons will be more numerous than living sagebrush. Bunchgrasses may or may not be present. Bottlebrush squirreltail or mat forming forbs may be present in trace amounts. Bare ground interspaces are large and connected. Soil redistribution is evident.

Granitic Slope 10-12 (026XY026NV) Tree State P. Novak-Echenique, May 2015

Shallow Loam 10-12” (026XY015NV) Tree State P. Novak-Echenique, April 2015

Community Phase Pathway 5.2a, from phase 5.2 to 5.1:
Manual or mechanical thinning of trees allows understory regrowth due to less competition for resources. This treatment is typically done for fuel management.

T5A: Transition from Tree State 5.0 to Annual State 4.0:

Trigger: Catastrophic crown fire would reduce or eliminate trees to transition the site to 4.1. Tree removal when annual non-natives such as cheatgrass are present would also transition the site to state 4.0.

Slow variable: Increased seed production and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

R5A: Restoration from Tree State 5.0 to Shrub State 3.0:

Tree removal with no seeding. Treatments done in phase 5.1 will be more successful. Tree removal practices that minimize soil disturbance are recommended. Probability of success declines with increased presence of nonnative annual species.

R5B: Restoration from Tree State 5.0 to Seeded State 6.0:

Tree removal and seeding of desired species. Tree removal practices that minimize soil disturbance are recommended. Probability of success declines with increased presence of nonnative annual species.

Seeded State 6.0:

This state has three community phases; a grass-dominated phase, and grass-shrub dominated phase, and a shrub dominated phase. This state is characterized by the dominance of seeded introduced wheatgrass species in the understory and other desired seeded species including Wyoming big sagebrush, native and non-native forbs.

Community Phase 6.1:
Seeded wheatgrass and/or other seeded species dominate the community. Non-native annual species are present. Trace amounts of big sagebrush may be present, especially if seeded.

Loamy 10-12” (R026XY010NV) Seeded State T.K. Stringham, June 2016

Granitic Fan 10-12" (R026XY008NV) Seeded State P. Novak-Echenique, May 2017

Community Phase Pathway 6.1a, from Phase 6.1 to 6.2:
Time and lack of disturbance allow shrubs to increase. Pathway may be coupled with inappropriate grazing management.

Community Phase 6.2:
Big sagebrush increases and may be codominant with seeded wheatgrass species. Annual non-native species may be present in trace amounts.

Granitic Slope 10-12" (R026XY026NV) Seeded State T.K. Stringham, May 2015

Shallow Loam 10-12" (R026XY015NV) Seeded State P. Novak-Echenique, April 2016

Community Phase Pathway 6.2a, from Phase 6.2 to 6.1:
Fire and/or brush management allows seeded grasses to return to dominance.

Community Phase Pathway 6.2b, from Phase 6.2 to 6.3:
Inappropriate grazing reduces bunchgrasses and increases density of sagebrush. This is usually a slow transition.

Community Phase 6.3:
Sagebrush and/or sprouting shrubs dominate. Seeded wheatgrass species decrease. Annual non-native species may be present. Pinyon and /or juniper may be present.

Granitic Slope 10-12" (R026XY026NV) Phase 6.3, T.K. Stringham May 2016

Community Phase Pathway 6.3a, from Phase 6.3 to 6.1:
Fire or brush management with minimal soil disturbance.

Potential Resilience Differences in other Ecological Sites

Loamy Hill 10-12" (R026XY017NV):

This site occurs in similar landscapes as the modal site at lower elevations from 4,500 to 6,500 feet. It also has a similar vegetation community but with more Utah juniper. The soils of this site are shallow to moderately deep and well drained. Available water capacity is low as well as rooting depth. The soil contains high amounts of rock fragments at the surface and throughout the profile. Production is lower than the modal site at 600 lbs/ac in a normal year.

Granitic Fan 10-12" (R026XY008NV):

This site occurs on piedmont slopes that border mountains and foothills of granitic parent material. Slopes generally range from 4 to 15 percent. Elevations are 4,500 to 5,500 feet. This site has a similar vegetation community but with needleandthread as the dominant grass. The soils on this site are very deep, excessively drained and have low to very low water holding capacity. The coarse textured soil surface horizon allows for rapid intake of moisture and loss to evaporation. Deep percolating moisture is available to deep-rooted plants. The droughty surface layer limits seedling establishment. The soils are highly susceptible to water erosion when vegetative cover is removed.

Granitic South Slope 10-12" (R026XY018NV):

This site occurs on foothills and lower mountain slopes and is most common found on south-facing sideslopes. Slopes typically range from 30 to 50 percent. Elevations are 5,000 to 6,000 feet. This site has a similar vegetation community as the modal site but with desert needlegrass as the dominant grass and antelope bitterbrush as the dominant shrub with Wyoming big sagebrush as the subdominant shrub. The soils on this site are shallow to weathered granitic bedrock. They are excessively drained and available water capacity is very low. A shallow rooting depth and excessive drainage are the most limiting factors in the restoration of this site. Production is lower than the modal site with 600 lbs/ac in a normal year.

Granitic Slope 10-12" (R026XY026NV):

This site occurs on foothills and lower mountain sideslopes on all aspects. Slopes typically range from 30 to 50 percent. Elevations are 4,500 to 6,500 feet. The vegetation community is similar to the modal site. The soils on this site are moderately deep to deep and somewhat excessively drained. The available water capacity is low. Susceptibility to sheet and rill erosion is severe. The production of this site is lower than the modal site with 600 lbs/ac in a normal year.

Shallow Loam 10-12" (R026XY015NV):

This site occurs on upper pediment slopes, hills and lower mountain sideslopes. Slopes typically range from 15 to 30 percent. Elevations are 5,000 to 6,000 feet. This site has a similar vegetation community as the modal site but with desert needlegrass as the dominant grass. The soils in this site are shallow, well drained and have a very low available water capacity. Inherent soil fertility is high, but because of the shallow rooting depth, productivity and plant density are reduced. Surface gravel, cobbles or stones provide a stabilizing effect on surface erosion. This site has 500 lbs/ac of production in a normal year.

Stony Slope 10-12" (R026XY100NV):

This site is similar to the modal site, with similar dominant shrubs, grasses, and annual production. It may have muttongrass (*Poa fendleriana*) in the understory. Boulders, stones, and cobbles may cover a significant amount of the soil surface and reduce production and density of plants.

Granitic Loam 10-12" (R026XY103NV):

This site occurs on alluvial fans and fan remnants. Slopes range from 8 to 15 percent and elevations are 4,800 to 6,000 feet. This site has a similar vegetation community compared to the modal site, but has desert needlegrass as the dominant grass. The soils on this site are deep, well drained and formed from mixed igneous rocks. The available water capacity is very low and the soil profile is modified with rock fragments. The moisture regime is aridic that borders on xeric. The soils have a mollic epipedon and susceptible to moderate sheet and rill erosion.

Gravelly Coarse Loamy (R026XF004CA)

The vegetation community is similar to the modal site but with Indian ricegrass and needleandthread as the dominant grasses. This site has deep ashy soils, making it more productive than the modal site with 900 lbs/ac in normal years.

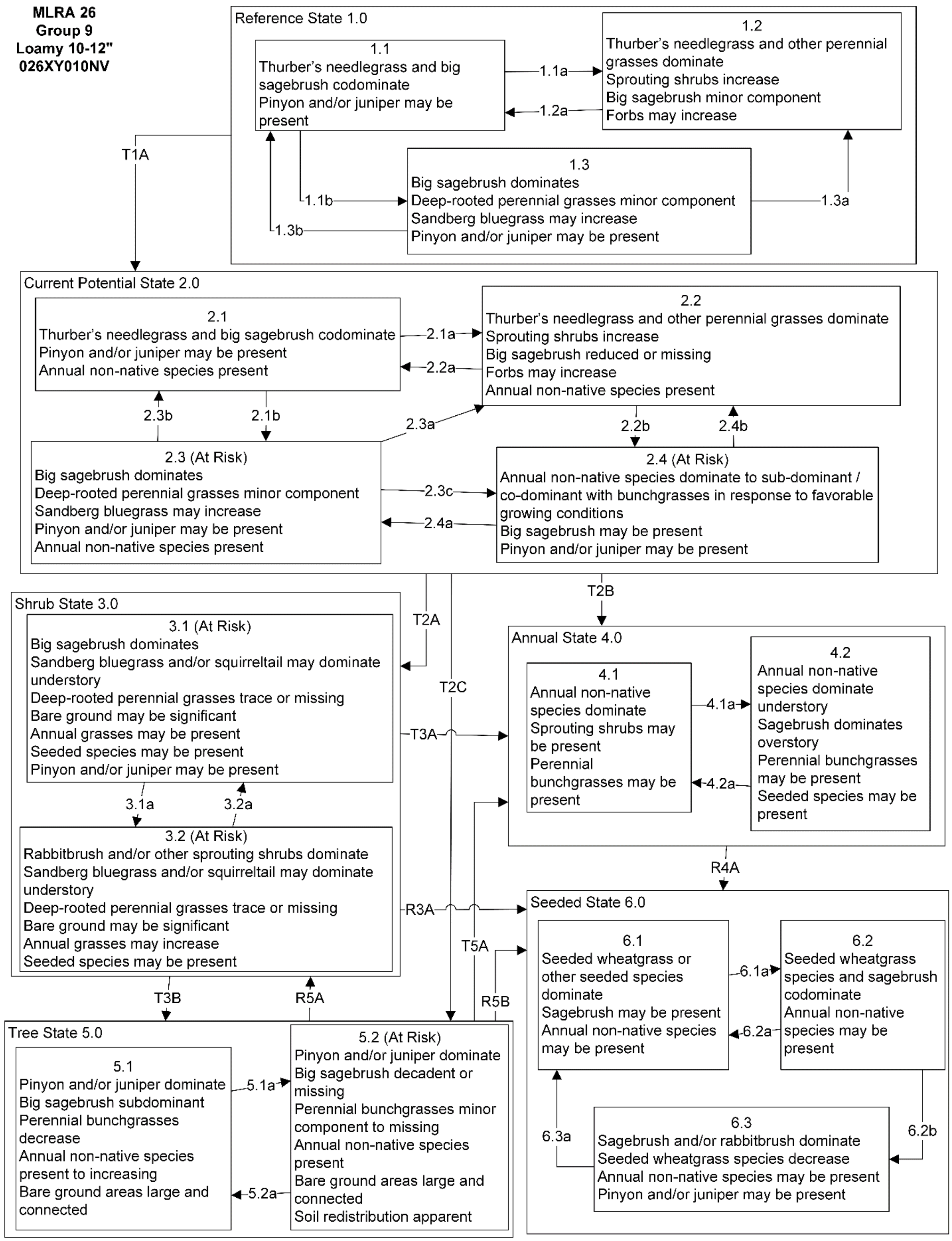
Shallow South Slope 10-14" (R026XF070CA)

This site occurs on upper pediment slopes, hills, and mountains. Slopes typically range from 15 to 30 percent. Elevations are 5,000 to 7,500 feet. The vegetation community is similar to the modal site but with desert needlegrass as the dominant grass and a significant component of bitterbrush in the overstory. This site is generally dominated by mountain big sagebrush only. This site has shallow soils and is much less productive than the modal site with only 450 lbs/ac in a normal year.

Shallow Loam 10-14" (R026XF069CA)

This site occurs on hills and lower mountain sideslopes. Slopes typically range from 15 to 30 percent. Elevations are 4,800 to 7,500 feet. The vegetation community is similar to the modal site but is generally dominated by mountain big sagebrush only. This site has shallow to moderately deep soils and is much less productive than the modal site with only 450 lbs/ac in a normal year.

Modal State and Transition Model for Group 9 in MLRA 26


MLRA 26
Group 9
Loamy 10-12"
026XY010NV
Reference State 1.0
1.1
Thurber's needlegrass and big sagebrush codominate
Pinyon and/or juniper may be present
1.2
Thurber's needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush minor component
Forbs may increase
1.3
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
1.1a
1.2a
1.1b
1.3b
1.3a
T1A
Current Potential State 2.0
2.1
Thurber's needlegrass and big sagebrush codominate
Pinyon and/or juniper may be present
Annual non-native species present
2.2
Thurber's needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush reduced or missing
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species dominate to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.3b
2.1b
2.3a
2.2b
2.4b
2.3c
2.4a
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Big sagebrush dominates
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may be present
Seeded species may be present
Pinyon and/or juniper may be present
3.2 (At Risk)
Rabbitbrush and/or other sprouting shrubs dominate
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may increase
Seeded species may be present
3.1a
3.2a
T3A
R3A
T3B
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2
Annual non-native species dominate understory
Sagebrush dominates overstory
Perennial bunchgrasses may be present
Seeded species may be present
4.1a
4.2a
R4A
Seeded State 6.0
6.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
6.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
6.3
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species may be present
Pinyon and/or juniper may be present
6.1a
6.2a
6.2b
6.3a
T5A
R5A
R5B
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush subdominant
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.2 (At Risk)
Pinyon and/or juniper dominate
Big sagebrush decadent or missing
Perennial bunchgrasses minor component to missing
Annual non-native species present
Bare ground areas large and connected
Soil redistribution apparent
5.1a
5.2a

MLRA 26
Group 9
Loamy 10-12"
026XY010NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

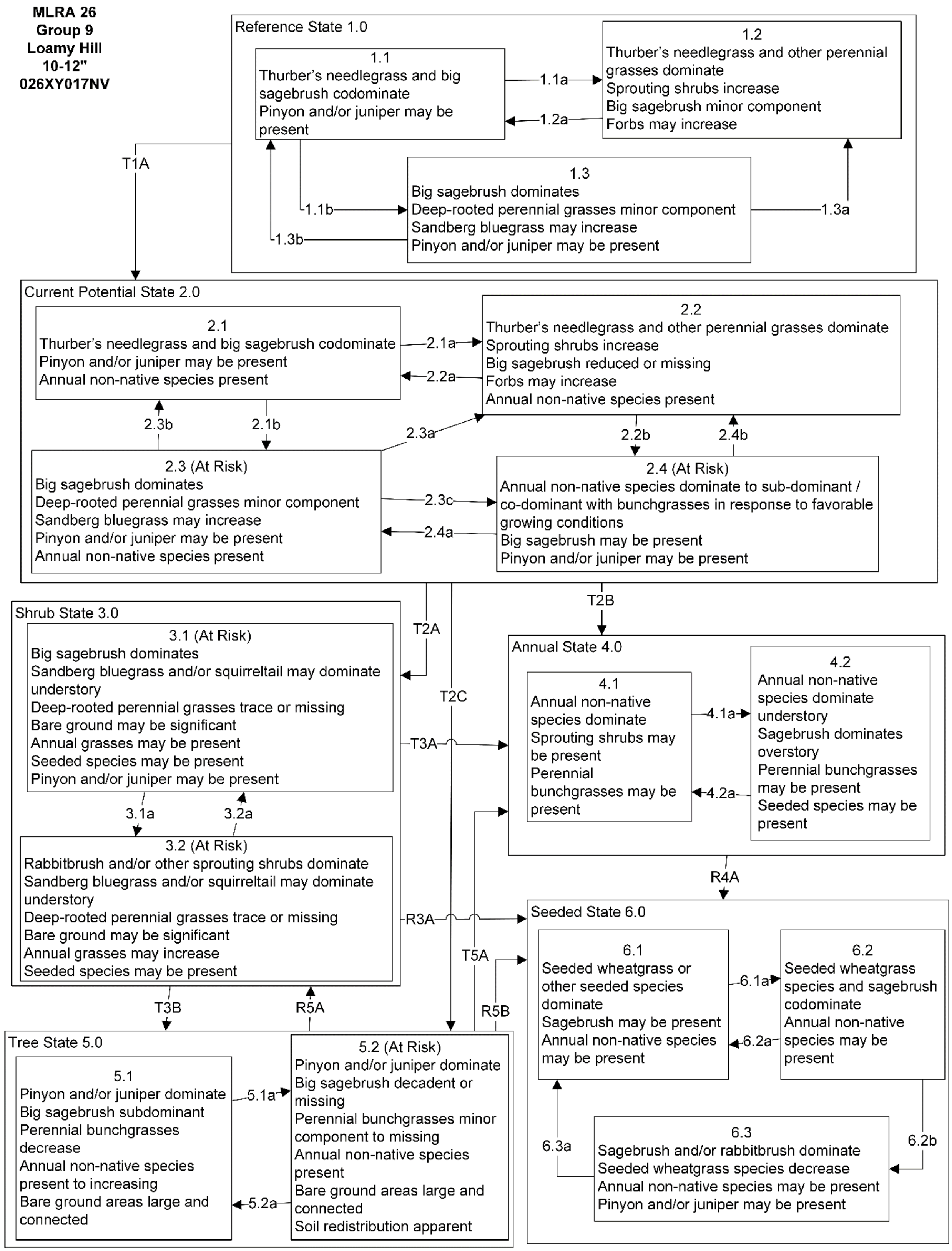
Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.

Additional State and Transition Model for Group 9 in MLRA 26



MLRA 26
Group 9
Loamy Hill
10-12"
026XY017NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

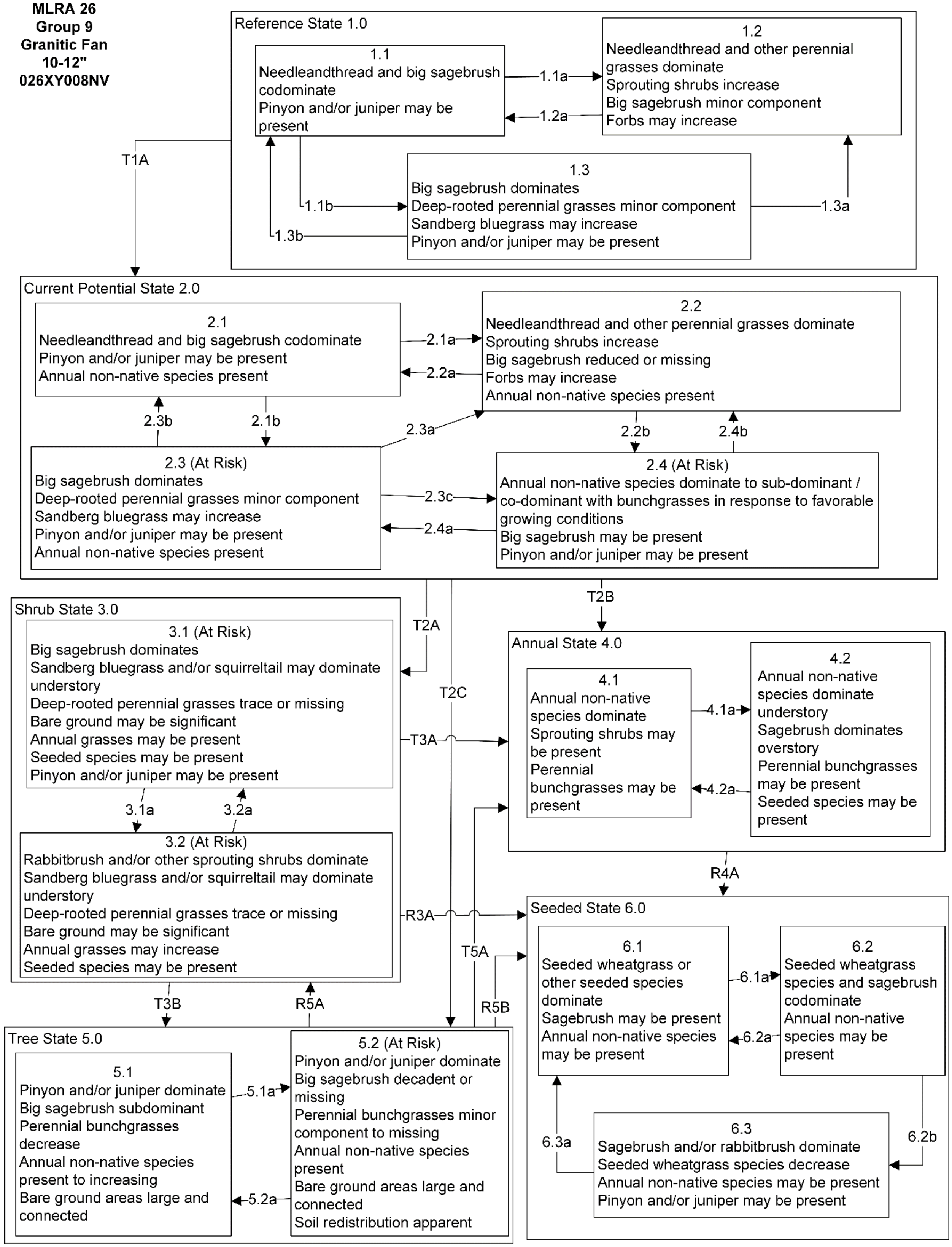
Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.

MLRA 26
Group 9
Granitic Fan
10-12"
026XY008NV



MLRA 26
Group 9
Granitic Fan
10-12"
026XY008NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

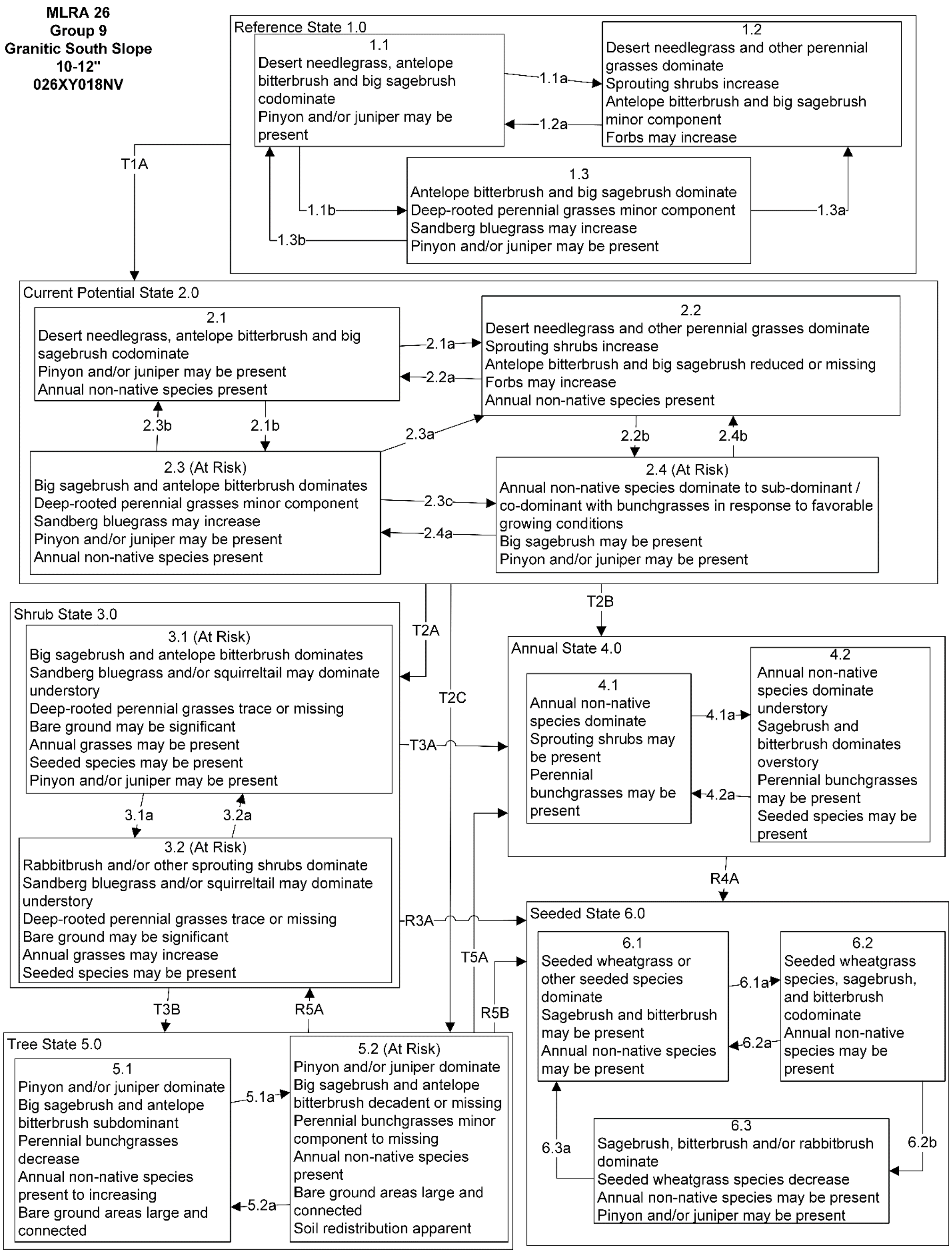
Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.


MLRA 26
Group 9
Granitic South Slope
10-12"
026XY018NV
Reference State 1.0
1.1
Desert needlegrass, antelope bitterbrush and big sagebrush codominate
Pinyon and/or juniper may be present
1.2
Desert needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Antelope bitterbrush and big sagebrush minor component
Forbs may increase
1.3
Antelope bitterbrush and big sagebrush dominate
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
1.1a
1.2a
1.1b
1.3b
1.3a
T1A
Current Potential State 2.0
2.1
Desert needlegrass, antelope bitterbrush and big sagebrush codominate
Pinyon and/or juniper may be present
Annual non-native species present
2.2
Desert needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Antelope bitterbrush and big sagebrush reduced or missing
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Big sagebrush and antelope bitterbrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species dominate to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.3b
2.1b
2.3a
2.2b
2.4b
2.3c
2.4a
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Big sagebrush and antelope bitterbrush dominates
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may be present
Seeded species may be present
Pinyon and/or juniper may be present
3.1a
3.2a
3.2 (At Risk)
Rabbitbrush and/or other sprouting shrubs dominate
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may increase
Seeded species may be present
T3A
R3A
T3B
R5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2
Annual non-native species dominate understory
Sagebrush and bitterbrush dominates overstory
Perennial bunchgrasses may be present
Seeded species may be present
4.1a
4.2a
R4A
T5A
R5B
Seeded State 6.0
6.1
Seeded wheatgrass or other seeded species dominate
Sagebrush and bitterbrush may be present
Annual non-native species may be present
6.2
Seeded wheatgrass species, sagebrush, and bitterbrush codominate
Annual non-native species may be present
6.3
Sagebrush, bitterbrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species may be present
Pinyon and/or juniper may be present
6.1a
6.2a
6.2b
6.3a
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush and antelope bitterbrush subdominant
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.2 (At Risk)
Pinyon and/or juniper dominate
Big sagebrush and antelope bitterbrush decadent or missing
Perennial bunchgrasses minor component to missing
Annual non-native species present
Bare ground areas large and connected
Soil redistribution apparent
5.1a
5.2a

MLRA 26
Group 9
Granitic South Slope
10-12"
026XY008NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

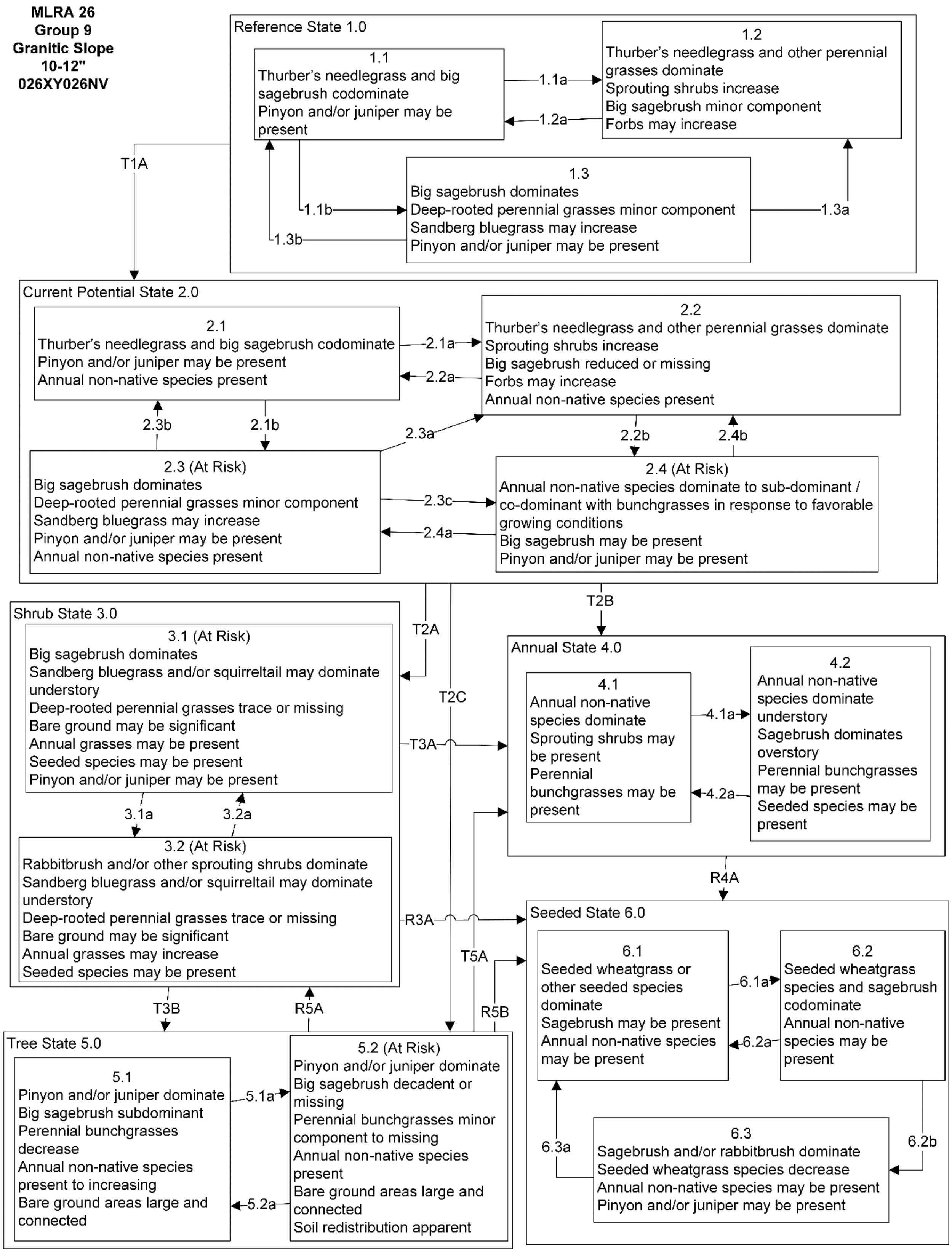
Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.


MLRA 26
Group 9
Granitic Slope
10-12"
026XY026NV
Reference State 1.0
1.1
Thurber's needlegrass and big sagebrush codominate
Pinyon and/or juniper may be present
1.1a
1.2a
1.2
Thurber's needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush minor component
Forbs may increase
1.3
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
1.1b
1.3b
1.3a
T1A
Current Potential State 2.0
2.1
Thurber's needlegrass and big sagebrush codominate
Pinyon and/or juniper may be present
Annual non-native species present
2.1a
2.2a
2.2
Thurber's needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush reduced or missing
Forbs may increase
Annual non-native species present
2.3b
2.1b
2.3a
2.2b
2.4b
2.3 (At Risk)
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.3c
2.4a
2.4 (At Risk)
Annual non-native species dominate to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Pinyon and/or juniper may be present
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Big sagebrush dominates
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may be present
Seeded species may be present
Pinyon and/or juniper may be present
T3A
3.1a
3.2a
3.2 (At Risk)
Rabbitbrush and/or other sprouting shrubs dominate
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may increase
Seeded species may be present
R3A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.1a
4.2a
4.2
Annual non-native species dominate understory
Sagebrush dominates overstory
Perennial bunchgrasses may be present
Seeded species may be present
R4A
Seeded State 6.0
6.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
6.1a
6.2a
6.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
6.3a
6.2b
6.3
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species may be present
Pinyon and/or juniper may be present
T5A
R5B
T3B
R5A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush subdominant
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Big sagebrush decadent or missing
Perennial bunchgrasses minor component to missing
Annual non-native species present
Bare ground areas large and connected
Soil redistribution apparent

MLRA 26
Group 9
Granitic Slope
10-12"
026XY026NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

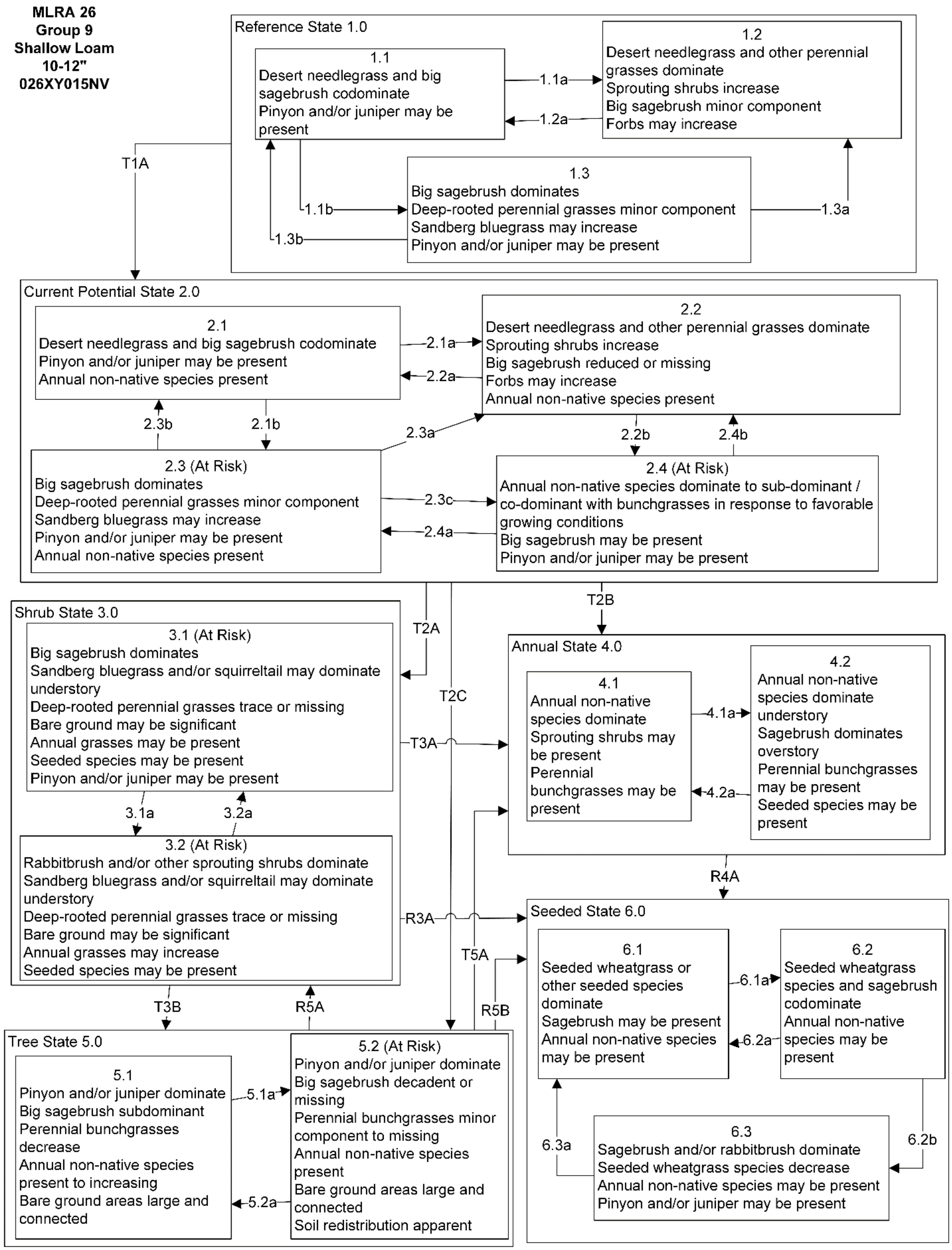
Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.


MLRA 26
Group 9
Shallow Loam
10-12"
026XY015NV
Reference State 1.0
1.1
Desert needlegrass and big sagebrush codominate
Pinyon and/or juniper may be present
1.1a
1.2a
1.2
Desert needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush minor component
Forbs may increase
T1A
1.3
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
1.1b
1.3b
1.3a
Current Potential State 2.0
2.1
Desert needlegrass and big sagebrush codominate
Pinyon and/or juniper may be present
Annual non-native species present
2.1a
2.2a
2.2
Desert needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush reduced or missing
Forbs may increase
Annual non-native species present
2.3b
2.1b
2.3a
2.2b
2.4b
2.3 (At Risk)
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.3c
2.4a
2.4 (At Risk)
Annual non-native species dominate to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Pinyon and/or juniper may be present
T2B
Shrub State 3.0
3.1 (At Risk)
Big sagebrush dominates
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may be present
Seeded species may be present
Pinyon and/or juniper may be present
T2A
T2C
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.1a
4.2a
4.2
Annual non-native species dominate understory
Sagebrush dominates overstory
Perennial bunchgrasses may be present
Seeded species may be present
3.1a
3.2a
3.2 (At Risk)
Rabbitbrush and/or other sprouting shrubs dominate
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may increase
Seeded species may be present
R3A
R4A
Seeded State 6.0
6.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
6.1a
6.2a
6.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
T5A
R5B
T3B
R5A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush subdominant
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Big sagebrush decadent or missing
Perennial bunchgrasses minor component to missing
Annual non-native species present
Bare ground areas large and connected
Soil redistribution apparent
6.3a
6.2b
6.3
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species may be present
Pinyon and/or juniper may be present

MLRA 26
Group 9
Shallow Loam
10-12"
026XY015NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

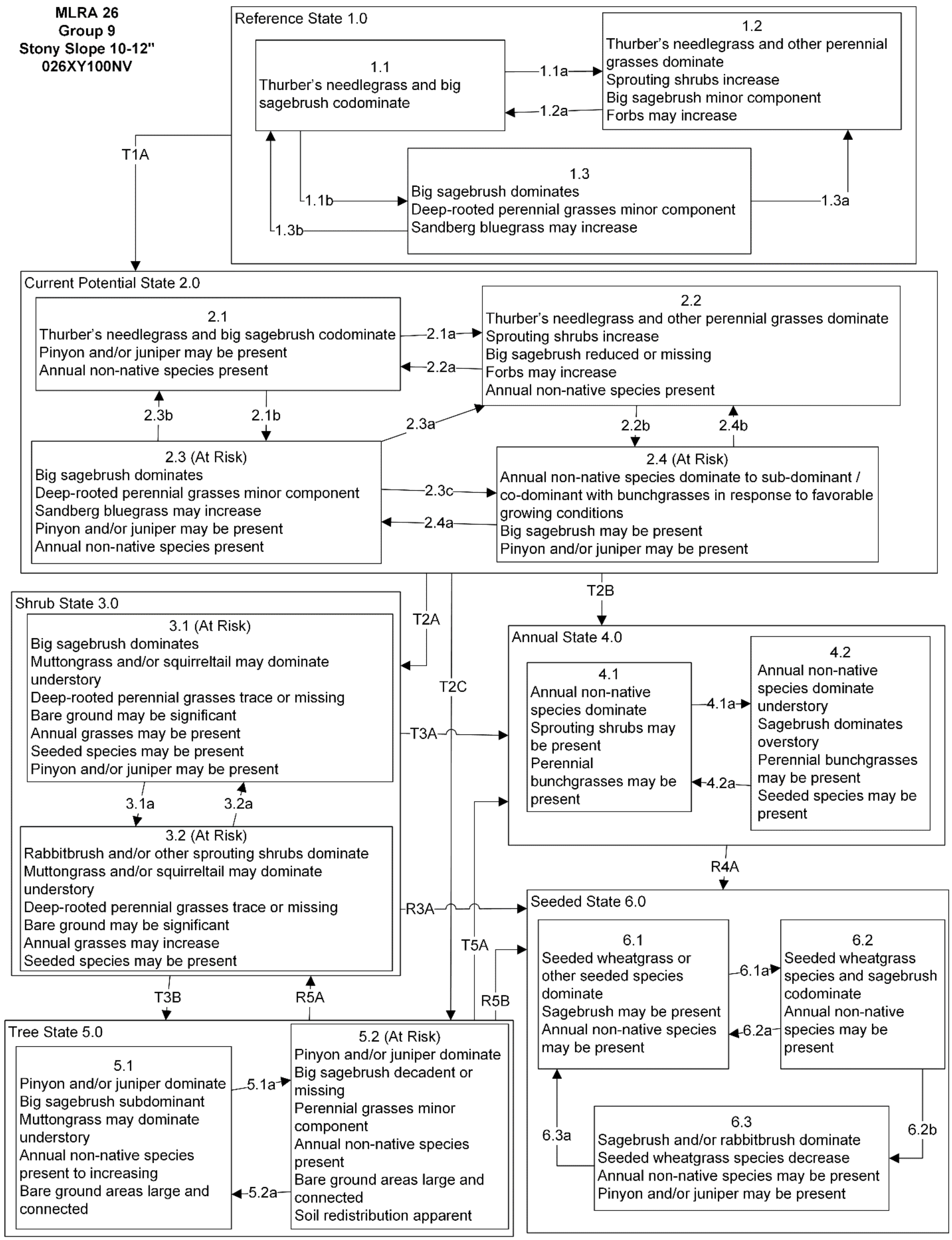
Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.

MLRA 26
Group 9
Stony Slope 10-12"
026XY100NV



MLRA 26
Group 9
Stony Slope 10-12"
026XY100NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

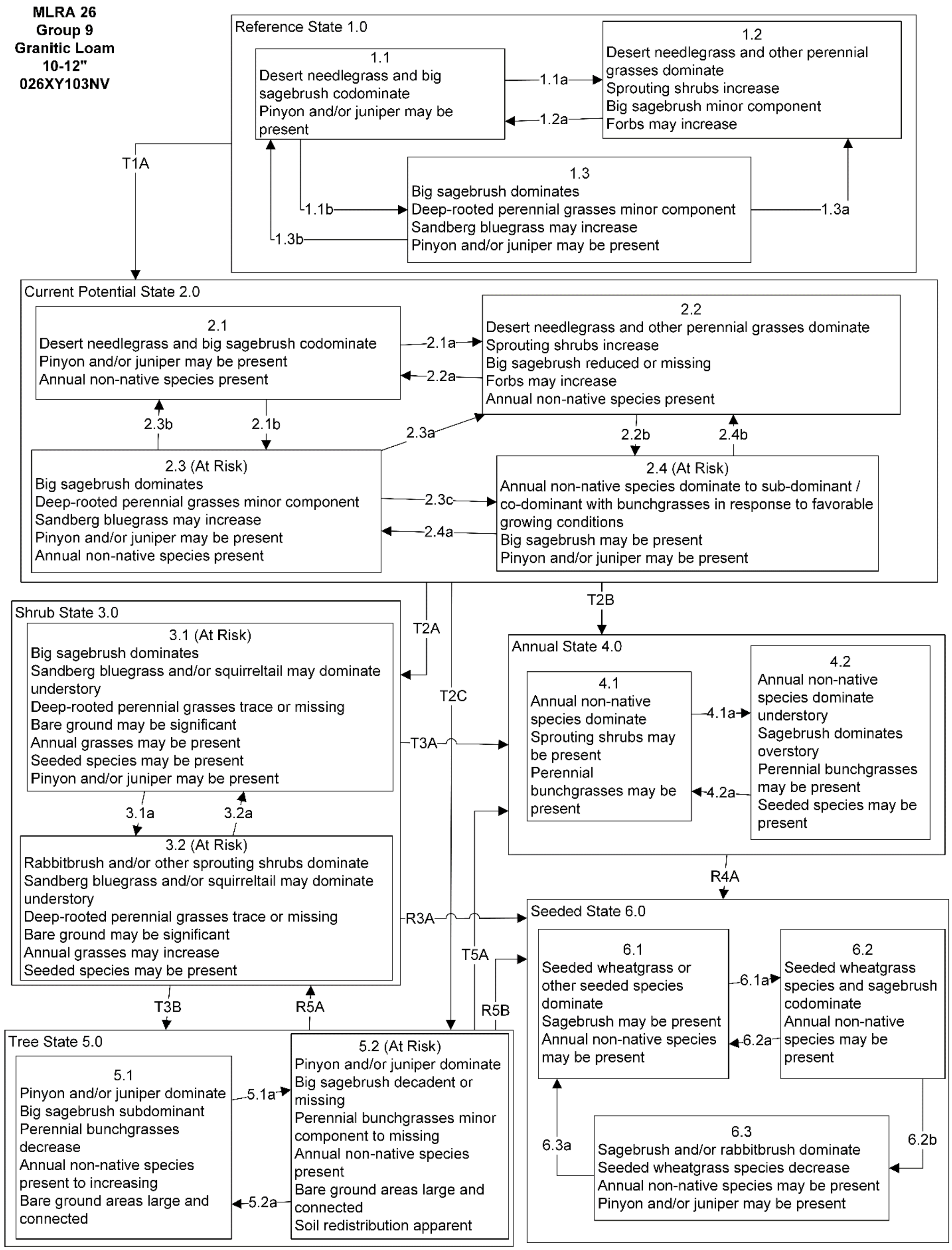
Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.


MLRA 26
Group 9
Granitic Loam
10-12"
026XY103NV
Reference State 1.0
1.1
Desert needlegrass and big sagebrush codominate
Pinyon and/or juniper may be present
1.1a
1.2a
1.2
Desert needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush minor component
Forbs may increase
T1A
1.1b
1.3b
1.3
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
1.3a
Current Potential State 2.0
2.1
Desert needlegrass and big sagebrush codominate
Pinyon and/or juniper may be present
Annual non-native species present
2.1a
2.2a
2.2
Desert needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush reduced or missing
Forbs may increase
Annual non-native species present
2.3b
2.1b
2.3a
2.2b
2.4b
2.3 (At Risk)
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.3c
2.4a
2.4 (At Risk)
Annual non-native species dominate to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Pinyon and/or juniper may be present
T2B
Shrub State 3.0
T2A
3.1 (At Risk)
Big sagebrush dominates
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may be present
Seeded species may be present
Pinyon and/or juniper may be present
T2C
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.1a
4.2a
4.2
Annual non-native species dominate understory
Sagebrush dominates overstory
Perennial bunchgrasses may be present
Seeded species may be present
3.1a
3.2a
3.2 (At Risk)
Rabbitbrush and/or other sprouting shrubs dominate
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may increase
Seeded species may be present
R3A
R4A
Seeded State 6.0
T5A
6.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
6.1a
6.2a
6.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
T3B
R5A
R5B
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush subdominant
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Big sagebrush decadent or missing
Perennial bunchgrasses minor component to missing
Annual non-native species present
Bare ground areas large and connected
Soil redistribution apparent
6.3a
6.3
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species may be present
Pinyon and/or juniper may be present
6.2b

MLRA 26
Group 9
Granitic Loam
10-12"
026XY103NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

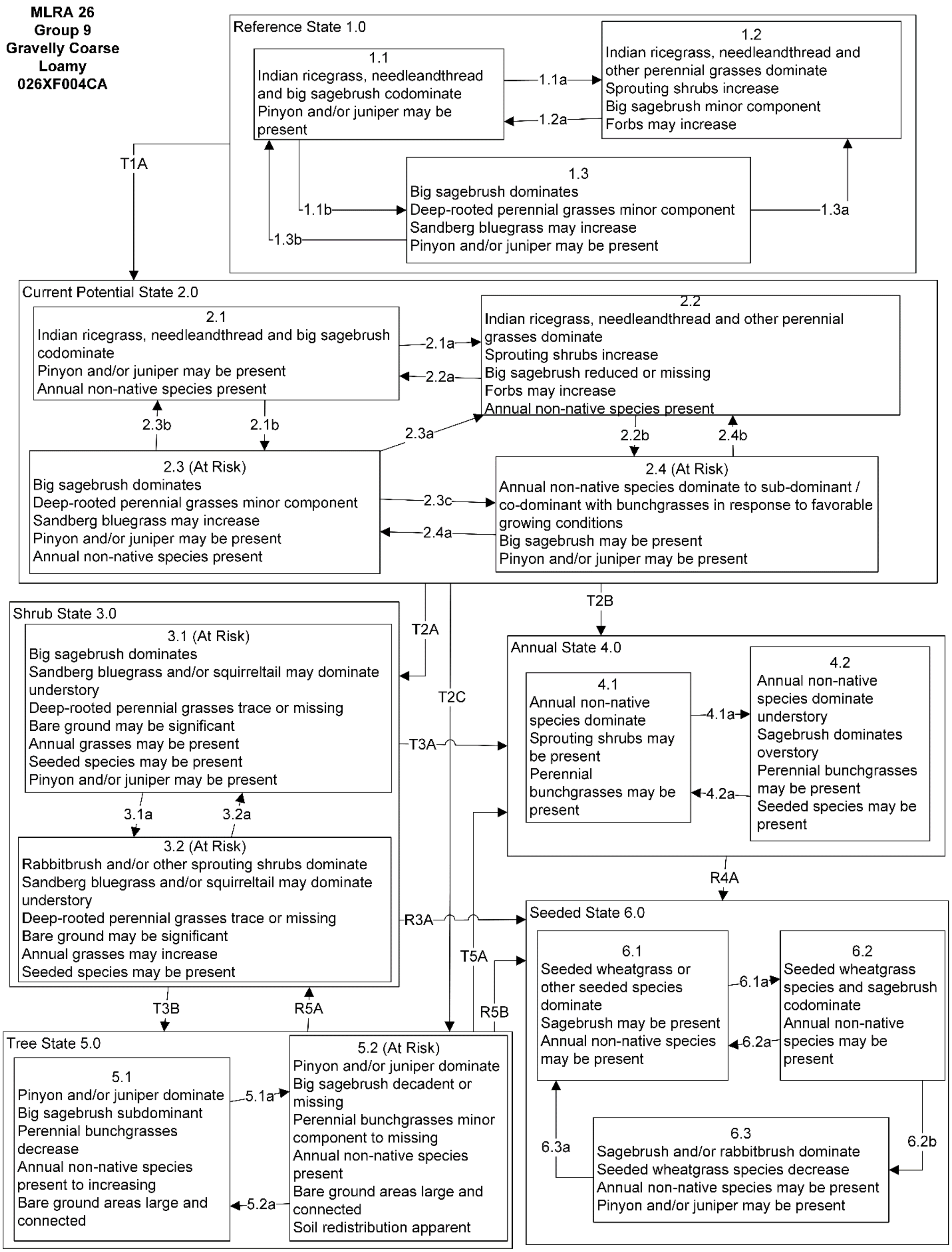
Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.


MLRA 26
Group 9
Gravelly Coarse
Loamy
026XF004CA
Reference State 1.0
1.1
Indian ricegrass, needleandthread and big sagebrush codominate
Pinyon and/or juniper may be present
1.2
Indian ricegrass, needleandthread and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush minor component
Forbs may increase
1.3
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
1.1a
1.2a
1.1b
1.3b
1.3a
T1A
Current Potential State 2.0
2.1
Indian ricegrass, needleandthread and big sagebrush codominate
Pinyon and/or juniper may be present
Annual non-native species present
2.2
Indian ricegrass, needleandthread and other perennial grasses dominate
Sprouting shrubs increase
Big sagebrush reduced or missing
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species dominate to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.3b
2.1b
2.3a
2.2b
2.4b
2.3c
2.4a
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Big sagebrush dominates
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may be present
Seeded species may be present
Pinyon and/or juniper may be present
3.1a
3.2a
3.2 (At Risk)
Rabbitbrush and/or other sprouting shrubs dominate
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may increase
Seeded species may be present
T3A
R3A
T3B
R5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2
Annual non-native species dominate understory
Sagebrush dominates overstory
Perennial bunchgrasses may be present
Seeded species may be present
4.1a
4.2a
R4A
Seeded State 6.0
6.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
6.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
6.3
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species may be present
Pinyon and/or juniper may be present
6.1a
6.2a
6.2b
6.3a
T5A
R5B
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush subdominant
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.2 (At Risk)
Pinyon and/or juniper dominate
Big sagebrush decadent or missing
Perennial bunchgrasses minor component to missing
Annual non-native species present
Bare ground areas large and connected
Soil redistribution apparent
5.1a
5.2a

MLRA 26
Group 9
Gravelly Coarse Loamy
026XF004CA
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

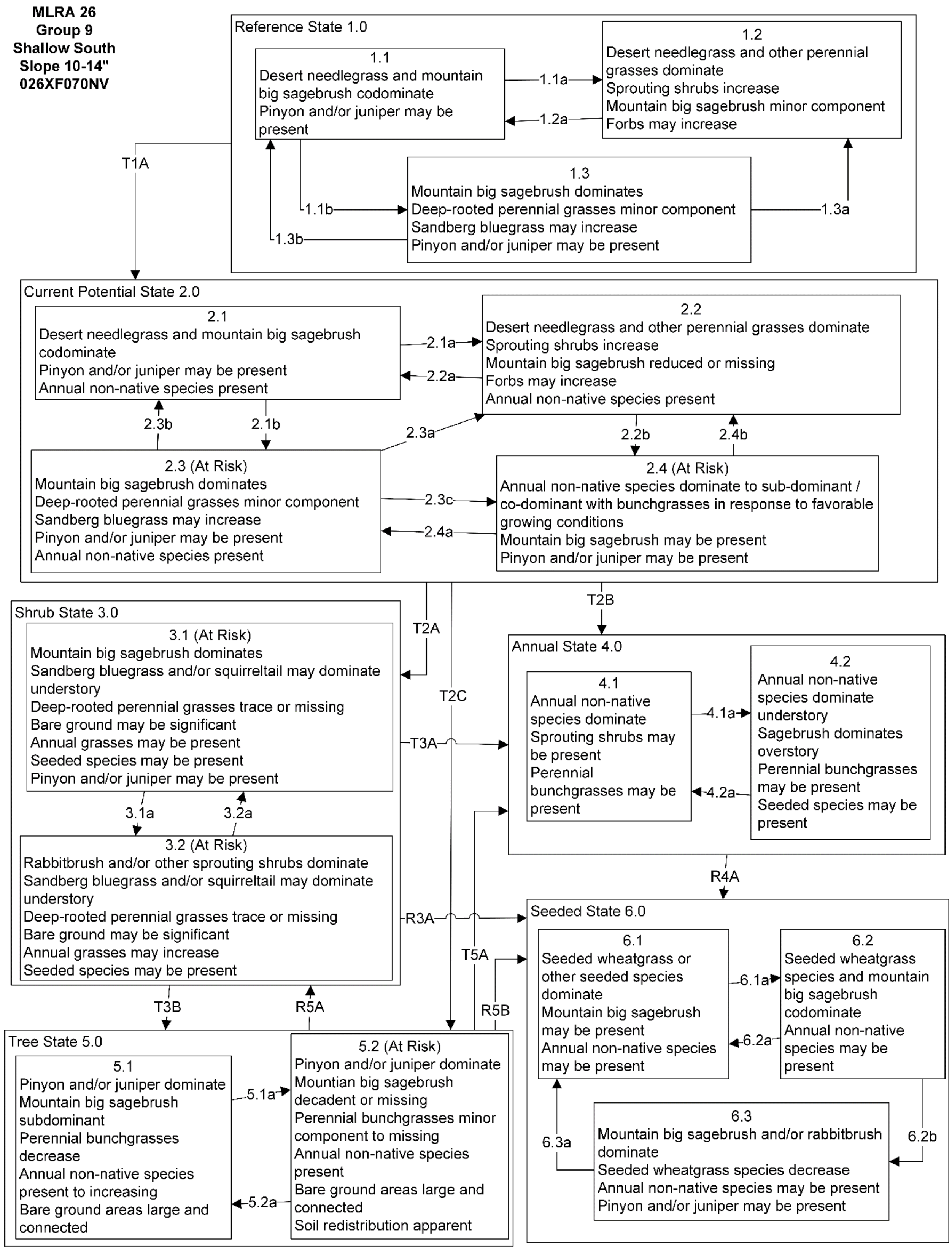
Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.


MLRA 26
Group 9
Shallow South
Slope 10-14"
026XF070NV
Reference State 1.0
1.1
Desert needlegrass and mountain big sagebrush codominate
Pinyon and/or juniper may be present
1.2
Desert needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Mountain big sagebrush minor component
Forbs may increase
1.3
Mountain big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
1.1a
1.2a
1.1b
1.3b
1.3a
T1A
Current Potential State 2.0
2.1
Desert needlegrass and mountain big sagebrush codominate
Pinyon and/or juniper may be present
Annual non-native species present
2.2
Desert needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Mountain big sagebrush reduced or missing
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Mountain big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species dominate to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Mountain big sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.3b
2.1b
2.3a
2.2b
2.4b
2.3c
2.4a
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may be present
Seeded species may be present
Pinyon and/or juniper may be present
3.2 (At Risk)
Rabbitbrush and/or other sprouting shrubs dominate
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may increase
Seeded species may be present
3.1a
3.2a
T3A
R3A
T3B
R5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2
Annual non-native species dominate understory
Sagebrush dominates overstory
Perennial bunchgrasses may be present
Seeded species may be present
4.1a
4.2a
R4A
T5A
R5B
Seeded State 6.0
6.1
Seeded wheatgrass or other seeded species dominate
Mountain big sagebrush may be present
Annual non-native species may be present
6.2
Seeded wheatgrass species and mountain big sagebrush codominate
Annual non-native species may be present
6.3
Mountain big sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species may be present
Pinyon and/or juniper may be present
6.1a
6.2a
6.3a
6.2b
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Mountain big sagebrush subdominant
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.2 (At Risk)
Pinyon and/or juniper dominate
Mountian big sagebrush decadent or missing
Perennial bunchgrasses minor component to missing
Annual non-native species present
Bare ground areas large and connected
Soil redistribution apparent
5.1a
5.2a

MLRA 26
Group 9
Shallow South Slope 10-14"
026XF070CA
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

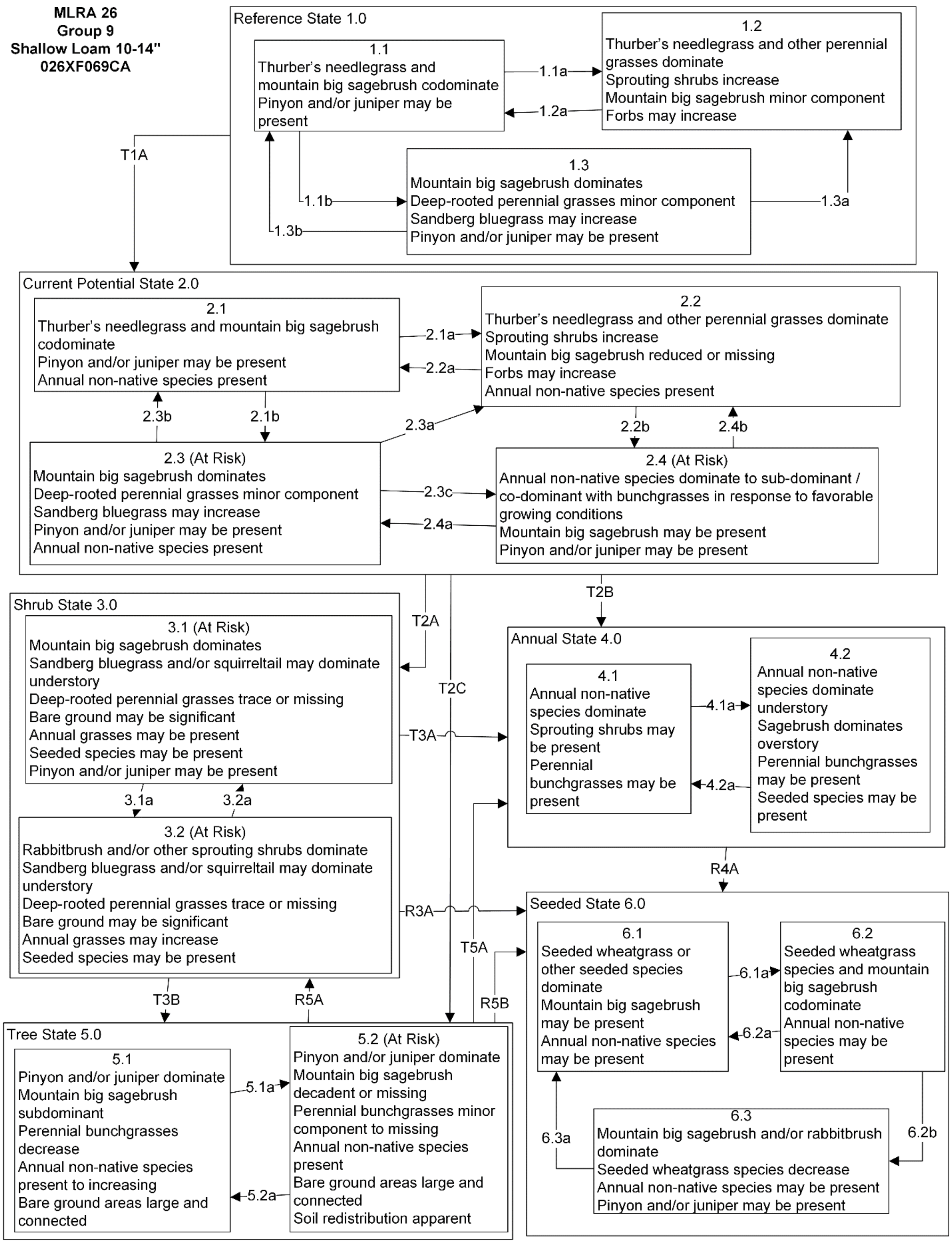
Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.


MLRA 26
Group 9
Shallow Loam 10-14"
026XF069CA
Reference State 1.0
1.1
Thurber's needlegrass and mountain big sagebrush codominate
Pinyon and/or juniper may be present
1.2
Thurber's needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Mountain big sagebrush minor component
Forbs may increase
1.3
Mountain big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Thurber's needlegrass and mountain big sagebrush codominate
Pinyon and/or juniper may be present
Annual non-native species present
2.2
Thurber's needlegrass and other perennial grasses dominate
Sprouting shrubs increase
Mountain big sagebrush reduced or missing
Forbs may increase
Annual non-native species present
2.3 (At Risk)
Mountain big sagebrush dominates
Deep-rooted perennial grasses minor component
Sandberg bluegrass may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species dominate to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Mountain big sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.3b
2.1b
2.3a
2.2b
2.4b
2.3c
2.4a
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may be present
Seeded species may be present
Pinyon and/or juniper may be present
3.2 (At Risk)
Rabbitbrush and/or other sprouting shrubs dominate
Sandberg bluegrass and/or squirreltail may dominate understory
Deep-rooted perennial grasses trace or missing
Bare ground may be significant
Annual grasses may increase
Seeded species may be present
3.1a
3.2a
T3A
R3A
T3B
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2
Annual non-native species dominate understory
Sagebrush dominates overstory
Perennial bunchgrasses may be present
Seeded species may be present
4.1a
4.2a
R4A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Mountain big sagebrush subdominant
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
5.2 (At Risk)
Pinyon and/or juniper dominate
Mountain big sagebrush decadent or missing
Perennial bunchgrasses minor component to missing
Annual non-native species present
Bare ground areas large and connected
Soil redistribution apparent
5.1a
5.2a
R5A
T5A
R5B
Seeded State 6.0
6.1
Seeded wheatgrass or other seeded species dominate
Mountain big sagebrush may be present
Annual non-native species may be present
6.2
Seeded wheatgrass species and mountain big sagebrush codominate
Annual non-native species may be present
6.3
Mountain big sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species may be present
Pinyon and/or juniper may be present
6.1a
6.2a
6.3a
6.2b

MLRA 26
Group 9
Shallow Loam 10-14"
026XF069CA
Key

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community.
1.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover leading to early or mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (to 3.1), or fire, if coming from phase 2.3 or 2.4 (to 3.2).
Transition T2B: Severe fire and/or multiple fires, or brush management causing severe soil disturbance.
Transition T2C: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Shrub State 3.0 Community Phase Pathways
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire or multiple fires, and/or treatments that disturb the existing plant community (to 4.1). Transition to 4.2 caused by continued inappropriate grazing management in the presence of annual grasses.
Transition T3B: Time and lack of fire allows pinyon and/or juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

Tree State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire (to 4.1).

Restoration R5A: Tree removal with no seeding from Phase 5.1.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways
6.1a: Time and lack of disturbance, coupled with repeated spring grazing allows shrubs to regenerate.
6.2a: Fire and/or brush management allows seeded grasses to return to dominance.
6.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
6.3a: Fire or brush treatment with minimal soil disturbance.

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MLRA 26 Group 10: Sandy soils with diverse shrubs and a needlegrass understory

Description of MRLA 26 Disturbance Response Group 10

Disturbance Response Group (DRG) 10 consists of six ecological sites. The precipitation zone for these sites ranges from 8 to 12 inches. The elevation range of this group is 3,900 to 7,300 feet with the majority falling between 3,900 and 5,500 feet. Slopes range from 0 to 30 percent, however slopes less than 10 percent are most typical. Soils on these sites range from moderately deep to very deep with available water capacity ranging from very low to moderate. These soils are typically sandy and exhibit rapid intake and deep percolation. These conditions permit deep-rooted plants. Moisture loss from evaporation and runoff is negligible, but these soils are susceptible to wind erosion when vegetation is removed. Annual production in a normal year ranges from 600 to 1000 lbs/ac for the group. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is primarily dominated by Wyoming big sagebrush (*Artemisia tridentata* ssp*. wyomingensis*) and basin big sagebrush (*Artemisia tridentata* ssp*. tridentata*). These sites are characterized by a diverse community of other shrubs, including spiny hopsage (*Grayia spinosa)*, fourwing saltbush (*Atriplex canescens*), Antelope bitterbrush (*Purshia tridentata),* desert peach (*Prunus andersonii*), and ephedra (*Ephedra* spp.). The understory is dominated by deep-rooted perennial bunchgrasses, primarily Indian ricegrass (*Achnatherum hymenoides*) and needleandthread grass (*Hesperostipa comata*). Basin wildrye (*Leymus cinereus*) is an important component of some sites.

Disturbance Response Group 10 Ecological Sites:

Sandy 8-10" Modal Site	R026XY020NV
Dune 10-12"	R026XY014NV
Sandy Plain	R026XY096NV
Deep Ashy 10-12”	R026XF005CA

Modal Site:

The Sandy 8-10” ecological site is the modal for this group as it has the most acres mapped in this MLRA. This site occurs on sand sheets covering piedmont slopes in depositional positions of low hills. Slope generally ranges from 0 to 15 percent. Elevations are 4,000 to 5,500 feet. Average annual precipitation is 8 to 10 inches. The soils of this site are moderately deep to deep and are excessively drained. The available water capacity is very low. Due to rapid intake and deep percolation of precipitation, moisture loss from evaporation and runoff is negligible. These conditions permit deep rooted plants to grow vigorously under arid conditions. The soils are highly susceptible to erosion by wind if the vegetative cover is removed. The plant community is dominated by needleandthread (*Hesperostipa comata*) grass and a mix of Wyoming and basin big sagebrush (*Artemisia tridentata ssp. wyomingensis* and *ssp. tridentata*). Fourwing saltbush, ephedra (*Ephedra* spp.), Anderson’s peachbrush (*Prunus andersonii*), spiny hopsage and desert needlegrass are other important species associated with this site. Total annual production ranges from 400 to 900 lbs/ac, with 600 lbs/ac in normal years.

Ecological Dynamics and Disturbance Response

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by deep-rooted cool season perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m (Dobrowolski et al. 1990). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The dominant perennial bunchgrass is needleandthread grass. This species generally has a somewhat shallower root system than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition or can increase resource pools by the decomposition of dead plant material following disturbance. The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007). Variability in plant community composition and production depends on soil surface texture and depth. The amount of sagebrush in the plant community is dependent upon disturbances like fire, Aroga moth (*Aroga websteri*) infestations, wildfire, and grazing.

Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historic precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks especially a sagebrush defoliator, Aroga moth. Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and have been ongoing in Nevada since 2004 (Bentz, et al 2008). Thousands of acres of big sagebrush have been impacted, with partial to complete die-off observed. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975).

The perennial bunchgrasses that dominate this group are Indian ricegrass, needleandthread grass, and basin wildrye. Other species are present in smaller amounts. Indian ricegrass is a deep-rooted cool season perennial bunchgrass that is adapted primarily to sandy soils. Needleandthread is a very drought-tolerant tufted perennial grass that is frequently found on course, well-drained soil.

Perennial bunchgrasses generally have somewhat shallower root systems than the shrubs in this group. Root densities are often as high as or higher than those of shrubs in the upper 0.5 m and taper off more rapidly than shrubs. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Basin wildrye is a large, cool-season perennial bunchgrass with an extensive deep, coarse, fibrous root system (Reynolds and Fraley 1989). Clumps may reach up to six feet in height (Ogle et al 2012b). Basin wildrye does not tolerate long periods of inundation; it prefers cycles of wet winters and dry summers and is most commonly found in deep soils with high water holding capacities or seasonally high water tables (Ogle et al 2012b, Perryman and Skinner 2007). Basin wildrye is weakly rhizomatous and has been found to root to depths of up to 2 meters and exhibits greater lateral root spread than many other grass species (Abbott et al. 1991, Reynolds and Fraley 1989).

Wyoming big sagebrush is the most drought tolerant of the big sagebrushes (Winward 1980). When growing together with Wyoming big sagebrush, basin big sagebrush tends to occupy areas with deeper soil that receives run-on moisture (Barker and McKell 1983, Winward 1980). Both species exist on this site. Big sagebrush is generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings of both subspecies is dependent on adequate moisture conditions.

There is potential for infilling by Utah juniper (*Juniperus osteosperma*) and/or singleleaf pinyon (*Pinus monophylla*) on these sites. Infilling may occur if the site is adjacent to woodland sites or other ecological sites with juniper present. Without disturbance in these areas, pinyon or juniper will eventually dominate the site and out-compete sagebrush for water and sunlight, severely reducing both the shrub and herbaceous understory (Miller and Tausch 2000, Lett and Knapp 2005). The potential for soil erosion increases as the woodland matures and the understory plant community cover declines (Pierson et al. 2010).

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Five possible alternative stable states have been identified for this DRG.

Fire Ecology:

In many basin big sagebrush communities, changes in fire frequency occurred along with fire suppression, livestock grazing, and OHV use. Fire severity in big sagebrush communities is described as "variable" depending on weather, fuels, and topography. However, fire in basin big sagebrush communities are typically stand-replacing (Sapsis and Kauffman 1991). Basin big sagebrush and Wyoming big sagebrush are easily killed by fire and do not sprout after fire. Repeated fires may eliminate the onsite seed source; reinvasion into these areas may be extremely slow (Bunting et al. 1987). Big sagebrush communities historically had low fuel loads, and patchy fires that burned in a mosaic pattern were common at 10 to 70 year return intervals (Young et al. 1983, West and Hassan 1985, Bunting et al. 1987). Davies et al. (2006) suggest fire return intervals in Wyoming big sagebrush communities were around 50 to 100 years. Basin big sagebrush and Wyoming big sagebrush reinvade a site primarily by off-site seed or seed from plants that survive in unburned patches. Approximately 90% of big sagebrush seed is dispersed within 30 feet (9 m) of the parent shrub (Goodrich et al. 1985) with maximum seed dispersal at approximately 108 feet (33 m) from the parent shrub (Shumar and Anderson 1986). Therefore, regeneration of big sagebrush after stand replacing fires is difficult for it is dependent upon the proximity of residual mature plants and favorable moisture conditions (Johnson and Payne 1968, Humphrey 1984). Reestablishment after fire may require 50 to 120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities.

Antelope bitterbrush is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires may allow bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006). Only 1.5% of measured bitterbrush plants sprouted from the root crown in one study (Ziegenhagen and Miller 2009). If cheatgrass is present, bitterbrush seedling success is much lower. The factor that most limits establishment of bitterbrush seedlings is competition for water resources with the invasive species cheatgrass (Clements and Young 2002).

Depending on fire severity, various sprouting shrubs may increase after fire. Yellow rabbitbrush is top-killed by fire, but sprouts vigorously after fire (Kuntz 1982, Akinsoji 1988). As cheatgrass increases, fire frequencies will also increase. If fire occurs more frequently than every 5 years, even sprouting shrubs such as rabbitbrush will not survive (Whisenant 1990).

Spiny hopsage is a shrub that is capable of sprouting after fire (Daubenmire 1970). Spiny hopsage is loses its leaves in the summer, and thus are considered dormant during the time period most likely to experience fire (Rickard and McShane 1994). These shrubs tend to sprout the following spring after a wildfire (Daubenmire 1970), and can produce significant new growth if there is enough moisture available (Shaw 1992). Other environmental conditions also determine the level of re-establishment that occurs, such as the salinity and temperature of soil. Rickard and Spencer recorded post-fire mortality of spiny hopsage in a site where it co-occurred with black greasewood, potentially indicating that the site conditions were sub-optimal for the plant. Simmons and Rickard (2003) also recorded total stand mortality after a fire on the Colombia Plateau. The authors indicated the plants may have been drought-stressed. Spiny hopsage is capable of reproducing by seed, however seedlings do not compete well with annual invasive species and re-colonization of burn scars by seeding has rarely been recorded (Simmons and Rickard 2003, Monsen et al. 2004).

Fourwing saltbush is the most widely distributed shrubby saltbush in North America (Meyer 2003). It is highly variable across landscapes and even within populations (McArthur et al. 1983, Petersen et al. 1987). Its ability to sprout following fire may depend on the population and fire severity. A study by

Parmenter (2008) showed 58% mortality rate of fourwing saltbush following fire in New Mexico, the surviving shrubs produced sprouts shortly after fire.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses, the growing points are located at or below the soil surface, providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983)

Needleandthread is a fine-leaved grass and is considered sensitive to fire due (Miller et al. 2013). It is top-killed by fire but is likely to resprout if fire does not entirely consume aboveground stems (Akinsoji 1988, Bradley et al. 1992). In a study by Wright and Klemmedson (1965), season of burn rather than fire intensity seemed to be the crucial factor in mortality for needle and thread grass. Early spring season burning was found to kill the plants, while August burning had no effect. Thus, under typical wildfire scenarios, needleandthread is often present in the post-burn community.

Indian ricegrass is fairly fire tolerant (Wright 1985), due to its low culm density and below-ground root crowns. Vallentine (1989) cites several studies in the sagebrush zone that classified Indian ricegrass as being slightly damaged from late summer burning. Indian ricegrass has also been found to reestablish on burned sites through seed dispersed from adjacent unburned areas (West 1994, Young, 1983). Thus, the presence of surviving, seed producing plants facilitates the reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

Basin wildrye is relatively resistant to fire, particularly dormant season fire, as plants sprout from surviving root crowns and rhizomes (Zschaechner 1985). Miller et al. (2013) reported increased total shoot and reproductive shoot densities in the first year following fire, although by year two there was little difference between burned and control treatments.

The grass most likely to invade this site is cheatgrass. This invasive grass displaces desirable perennial grasses, reduces livestock forage, and accumulates large fuel loads that foster frequent fires (Davies and Svejcar 2008). Invasion by annual grasses can alter the fire cycle by increasing fire size, fire season length, rate of spread, numbers of individual fires, and likelihood of fires spreading into native or managed ecosystems (D’Antonio and Vitousek 1992, Brooks et al. 2004). Areas dominated with cheatgrass are estimated to have a fire return interval of 3-5 years (Whisenant 1990). The mechanisms by which invasive annual grasses alter fire regimes likely interact with climate. For example, cheatgrass cover and biomass vary with climate (Chambers et al. 2007) and are promoted by wet and warm conditions during the fall and spring. Invasive annual species have been shown able to take advantage of high N availability following fire through higher growth rates and increased seedling establishment relative to native perennial grasses (Monaco et al. 2003).

Conversely, without fire, sagebrush will increase and the potential for encroachment by pinyon and/or juniper also increases. Without fire or changes in management, pinyon and/or juniper will dominate the site and big sagebrush will be severely reduced. The herbaceous understory will also be reduced. The potential for soil erosion increases as the juniper woodland matures and the understory plant community cover declines. Catastrophic wildfire in juniper-controlled sites may lead to an annual weed dominated site.

Livestock/Wildlife Grazing Interpretations:

Big sagebrush is browsed in the winter by native ungulates. Personius et al. (1987) found Wyoming big sagebrush and basin big sagebrush to be intermediately palatable to mule deer when compared to mountain big sagebrush (most palatable) and black sagebrush (least palatable).

Antelope bitterbrush is an important shrub species to a variety of animals, such as domestic livestock, antelope, deer, and elk. Bitterbrush is critical browse for mule deer, as well as domestic livestock, antelope, and elk (Wood et al. 1995). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison 1953).

Spiny hopsage is palatable to livestock, especially sheep, during the spring and early summer (Phillips et al. 1996). However, the shrub goes to seed and loses its leaves in July and August so its usefulness in the fall and winter is limited (Sanderson and Stutz 1992). Two studies showed little to no utilization by sheep during the winter (Harrison and Thatcher 1970, Green et al. 1951). Some scientists are concerned about the longevity of the species. One study showed no change in cover or density when excluded from livestock and wildlife grazing for 10+ years (Rice and Westoby 1978), while another seldom observed seedling establishment (Daubenmire 1970). With poor recruitment rates, some are concerned that with repeated fires and overgrazing, local populations of spiny hopsage may be lost (Simmons and Rickard 2003).

Fourwing saltbush is one of the most important forage shrubs in arid sites. Its importance is due to its abundance, accessibility, size, large volume of forage, evergreen habit, high palatability and nutritive value. The palatability rates from fairly good to good for cattle, and as good for sheep and goats, deer usually relish it as a winter browse (Dayton, 1937). It has similar protein, fat, and carbohydrate levels as alfalfa (*Medicago sativa*) (Catlin, 1925). It is especially valuable as winter forage. It was noted in a study by Otsyina et al. (1982) that sheep readily grazed fourwing saltbush when introduced into a new pasture.

Indian ricegrass is a deep-rooted, cool season perennial bunchgrass that is adapted primarily to coarse textured soils. Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971), however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck et al. 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1965). Cook and Child (1971) found significant reduction in plant cover after seven years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended. In summary, adaptive management is required to manage this bunchgrass well.

Needleandthread is not grazing tolerant and will be one of the first grasses to decrease under heavy grazing pressure (Smoliak et al. 1972, Tueller and Blackburn 1974). Heavy grazing is likely to reduce basal area of these plants (Smoliak et al. 1972).

Reduced bunchgrass vigor or density provides an opportunity for cheatgrass and other invasive species to occupy interspaces, leading to increased fire frequency and potentially an annual plant community. This site is likely to see an increase in shrubs and will have significant bare ground in the interspaces as few native perennial species are able to recolonize the sandy soil surfaces.

Basin wildrye is valuable forage for livestock (Ganskopp et al. 2007) and wildlife, but is intolerant of heavy, repeated, or spring grazing (Krall et al. 1971). Basin wildrye is used often as a winter feed for livestock and wildlife; not only providing roughage above the snow but also cover in the early spring months (Majerus 1992).

State and Transition Model Narrative for Group 10

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 10.

Reference State 1.0 Community Phase Pathways:

The Reference State 1.0 is a representation of the natural range of variability under pristine conditions. The reference state has three general community phases; a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought, and/or insect or disease attack.

Community Phase 1.1:
This community is dominated by needleandthread grass, Indian ricegrass and big sagebrush. Fourwing saltbush, ephedra, and other shrubs are present. Desert needlegrass, basin wildrye, and a variety of perennial and annual forbs are also present in this phase.

Community Phase Pathway 1.1a, from phase 1.1 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Low severity fire creates sagebrush/grass mosaic. High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs. Release from drought may allow needleandthread and Indian ricegrass to increase in production.

Community Phase Pathway 1.1b, from phase 1.1 to 1.3:
Time and lack of disturbance such as fire or drought allows shrubs to become dominant. Excessive herbivory and/or long-term drought may also reduce perennial herbaceous understory.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early seral community. Needleandthread, Indian ricegrass and other perennial grasses dominate. Big sagebrush is a minor component. Forbs and sprouting shrubs may increase.

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Time and lack of disturbance allows sagebrush to reestablish.

Community Phase 1.3:
Big sagebrush increases in the absence of disturbance. Needleandthread, Indian ricegrass and other perennial grasses may be a minor component.

Community Phase Pathway 1.3a, from phase 1.3 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Low severity fire creates sagebrush/grass mosaic. High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community

dominated by grasses and forbs. This pathway may also occur after a severe Aroga moth infestation that significantly reduces live sagebrush cover.

Community Phase Pathway 1.3b, from phase 1.3 to 1.1:
Aroga moth infestation reduces live sagebrush cover and allows grasses to increase in the understory. Release from drought may allow needleandthread and Indian ricegrass to increase in production.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass, mustard (*Descurainia* or *Sisymbrium spp.*), and Russian thistle (*Salsola tragus)*.

Slow variables: Over time the annual non-native plants will increase within the community, decreasing organic matter inputs from deep-rooted perennial bunchgrasses. This leads to reductions in soil water holding capacity.

Threshold: Any amount of introduced non-native species causes an immediate reduction in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0 Community Phase Pathways:

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases as the Reference State. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks reduce ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal. Additionally, the presence of highly flammable annual non-native species reduces State resilience because these species can promote fire where historically fire has been infrequent. This leads to positive feedbacks that further the degradation of the system.

Community Phase 2.1:
This community is dominated by needleandthread grass, Indian ricegrass and big sagebrush. Fourwing saltbush, ephedra, and other shrubs are present. Desert needlegrass, basin wildrye, and a variety of perennial and annual forbs are also present in this phase. Annual non-native species present.

Sandy 8-10” (R026XY020NV) Phase 2.3, T.K. Stringham, July 2015

Community Phase Pathway 2.1a, from phase 2.1 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Low severity fire creates sagebrush/grass mosaic. High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.

Community Phase Pathway 2.1b, from phase 2.1 to 2.3:
Time, long-term drought, grazing management that favors shrubs or combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early seral community. Needleandthread, Indian ricegrass and other perennial grasses dominate. Big sagebrush is a minor component. Forbs and sprouting shrubs may increase. Annual non-native species present.

Community Phase Pathway 2.2a, from phase 2.2 to 2.1:
Absence of disturbance over time allows for the sagebrush to recover. This may be combined with grazing management that favors shrubs.

Community Phase 2.3 (At-Risk):
Big sagebrush dominates and the perennial grasses become a minor component. Pinyon and juniper may be present. Annual non-native species present.

Sandy 8-10" (026XY020NV) Phase 2.3, P. Novak-Echenique, April 2015

Sandy 8-10" (026XY020NV) Phase 2.3, P. Novak-Echenique, April 2015

Dune 10-12" (R026XY014NV) Phase 2.3, P. Novak-Echenique, April 2016

Community Phase Pathway 2.3a, from phase 2.3 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Low severity fire creates sagebrush/grass mosaic. High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs. This pathway may also occur after a severe Aroga moth infestation that significantly reduces live sagebrush cover. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. Annual non-native species are present and may increase in the community.

Community Phase Pathway 2.3b, from phase 2.3 to 2.1:
A change in grazing management that reduces shrubs will allow the perennial bunchgrasses in the understory to dominate. Heavy late-fall or winter grazing may cause mechanical damage and subsequent death to sagebrush, facilitating an increase in the herbaceous understory. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. A low severity fire would decrease the overstory of sagebrush or leave patches of shrubs, and would allow the understory perennial grasses to dominate. This pathway may also occur after a severe Aroga moth infestation that significantly reduces live sagebrush cover. Annual non-native species are present and may increase in the community.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during the growing season would favor shrubs and initiate transition to Community Phase 3.1. Fire would cause a transition to Community Phase 3.2.

Slow variables: Long term decrease in deep-rooted perennial grass density resulting in a decrease in organic matter inputs and subsequent soil water decline.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter.

T2B: Transition from Current Potential State 2.0 to Tree State 4.0:

Trigger: Time and lack of disturbance or management action allows juniper and/or Pinion to dominate. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources Feedbacks and ecological processes: Trees increasingly dominate use of soil water, contributing to reductions in soil water availability to grasses and shrubs. Overtime, grasses and shrubs are outcompeted. Reduced herbaceous and shrub production slows soil organic matter inputs and increases soil erodibility through loss of cover and root structure.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Trees dominate ecological processes and number of shrub skeletons exceed number of live shrubs. Minimal recruitment of new shrub cohorts.

Shrub State 3.0 Community Phase Pathways:

This state has two community phases: a big sagebrush dominated phase and a sprouting shrub dominated phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Shrubs dominate the plant community. If coming from phase 2.3, big sagebrush canopy cover is high and these plants may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. Typically this state has little herbaceous understory and may be experiencing soil movement in the interspaces. The shrub overstory dominates site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1:
Big sagebrush and other shrubs dominate. Needleandthread, Indian ricegrass and other perennial grasses are only present in trace amounts, under shrubs, or may be missing entirely. Pinyon and/or juniper may be present. Annual non-native species may be present.

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire, heavy fall grazing that causes mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance will greatly reduce the overstory shrubs to trace amounts and allow annual forbs and sprouting shrubs to dominate the site.

Dune 10-12” (026XY014NV) Phase 3.1 P. Novak-Echenique, April 2015

Dune 10-12" (R026XY014NV) Shrub State T.K. Stringham, April 2016

Community Phase 3.2:
Sprouting shrubs such as fourwing saltbush, spiny hopsage, ephedra, and desert peach dominate the site. Annual forbs may dominate the understory. Perennial grasses and sagebrush may be a minor component or missing entirely. Bitterbrush may be present. Bare ground may be significant. Annual non-native species may be present.

Deep Ashy (026XF005CA) Phase 3.2, D. Snyder, July 2017

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Time and lack of disturbance allows the shrub component to recover. The establishment of sagebrush can take many years unless aided with restoration efforts.

T3A: Transition from Shrub State 3.0 to Tree State 4.0:

Trigger: Lack of fire allows trees to dominate site. This may be coupled with inappropriate grazing management that reduces fine fuels.

Slow variables: Increased establishment and cover of juniper trees, reduction in organic matter inputs.

Threshold: Trees overtop Wyoming big sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

T3B: Transition from Shrub State 3.0 to Eroded State 5.0:

Trigger: High-intensity fire (from 3.1) kills all non-sprouting shrubs and many sprouting shrubs.

Slow variables: Increased dominance of sagebrush and/or bitterbrush creates extreme woody fuel conditions. Loss of the deep-rooted bunchgrass understory leaves few plants capable of regenerating post-fire, and eliminates the seed bank of these species.

Threshold: Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses truncates energy capture and impacts nutrient cycling and distribution. Large, potentially decadent shrubs dominate the landscape with a closed canopy.

Tree State 4.0 Community Phase Pathway:

This state has two community phases that are characterized by the dominance of Utah juniper and/or singleleaf pinyon in the overstory. Wyoming big sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients, soil organic matter distribution and nutrient cycling have been spatially and temporally altered.

Community Phase 4.1:
Utah juniper and/or singleleaf pinyon dominate the overstory and site resources. Trees are actively growing with noticeable leader growth. Trace amounts of bunchgrasses may be found under tree canopies and in interspaces. Sagebrush is stressed and dying. Annual non-native species are present under tree canopies. Bare ground interspaces are large and connected.

Community Phase Pathway 4.1a, from phase 4.1 to 4.2:
Time and lack of disturbance or management action allows Utah juniper and/or singleleaf pinyon to mature further and dominate site resources.

Community Phase 4.2:
Utah juniper and/or singleleaf pinyon dominate the site and tree leader growth is minimal. Aannual non-native species may be the dominant understory species and will typically be found under the tree canopies. Trace amounts of sagebrush may be present, however, dead shrub skeletons will be more numerous than live sagebrush. Bunchgrasses may or may not be present. Needleandthread or mat forming forbs may be present in trace amounts. Bare ground interspaces are large and connected. Soil redistribution is evident.

Eroded State 5.0:

This state has one community phase. Abiotic factors including soil redistribution, erosion, and soil temperature are primary drivers of ecological condition within this state. Soil moisture, soil nutrients, and soil organic matter distribution and cycling are severely altered due to degraded soil surface conditions. Soil movement inhibits the germination of new seedlings. Regeneration of shrubs is not evident.

Community Phase 5.1:
Vegetation is sparse and bare ground dominates the visual aspect. Plants that tolerate soil movement and may remain, including Indian ricegrass, needleandthread, desert peach, and annual forbs. Russian thistle may be present. Soil deposition is apparent at the bases of plants and may form small dunes. Skeletons of burned shrubs may be present.


Deep Ashy (026XF005CA) Phase 5.1, D. Snyder, July 2017

Potential Resilience Differences with other Ecological Sites

Dune 10-12” (R026XY014NV)

This site is only slightly more productive than the modal site, but the dominant shrub is Antelope bitterbrush. This site occurs on stabilized sand dunes formed on beach terraces and lower piedmont slopes at elevations of 4,000 to 5,000 feet and typical slopes of 4-15 percent. Annual precipitation is higher than the modal site at 10-12 inches a year. Soils are very deep, excessively drained, and coarse in texture.

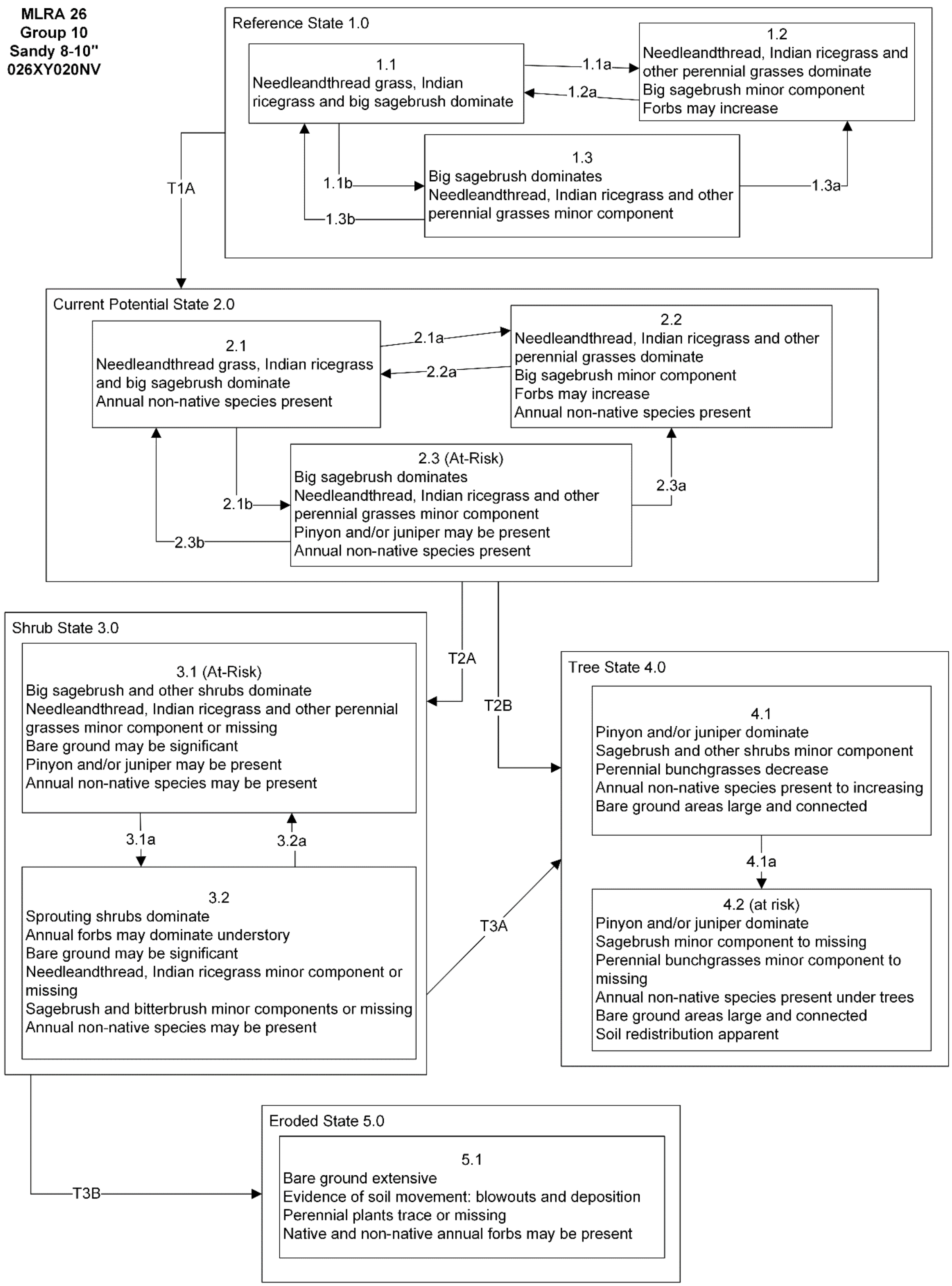
Sandy Plain (R026XY096NV)

This site is very similar to the modal site, however Indian ricegrass and basin wildrye are the dominant understory grasses. This site occurs on sand sheets covering inter-plateau valley fans and plateau toeslopes. Elevation ranges between 4,500 feet and 5,300 feet with typical slopes of 2-8 percent. Soils are moderately deep to deep and well drained. Surface soils are coarse textured and have low water holding capacity.

Deep Ashy 10-12” (R026XF005CA)

This site occurs at higher elevations and has higher annual production than the modal site. It receives more annual precipitation and has a higher soil water holding capacity, largely due to the high ash content in the soil. Antelope bitterbrush is a subdominant shrub in this site. Despite the productivity in this site, the soils are erodible and it has been documented in the Eroded State.

Modal State and Transition Model for Group 10 in MLRA 26:



MLRA 26
Group 10
Sandy 8-10"
026XY020NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early mid-seral community.
1.3b: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Time and lack of disturbance allows maturation of the tree community.

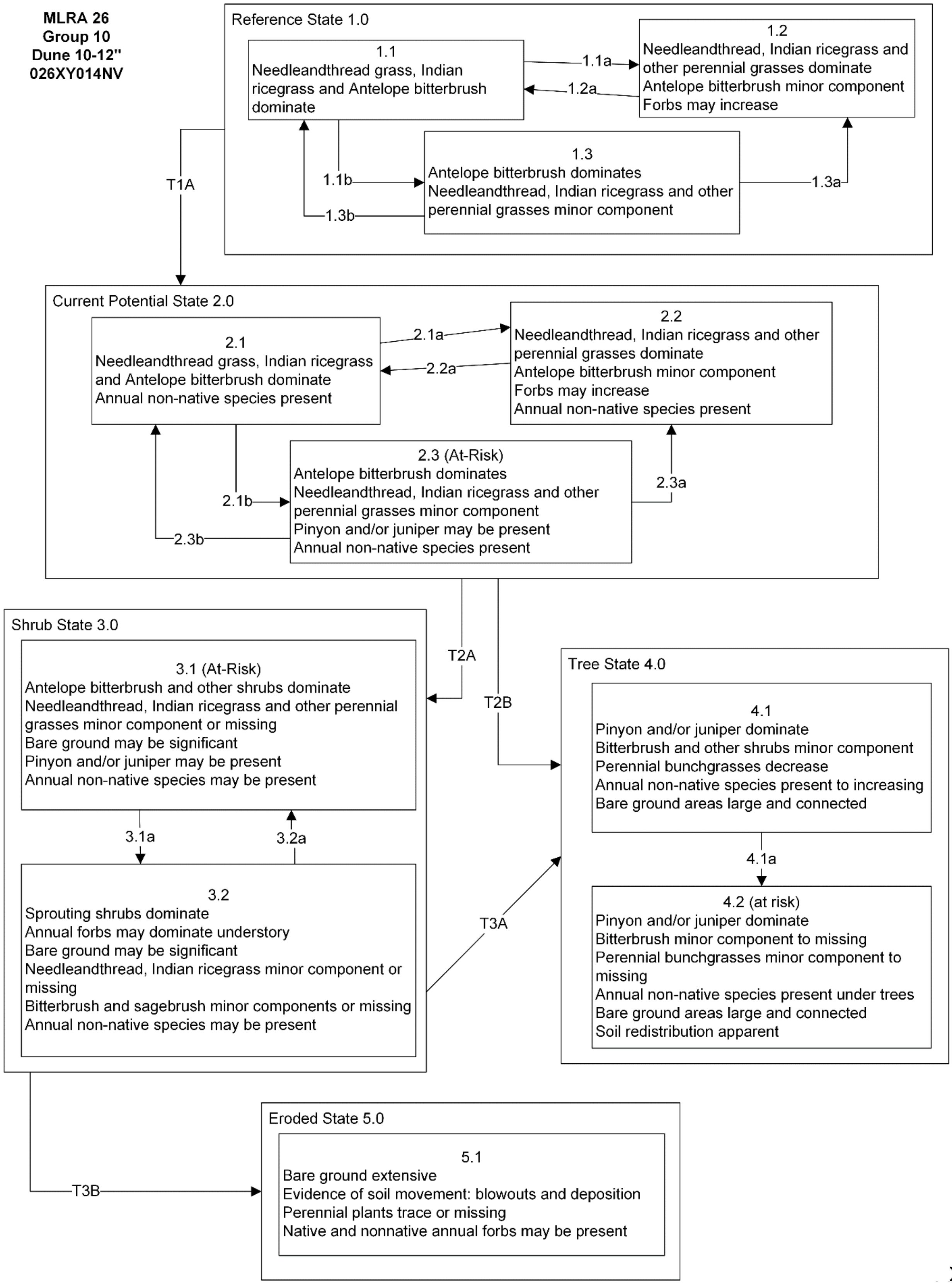
Shrub State 3.0 Community Phase Pathways
3.1a: Fire reduces shrub canopy.
3.2a: Time and lack of disturbance allows for regeneration of sagebrush.

Transition T3A: Time and lack of disturbance allows maturation of the tree community.
Transition T3B: Catastrophic fire in dense shrub cover results in mortality of most perennial plants. Possible from phase 3.1.

Tree State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance allows for maturation of tree community.
4.2a: Tree thinning treatment (typically for fuels management).

Eroded State 5.0 Community Phase Pathways
None.

Additional State and Transition Models for Group 10 in MLRA 26:



MLRA 26
Group 10
Dune 10-12"
026XY014NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces bitterbrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire significantly reduces sagebrush cover leading to early mid-seral community.
1.3b: Low severity fire resulting in a mosaic pattern.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates bitterbrush/grass mosaic; high severity fire significantly reduces bitterbrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of bitterbrush.
2.3a: Low severity fire creates bitterbrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces bitterbrush.
2.3b: Low severity fire resulting in a mosaic pattern.

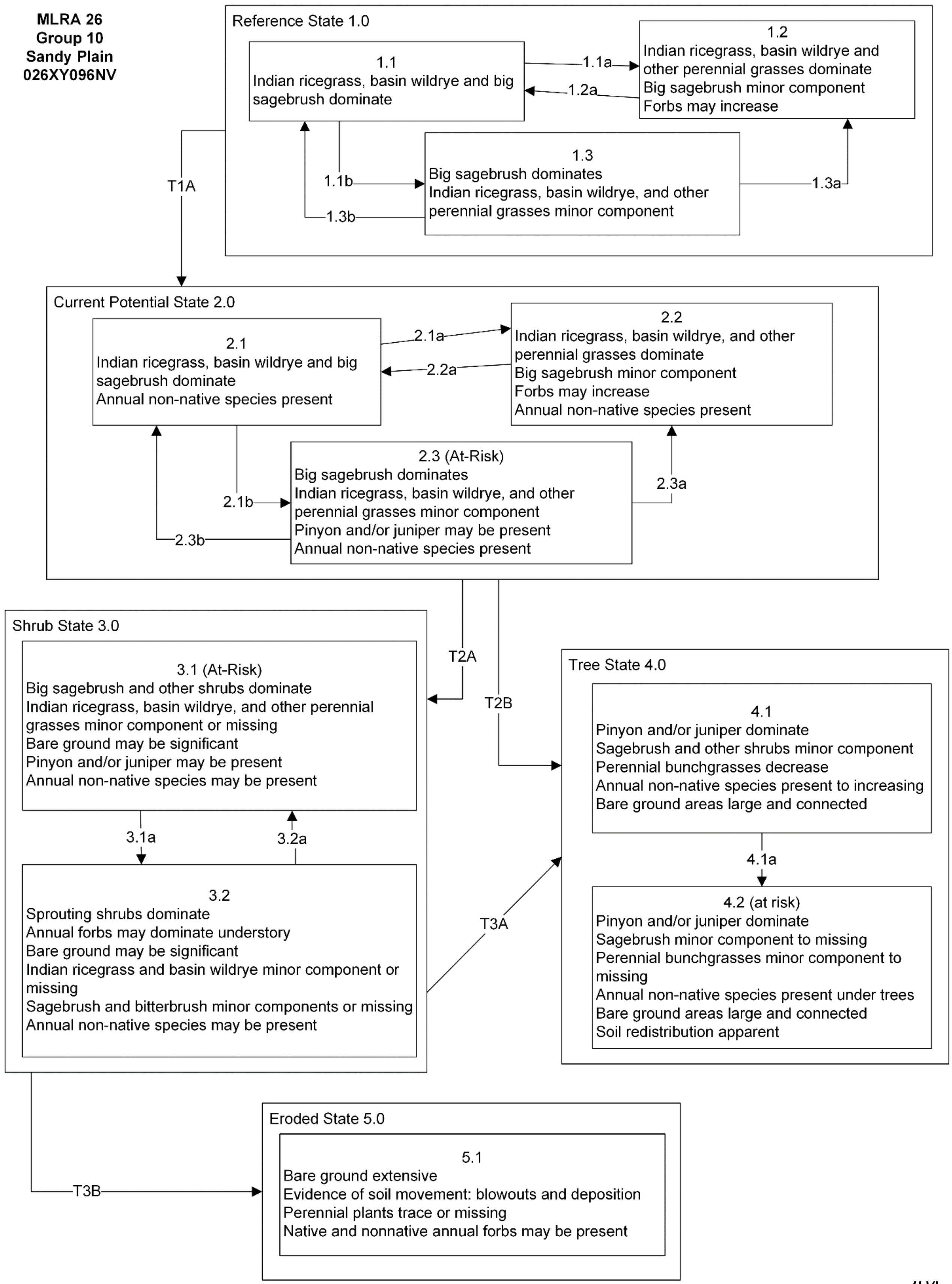
Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Time and lack of disturbance allows maturation of the tree community.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire reduces shrub canopy.
3.2a: Time and lack of disturbance allows for regeneration of bitterbrush.

Transition T3A: Time and lack of disturbance allows maturation of the tree community.
Transition T3B: Catastrophic fire in dense shrub cover results in mortality of most perennial plants. Possible from phase 3.1.

Tree State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance allows for maturation of tree community.
4.2a: Tree thinning treatment (typically for fuels management).

Eroded State 5.0 Community Phase Pathways
None.


MLRA 26
Group 10
Sandy Plain
026XY096NV
Reference State 1.0
1.1
Indian ricegrass, basin wildrye and big sagebrush dominate
1.2
Indian ricegrass, basin wildrye and other perennial grasses dominate
Big sagebrush minor component
Forbs may increase
1.3
Big sagebrush dominates
Indian ricegrass, basin wildrye, and other perennial grasses minor component
1.1a
1.2a
1.1b
1.3b
1.3a
T1A
Current Potential State 2.0
2.1
Indian ricegrass, basin wildrye and big sagebrush dominate
Annual non-native species present
2.2
Indian ricegrass, basin wildrye, and other perennial grasses dominate
Big sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (At-Risk)
Big sagebrush dominates
Indian ricegrass, basin wildrye, and other perennial grasses minor component
Pinyon and/or juniper may be present
Annual non-native species present
2.1a
2.2a
2.1b
2.3b
2.3a
T2A
T2B
Shrub State 3.0
3.1 (At-Risk)
Big sagebrush and other shrubs dominate
Indian ricegrass, basin wildrye, and other perennial grasses minor component or missing
Bare ground may be significant
Pinyon and/or juniper may be present
Annual non-native species may be present
3.1a
3.2a
3.2
Sprouting shrubs dominate
Annual forbs may dominate understory
Bare ground may be significant
Indian ricegrass and basin wildrye minor component or missing
Sagebrush and bitterbrush minor components or missing
Annual non-native species may be present
Tree State 4.0
4.1
Pinyon and/or juniper dominate
Sagebrush and other shrubs minor component
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
4.1a
4.2 (at risk)
Pinyon and/or juniper dominate
Sagebrush minor component to missing
Perennial bunchgrasses minor component to missing
Annual non-native species present under trees
Bare ground areas large and connected
Soil redistribution apparent
T3A
T3B
Eroded State 5.0
5.1
Bare ground extensive
Evidence of soil movement: blowouts and deposition
Perennial plants trace or missing
Native and nonnative annual forbs may be present

MLRA 26
Group 10
Sandy Plain
026XY096NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush cover leading to early mid-seral community.
1.3b: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.

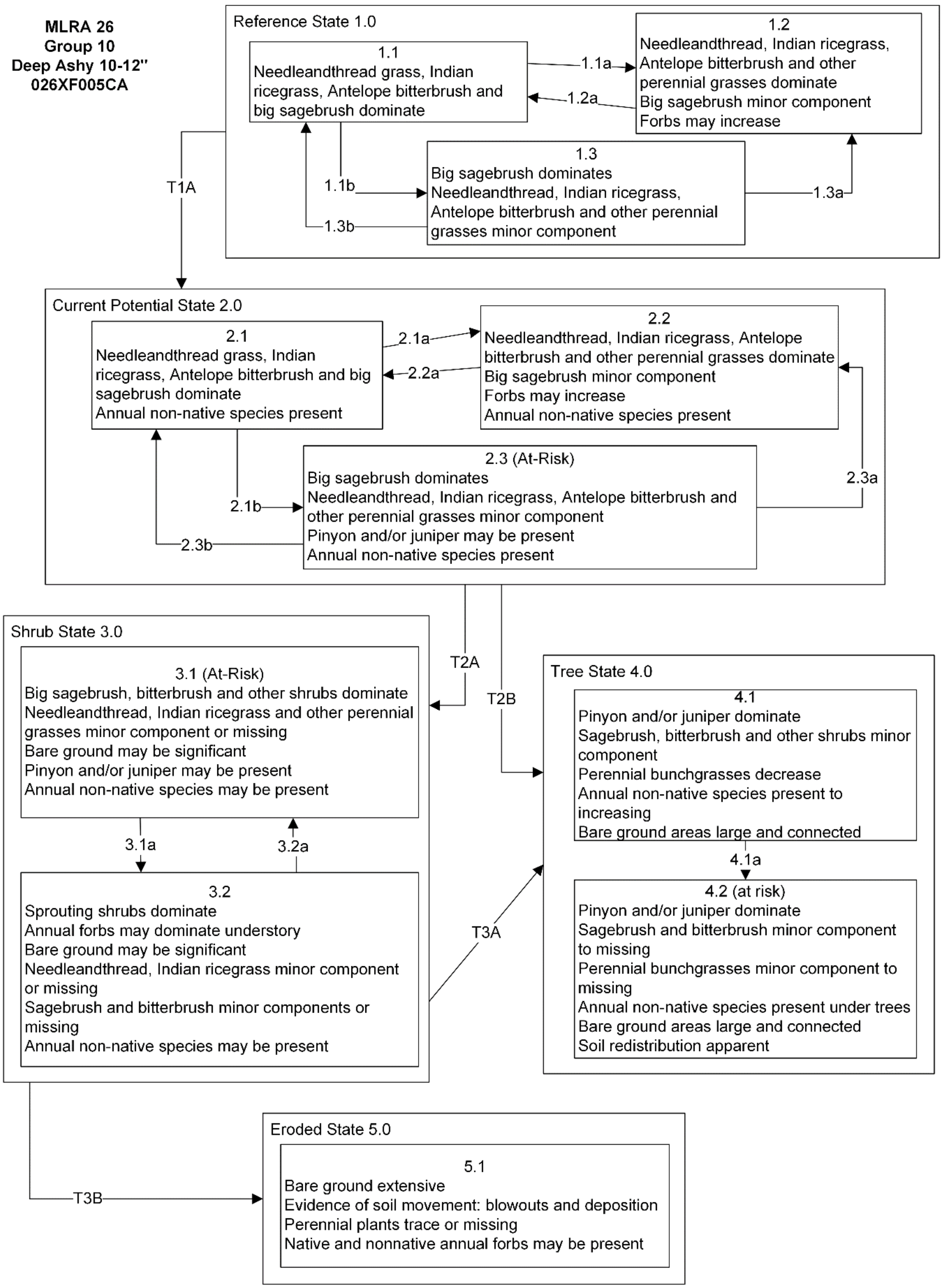
Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Time and lack of disturbance allows maturation of the tree community.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire reduces shrub canopy.
3.2a: Time and lack of disturbance allows for regeneration of sagebrush.

Transition T3A: Time and lack of disturbance allows maturation of the tree community.
Transition T3B: Catastrophic fire in dense shrub cover results in mortality of most perennial plants. Possible from phase 3.1.

Tree State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance allows for maturation of tree community.
4.2a: Tree thinning treatment (typically for fuels management).

Eroded State 5.0 Community Phase Pathways
None.


MLRA 26
Group 10
Deep Ashy 10-12"
026XF005CA
Reference State 1.0
1.1
Needleandthread grass, Indian ricegrass, Antelope bitterbrush and big sagebrush dominate
1.2
Needleandthread, Indian ricegrass, Antelope bitterbrush and other perennial grasses dominate
Big sagebrush minor component
Forbs may increase
1.3
Big sagebrush dominates
Needleandthread, Indian ricegrass, Antelope bitterbrush and other perennial grasses minor component
1.1a
1.2a
1.1b
1.3b
1.3a
T1A
Current Potential State 2.0
2.1
Needleandthread grass, Indian ricegrass, Antelope bitterbrush and big sagebrush dominate
Annual non-native species present
2.2
Needleandthread, Indian ricegrass, Antelope bitterbrush and other perennial grasses dominate
Big sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (At-Risk)
Big sagebrush dominates
Needleandthread, Indian ricegrass, Antelope bitterbrush and other perennial grasses minor component
Pinyon and/or juniper may be present
Annual non-native species present
2.1a
2.2a
2.1b
2.3b
2.3a
T2A
T2B
Shrub State 3.0
3.1 (At-Risk)
Big sagebrush, bitterbrush and other shrubs dominate
Needleandthread, Indian ricegrass and other perennial grasses minor component or missing
Bare ground may be significant
Pinyon and/or juniper may be present
Annual non-native species may be present
3.1a
3.2a
3.2
Sprouting shrubs dominate
Annual forbs may dominate understory
Bare ground may be significant
Needleandthread, Indian ricegrass minor component or missing
Sagebrush and bitterbrush minor components or missing
Annual non-native species may be present
T3A
Tree State 4.0
4.1
Pinyon and/or juniper dominate
Sagebrush, bitterbrush and other shrubs minor component
Perennial bunchgrasses decrease
Annual non-native species present to increasing
Bare ground areas large and connected
4.1a
4.2 (at risk)
Pinyon and/or juniper dominate
Sagebrush and bitterbrush minor component to missing
Perennial bunchgrasses minor component to missing
Annual non-native species present under trees
Bare ground areas large and connected
Soil redistribution apparent
T3B
Eroded State 5.0
5.1
Bare ground extensive
Evidence of soil movement: blowouts and deposition
Perennial plants trace or missing
Native and nonnative annual forbs may be present

MLRA 26
Group 10
Deep Ashy 10-12"
026XF005CA
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: High severity fire and/or severe Aroga moth infestation significantly reduces sagebrush and bitterbrush cover leading to early mid-seral community.
1.3b: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush and bitterbrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush and bitterbrush.
2.3a: Low severity fire creates sagebrush/grass mosaic, herbivory or combinations. Brush management with minimal soil disturbance reduces sagebrush and bitterbrush.
2.3b: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Time and lack of disturbance allows maturation of the tree community.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire reduces shrub canopy.
3.2a: Time and lack of disturbance allows for regeneration of sagebrush.

Transition T3A: Time and lack of disturbance allows maturation of the tree community.
Transition T3B: Catastrophic fire in dense shrub cover results in mortality of most perennial plants. Possible from phase 3.1.

Tree State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance allows for maturation of tree community.
4.2a: Tree thinning treatment (typically for fuels management).

Eroded State 5.0 Community Phase Pathways
None.

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MLRA 26 Group 11: Deep soils with sagebrush, saltbush, and deep-rooted perennial bunchgrasses

Description of MRLA 26 Disturbance Response Group 11

Disturbance Response Group (DRG) 11 consists of three ecological sites. The precipitation zone for these sites ranges from 8 to 12 inches. The elevation range of this group is 4,500 to 5,600 feet. Slopes range from 0 to 15%, however slopes under 4% are most typical. Soils on these sites are very deep with high available water capacity. These soils can be somewhat poorly drained and may be alkaline. Annual production in a normal year ranges from 800 to 1,200 lbs/ac for the group. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by basin big sagebrush (*Artemisia tridentata ssp. tridentata*), mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) and fourwing saltbush (*Atriplex canescens)*. Rubber rabbitbrush (*Ericameria nauseosa)* and Torrey's saltbush (*Atriplex torreyi*) are also important shrub species. The understory is dominated by deep-rooted perennial bunchgrasses, primarily basin wildrye (*Leymus cinereus*). Other important grasses include western wheatgrass (*Pascopyrum smithii) and* Indian ricegrass (*Achnatherum hymenoides).*

Disturbance Response Group 11 Ecological Sites:

Dry Floodplain – Modal Site	R026XY012NV
Deep Sodic Fan	R026XY032NV
Wash 8-12"	R026XY034NV

Modal Site:

The Dry Floodplain ecological site is the modal for this group as it has the most acres mapped. This site occurs on axial-stream floodplains. Slope generally ranges from 0 to 4 percent. Elevations are 4,500 to 5,500 feet. Average annual precipitation is 8 to 10 inches. The soils of this site are very deep and are well drained to somewhat poorly drained. The available water capacity is high. Occurring most commonly on river terraces, the soils have not undergone adequate leaching to remove all salts and alkali. The soil surface tends to be moderately sodium affected and will crust and bake upon drying. The water table fluctuates between 36 inches in spring to over 60 inches during drier periods. These soils are subject to flooding on an average of at least one year in three. Deep rooted plants are able to utilize moisture from the water table and capillary fringe. The plant community is dominated by basin wildrye and basin big sagebrush. Rubber rabbitbrush (*Ericameria nauseosa)*, western wheatgrass (*Pascopyrum smithii)*, and creeping wildrye (*Leymus triticoides)* are other important species associated with this site. Total annual production ranges from 900 to 1,700 lbs/ac, with 1,200 lbs/ac in normal years.

Ecological Dynamics and Disturbance Response

An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire,

herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by deep-rooted cool season perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m (Dobrowolski et al. 1990). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The dominant perennial bunchgrass is basin wildrye. This species, like other perennial grasses,generally has a somewhat shallower root system than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Periodic drought regularly influences sagebrush ecosystems, and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historic precipitation patterns have the greatest potential to alter ecosystem function and productivity (Snyder et al. 2019). Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons (MacMahon 1980). Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The invasibility of plant communities is often linked to resource availability. Disturbance changes resource uptake and increases nutrient availability, often to the benefit of non-native species; native species are often damaged and their ability to use resources is depressed for a time, but resource pools may increase from lack of use and/or the decomposition of dead plant material following disturbance (Whisenant 1999, Miller et al. 2013). The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Beckstead and Augspurger 2004, Chambers et al. 2007, Johnson et al. 2011).

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks especially sagebrush defoliator, Aroga moth (*Aroga websteri*). Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and have been ongoing in Nevada since 2004 (Bentz et al. 2008). Thousands of acres of big sagebrush have been impacted, with partial to complete die-off observed. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975).

Basin big sagebrush tends to occupy areas with deeper soil that receive run-on moisture (Barker and McKell 1983, Winward 1980). Big sagebrush is generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings of big sagebrush is dependent on adequate moisture conditions.

Basin wildrye is the dominant grass on this site. It is weakly rhizomatous and has been found to root to depths of up to 2 meters, and exhibits greater lateral root spread than many other grass species (Abbott et al. 1991, Reynolds and Fraley 1989). Basin wildrye is a large, cool-season perennial bunchgrass with an extensive deep coarse fibrous root system (Reynolds and Fraley 1989). Clumps may reach up to six feet in height (Ogle et al. 2012b). Basin wildrye does not tolerate long periods of inundation; it prefers cycles of wet winters and dry summers and is most commonly found in deep soils with high water holding capacities or seasonally high water tables (Ogle et al. 2012b, Perryman and Skinner 2007). Western wheatgrass is a rhizomatous grass it is capable of spreading vegetatively and thrives in disturbed soil (Cronquist et al. 1994).

Seasonally high water tables have been found to be necessary for maintenance of site productivity and reestablishment of basin wildrye stands following disturbances such as fire, drought or excessive herbivory (Eckert et al. 1973). The sensitivity of basin wildrye seedling establishment to reduced soil water availability is increased as soil pH increases (Stuart et al. 1971). Lowering of the water table through extended drought, channel incision or groundwater pumping will decrease basin wildrye production and establishment, while sagebrush, rabbitbrush, and invasive weeds increase.

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. Increased resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Five possible alternative stable states have been identified for this DRG.

Invasive Annual Grasses:

The species most likely to invade these sites is cheatgrass. Cheatgrass is a cool season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead.

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass “die-off” provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but there is ongoing work to try to predict where they occur, in the hopes of aiding conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, are able to suppress cheatgrass growth when mature (Blank et al. 2020). Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, as only one year of data was reported.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz./ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Natural fire return intervals are estimated to vary between less than 35 years up to 100 years in sagebrush ecosystems with basin wildrye (Paysen et al. 2000). In many basin big sagebrush communities, changes in fire frequency occurred along with fire suppression, livestock grazing and OHV use. Few if any fire history studies have been conducted on basin big sagebrush; however, Sapsis and Kauffman (1991) suggest that fire return intervals in basin big sagebrush are intermediate between mountain big sagebrush (15 to 25 years) and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) (50 to 100 years). Fire severity in big sagebrush communities is described as "variable" depending on weather, fuels, and topography. However, fire in basin big sagebrush communities are typically stand replacing (Sapsis and Kauffman 1991). Basin big sagebrush does not sprout after fire. Because of the time needed to produce seed, it is eliminated by frequent fires (Bunting et al. 1987).

Basin big sagebrush reinvades a site primarily by off-site seed or seed from plants that survive in unburned patches. Approximately 90% of big sagebrush seed is dispersed within 30 feet (9 m) of the parent shrub (Goodrich et al. 1985) with maximum seed dispersal at approximately 108 feet (33 m) from the parent shrub (Shumar and Anderson 1986). Therefore, regeneration of basin big sagebrush after stand replacing fires is difficult and dependent upon proximity of residual mature plants and favorable moisture conditions (Johnson and Payne 1968, Humphrey 1984). Higher production sites will have experienced fire more frequently than lower production sites. Fire maintained the grass dominance of these ecosystems, therefore, increases in the fire return interval favors the shrub component of the plant community, potentially facilitating a rise in bare ground and invasive weeds. Lack of fire combined with excessive herbivory converts these sites to big sagebrush and rabbitbrush dominance.

Fourwing saltbush is the most widely distributed shrubby saltbush in North America (Meyer 2003). It is highly variable across landscapes and even within populations (McArthur et al. 1983, Petersen et al. 1987). Its ability to sprout following fire may depend on the population and fire severity. A study by

Parmenter (2008) showed 58% mortality rate of fourwing saltbush following fire in New Mexico, the surviving shrubs produced sprouts shortly after fire.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). In addition, season and severity of the fire will influence plant response as will post-fire soil moisture availability.

Basin wildrye is relatively resistant to fire, particularly dormant season fire, as plants sprout from surviving root crowns and rhizomes (Zschaechner 1985). Miller et al. (2013) reported increased total shoot and reproductive shoot densities in the first year following fire, although by year two there was little difference between burned and control treatments. The rhizomatous growth form of western wheatgrass makes it capable of surviving fire and may increase vegetative growth afterward (Bushey 1987, Wasser 1982).

The majority of research concerning rabbitbrush has been conducted on green rabbitbrush (*Chrysothamnus viscidiflorus*). Green rabbitbrush has a large taproot and is known to be shorter-lived and less competitive than sagebrush. Seedling density, flower production, and shoot growth decline as competition from other species increases (McKell and Chilcote 1957, Miller et al. 2013). Depending on fire severity, rabbitbrush may increase after fire. Rubber rabbitbrush is top-killed by fire, but can resprout after fire and can also establish from seed (Young 1983).

The grass most likely to invade this site is cheatgrass. This invasive grass displaces desirable perennial grasses, reduces livestock forage, and accumulates large fuel loads that foster frequent fires (Davies and Svejcar 2008). Invasion by annual grasses can alter the fire cycle by increasing fire size, fire season length, rate of spread, numbers of individual fires, and likelihood of fires spreading into native or managed ecosystems (D'Antonio and Vitousek 1992, Brooks et al. 2004). Areas dominated with cheatgrass are estimated to have a fire return interval of 3-5 years (Whisenant 1990). The mechanisms by which invasive annual grasses alter fire regimes likely interact with climate. For example, cheatgrass cover and biomass vary with climate (Chambers et al. 2007) and are promoted by wet and warm conditions during the fall and spring. Invasive annual species have been shown able to take advantage of high N availability following fire through higher growth rates and increased seedling establishment relative to native perennial grasses (Monaco et al. 2003).

Livestock/ Wildlife Grazing Interpretations:

Big sagebrush is browsed in the winter by native ungulates. Personius et al. (1987) found Wyoming big sagebrush and basin big sagebrush to be intermediately palatable to mule deer when compared to mountain big sagebrush (most palatable) and black sagebrush (least palatable).

Fourwing saltbush is one of the most important forage shrubs in arid sites. Its importance is due to its abundance, accessibility, size, large volume of forage, evergreen habit, high palatability and nutritive value. The palatability rates from fairly good to good for cattle, and as good for sheep and goats, deer usually relish it as a winter browse (USDA 1988). It has similar protein, fat, and carbohydrate levels as alfalfa (*Medicago sativa*) (Catlin, 1925). It is especially valuable as winter forage. It was noted in a study by Otsyina et al. (1982) that sheep readily grazed fourwing saltbush when introduced into a new pasture.

During settlement, many of the cattle in the Great Basin were wintered on extensive basin wildrye stands, however, due to sensitivity to spring use, many stands were decimated by early in the 20th century (Young et al. 1976). Less palatable species such as big sagebrush and rabbitbrush increased in dominance along with invasive non-native species such as Russian thistle (*Salsola tragus*), mustards, and cheatgrass (Roundy 1985). The early growth and abundant production of basin wildrye make it a valuable source of forage for livestock. It is important forage for cattle and is readily grazed by cattle and horses in early spring and fall. Though coarse-textured during the winter, basin wildrye may be utilized more frequently by livestock and wildlife when snow has covered low shrubs and other grasses. Basin wildrye is used often as a winter feed for livestock and wildlife; not only providing roughage above the snow but also cover in the early spring months (Majerus 1992). Inadequate rest and recovery from defoliation causes a decrease in basin wildrye and an increase in basin big sagebrush and rubber rabbitbrush (Young et al. 1976, Roundy 1985). Spring defoliation of basin wildrye and/or consistent, heavy grazing during the growing season has been found to significantly reduce basin wildrye production and density (Krall et al. 1971). Additionally, native basin wildrye suffers from low seed viability and low seedling vigor (Young and Evans 1981). Roundy (1985) found that although basin wildrye is adapted to seasonally dry saline soils, high and frequent spring precipitation is necessary to establish it from seed. This suggests that establishment of basin wildrye seedlings occurs only during years of unusually high precipitation. Therefore, reestablishment of a stand may be episodic.

Western wheatgrass is a preferred feed for livestock and wildlife, but is not a very productive plant (Enevoldsen and Lewis 1978, Hafenrichter et al. 1968). It is short in stature and has sparse growth in low-water conditions. Compared to native bunchgrasses, western wheatgrass is not as palatable (Hafenrichter et al. 1968).

Overgrazing leads to an increase in big sagebrush and a decline in understory plants like basin wildrye. Reduced bunchgrass vigor or density provides an opportunity for cheatgrass and other invasive species to occupy interspaces. Reduced bunchgrass vigor or density provides an opportunity for cheatgrass and other invasive species to occupy interspaces, leading to increased fire frequency and potentially an annual plant community. This site is likely to see an increase in shrubs and will have significant bare ground in the interspaces as few native perennial species are able to recolonize the sandy soil surfaces.

Urban/Agricultural Use:

Sites in this group exist in flat, accessible areas near water in western Nevada that have been developed for agriculture production and housing developments. The Deep Sodic Fan site, as mapped, no longer exists in a natural condition outside of these developed areas, but we have included it in our assessment in case inclusions exist elsewhere.

Seasonally high water tables have been found to be necessary for maintenance of site productivity and reestablishment of basin wildrye stands following disturbances such as fire, drought or excessive herbivory (Eckert et al. 1973). The sensitivity of basin wildrye seedling establishment to reduced soil water availability is increased as soil pH increases (Stuart et al. 1971). Lowering of the water table through extended drought, channel incision or groundwater pumping will decrease basin wildrye production and establishment, while sagebrush, rabbitbrush, and invasive weeds increase. Farming and abandonment may facilitate the creation of vesicular crust on the soil surface, increased surface ponding, and decreased infiltration; which leads to dominance by sprouting shrubs and an annual understory. While sites exhibiting significant hydrologic alteration were not seen during field visits for this project, this dynamic is included in the STM narrative since it has been seen on similar sites in other MLRAs.

State and Transition Model Narrative for Group 11

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 11.

Reference State 1.0:

The Reference State 1.0 is a representation of the natural range of variability under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase, and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
Basin wildrye and basin big sagebrush dominate the plant community. Forbs and other grasses make up smaller components.

Community Phase Pathway 1.1a, from phase 1.1 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses and forbs to dominate the site. Fires would typically be small and patchy due to low or moist fuel loads.

Community Phase Pathway 1.1b, from phase 1.1 to 1.3:
Time and lack of disturbance such as fire allows sagebrush to increase and become dominant. Long-term drought, herbivory, or combinations of these would cause a decline in basin wildrye and fine fuels, leading to a reduced fire frequency allowing big sagebrush to dominate the site.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early- to mid-seral community. Basin wildrye, western wheatgrass, and other perennial bunchgrasses dominate. Depending on fire severity or intensity of Aroga moth infestation, patches of intact sagebrush may remain. Rabbitbrush may be sprouting and may be a significant component of the plant community.

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Time and lack of disturbance allows sagebrush to reestablish.

Community Phase 1.3:

Big sagebrush dominates in the absence of disturbance. Mature sagebrush may be decadent. The deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or from herbivory. Basin wildrye is a minor component.

Community Phase Pathway 1.3a, from phase 1.3 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Fires would typically be low severity resulting in a mosaic pattern due to low fine fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels, may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

Community Phase Pathway 1.3b, from phase 1.3 to 1.1:
Low severity fire, Aroga moth, or a combination of both will reduce some of the sagebrush overstory and allow grass species to increase.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass, mustard and Russian thistle.

Slow variables: Over time, the annual non-native plants will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0 with the addition of one community phase. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate and adaptations for seed dispersal. Additionally, the presence of highly flammable non-native species reduces State resilience because these species can promote fire where historically fire has been infrequent leading to positive feedbacks that further the degradation of the system. Seeded species may be present in all phases of this group. This site was not seen in a seeded state, however crested wheatgrass was found, likely from nearby seedings.

Community Phase 2.1:

This community phase is similar to Reference State Community Phase 1.1, with the presence of non-native annual species present. Basin wildrye and basin big sagebrush dominate the plant community. Forbs and other grasses make up smaller components.

Community Phase Pathway 2.1a, from phase 2.1 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses and forbs to dominate the site. Fires would typically be small and patchy due to low or moist fuel loads.

Community Phase Pathway 2.1b, from phase 2.1 to 2.3:
Time without disturbance, long-term drought, grazing management that favors shrubs, or combinations of these would allow the sagebrush overstory to increase and dominate the site.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early- to mid-seral community. Basin wildrye, western wheatgrass, and other perennial bunchgrasses dominate. Depending on fire severity or intensity of Aroga moth infestation, patches of intact sagebrush may remain. Rabbitbrush may be sprouting and may be a significant component of the plant community. Annual non-native species are stable or increasing within the community.

Community Phase Pathway 2.2a, from phase 2.2 to 2.1:
Absence of disturbance over time allows sagebrush to recover. This may be combined with grazing management that favors shrubs.

Community Phase Pathway 2.2b, from phase 2.2. to 2.4:
Fall and spring growing conditions that favor the germination and production of non-native, annual grasses cause these species to codominate with bunchgrasses in the understory. This pathway typically occurs three to five years post fire and phase 2.4 may be a transitory plant community.

Community Phase 2.3:
Big sagebrush dominates in the absence of disturbance. Mature sagebrush may be decadent. The deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or from herbivory. Basin wildrye is a minor component. Rabbitbrush may be a significant component. Annual non-natives species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, drought, and fire.

Dry Floodplain (R026XY012NV) Phase 2.3, T.K. Stringham, May 2017

Community Phase Pathway 2.3a, from phase 2.3 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Fires would typically be low severity resulting in a mosaic pattern due to low fine fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels, may be more severe and reduce sagebrush cover to trace amounts. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs. Annual non-native species respond well to fire and may increase post-burn. Brush management with minimal soil disturbance and/or late-fall/winter grazing that causes mechanical damage to sagebrush may also cause this change.

Community Phase Pathway 2.3b, from phase 2.3 to 2.1:
A change in grazing management that decreases shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall/winter grazing will reduce sagebrush and increase the herbaceous understory. A moderate infestation of Aroga moth may reduce some sagebrush overstory and allow perennial grasses to increase in the community. Brush treatments with minimal soil disturbance will also decrease sagebrush and release the perennial understory. Annual non-native species are present in the community.

Community Phase Pathway 2.3c, from phase 2.3 to 2.4:
Fall and spring growing season conditions that favor the germination and production of non-native annual grasses cause these species to become dominant. This phase may be a transitory plant community.

Community Phase 2.4:
This community is at risk of crossing to an annual state. Native bunchgrasses and forbs still comprise 50% or more of the understory annual production, however, non-native annual grasses are nearly codominant. If this site originated from phase 2.3 there may be significant shrub cover as well. Annual production and abundance of these annuals may increase drastically in years with heavy spring precipitation. Seeded species may be present. This site is susceptible to further degradation from grazing, drought and fire.

Community Phase Pathway 2.4a, from phase 2.4 to 2.3:
Growing season conditions that favor perennial bunchgrass production and reduce cheatgrass production.

Community Phase Pathway 2.4b, from phase 2.4 to 2.2:
Growing season conditions that favor perennial bunchgrass production and reduce cheatgrass production. May occur as site recovers from fire.

Wash 8-12" (R026XY034NV) Phase 2.4, P. Novak-Echenique, April 2016

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during growing season favors shrubs and initiates the transition to Phase 3.1 from Phase 2.3. May be exacerbated by a lowered seasonal water table. Fire causes a transition to Community Phase 3.2.

Slow variables: Long term reduction in deep-rooted perennial grass density results in a decrease in organic matter inputs and subsequent soil water decline.

Threshold: Loss of deep-rooted perennial bunchgrasses spatially and temporally changes nutrient cycling and redistribution, and reduces soil organic matter. Loss of high seasonal water table prevents regeneration of basin wildrye.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Severe fire or multiple fires, long term inappropriate grazing, and/or soil disturbing treatments such as plowing.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs truncates, spatially and temporally, nutrient capture and cycling within the community. Increased, continuous fine fuels from annual non-native plants modify the fire regime by changing intensity, size and spatial variability of fires.

Shrub State 3.0:

This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Sagebrush dominates the overstory and rabbitbrush may be a significant component. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory dominates site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1:
Sagebrush and/or rabbitbrush dominates the overstory and other shrubs may be a significant component. Perennial bunchgrasses are a minor component. Annual non-native species are present to increasing. Understory may be sparse, with bare ground increasing.

Wash 8-12" (R026XY034NV) Shrub State, T.K. Stringham, June 2016

Dry Floodplain 8-10" (R026XY012NV) Phase 3.1, T.K. Stringham, April 2017

Community Phase Pathway 3.1a, from phase 3.1 to 3.2:
Fire or heavy fall grazing reduces or eliminates the overstory of sagebrush to trace amounts and allows bunchgrasses to dominate the site. Brush treatments causing minimal soil disturbance causing mechanical damage to shrubs may also cause this change.

Community Phase 3.2:
Rabbitbrush dominates the overstory. Annual non-native species may be present in the understory but are not dominant. Perennial bunchgrasses may be a minor component. Bare ground may be increasing.

Community Phase Pathway 3.2a, from phase 3.2 to 3.1:
Time and lack of disturbance over time and/or grazing management that favors the establishment and growth of sagebrush allows sagebrush to recover.

T3A: Transition from Shrub State 3.0 to Annual State 4.0:

Trigger: Fire or inappropriate grazing management can eliminate the perennial community and transition to community phase 4.1 or 4.2. This may be coupled with gullying and loss of seasonally high water table that maintains basin wildrye.

Slow variable: Increased seed production and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

R3A: Restoration from Shrub State 3.0 to Current Potential State 2.0:

Brush management coupled with seeding of desired perennial bunchgrass. Concurrent herbicide treatment may be needed to avoid an increase in annual invasive species. If changes in vegetation were caused by altered hydrology, restoration of associated channels will be needed to achieve success.

Annual State 4.0:

An abiotic threshold has been crossed and state dynamics are driven by fire and time. The herbaceous understory is dominated by annual non-native species such as cheatgrass and mustards. Resiliency has declined and further degradation from fire facilitates a cheatgrass and sprouting shrub plant community. Fire return interval has shortened due to the dominance of cheatgrass in the understory and is a driver in site dynamics.

Community Phase 4.1:
Big sagebrush dominates the overstory, with non-native annual grasses and forb species in the understory. Perennial grasses are a minor component and may be missing entirely.

Community Phase pathway 4.1a, from phase 4.1 to 4.2:
Fire and/or a failed brush treatment or seeding eliminates the shrub overstory. Annuals such as cheatgrass increase after fire and dominate the site.

Community Phase 4.2:
Annual non-native plants such as cheatgrass dominate the site. This phase may have seeded species present if resulting from a failed seeding attempt. Perennial bunchgrasses and forbs may still be present in trace amounts. Rabbitbrush may be sprouting Surface erosion may increase with summer convection storms; increased pedestalling of plants, rill formation, or extensive water flow paths identify these events.

Potential Resilience Differences with other Ecological Sites:

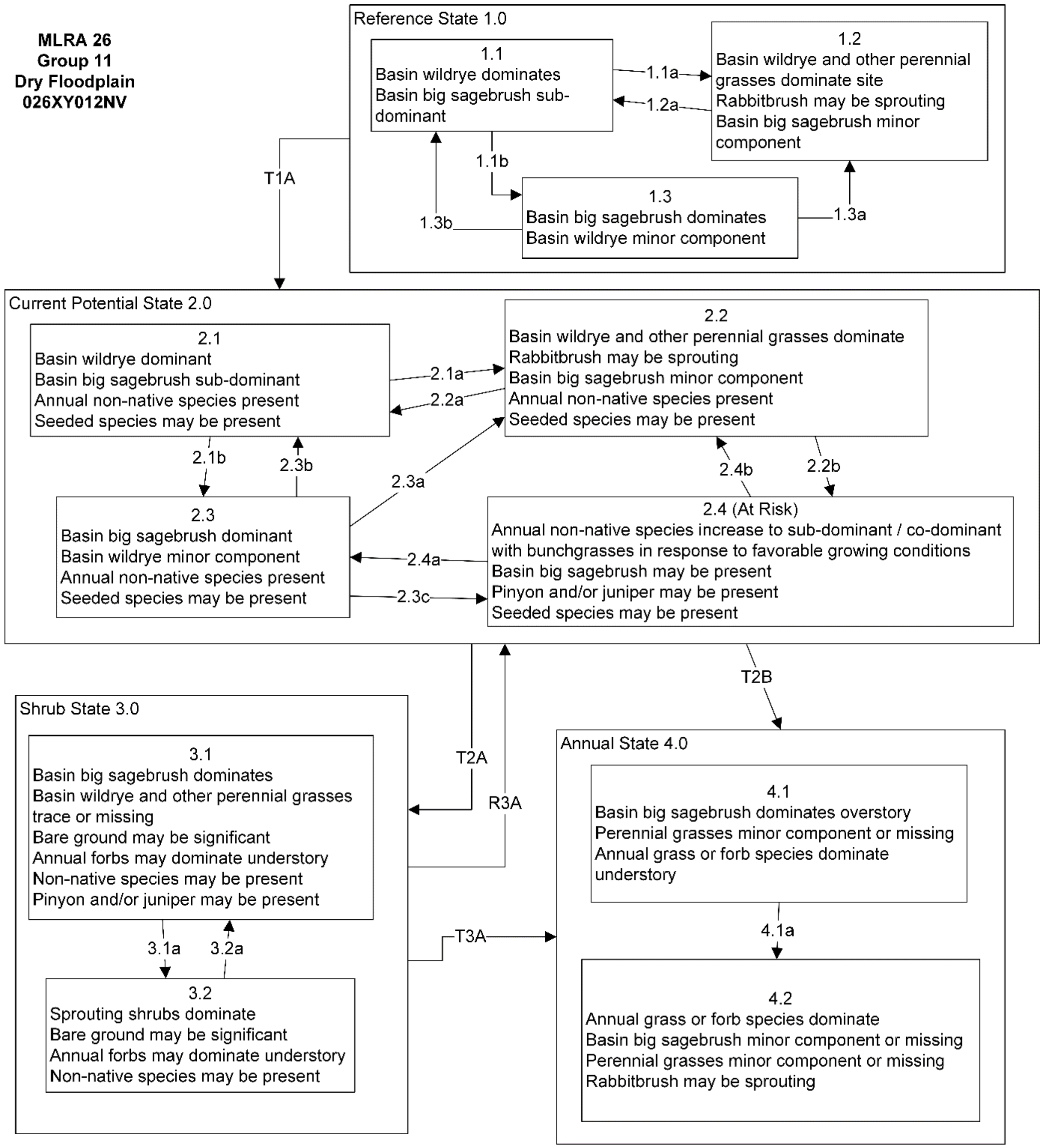
Deep Sodic Fan (026XY032NV):

Fourwing saltbush is the dominant shrub on this site, with basin wildrye and Indian ricegrass in the understory. This site occurs on inset fans and lower piedmont slops at a slightly higher range of elevation compared to the modal site, from 4,700 to 5,300 ft. The soils in this site are formed in alluvium derived from mixed rock and tend to be very deep and well drained. Annual production is similar to that of the modal site.

Wash 8-12" (026XY034NV):

This site has similar vegetation to the modal site but antelope bitterbrush as a subdominant shrub. This site occurs on inset fans at elevations of 5,000 to 5,600 ft. Soils are not as alkaline as the modal site in this group. The range of annual precipitation is 8-12" which is a slightly wider range than the modal site. Normal year production is significantly lower, however, at 800 lbs/ac.

Modal State and Transition Model for Group 11 in MLRA 26:



MLRA 26
Group 11
Dry Floodplain
026XY012NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory, chronic drought or combinations may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.
1.3b: A low severity fire, Aroga moth, or combinations will reduce some of the sagebrush overstory and allow grass species to increase.

Transition T1A: Introduction of non-native species such as cheatgrass.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs: non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub reestablishment.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover and allows grass species to dominate.
2.3b: A low severity fire, Aroga moth, or combinations will reduce some of the sagebrush overstory and allow grass species to increase.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Hydrologic alteration (lowering of water table i.e. gullying of associated channel), inappropriate grazing management or combinations of these lead to 3.1. Fire can lead to phase 3.2.
Transition T2B: Inappropriate grazing management in the presence of non-native annual species leads to 4.1. Fire in the presence of annual species leads to 4.2.

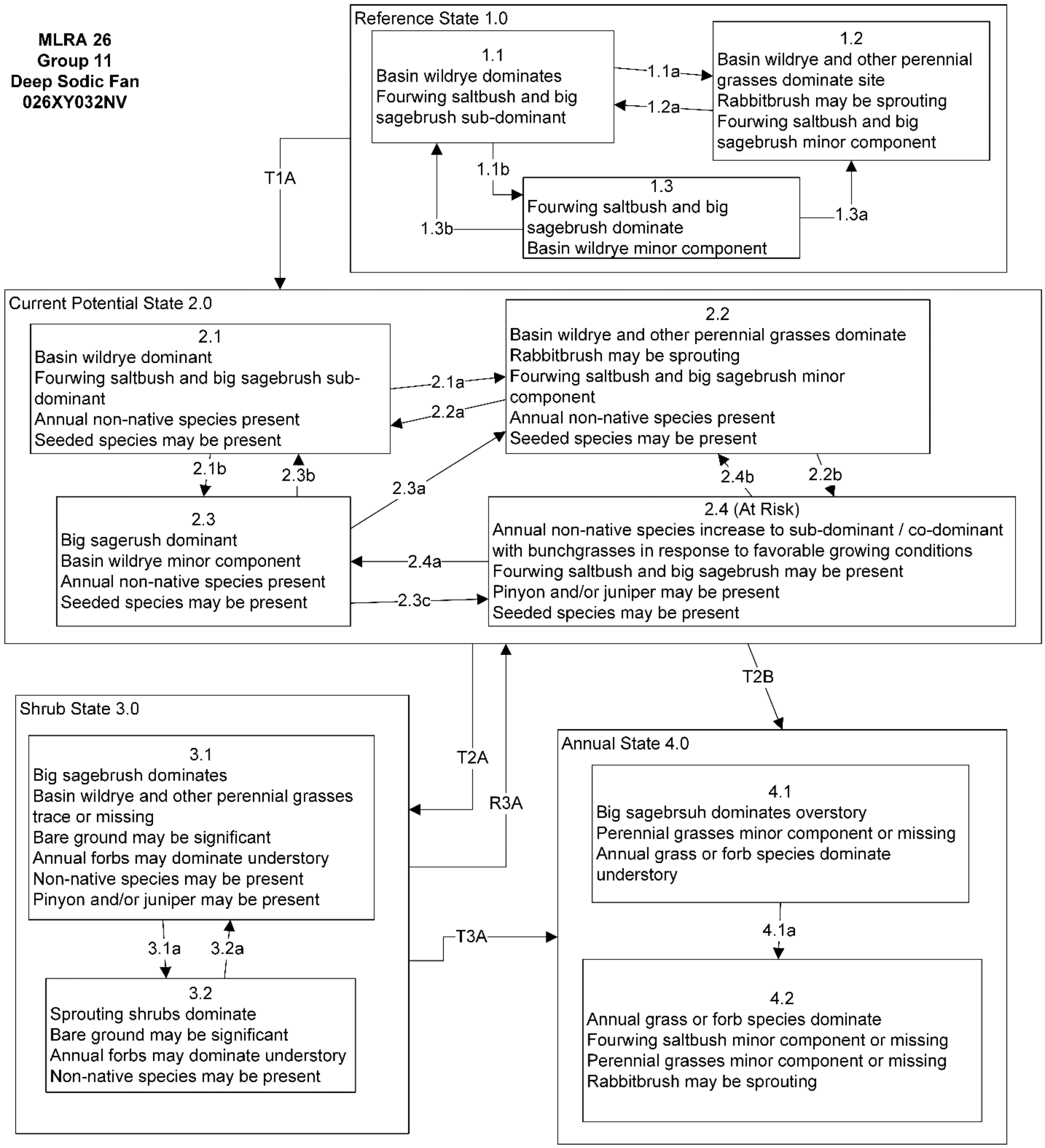
Shrub State 3.0 Community Phase Pathways.
3.1a: Fire and/or brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (not likely to occur).

Transition T3A: Continual inappropriate grazing management and/or hydrologic alteration (i.e. gullying of associated channel) (4.1). Severe fire, and/or failed brush management and seeding (4.2).

Restoration R3A: Brush management and seeding of desired perennial bunchgrass, may be coupled with restoration of channel (2.2).

Annual State 4.0 Community Phase Pathways.
4.1a: Severe fire or failed brush treatment and seeding.

Additional State and Transition Models for Group 11 in MLRA 26:



MLRA 26
Group 11
Deep Sodic Fan
026XY032NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory, chronic drought or combinations may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.
1.3b: A low severity fire, Aroga moth, or combinations will reduce some of the sagebrush overstory and allow grass species to increase.

Transition T1A: Introduction of non-native species such as cheatgrass.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs: non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub reestablishment.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover and allows grass species to dominate.
2.3b: A low severity fire, Aroga moth, or combinations will reduce some of the sagebrush overstory and allow grass species to increase.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

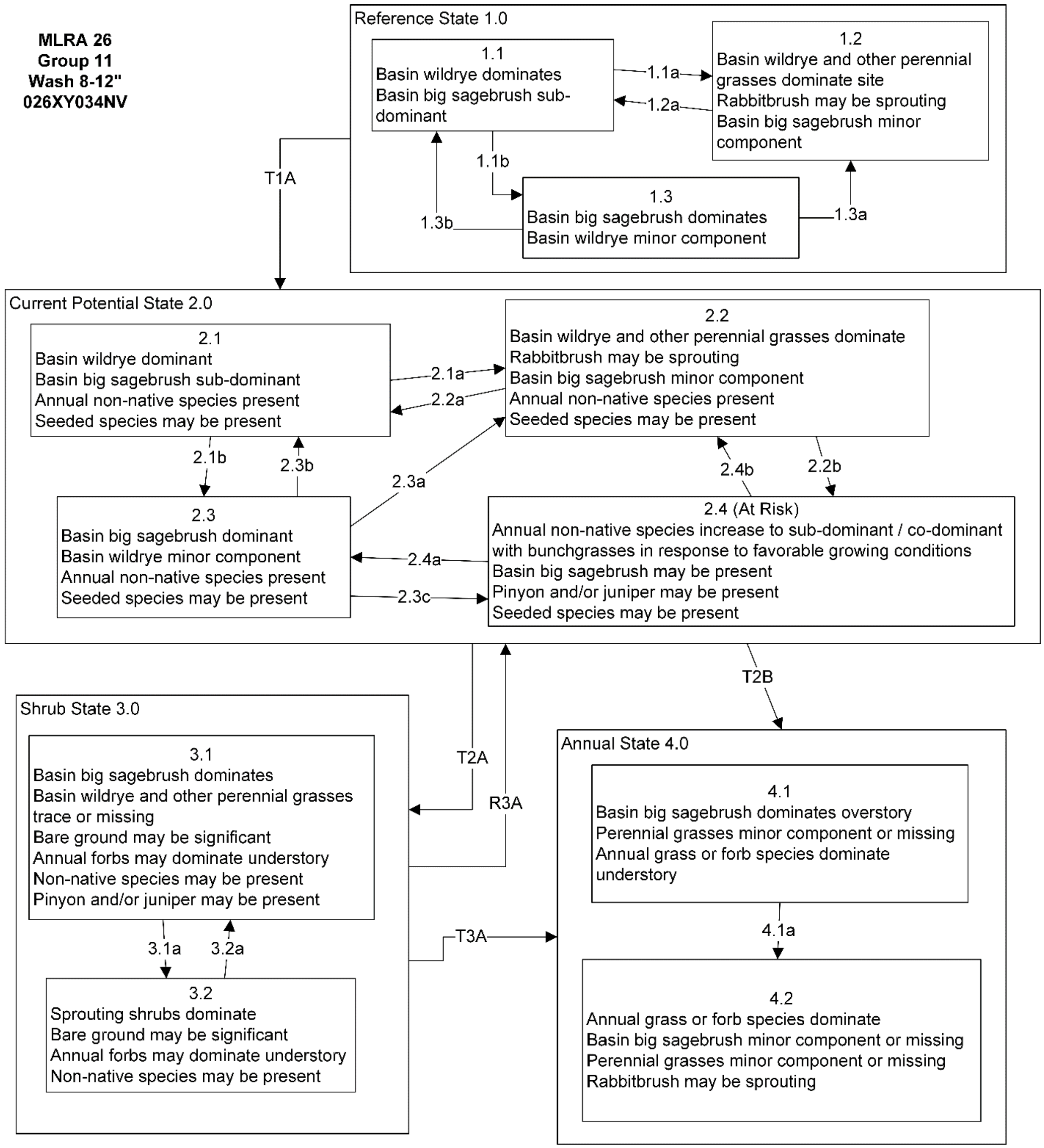
Transition T2A: Hydrologic alteration (lowering of water table i.e. gullying of associated channel), inappropriate grazing management or combinations of these lead to 3.1. Fire can lead to phase 3.2.
Transition T2B: Inappropriate grazing management in the presence of non-native annual species leads to 4.1. Fire in the presence of annual species leads to 4.2.

Shrub State 3.0 Community Phase Pathways.
3.1a: Fire and/or brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (not likely to occur).

Transition T3A: Continual inappropriate grazing management and/or hydrologic alteration (i.e. gullying of associated channel) (4.1). Severe fire, and/or failed brush management and seeding (4.2).

Restoration R3A: Brush management and seeding of desired perennial bunchgrass, may be coupled with restoration of channel (2.2).

Annual State 4.0 Community Phase Pathways.
4.1a: Severe fire or failed brush treatment and seeding.



MLRA 26
Group 11
Wash 8-12"
026XY034NV
Reference State 1.0
1.1
Basin wildrye dominates
Basin big sagebrush sub-dominant
1.2
Basin wildrye and other perennial grasses dominate site
Rabbitbrush may be sprouting
Basin big sagebrush minor component
1.3
Basin big sagebrush dominates
Basin wildrye minor component
1.1a
1.2a
1.1b
1.3b
1.3a
T1A
Current Potential State 2.0
2.1
Basin wildrye dominant
Basin big sagebrush sub-dominant
Annual non-native species present
Seeded species may be present
2.2
Basin wildrye and other perennial grasses dominate
Rabbitbrush may be sprouting
Basin big sagebrush minor component
Annual non-native species present
Seeded species may be present
2.3
Basin big sagebrush dominant
Basin wildrye minor component
Annual non-native species present
Seeded species may be present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Basin big sagebrush may be present
Pinyon and/or juniper may be present
Seeded species may be present
2.1a
2.2a
2.1b
2.3b
2.3a
2.4b
2.2b
2.4a
2.3c
T2A
R3A
T2B
Shrub State 3.0
3.1
Basin big sagebrush dominates
Basin wildrye and other perennial grasses trace or missing
Bare ground may be significant
Annual forbs may dominate understory
Non-native species may be present
Pinyon and/or juniper may be present
3.2
Sprouting shrubs dominate
Bare ground may be significant
Annual forbs may dominate understory
Non-native species may be present
3.1a
3.2a
T3A
Annual State 4.0
4.1
Basin big sagebrush dominates overstory
Perennial grasses minor component or missing
Annual grass or forb species dominate understory
4.2
Annual grass or forb species dominate
Basin big sagebrush minor component or missing
Perennial grasses minor component or missing
Rabbitbrush may be sprouting
4.1a

MLRA 26
Group 11
Wash 8-12"
026XY034NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory, chronic drought or combinations may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.
1.3b: A low severity fire, Aroga moth, or combinations will reduce some of the sagebrush overstory and allow grass species to increase.

Transition T1A: Introduction of non-native species such as cheatgrass.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs: non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub reestablishment.
2.2b: Fall and spring growing conditions that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and 2.4 may be a transitory plant community.
2.3a: High severity fire significantly reduces sagebrush cover and allows grass species to dominate.
2.3b: A low severity fire, Aroga moth, or combinations will reduce some of the sagebrush overstory and allow grass species to increase.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Hydrologic alteration (lowering of water table i.e. gullying of associated channel), inappropriate grazing management or combinations of these lead to 3.1. Fire can lead to phase 3.2.
Transition T2B: Inappropriate grazing management in the presence of non-native annual species leads to 4.1. Fire in the presence of annual species leads to 4.2.

Shrub State 3.0 Community Phase Pathways.
3.1a: Fire and/or brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (not likely to occur).

Transition T3A: Continual inappropriate grazing management and/or hydrologic alteration (i.e. gullying of associated channel) (4.1). Severe fire, and/or failed brush management and seeding (4.2).

Restoration R3A: Brush management and seeding of desired perennial bunchgrass, may be coupled with restoration of channel (2.2).

Annual State 4.0 Community Phase Pathways.
4.1a: Severe fire or failed brush treatment and seeding.

References

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MLRA 26 Group 12: Mountain big sagebrush and bitterbrush with needlegrass understory

Description of MRLA 26 Disturbance Response Group 12:

Disturbance Response Group (DRG) 12 consists of thirteen ecological sites. The precipitation zone ranges from 12 to 16 inches. Slopes range from 2 to 75%, but are typically from 4 to 50%. Elevations range from 5,500 to 9,600 feet. The soils are typified by a mollic epipedon and most have an argillic horizon. Soil textures are variable and may be modified by high volumes of rock fragments. Production ranges between 600 to 1500 lbs/ac for a normal year. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana)* and antelope bitterbrush (*Purshia tridentata)*. Other important shrubs include snowberry (*Symphoricarpos* spp.). The understory is dominated by deep-rooted cool season perennial bunchgrasses, primarily western needlegrass (*Achnatherum occidentale*), Columbia needlegrass (*Achnatherum nelsonii*), Letterman's needlegrass (*Achnatherum lettermanii*), and basin wildrye (*Leymus cinereus*). Other important grasses include Indian ricegrass (*Achnatherum hymenoides*), Nevada needlegrass (*Achnatherum nevadense),* and desert needlegrass (*Achnatherum speciosum).* Old growth singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) may occur on these sites, but trees are a minor component.

Disturbance Response Group 12 Ecological Sites:

Loamy 12-14" – Modal Site	R026XY005NV
Gravelly Loamy Slope 14-16"	R026XY105NV
Granitic Slope 12-14"	R026XY046NV
Granitic Loam 14+"	R026XY006NV
Loamy Slope 12-14"	R026XY048NV
Shallow Loam 12-14"	R026XY111NV
Gravelly Loam 14+"	R026XY040NV
South Slope 14-16"	R026XY106NV
South Slope 12-14"	R026XY089NV
Ashy Shallow Loam 14-16"	R026XF057CA
Ashy South Slope 12-14"	R026XF063CA
Granitic Upland 14-16"	R026XF064CA

Modal Site:

The Loamy 12-14" ecological site is the modal site that represents this DRG, as it has the most acres mapped. This site occurs on mountain sideslopes and toeslopes, and mountain valley fans on all aspects. Slopes range from 2 to 50 percent, but slope gradients of 4 to 30 percent are most typical. Elevations are 6,000 to over 8,000 feet. Soils are typically deep to very deep and are well drained. Some soils are modified with high volumes of rock fragments throughout the soil profile. Available water holding capacity is moderate to high. Runoff is slow to moderate and the potential for sheet and rill erosion is moderate to high depending on slope. The shrub component of the plant community is dominated by mountain big sagebrush and the herbaceous component is co-dominated by western needlegrass, Columbia needlegrass, and Letterman's needlegrass. Antelope bitterbrush and basin wildrye are also components of the herbaceous understory. Normal year production is 1500 lbs/ac.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by deep-rooted cool season perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of two meters in alluvial soils in Utah (Richards and Caldwell 1987). Tap roots of antelope bitterbrush have been documented from 4.5 to 5.4 m in length (McConnell 1961). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The perennial bunchgrasses that are dominant include western needlegrass, Columbia needlegrass, Letterman's needlegrass, and basin wildrye. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The moisture resource supporting the greatest amount of plant growth is usually the water stored in the soil profile during the winter. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition, or it can increase resource uptake by the decomposition of dead plant material following disturbance. The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al 2007). Dobrowolski et al. (1990) cite multiple authors on the extent of the soil profile exploited by the competitive exotic annual cheatgrass. Specifically, the depth of rooting is dependent on the size the plant achieves, and in competitive environments cheatgrass roots were found to penetrate only 15 cm, whereas isolated plants and pure stands were found to root at least 1 m in depth with some plants rooting as deep as 1.5 to 1.7 m.

Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

Native insect outbreaks are also important drivers of ecosystem dynamics in big sagebrush communities. Climate influences the timing of insect outbreaks, especially a sagebrush defoliator, Aroga moth (*Aroga websteri*). Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and have been ongoing in Nevada since 2004 (Bentz et al. 2008). Thousands of acres of big sagebrush have been impacted, with partial to complete die-off observed. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975).

Mountain big sagebrush and antelope bitterbrush are generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

The perennial bunchgrasses that are co-dominant with the shrubs in this group include western needlegrass, Letterman's needlegrass, and Columbia needlegrass. Basin wildrye is an important species as well. These species generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m and taper off more rapidly than shrubs. General differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems.

Letterman needlegrass is an erect, densely tufted perennial bunchgrass that forms large clumps. It is found on dry soils in a variety of vegetation communities, including, high elevation meadows, subalpine grasslands, open areas underneath aspen, and in sagebrush communities. It grows best on loamy soils that are greater than 20 cm deep (Dittberner and Olson 1983).

Basin wildrye is a large, cool-season perennial bunchgrass with an extensive deep coarse fibrous root system (Reynolds and Fraley 1989). Clumps may reach up to six feet in height (Ogle et al. 2012b). Basin wildrye does not tolerate long periods of inundation; it prefers cycles of wet winters and dry summers and is most commonly found in deep soils with high water holding capacities or seasonally high water tables (Ogle et al. 2012b, Perryman and Skinner 2007).

Infilling by singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma)* may also occur with an extended fire return interval. Eventually, singleleaf pinyon and Utah juniper will dominate the site and mountain big sagebrush will be severely reduced along with the herbaceous understory. Bluegrasses (*Poa* spp.) and bottlebrush squirreltail *(Elymus elymoides*) may remain underneath trees on north-facing slopes. The potential for soil erosion increases as the pinyon and/or juniper woodland matures and the understory plant community cover declines.

Millions of acres in the arid and semi-arid West were brush-beaten and planted with crested wheatgrass in the mid 1900's for the purpose of competing with weed species and increasing grass production on rangelands. Success and longevity of these seeding projects have been mixed (Williams et al. 2017). Crested wheatgrass is a cool-season, medium height, exotic perennial bunchgrass native to Asia. Sites within this DRG may exhibit an understory of crested wheatgrass in areas where historical seedings have occurred or where crested wheatgrass has been used in post-fire rehabilitation seedings.

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Long-term disturbance response may be influenced by small differences in landscape topography. North slopes are also more resilient than south slopes because lower soil surface temperatures operate to keep moisture content higher on northern exposures. Six possible alternative stable states have been identified for this DRG.

Invasive Annual Grasses:

The species most likely to invade these sites is cheatgrass. Cheatgrass is a cool season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead.

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass “die-off” provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but there is ongoing work to try to predict where they occur, in the hopes of aiding conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, are able to suppress cheatgrass growth when mature (Blank et al. 2020). Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, as only one year of data was reported.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz./ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Fire is believed to be the dominant disturbance force in natural big sagebrush communities. Several authors suggest pre-settlement fire return intervals in mountain big sagebrush communities varied from 15 to 25 years (Burkhardt and Tisdale 1969, Houston 1973, and Miller et al. 2000). Kitchen and McArthur (2007) suggest a mean fire return interval of 40 to 80 years for mountain big sagebrush communities. Natural fire return intervals are estimated to vary between less than 35 years up to 100 years in sagebrush ecosystems with basin wildrye (Brown and Smith 2000). The range from 15 to 80 years is probably more accurate and reflects the differences in elevation and precipitation where mountain big sagebrush communities occur. On a landscape scale, multiple seral stages were represented in a mosaic reflecting periodic reoccurrence of fire and other disturbances (Crawford et al. 2004). Post-fire hydrologic recovery and resilience is primarily influenced by pre-fire site conditions, fire severity, and post-fire weather and land use that relate to vegetation recovery. Fire adaptation by herbaceous species is generally superior to the dominant shrubs, which are typically killed by fire. Sites with low abundances of native perennial grasses and forbs typically have reduced resiliency following disturbance and are less resistant to invasion or increases in cheatgrass (Miller et al. 2013).

Mountain big sagebrush is killed by fire (Neunschwander 1980, Blaisdell et al. 1982) and does not resprout (Blaisdell 1953). Post-fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and may reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). Mountain big sagebrush may return to pre-burn density and cover within 15 to 20 years following fire, but establishment after severe fires may proceed more slowly (Bunting et al. 1987).

Antelope bitterbrush is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however, sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture, and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires may allow for bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006). If cheatgrass is present, bitterbrush seedling success is much lower. The factor that most limits establishment of bitterbrush seedlings is competition for water resources with the invasive species cheatgrass (Clements and Young 2002).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Young 1983, Wright 1971). Plant response will vary depending on post-fire soil moisture availability.

Columbia needlegrass resprouts quickly after fire (Monsen et al. 2004). Fall burning has been shown to increase seed production in Columbia needlegrass (Patton et al. 1988). Letterman's needlegrass recovers well after fire (Monsen et al. 2004). Emergence of western needlegrass seeds was shown to significantly improve with additions of smoke and burned soil (Blank and Young 1996).

Basin wildrye is relatively resistant to fire, particularly dormant season fire, as plants sprout from surviving root crowns and rhizomes (Zschaechner 1985). Miller et al. (2013) reported increased total shoot and reproductive shoot densities in the first year following fire, although by year two there was little difference between burned and control treatments.

Bottlebrush squirreltail is considered to be relatively tolerant to fire due to its small size, coarse stems, and sparse leafy material (Britton et al. 1990). Post-fire regeneration occurs from surviving root crowns and from on- and off-site seed sources. Bottlebrush squirreltail has the ability to produce large numbers of seeds with high germination rates when exposed to the correct environmental cues (Young and Evans 1977). Early spring growth and ability to grow at low temperatures contribute to the persistence of bottlebrush squirreltail on sites with high cover of cheatgrass (Hironaka and Tisdale 1973).
Cheatgrass accumulates fuel loads that foster frequent fires (Davies and Svejcar 2008). Invasion by annual grasses can alter the fire cycle by increasing fire size, rate of spread, numbers of individual fires, fire season length, and likelihood of fires spreading into native or managed ecosystems (D'Antonio and Vitousek 1992, Brooks et al. 2004). Areas dominated with cheatgrass are estimated to have a fire return interval of 3 to 5 years (Whisenant 1990). The mechanisms by which invasive annual grasses alter fire regimes likely interact with climate. For example, cheatgrass cover and biomass vary with climate (Chambers et al. 2007) and are promoted by wet and warm conditions during the fall and spring. Invasive annual species have been shown able to take advantage of high N availability following fire through higher growth rates and increased seedling establishment relative to native perennial grasses (Monaco et al. 2003).

Catastrophic wildfire in Utah juniper and/or singleleaf pinyon dominated sites may lead to an annual weed dominated site. Depending on fire severity, rabbitbrush and snowberry may increase after fire. Rubber rabbitbrush (*Ericameria nauseosa*) is top-killed by fire, but can resprout after fire and can also establish from seed (Young 1983). Douglas' rabbitbrush (*Chrysothamnus viscidiflorus*) is top-killed by fire, but sprouts vigorously after fire (Kuntz 1982, Akinsoji 1988). Snowberry is also top-killed by fire, but resprouts after fire from rhizomes (Noste and Bushey 1987). If arrowleaf balsamroot (*Balsamorhiza sagittata*) or mule-ears (*Wyethia amplexicaulis*) is common before fire, they will increase after fire. These species may increase with heavy grazing as well.

Livestock/Wildlife Grazing Interpretations:

Despite low palatability, mountain big sagebrush is eaten by sheep, cattle, goats, and horses. Chemical analysis indicates that the leaves of big sagebrush equal alfalfa meal in protein, have a higher carbohydrate content, and yield twelvefold more fat (USDA-Forest Service 1937). Many wildlife species are dependent on the sagebrush ecosystem including the greater sage grouse, sage sparrow, pygmy rabbit and the sagebrush vole. Dobkin and Sauder (2004) identified 61 species, including 24 mammals and 37 birds, associated with the shrub-steppe habitats of the Intermountain West.

Mountain big sagebrush sites provide nesting, brood-rearing, and fall and winter habitat for sage grouse (*Centrocercus urophasianus*). Sage grouse require sagebrush for food and cover during each stage of their life cycle. The abundance and diversity of perennial forbs and grasses provides important food for hens during the pre-laying period and comprise more than half of the juvenile diet until the broods are approximately three months old (McAdoo and Back 2001).

Antelope bitterbrush is an important shrub species to a variety of animals, such as domestic livestock, antelope, deer, and elk. Bitterbrush is critical browse for mule deer, as well as domestic livestock, antelope, and elk (Wood 1995, Clements and Young 2002). Antelope bitterbrush is most commonly found on soils which provide minimal restriction to deep root penetration, such as coarse textured soil, or finer textured soil with high stone content (Driscoll 1964). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison 1953).

The three primary needlegrass species found on this site, Letterman's, Columbia, and western, are common in cooler, moist, higher elevation areas of the sagebrush biome, and are considered to act as increasers with heavy grazing (Tisdale and Hironaka 1981, Hironaka and Fosberg 1979, Monsen et al. 2004). This may be because all grasses become less palatable when mature, due to their characteristic hardened pointed calluses. While Letterman's needlegrass provides forage for both livestock and wildlife (Parker 1975), it is only rated as fair for cattle and poor for sheep (USDA Forest Service 1937). It begins growth early in the year and is available to be utilized when other grasses are not yet palatable. This plant is especially important fall forage for big game (Monsen et al. 2004). Letterman's needlegrass has been shown to increase under long-term sheep grazing (Ellison 1954). There is some evidence that it decreases under cattle and horse grazing (Bowns and Bagley 1986).

Columbia needlegrass is a good forage source in the spring and summer, but livestock tend to avoid it as the seeds mature; the pointed callus in the mature inflorescence sometimes becomes injurious (Monsen et al. 2004). This grass recovers well with rest from grazing (Monsen et al. 2004).

The early growth and abundant production of basin wildrye make it a valuable source of forage for livestock. It is important forage for cattle and is readily grazed by cattle and horses in early spring and fall. Though coarse-textured during the winter, basin wildrye may be utilized more frequently by livestock and wildlife when snow has covered low shrubs and other grasses. Basin wildrye is used often as a winter feed for livestock and wildlife; not only providing roughage above the snow but also cover in the early spring months (Majerus 1992). Inadequate rest and recovery from defoliation causes a decrease in basin wildrye and an increase in sagebrush and rubber rabbitbrush (Young et al. 1976, Roundy 1985). Spring defoliation of basin wildrye and/or consistent, heavy grazing during the growing season has been found to significantly reduce basin wildrye production and density (Krall et al. 1971). Additionally, native basin wildrye suffers from low seed viability and low seedling vigor (Young and Evans 1981). Roundy (1985) found that although basin wildrye is adapted to seasonally dry soils, high and frequent spring precipitation is necessary to establish it from seed. This suggests that establishment of basin wildrye seedlings occurs only during years of unusually high precipitation. Therefore, reestablishment of a stand may be episodic.

Bottlebrush squirreltail generally increases in abundance when moderately grazed or protected (Hutchings & Stewart, 1953). Muttongrass (*Poa fendleriana*), a minor component on this ecological site, is relatively grazing tolerant. It is palatable and nutritional forage for livestock and wildlife when it is in the early stages of growth. It rates as excellent forage for cattle and horses, and good for sheep, elk and deer (Dayton 1937). Muttongrass persists well in open areas and under canopies of oak and other shrubs (Monsen et al. 2004). Muttongrass may be more shade tolerant than other perennial bunchgrasses and may persist in the understory as the canopy closes (Erdman 1970).

Overgrazing leads to an increase in big sagebrush and a decline in understory plants like basin wildrye. Grasses like squirreltail and bluegrasses (*Poa fendleriana* and *P. secunda*) are more tolerant of grazing and can become dominant. Bluegrass species are less common on certain sites in this group. Reduced bunchgrass vigor or density also provides an opportunity for cheatgrass and other invasive species to occupy interspaces. Over time, this leads to increased fire frequency and potentially an annual plant community. This site is likely to see an increase in shrubs and will have significant bare ground in the interspaces understory plant health declines.

State and Transition Model Narrative for Group 12:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 12.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability of this site under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought, and/or insect or disease attack.

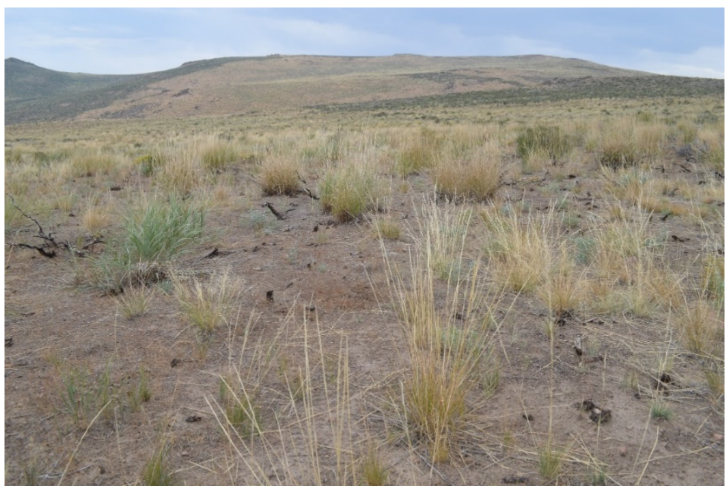
Community Phase 1.1:
Needlegrasses, basin wildrye, and mountain big sagebrush dominate the site. Bitterbrush may be a significant component. Pinyon and juniper may be present.

Ashy Shallow Loam 14-16” (R026XF057CA) Phase 1.1, T.K. Stringham, July 2015

Community Phase Pathway 1.1a, from phase 1.1 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses and perennial forbs to dominate the site. Fires would typically be small and patchy due to low fuel loads. Low severity fire creates sagebrush/grass mosaic. High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.

Community Phase Pathway 1.1b, from phase 1.1 to 1.3:
Time and lack of disturbance such as fire or drought allow for an increase in mountain big sagebrush. Excessive herbivory and/or long-term drought may also reduce perennial understory.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early- to mid-seral plant community. Needlegrasses, basin wildrye, and perennial grasses and forbs dominate. Mountain big sagebrush is a minor component. Bitterbrush may be sprouting. Forbs may increase.



Gravelly Loamy Slope 14-16" (R026XY105NV) Phase 1.2, D. Snyder, September 2017

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Time and lack of disturbance allows for sagebrush to reestablish.

Community Phase 1.3:
Mountain big sagebrush increases in the absence of disturbance and becomes dominant. Bitterbrush may be a significant component. Needlegrasses and other perennial grasses are reduced. Squirreltail and/or bluegrasses may increase. Pinyon and juniper may be present.


Ashy Shallow Loam 14-16” (R026XF057CA) Phase 1.3, T.K. Stringham, July 2015


Gravelly Loamy Slope 14-16” (R026XY105NV) Phase 1.3 T.K. Stringham, July 2015


Ashy Shallow Loam 14-16” (R026XF057CA) Phase 1.3 P. Novak-Echenique, July 2017

Community Phase Pathway 1.3a, from phase 1.3 to 1.2:
Fire. A low severity fire creates a sagebrush/grass mosaic, while a high-severity fire reduces sagebrush to trace amounts.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass, mustard and Russian thistle (*Salsola tragus*).

Slow variables: Over time the annual non-native plants will increase within the community, decreasing organic matter inputs from deep-rooted perennial bunchgrasses. This results in reductions in soil water availability for perennial bunchgrasses.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

T1B: Transition from Reference State 1.0 to Shrub State 3.0

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during the growing season would favor shrubs and initiate transition to Community Phase 3.1.

Slow variables: Long term decrease in deep-rooted perennial grass density.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution and reduces soil organic matter and soil moisture.

T1C: Transition from Reference State 1.0 to Tree State 5.0

Trigger: Time and lack of disturbance or management action allows pinyon or juniper to dominate. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources.

Feedbacks and ecological processes: Trees increasingly dominate use of soil water, contributing to reductions in soil water availability to grasses and shrubs. Overtime, grasses and shrubs are outcompeted. Reduced herbaceous and shrub production slows soil organic matter inputs and increases soil erodibility through loss of cover and root structure.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Trees dominate ecological processes and the number of shrub skeletons exceed number of live shrubs.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however, the resiliency of the state has been reduced by the presence of invasive weeds. This state has four general community phases. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate and adaptations for seed dispersal. Additionally, the presence of highly flammable, non-native species reduces State resilience because these species can promote fire where historically fire has been infrequent leading to positive feedbacks that further the degradation of the system.

Community Phase 2.1:
Needlegrasses, basin wildrye and mountain big sagebrush dominate the site. Bitterbrush may be a significant component. Pinyon and juniper may be present. Annual non-native species present.

Gravelly Loamy Slope 14-16" (R026XY105NV) Phase 2.1 T.K. Stringham, July 2015.

Community Phase Pathway 2.1a, from phase 2.1 to 2.2:
Fire. Low severity fire creates sagebrush/grass mosaic while a high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs. Non-native annual species present.

Community Phase Pathway 2.1b, from phase 2.1 to 2.3:
Time, lack of disturbance, long-term drought, grazing management that favors shrubs or combinations of these would allow the sagebrush overstory to increase and dominate the site, causing a reduction in the perennial bunchgrasses.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early-seral plant community. Needlegrasses and other perennial grasses and perennial forbs dominate. Mountain big sagebrush is a minor component. Bitterbrush may be sprouting. Forbs may increase. Annual non-native species are present.

Gravelly Loamy Slope 14-16” (R026XY105NV) Phase 2.2 T.K. Stringham, July 2015

Community Phase Pathway 2.2a, from phase 2.2 to 2.1:
Absence of disturbance over time allows for the sagebrush to recover. This may be combined with grazing management that favors shrubs.

Community Phase Pathway 2.2b, from Phase 2.2 to 2.4:
Higher than normal spring precipitation favors annual non-native species such as cheatgrass. Non-native annual species will increase in production and density throughout the site. Shrub removal or prescribed burning may increase invasive annuals. Perennial bunchgrasses may also increase in production.

Community Phase 2.3:
Mountain big sagebrush is dominant and the perennial understory is reduced. Bitterbrush may be a significant component. Bluegrass may increase. Pinyon and juniper may be present. Annual non-native species are present.

Gravelly Loamy Slope 14-16” (R026XY105NV) Phase 2.3 T.K. Stringham, July 2015

Shallow Loam 12-14" (R026XY111NV) Phase 2.3 T.K. Stringham, June 2016

Community Phase Pathway 2.3a, from phase 2.3 to 2.1:
Low severity fire creates sagebrush/grass mosaic. Other disturbances/practices include brush management with minimal soil disturbance leading to a reduction in sagebrush.

Community Phase Pathway 2.3b, from phase 2.3 to 2.2:
High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.

Community Phase Pathway 2.3c, from phase 2.3 to 2.4:
Fall and spring growing season conditions that favor the germination and production of non-native annual grasses.

Community Phase 2.4:
This community is at risk of crossing to an annual state. Native bunchgrasses and forbs still comprise 50% or more of the understory annual production, however non-native annual grasses are nearly codominant. If this site originated from phase 2.3 there may be significant shrub cover as well. Annual production and abundance of these annuals may increase drastically in years with heavy spring precipitation. This site is susceptible to further degradation from grazing, drought, and fire.

Granitic Upland (R026XF064CA) Phase 2.4 P. Novak-Echenique, July 2017

Community Phase Pathway 2.4a, from phase 2.4 to 2.2:
Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Community Phase Pathway 2.4b, from phase 2.4 to 2.3:
Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during growing season would favor shrubs and initiate transition to Community Phase 3.1.

Slow variables: Long term declines in deep-rooted perennial grass density.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution and reduces soil organic matter.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Fire and/or multiple fires lead to plant community phase 4.1, inappropriate grazing management that favors shrubs in the presence of non-native annual species leads to community phase 4.2.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs truncates, spatially and temporally, nutrient capture and cycling within the community. Increased, continuous fine fuels from annual non-native plants modify the fire regime by changing intensity, size and spatial variability of fires.

T2C: Transition from Current Potential 2.0 to Tree State 5.0:

Trigger: Time and lack of disturbance or management action allows pinyon and juniper to dominate. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources.

Feedbacks and ecological processes: Trees increasingly dominate use of soil water, contributing to reductions in soil water availability to grasses and shrubs. Overtime, grasses and shrubs are outcompeted. Reduced herbaceous and shrub production slows soil organic matter inputs and increases soil erodibility through loss of cover and root structure.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Trees dominate ecological processes and number of shrub skeletons exceed the number of live shrubs.

Shrub State 3.0:

This state has two community phases: a mountain big sagebrush dominated phase and a squirreltail-dominated phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Squirreltail will increase with a reduction in deep rooted perennial bunchgrass competition and become the dominant grass. Sagebrush and bitterbrush dominate the overstory. Sagebrush canopy cover is high and sagebrush may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and bluegrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1:
This site is at risk of transitioning to another state. Mountain big sagebrush, possibly decadent, dominates the overstory. Antelope bitterbrush may be a significant component. Deep-rooted perennial bunchgrasses are present in only trace amounts and may be absent from the community. Squirreltail may be dominant in the understory. Understory may be sparse, with bare ground increasing. Pinyon and/or juniper may be present as a result of encroachment from neighboring sites and lack of disturbance. Annual non-native species are present to increasing.

Ashy Shallow Loam 14-16" (R026XF057CA) Phase 3.1, T.K. Stringham, July 2015

Loamy 12-14" (R026XY005NV) Phase 3.1, T.K. Stringham, May 2016

Community Phase Pathway 3.1a, from phase 3.1 to 3.2:
Fire reduces or eliminates the overstory of sagebrush. Non-native annual species increase with higher-than-normal spring precipitation.

Community Phase 3.2:
Squirreltail dominates the site. Needlegrasses and other perennial grasses are reduced. Mountain big sagebrush is reduced or missing. Bitterbrush may be sprouting. Annual non-native species are increasing and may be co-dominant in the understory.

Community Phase Pathway 3.2a, from phase 3.2 to 3.1:
Absence of disturbance over time would allow for sagebrush and other shrubs to recover.

T3A: Transition from Shrub State 3.0 to Annual State 4.0:

Trigger: Fire or inappropriate grazing management can eliminate the squirreltail understory and transition to community phase 4.1 or 4.2.

Slow variable: Increased seed production and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and big sagebrush truncate energy capture and impact the nutrient cycling and distribution.

T3B: Transition from Shrub State 3.0 to Tree State 5.0:

Trigger: Time and lack of disturbance allows for maturation of the tree community. This may be coupled with grazing management that favors shrub and tree growth.

Slow variable: Over time, with lack of fire, the abundance and size of trees increase.

Threshold: Trees overtop mountain big sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts. Bare ground areas are large and connected.

R3A: Restoration from Shrub State 3.0 to Seeded State 6.0:

Brush management and seeding of crested wheatgrass and/or other desired species. Presence of non-native annual species will make this restoration pathway difficult.

Annual State 4.0:

This state has two community phases, both characterized by a dominance of non-native annual grasses and forbs. Shrub cover is present in one phase, while the other is primarily annual grasses. Sagebrush and/or rabbitbrush may dominate the overstory. Annual non-native species dominate the understory. Ecological dynamics are significantly altered in this state. Annual non-native species create a highly combustible fuel bed that shortens the fire return interval. Nutrient cycling is spatially and temporally truncated as annual plants contribute significantly less to deep soil carbon. Because this is a productive site, some deep-rooted perennial grasses may remain, even in the annual state. Without management, it is unlikely these plants will be able to recruit in the presence of dominant annual grasses.

Community Phase 4.1:
Annual non-native plants such as cheatgrass dominate the site. This phase may have seeded species present if resulting from a failed seeding attempt. Needlegrasses, mountain big sagebrush, and other shrubs are only present in trace amounts and may be missing from the community.

South Slope 12-14" (R026XY089NV) Phase 4.1, T.K. Stringham, July 2015.

Loamy 12-14" (R026XY005NV) Phase 4.1, T.K. Stringham, July 2015

Community Phase Pathway 4.1a, from phase 4.1 to phase 4.2:
Time and lack of disturbance allows for shrubs to reestablish. Probability of sagebrush reestablishment is extremely low.

Community Phase 4.2:
Annual non-native species, primarily cheatgrass, dominate the understory. Sprouting shrubs dominate the overstory. Perennial bunchgrasses are a minor component or missing. Seeded species may be present.

Granitic Upland (R026XY064CA) Annual State P. Novak-Echenique, July 2017

Community Phase Pathway 4.2a, from phase 4.2 to 4.1:
Fire kills non-sprouting shrubs and allows annual non-native species to dominate site.

Tree State 5.0:

This state is characterized by a dominance of pinyon and/or juniper in the overstory. It occurs where sagebrush sites exist adjacent to stands of trees. Big sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Skeletons of dead sagebrush plants are apparent. Soil moisture, soil nutrients, soil organic matter distribution and nutrient cycling have been spatially and temporally altered.

Community Phase 5.1:
Pinyon and juniper dominate. Trees are actively growing with noticeable leader growth. Mountain big sagebrush is stressed and dying. Needlegrass and other perennial grasses reduced. Annual non-native species are present under tree canopies. Bare ground interspaces are large and connected.

South Slope 12-14” (R026XY089NV), Phase 5.1 (Phase II trees), T. Stringham July 2015

Granitic Slope 12-14" (R026XY046NV), Phase 5.1 (Phase II trees), T. Stringham August 2015

Ashy South Slope 14-16" P.Z. (R026XF063CA) Phase 5.1 (Phase II trees), P. Novak-Echenique Sept. 2017

Community Phase Pathway 5.1a, from phase 5.1 to 5.2:
Absence of disturbance over time allows for tree cover and density to further increase and out-compete the herbaceous understory species for sunlight and water.

Community Phase 5.2:
Pinyon and/or juniper dominate the site and tree leader growth is minimal. Annual non-native species may be the dominant understory species and will typically be found under tree canopies. Trace amounts of sagebrush may be present, however dead skeletons will be more numerous than living sagebrush. Bunchgrass may or may not be present. Bare ground areas are large and connected, and soil redistribution is apparent.

Ashy Shallow Loam 14-16" (R026XF057CA) Tree State T.K. Stringham, July 2015

Granitic Slope 12-14" (R026XY046NV) Tree State T.K. Stringham, August 2015

Community Phase Pathway 5.2a, from phase 5.2 to 5.1:
Tree thinning treatment (typically for fuels management) removes some tree cover and may allow sagebrush to survive. Without further management this pathway is temporary.

T5A: Transition from Tree State 5.0 to Annual State 4.0:

Trigger: Catastrophic crown fire would reduce or eliminate trees to transition the site to 4.1. Tree removal when annual non-natives such as cheatgrass are present would also transition the site to state 4.0.

Slow variable: Increased seed production and cover of annual non-native species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture and impact the nutrient cycling and distribution.

R5A: Restoration from Tree State 5.0 to Shrub State 6.0:

Tree removal with minimum soil disturbance such as hand felling or mastication within community phase 5.1 when native grasses are still present.

R5B: Restoration from Tree State 5.0 to Seeded State 6.0:

Tree removal and seeding of desired species. Tree removal practices that minimize soil disturbance are recommended. Probability of success declines with increased presence of non-native annual species.

Seeded State 6.0:

This state has two community phases: a grass-dominated phase and a shrub dominated phase. This state is characterized by the dominance of seeded introduced wheatgrass species in the understory. Crested wheatgrass is a dominant plant in this phase. Conservation practices such as brush management and prescribed grazing should be used to maintain the perennial bunchgrasses and other desirable species.

Community Phase 6.1:
Seeded wheatgrasses and/or other seeded species dominate the community. Non-native annual species are present. Trace amounts of mountain big sagebrush may be present, especially if seeded.

Community Phase Pathway 6.1a, from phase 6.1 to 6.2:
Time and lack of disturbance allows shrubs to dominate. This process may be accelerated through inappropriate grazing management.

Community Phase 6.2:
Mountain big sagebrush and/or bitterbrush increases and dominates the overstory. Seeded wheatgrass species are a minor component. Annual non-native species may be present in trace amounts. Pinyon and/or juniper may be present.

Community Phase Pathway 6.2a, from phase 6.2 to 6.1:
Fire, brush management and/or Aroga moth infestation reduces sagebrush overstory and allows for seeded wheatgrasses or other seeded grasses to increase.

T6A: Transition from Seeded State 6.0 to Annual State 4.0:

Trigger: Catastrophic fire.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Increased continuous fine fuels modify the fire regime by changing intensity, size, and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture spatially and temporally, thus impacting nutrient cycling and distribution.

T6B: Transition from Seeded State 6.0 to Tree State 5.0:

Trigger: Time and lack of disturbance or management action allows for pinyon and/or juniper to dominate. This may be coupled with grazing management that favors tree establishment by reducing understory herbaceous competition for site resources.

Slow variables: Over time, the abundance and size of trees will increase.

Threshold: Trees dominate ecological processes and number of shrub skeletons exceed number of live shrubs.

Potential Resilience Differences with other Ecological Sites:

Gravelly Loamy Slope 14-16" (R026XY105NV)

This site is characterized by soils formed in colluvium and residuum from volcanic rocks with surficial additions of eolian ash. There are many rock fragments in the form of gravels in the soil profile. The soil is shallow to very deep with an available water capacity of very low to moderate. The annual production for a normal year is 1200 lbs/ac.

Granitic Slope 12-14" (R026XY046NV)

This site is characterized by soils formed in residuum derived from granitic rock. They are shallow to moderately deep and well drained. The site has Thurber's needlegrass as a dominant grass, and Indian ricegrass as a secondary grass. The annual production for a normal year is much lower than the modal site at 700 lbs/ac.

Granitic Loam 14+ (R026XY006NV)

The soils on this site formed in residuum from granite and granodiorite parent material. They are excessively drained with a low to moderate available water capacity. The soil surface is coarse and droughty, which reduces seedling establishment. The onset of growth is delayed by cold soil and air temperatures. The vegetation is similar to that of the modal site, but with Nevada needlegrass codominant with western needlegrass. The annual production for a normal year is lower than the modal with 900 lbs/ac. Juniper is not present in the reference state.

Loamy Slope 12-14" (R026XY048NV)

This site is similar to the modal site, but with Thurber's needlegrass as the dominant grass. The annual production for a normal year is lower than the modal site at 1100 lbs/ac.

Shallow Loam 12-14" (R026XY111NV)

This site has Thurber's needlegrass as the dominant grass. Bluegrass and prairie junegrass are also present. The annual production for a normal year is 700 lbs/ac. Pinyon and juniper are not present in the reference state for this site.

Gravelly Loam 14+ (R026XY040NV)

This site is very similar to the modal site, but with antelope bitterbrush as the dominant shrub. The annual production for a normal year is 1300 lbs/ac.

South Slope 14-16" (R026XY106NV)

This site occurs on slopes from 25 to 65 percent, with 30 to 50 percent being typical. The soils are shallow, well drained, and consist of 35 to 50 percent rock fragments. The soils formed on volcanic ash over residuum and colluvium derived from andesitic rock. The annual production for a normal year is 1000 lbs/ac, and juniper is not present in the Reference state.

South Slope 12-14" (R026XY089NV)

This site is very similar to the modal site, but it occurs on south-facing sideslopes. It has Thurber's needlegrass and desert needlegrass as dominant grasses. The annual production for a normal year is much lower than the modal site at 900 lbs/ac.

Ashy Shallow Loam 14-16" (R026XF057CA)

The soils on this site developed in colluvium and residuum from volcanic rock. They have a mollic epipedon and the soil profile has a significant amount of volcanic glass present. They have a very low available water capacity, and a shallow rooting depth that reduced productivity and plant density. Surface gravel, cobble, or stones stabilize the soil against surface erosion. The vegetation is similar to the modal site, but with prairie Junegrass as an important species. The annual production for a normal year is 700 lbs/ac.

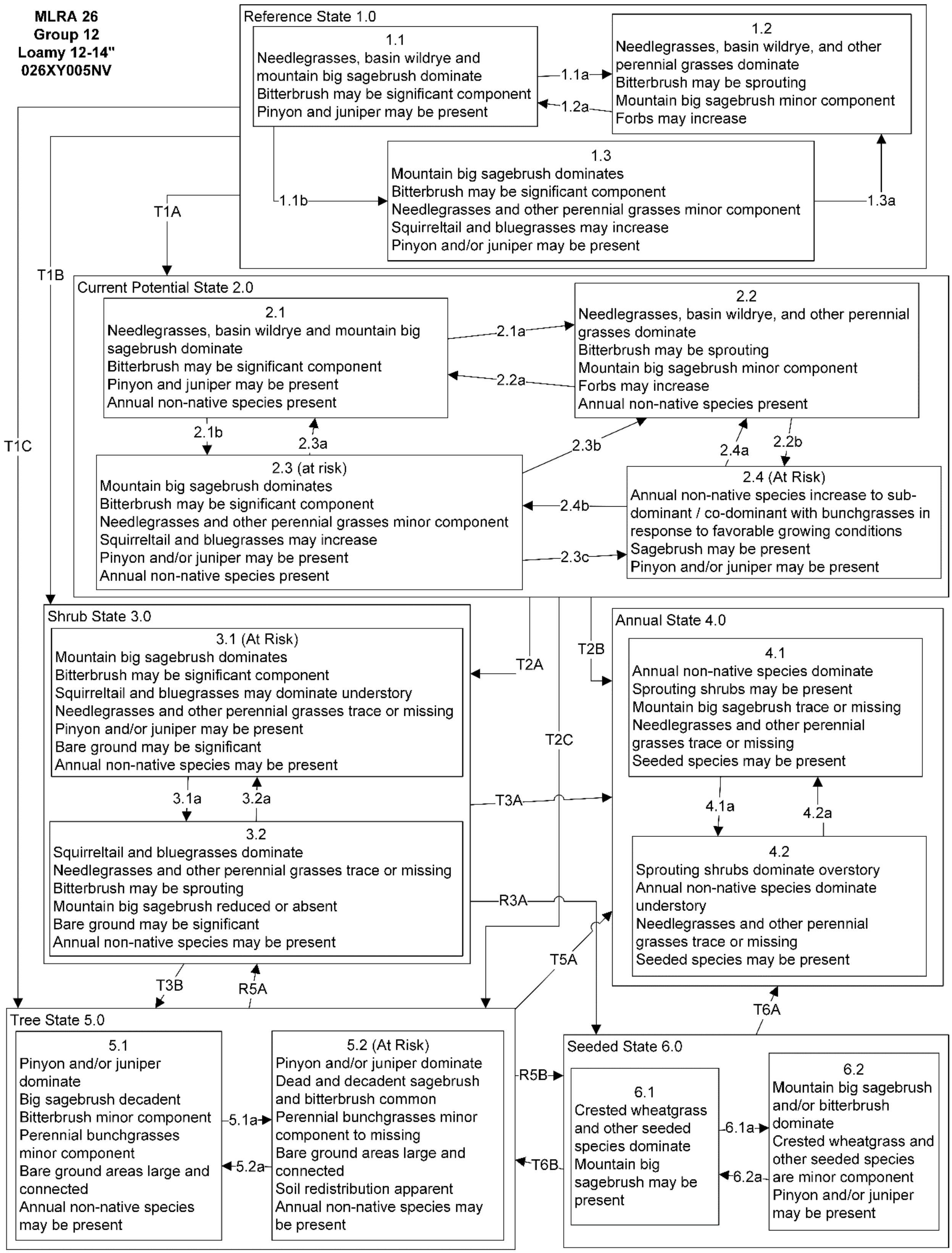
Ashy South Slope 12-14" (R026XF063CA)

This site contains soils with a mollic epipedon that formed in residuum and colluvium derived from andesitic or metavolcanic rocks with surface additions of eolian volcanic ash. The soil profile has significant amounts of volcanic glass. Permeability is moderately rapid and surface runoff is very high. Desert needlegrass and Indian ricegrass dominate the site, and the annual production for a normal year is 600 lbs/ac. Pinyon and juniper are not present in the Reference State.

Granitic Upland 14-16" (R026XF064CA)

This site is typically found on backslopes ranging from 30 to 50 percent slopes. The soils are shallow to very shallow and have formed in residuum and collivium derived from granitic rock and eolian volcanic ash. They have significant amounts of volcanic glass, and a mollic epipedon that is 9 or more inches thick. Desert needlegrass and Indian ricegrass are dominant, and the site produces 600 lbs/ac on a normal year. Pinyon and juniper are not present in the Reference state.

Modal State and Transition Model for Group 12 in MLRA 26:


MLRA 26
Group 12
Loamy 12-14"
026XY005NV
Reference State 1.0
1.1
Needlegrasses, basin wildrye and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
1.2
Needlegrasses, basin wildrye, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
1.1a
1.2a
1.1b
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Needlegrasses, basin wildrye and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
Annual non-native species present
2.2
Needlegrasses, basin wildrye, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail and bluegrasses may dominate understory
Needlegrasses and other perennial grasses trace or missing
Pinyon and/or juniper may be present
Bare ground may be significant
Annual non-native species may be present
3.2
Squirreltail and bluegrasses dominate
Needlegrasses and other perennial grasses trace or missing
Bitterbrush may be sprouting
Mountain big sagebrush reduced or absent
Bare ground may be significant
Annual non-native species may be present
3.1a
3.2a
T3A
R3A
T3B
R5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.1a
4.2a
T5A
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
5.1a
5.2a
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present
6.1a
6.2a

MLRA 26
Group 12
Loamy 12-14"
026XY005NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

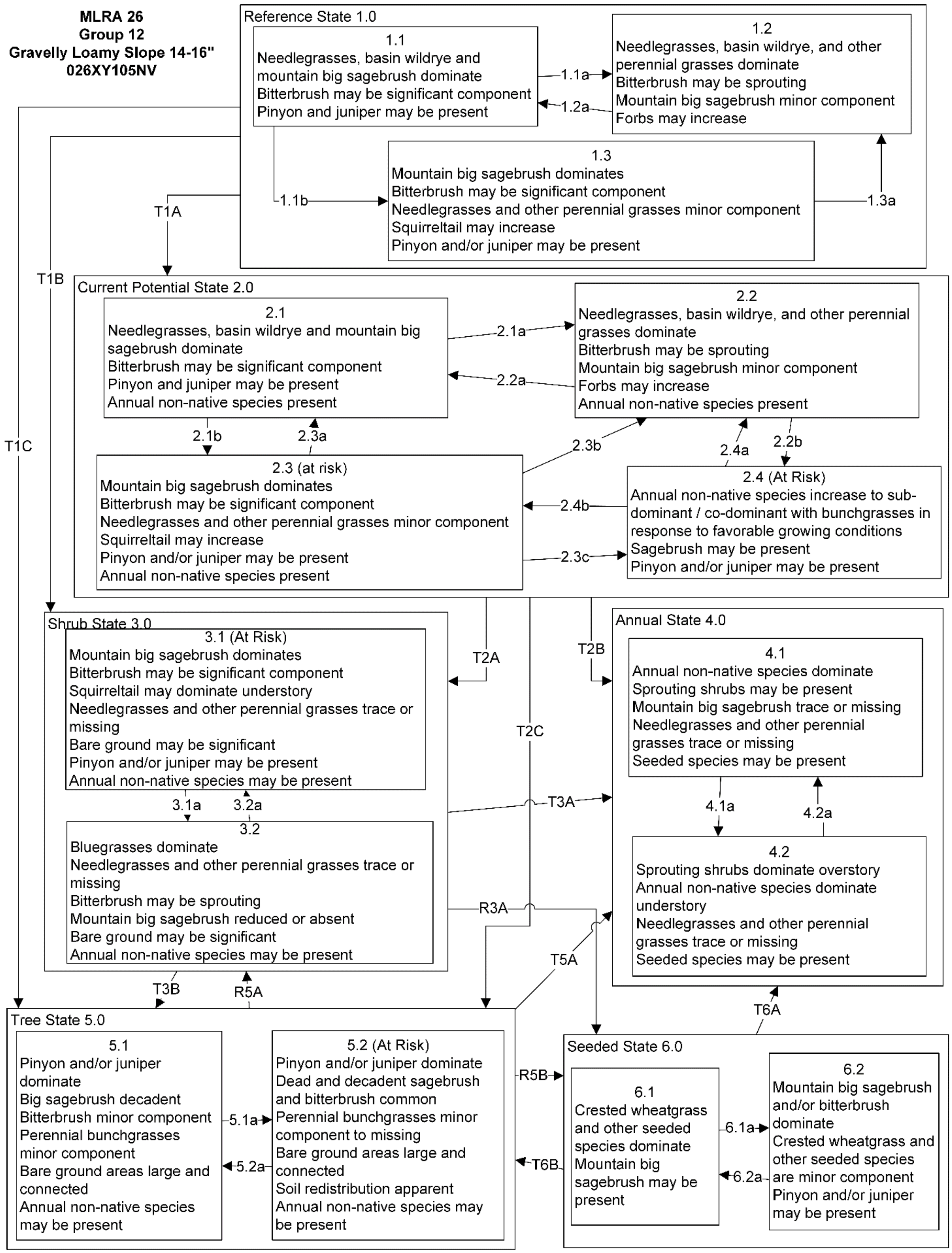
Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).

Additional State and Transition Models for Group 12 in MLRA 26:


MLRA 26
Group 12
Gravelly Loamy Slope 14-16"
026XY105NV
Reference State 1.0
1.1
Needlegrasses, basin wildrye and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
1.1a
1.2a
1.2
Needlegrasses, basin wildrye, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
1.1b
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail may increase
Pinyon and/or juniper may be present
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Needlegrasses, basin wildrye and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
Annual non-native species present
2.1a
2.2a
2.2
Needlegrasses, basin wildrye, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.1b
2.3a
2.3b
2.4a
2.2b
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4b
2.3c
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Pinyon and/or juniper may be present
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail may dominate understory
Needlegrasses and other perennial grasses trace or missing
Bare ground may be significant
Pinyon and/or juniper may be present
Annual non-native species may be present
3.1a
3.2a
3.2
Bluegrasses dominate
Needlegrasses and other perennial grasses trace or missing
Bitterbrush may be sprouting
Mountain big sagebrush reduced or absent
Bare ground may be significant
Annual non-native species may be present
T2A
T2C
T2B
T3A
R3A
T5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.1a
4.2a
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
T3B
R5A
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.1a
6.2a
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present

MLRA 26
Group 12
Gravelly Loamy Slope 14-16"
026XY105NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

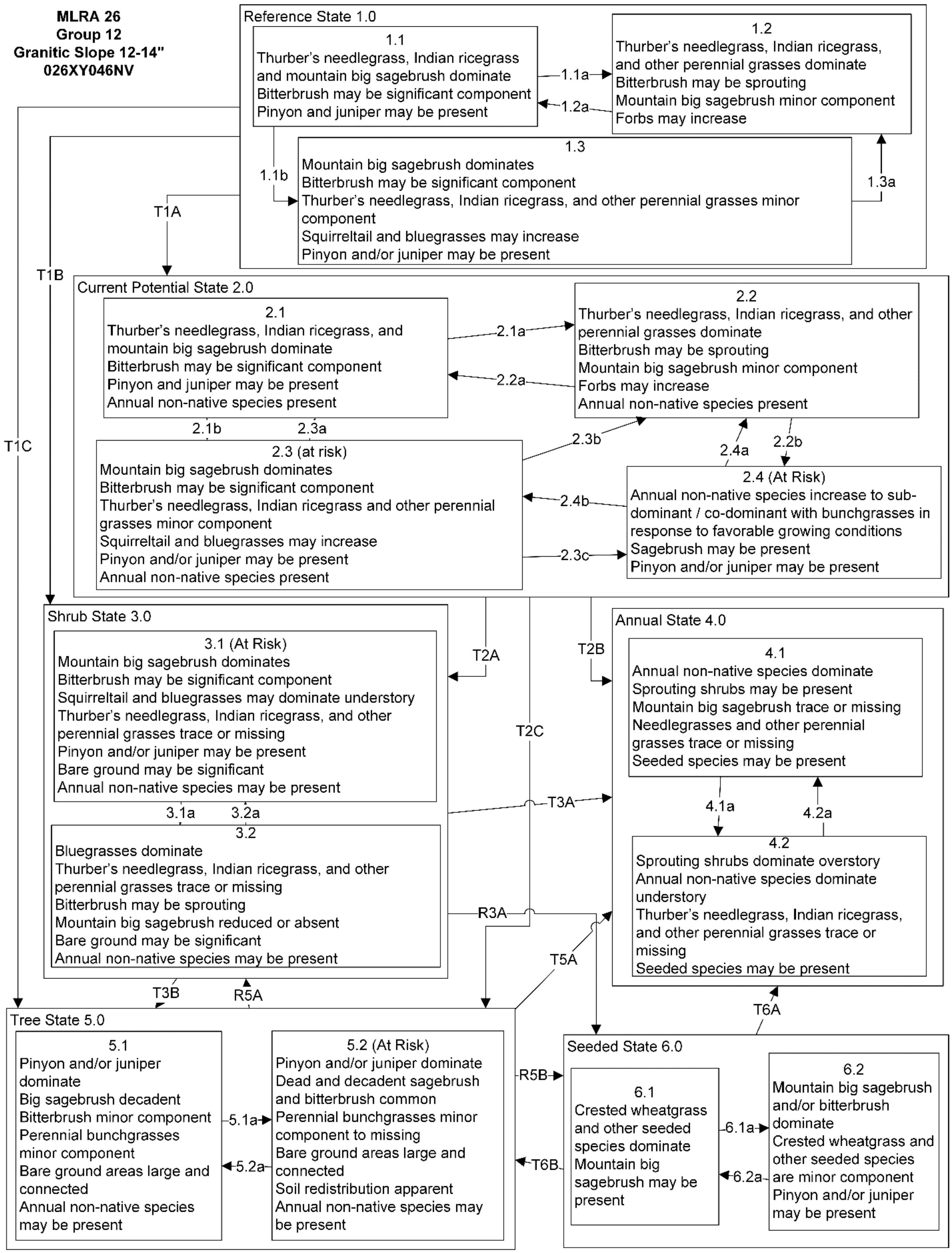
Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).


MLRA 26
Group 12
Granitic Slope 12-14"
026XY046NV
Reference State 1.0
1.1
Thurber's needlegrass, Indian ricegrass and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
1.1a
1.2a
1.2
Thurber's needlegrass, Indian ricegrass, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
1.1b
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Thurber's needlegrass, Indian ricegrass, and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Thurber's needlegrass, Indian ricegrass, and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
Annual non-native species present
2.1a
2.2a
2.2
Thurber's needlegrass, Indian ricegrass, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.1b
2.3a
2.3b
2.4a
2.2b
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Thurber's needlegrass, Indian ricegrass and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4b
2.3c
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Pinyon and/or juniper may be present
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail and bluegrasses may dominate understory
Thurber's needlegrass, Indian ricegrass, and other perennial grasses trace or missing
Pinyon and/or juniper may be present
Bare ground may be significant
Annual non-native species may be present
3.1a
3.2a
3.2
Bluegrasses dominate
Thurber's needlegrass, Indian ricegrass, and other perennial grasses trace or missing
Bitterbrush may be sprouting
Mountain big sagebrush reduced or absent
Bare ground may be significant
Annual non-native species may be present
T2A
T2B
T2C
T3A
R3A
T5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.1a
4.2a
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Thurber's needlegrass, Indian ricegrass, and other perennial grasses trace or missing
Seeded species may be present
T3B
R5A
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.1a
6.2a
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present

MLRA 26
Group 12
Granitic Slope 12-14"
026XY046NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

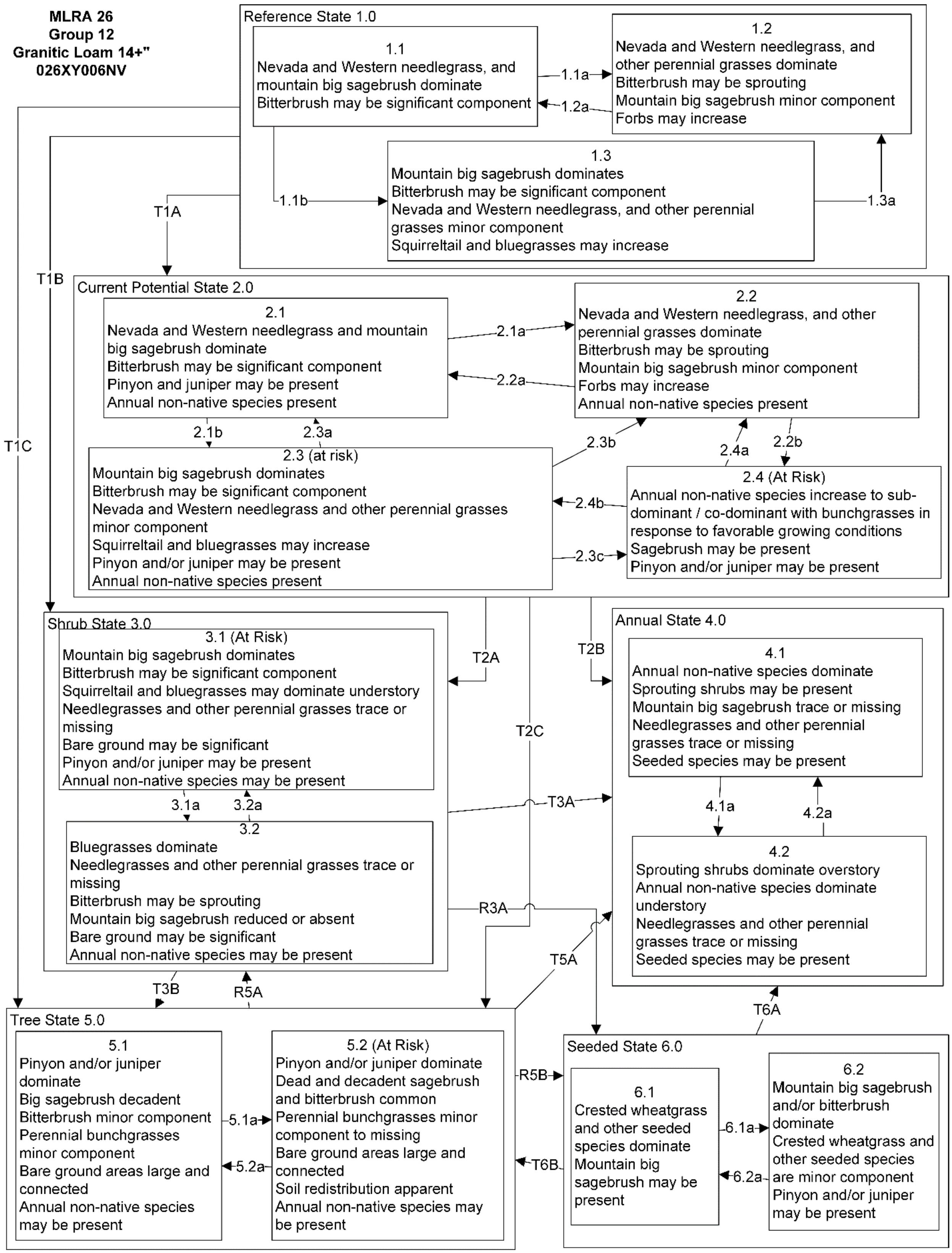
Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).



MLRA 26
Group 12
Granitic Loam 14+"
026XY006NV
Reference State 1.0
1.1
Nevada and Western needlegrass, and mountain big sagebrush dominate
Bitterbrush may be significant component
1.2
Nevada and Western needlegrass, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Nevada and Western needlegrass, and other perennial grasses minor component
Squirreltail and bluegrasses may increase
1.1a
1.2a
1.1b
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Nevada and Western needlegrass and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
Annual non-native species present
2.2
Nevada and Western needlegrass, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Nevada and Western needlegrass and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Pinyon and/or juniper may be present
2.4b
2.3c
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail and bluegrasses may dominate understory
Needlegrasses and other perennial grasses trace or missing
Bare ground may be significant
Pinyon and/or juniper may be present
Annual non-native species may be present
3.1a
3.2a
3.2
Bluegrasses dominate
Needlegrasses and other perennial grasses trace or missing
Bitterbrush may be sprouting
Mountain big sagebrush reduced or absent
Bare ground may be significant
Annual non-native species may be present
T2A
T2B
T2C
T3A
R3A
T5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.1a
4.2a
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
T3B
R5A
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.1a
6.2a
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present

MLRA 26
Group 12
Granitic Loam 14+"
026XY006NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

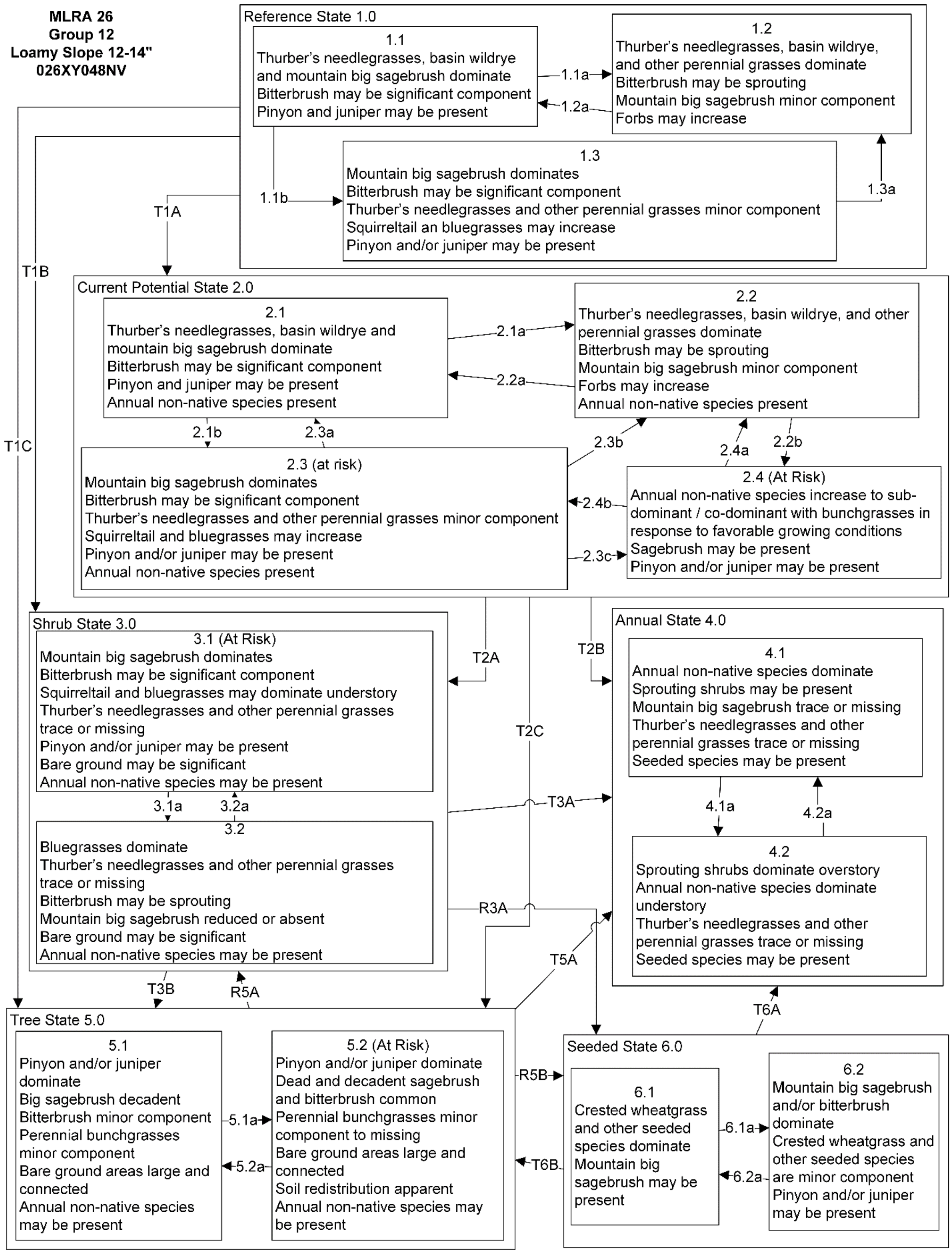
Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).


MLRA 26
Group 12
Loamy Slope 12-14"
026XY048NV
Reference State 1.0
1.1
Thurber's needlegrasses, basin wildrye and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
1.1a
1.2a
1.2
Thurber's needlegrasses, basin wildrye, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
1.1b
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Thurber's needlegrasses and other perennial grasses minor component
Squirreltail an bluegrasses may increase
Pinyon and/or juniper may be present
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Thurber's needlegrasses, basin wildrye and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
Annual non-native species present
2.1a
2.2a
2.2
Thurber's needlegrasses, basin wildrye, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.1b
2.3a
2.3b
2.4a
2.2b
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Thurber's needlegrasses and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4b
2.3c
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Pinyon and/or juniper may be present
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail and bluegrasses may dominate understory
Thurber's needlegrasses and other perennial grasses trace or missing
Pinyon and/or juniper may be present
Bare ground may be significant
Annual non-native species may be present
3.1a
3.2a
3.2
Bluegrasses dominate
Thurber's needlegrasses and other perennial grasses trace or missing
Bitterbrush may be sprouting
Mountain big sagebrush reduced or absent
Bare ground may be significant
Annual non-native species may be present
T2A
T2B
T2C
T3A
R3A
T5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Thurber's needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.1a
4.2a
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Thurber's needlegrasses and other perennial grasses trace or missing
Seeded species may be present
T3B
R5A
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.1a
6.2a
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present

MLRA 26
Group 12
Loamy Slope 12-14"
026XY048NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

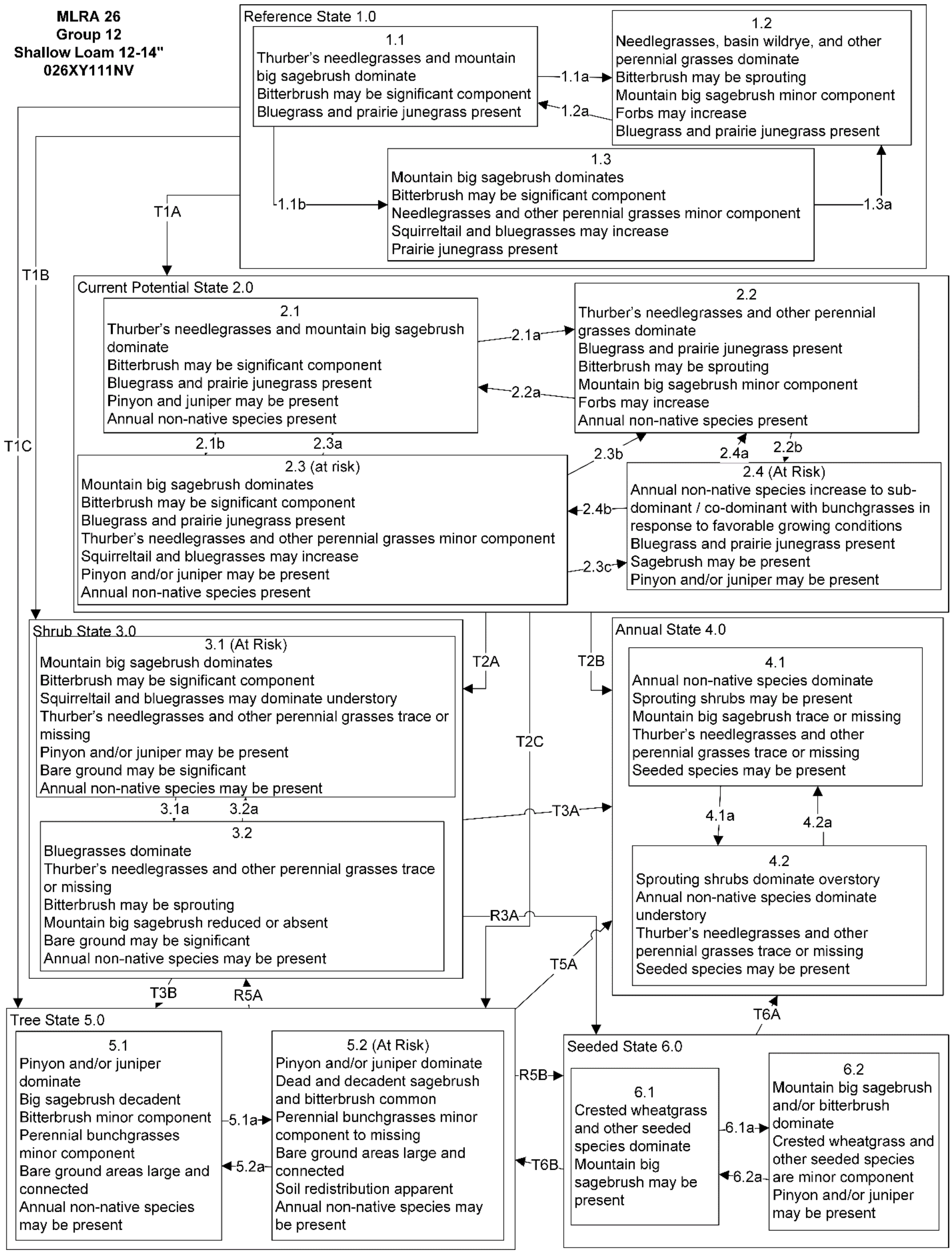
Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).


MLRA 26
Group 12
Shallow Loam 12-14"
026XY111NV
Reference State 1.0
1.1
Thurber's needlegrasses and mountain big sagebrush dominate
Bitterbrush may be significant component
Bluegrass and prairie junegrass present
1.2
Needlegrasses, basin wildrye, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Bluegrass and prairie junegrass present
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Prairie junegrass present
1.1a
1.2a
1.1b
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Thurber's needlegrasses and mountain big sagebrush dominate
Bitterbrush may be significant component
Bluegrass and prairie junegrass present
Pinyon and juniper may be present
Annual non-native species present
2.2
Thurber's needlegrasses and other perennial grasses dominate
Bluegrass and prairie junegrass present
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Bluegrass and prairie junegrass present
Thurber's needlegrasses and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Bluegrass and prairie junegrass present
Sagebrush may be present
Pinyon and/or juniper may be present
2.4b
2.3c
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail and bluegrasses may dominate understory
Thurber's needlegrasses and other perennial grasses trace or missing
Pinyon and/or juniper may be present
Bare ground may be significant
Annual non-native species may be present
3.1a
3.2a
3.2
Bluegrasses dominate
Thurber's needlegrasses and other perennial grasses trace or missing
Bitterbrush may be sprouting
Mountain big sagebrush reduced or absent
Bare ground may be significant
Annual non-native species may be present
T2A
T2B
T2C
T3A
R3A
T5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Thurber's needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.1a
4.2a
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Thurber's needlegrasses and other perennial grasses trace or missing
Seeded species may be present
T3B
R5A
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.1a
6.2a
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present

MLRA 26
Group 12
Shallow Loam 12-14"
026XY111NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

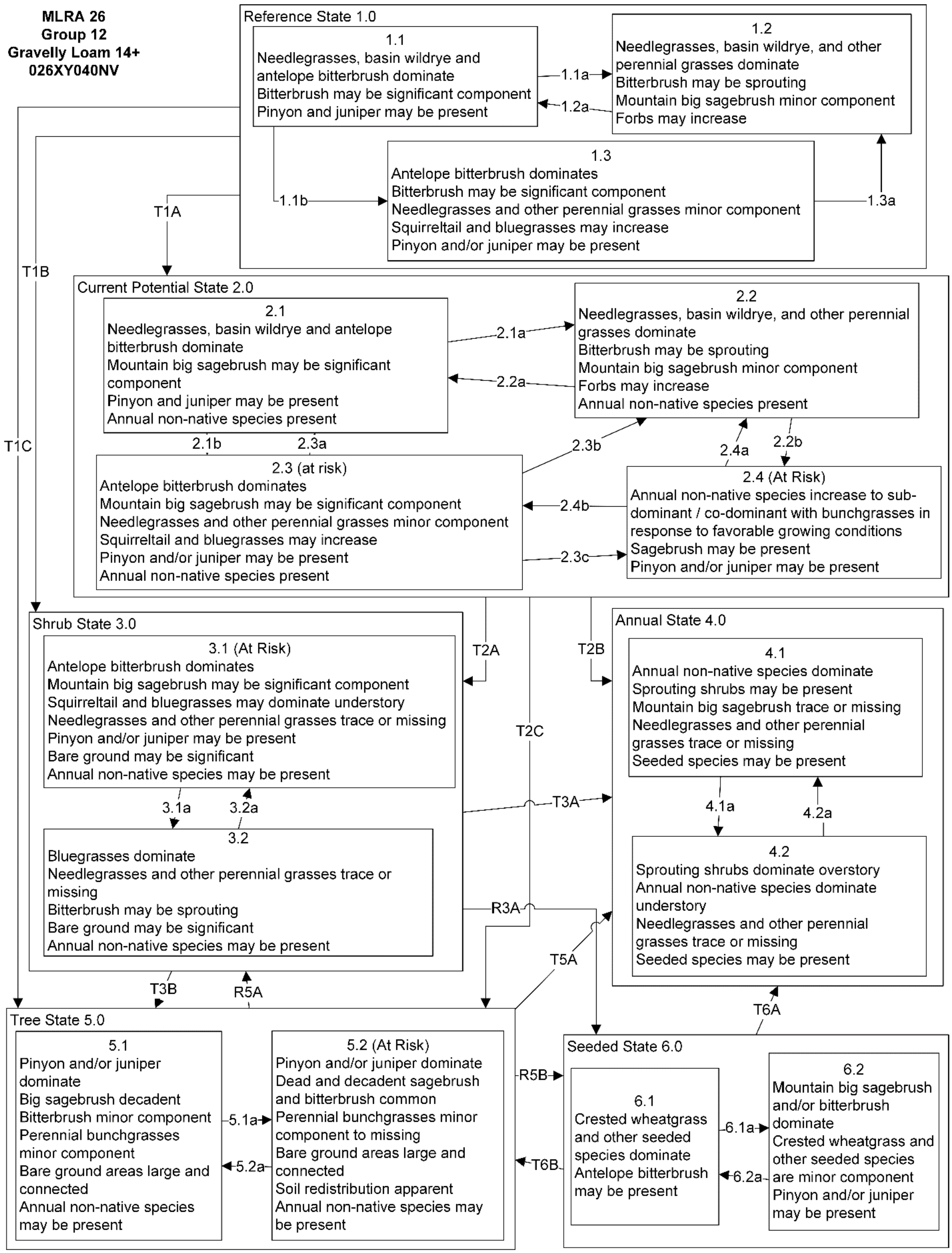
Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).

MLRA 26
Group 12
Gravelly Loam 14+
026XY040NV



MLRA 26
Group 12
Gravelly Loam 14+
026XY040NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces bitterbrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create shrub/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates shrub/grass mosaic; high severity fire significantly reduces bitterbrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of bitterbrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates shrub/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

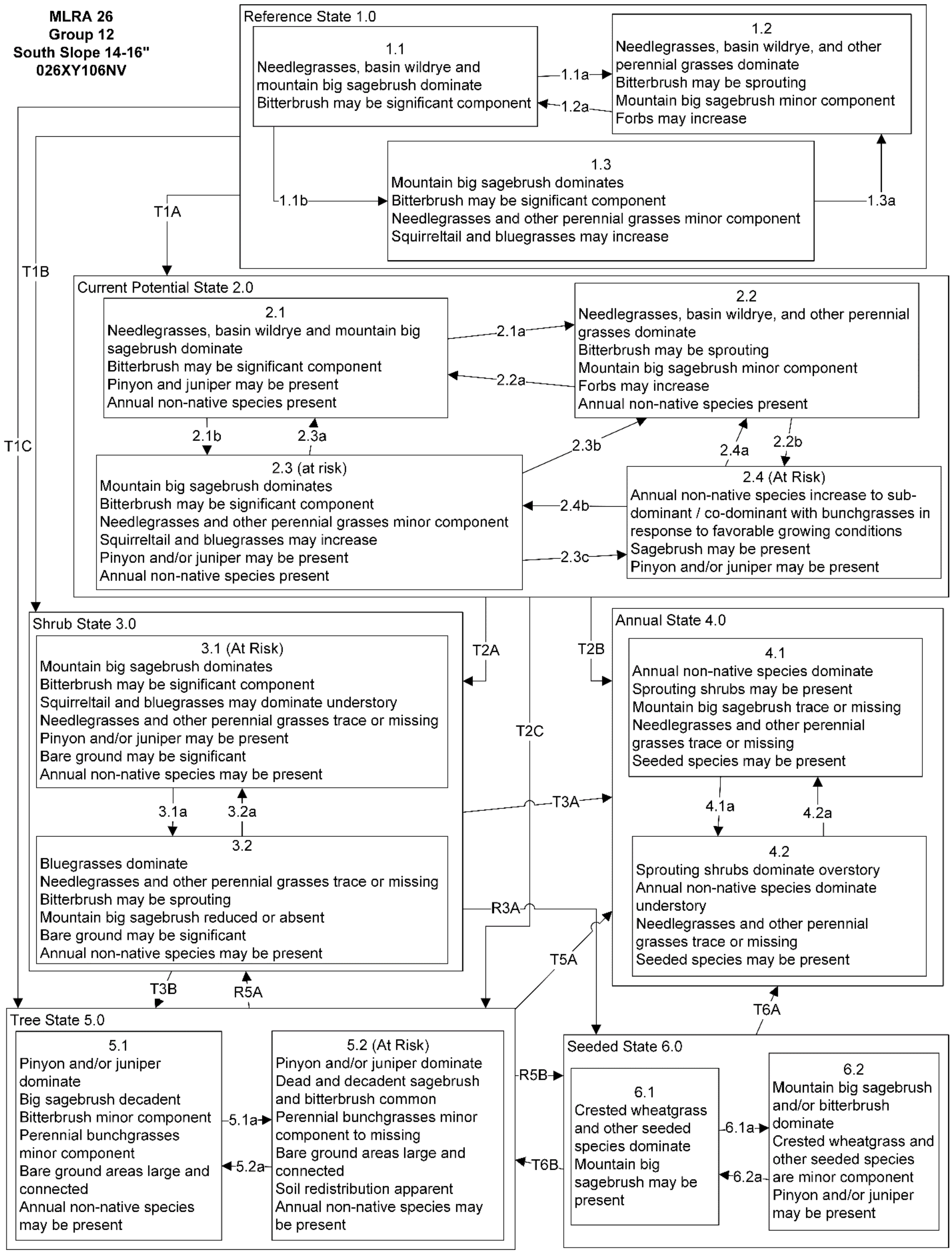
Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).



MLRA 26
Group 12
South Slope 14-16"
026XY106NV
Reference State 1.0
1.1
Needlegrasses, basin wildrye and mountain big sagebrush dominate
Bitterbrush may be significant component
1.2
Needlegrasses, basin wildrye, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail and bluegrasses may increase
1.1a
1.2a
1.1b
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Needlegrasses, basin wildrye and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
Annual non-native species present
2.2
Needlegrasses, basin wildrye, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail and bluegrasses may dominate understory
Needlegrasses and other perennial grasses trace or missing
Pinyon and/or juniper may be present
Bare ground may be significant
Annual non-native species may be present
3.1a
3.2a
3.2
Bluegrasses dominate
Needlegrasses and other perennial grasses trace or missing
Bitterbrush may be sprouting
Mountain big sagebrush reduced or absent
Bare ground may be significant
Annual non-native species may be present
T3A
R3A
T3B
R5A
T5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.1a
4.2a
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.1a
6.2a
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present

MLRA 26
Group 12
South Slope 14-16"
026XY106NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

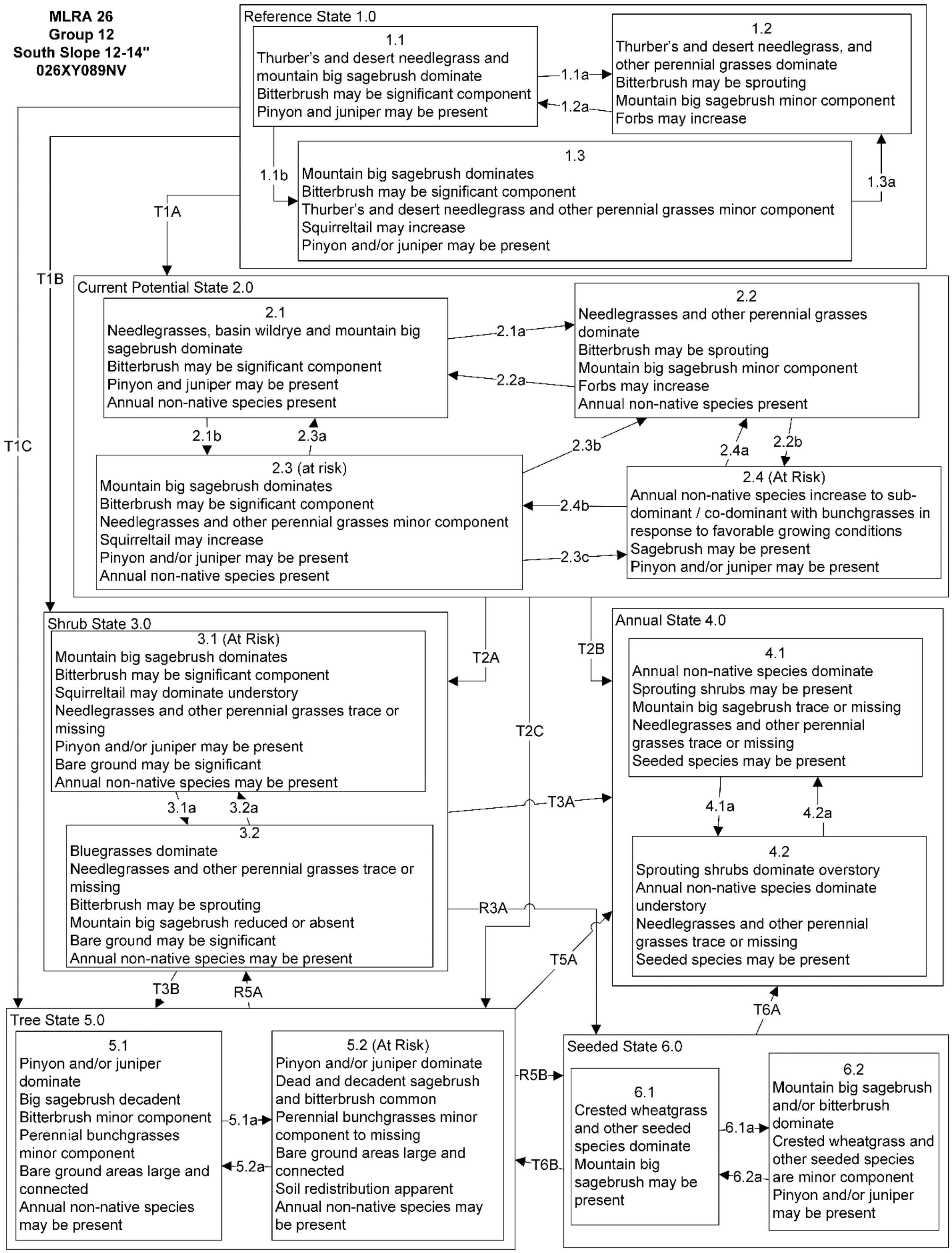
Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).


MLRA 26
Group 12
South Slope 12-14"
026XY089NV
Reference State 1.0
1.1
Thurber's and desert needlegrass and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
1.1a
1.2a
1.2
Thurber's and desert needlegrass, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
1.1b
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Thurber's and desert needlegrass and other perennial grasses minor component
Squirreltail may increase
Pinyon and/or juniper may be present
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Needlegrasses, basin wildrye and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
Annual non-native species present
2.1a
2.2a
2.2
Needlegrasses and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.1b
2.3a
2.3b
2.4a
2.2b
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4b
2.3c
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Pinyon and/or juniper may be present
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail may dominate understory
Needlegrasses and other perennial grasses trace or missing
Pinyon and/or juniper may be present
Bare ground may be significant
Annual non-native species may be present
T2A
T2B
T2C
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
T3A
3.1a
3.2a
4.1a
4.2a
3.2
Bluegrasses dominate
Needlegrasses and other perennial grasses trace or missing
Bitterbrush may be sprouting
Mountain big sagebrush reduced or absent
Bare ground may be significant
Annual non-native species may be present
R3A
T5A
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
T3B
R5A
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.1a
6.2a
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present

MLRA 26
Group 12
South Slope 12-14"
026XY089NV
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

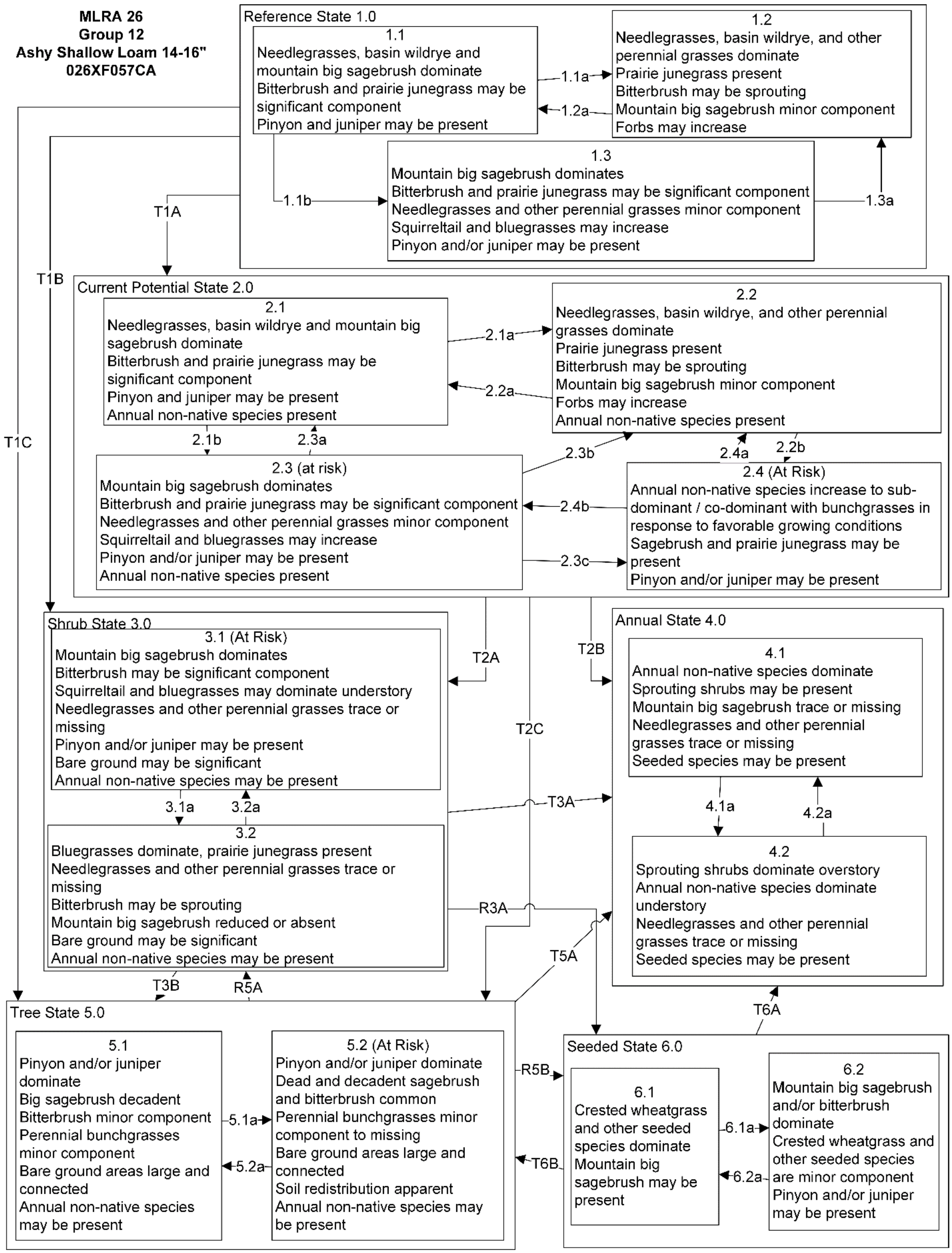
Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).

STM

MLRA 26
Group 12
Ashy Shallow Loam 14-16"
026XF057CA



MLRA 26
Group 12
Ashy Shallow Loam 14-16"
026XF057CA
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

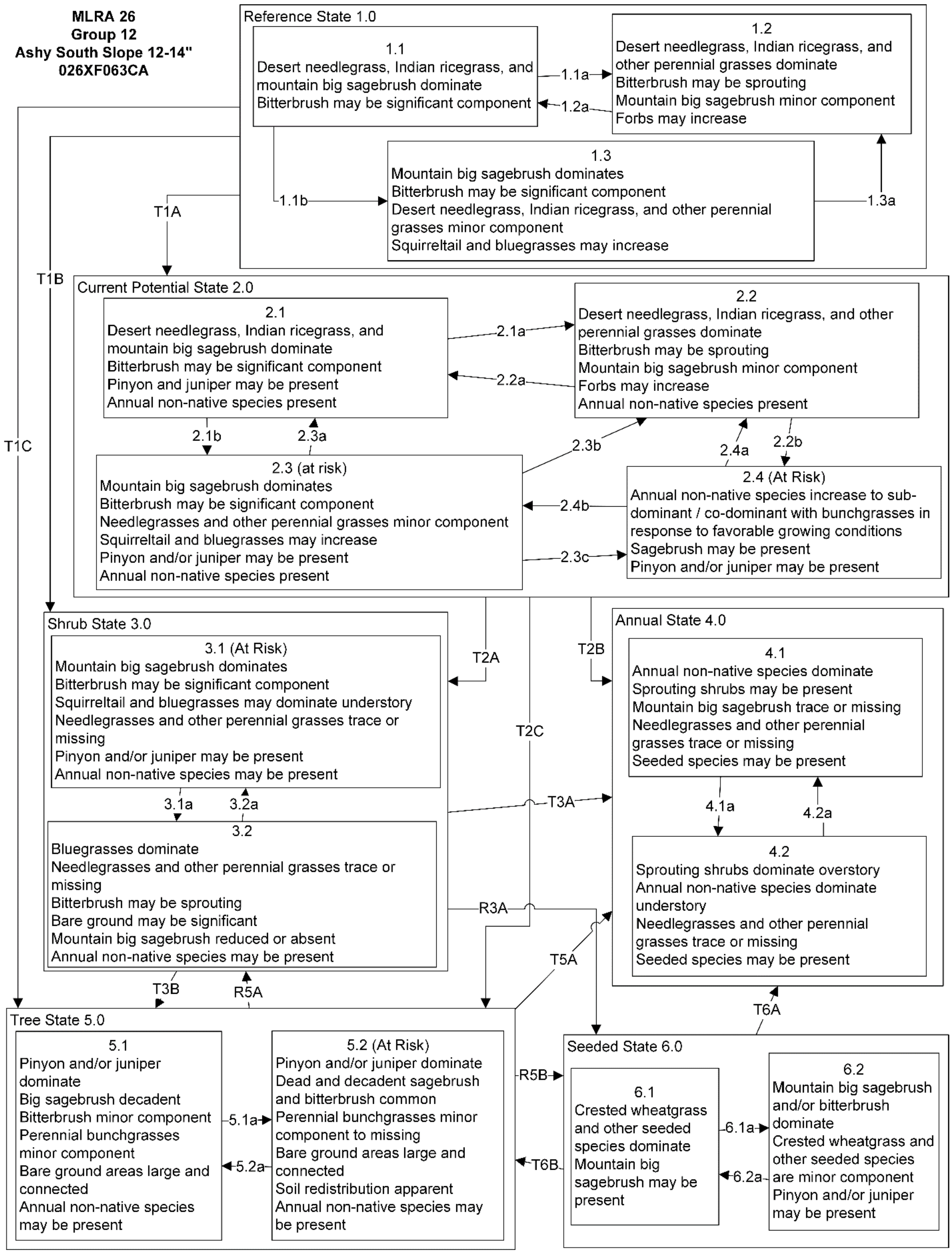
Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).


MLRA 26
Group 12
Ashy South Slope 12-14"
026XF063CA
Reference State 1.0
1.1
Desert needlegrass, Indian ricegrass, and mountain big sagebrush dominate
Bitterbrush may be significant component
1.1a
1.2a
1.2
Desert needlegrass, Indian ricegrass, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
1.1b
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Desert needlegrass, Indian ricegrass, and other perennial grasses minor component
Squirreltail and bluegrasses may increase
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Desert needlegrass, Indian ricegrass, and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
Annual non-native species present
2.1a
2.2a
2.2
Desert needlegrass, Indian ricegrass, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.1b
2.3a
2.3b
2.4a
2.2b
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4b
2.3c
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Pinyon and/or juniper may be present
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail and bluegrasses may dominate understory
Needlegrasses and other perennial grasses trace or missing
Pinyon and/or juniper may be present
Annual non-native species may be present
T2A
T2B
T2C
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
3.1a
3.2a
T3A
4.1a
4.2a
3.2
Bluegrasses dominate
Needlegrasses and other perennial grasses trace or missing
Bitterbrush may be sprouting
Bare ground may be significant
Mountain big sagebrush reduced or absent
Annual non-native species may be present
R3A
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
T5A
T3B
R5A
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.1a
5.2a
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.1a
6.2a
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present

MLRA 26
Group 12
Ashy South Slope 12-14"
026XF063CA
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

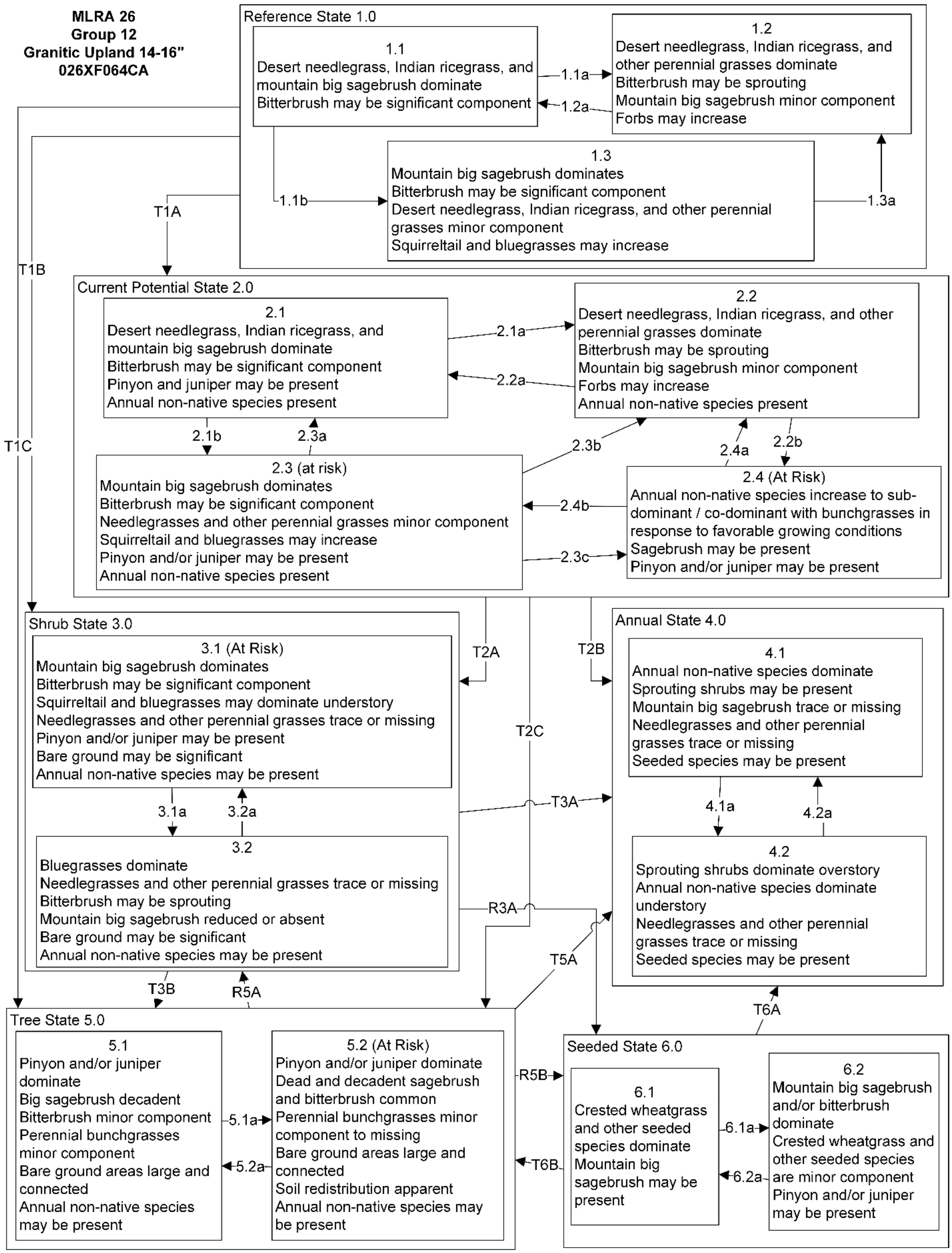
Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).


MLRA 26
Group 12
Granitic Upland 14-16"
026XF064CA
Reference State 1.0
1.1
Desert needlegrass, Indian ricegrass, and mountain big sagebrush dominate
Bitterbrush may be significant component
1.2
Desert needlegrass, Indian ricegrass, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
1.3
Mountain big sagebrush dominates
Bitterbrush may be significant component
Desert needlegrass, Indian ricegrass, and other perennial grasses minor component
Squirreltail and bluegrasses may increase
1.1a
1.2a
1.1b
1.3a
T1A
T1B
T1C
Current Potential State 2.0
2.1
Desert needlegrass, Indian ricegrass, and mountain big sagebrush dominate
Bitterbrush may be significant component
Pinyon and juniper may be present
Annual non-native species present
2.2
Desert needlegrass, Indian ricegrass, and other perennial grasses dominate
Bitterbrush may be sprouting
Mountain big sagebrush minor component
Forbs may increase
Annual non-native species present
2.3 (at risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Needlegrasses and other perennial grasses minor component
Squirreltail and bluegrasses may increase
Pinyon and/or juniper may be present
Annual non-native species present
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Pinyon and/or juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Mountain big sagebrush dominates
Bitterbrush may be significant component
Squirreltail and bluegrasses may dominate understory
Needlegrasses and other perennial grasses trace or missing
Pinyon and/or juniper may be present
Bare ground may be significant
Annual non-native species may be present
3.2
Bluegrasses dominate
Needlegrasses and other perennial grasses trace or missing
Bitterbrush may be sprouting
Mountain big sagebrush reduced or absent
Bare ground may be significant
Annual non-native species may be present
3.1a
3.2a
T3A
R3A
T3B
R5A
Annual State 4.0
4.1
Annual non-native species dominate
Sprouting shrubs may be present
Mountain big sagebrush trace or missing
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.2
Sprouting shrubs dominate overstory
Annual non-native species dominate understory
Needlegrasses and other perennial grasses trace or missing
Seeded species may be present
4.1a
4.2a
T5A
T6A
Tree State 5.0
5.1
Pinyon and/or juniper dominate
Big sagebrush decadent
Bitterbrush minor component
Perennial bunchgrasses minor component
Bare ground areas large and connected
Annual non-native species may be present
5.2 (At Risk)
Pinyon and/or juniper dominate
Dead and decadent sagebrush and bitterbrush common
Perennial bunchgrasses minor component to missing
Bare ground areas large and connected
Soil redistribution apparent
Annual non-native species may be present
5.1a
5.2a
R5B
T6B
Seeded State 6.0
6.1
Crested wheatgrass and other seeded species dominate
Mountain big sagebrush may be present
6.2
Mountain big sagebrush and/or bitterbrush dominate
Crested wheatgrass and other seeded species are minor component
Pinyon and/or juniper may be present
6.1a
6.2a

MLRA 26
Group 12
Granitic Upland 14-16"
026XF064CA
KEY

Reference State 1.0 Community Phase Pathways.
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire would create sagebrush/grass mosaic.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Inappropriate grazing management favoring shrub dominance (to 3.1).
Transition T1C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Current Potential State 2.0 Community Phase Pathways.
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.2b: Shrub removal treatment or prescribed burning in the presence of annual grass species coupled with heavy spring precipitation.
2.3a: Low severity fire creates sagebrush/grass mosaic. Brush management with minimal soil disturbance reduces sagebrush.
2.3b: High severity fire or brush management with minimal soil disturbance significantly reduces sagebrush and leads to early/mid-seral community.
2.3c: Fall and spring growing season conditions that favors the germination and production of non-native annual grasses.
2.4a: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Inappropriate grazing management (3.1), or high severity fire (3.2).
Transition T2B: Fire or brush management causing severe soil disturbance.
Transition T2C: Time without disturbance such as fire allows trees to become dominant. May be coupled with grazing management that favors shrub and tree dominance.

Shrub State 3.0 Community Phase Pathways.
3.1a: Low severity fire, non-native annual species increase with higher than normal spring precipitation.
3.2a: Time and lack of disturbance.

Transition T3A: Catastrophic fire and/or treatments that disturb the existing plant community.
Transition T3B: Time and lack of disturbance allows maturation of the tree community.

Restoration R3A: Brush management combined with seeding of desired species.

Annual State 4.0 Community Phase Pathways.
4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.
4.2a: Fire.

Tree State 5.0 Community Phase Pathways.
5.1a: Time and lack of disturbance allows for maturation of tree community.
5.2a: Tree thinning treatment (typically for fuels management).

Transition T5A: Catastrophic fire.

Restoration R5A: Tree removal allows for shrub dominance.
Restoration R5B: Tree management coupled with seeding of desired species.

Seeded State 6.0 Community Phase Pathways.
6.1a: Time and lack of disturbance.
6.2a: Fire and/or brush management.

Transition T6A: Fire and/or treatments that disturb the existing plant community, more likely from 6.2.
Transition T6B: Time and lack of disturbance allows maturation of the tree community (from 6.2).

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MLRA 26 Group 13: Higher elevations with mountain sagebrush and western needlegrass

Description of MRLA 26 Disturbance Response Group 13:

Disturbance Response Group (DRG) 13 consists of thirteen ecological sites. These sites are found on the summits, sideslopes, and shoulders of mountains at elevations between 7,000 to over 10,000 feet. The precipitation zone ranges from 14 to 20 inches. Slopes range from 2 to 75 percent, but are typically between 4 and 50 percent. Soils are deep to very deep and tend to have mollic epipedons. Where these soils occur on northerly aspects it is common for snow to accumulate as a result of blowing and drifting. These snow accumulations often persist late into the spring and enhance available water supply. Production ranges between 500 to 1,200 lbs/ac for a normal year. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana)*. Other important shrubs include antelope bitterbrush *(Purshia tridentata)*, snowberry (*Symphoricarpos* spp.), and shrubby buckwheat species (*Eriogonum* spp.). The understory is dominated by deep-rooted cool season perennial bunchgrasses, primarily western needlegrass (*Achnatherum occidentale*). Old growth singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) may occur on these sites but are a minor component.

Disturbance Response Group 13 Ecological Sites

Loamy Slope 14+ – Modal Site	R026XY038NV
Ashy Slope 14-16"	R026XY108NV
Gravelly Mountain Shoulders 16+	R026XY075NV
South Slope 16+	R026XY056NV
Shallow Loam 16+	R026XY052NV
Mountain Shoulders 16+	R026XY076NV
Loamy Slope 16+"	R026XY109NV
Ashy Pocket	R026XY112NV
Gravelly South Slope 16+	R026XY110NV
Ashy Mountain Shoulders 16-20"	R026XF059CA
Ashy Loamy Slope 16-20"	R026XF058CA

Modal Site:

The Loamy Slope 14+ ecological site is the modal site that represents this DRG, as it has the most acres mapped. This site occurs on smooth to slightly concave mountain sideslopes. Although this community occurs on all aspects, it is usually restricted to northerly aspects at lower elevations. Elevations are 7,000 to over 9,000 feet. Slopes range from 2 to 50 percent, but slope gradients of 4 to 30 percent are most typical. Soils are typically over 40 inches deep and are dark in color and well-drained. The soils have formed in residuum and colluvium from intermediate volcanic and granitic parent materials. Available water holding capacity is moderate. The shrub component of the plant community is dominated by mountain big sagebrush and the herbaceous component is dominated by western needlegrass. Letterman's needlegrass (*Achnatherum lettermanii*) is also a component of the herbaceous understory. Normal year production is 900 lbs/acre.

Ecological Dynamics and Disturbance Response

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasion. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al 2013).

The ecological sites in this DRG are dominated by deep-rooted, cool season perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 and over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of two meters in alluvial soils in Utah (Richards and Caldwell 1987). Tap roots of antelope bitterbrush have been documented from 4.5 to 5.4 m in length (McConnell 1961). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The dominant perennial bunchgrass is western needlegrass. This species generally has somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Mountain big sagebrush and antelope bitterbrush are generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

The perennial bunchgrasses that are co-dominant with the shrubs include western needlegrass, Letterman's needlegrass, sedges (*Carex* spp.), and spike fescue (*Leucopoa kingii*). These species generally have somewhat shallower root systems than the shrubs, but bunchgrass root densities are often as high as or higher than those of shrubs in the upper 0.5 m but taper off more rapidly than shrubs. General differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems.

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The moisture resource supporting the greatest amount of plant growth is usually the water stored in the soil profile during the winter. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition or can increase resource uptake by the decomposition of dead plant material following disturbance. The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al 2007). Sites in this group were not found to be influenced by cheatgrass invasions. Access to some areas where this site is mapped was limited due to landownership constraints.

Western needlegrass is a strongly tufted perennial grass that grows up to 4 dm in height (Cronquist et al. 1994). It grows in dry, well-drained soils from upper foothills up into the higher areas of the mountains in the western United States (USDA Forest Service 1988). The roots of this grass are deep, fibrous and spreading, which allows it to be more resistant to trampling and drought (USDA Forest Service 1988).

Letterman needlegrass is an erect, densely-tufted perennial bunchgrass that forms large clumps. It is found on dry soils in a variety of vegetation communities, including, high elevation meadows, subalpine grasslands, open areas underneath aspen, and in sagebrush communities (Tisdale and Hironaka 1981). It grows best on loamy soils that are greater than 20 cm deep (Dittberner and Olson 1983).

Basin wildrye is a large, cool-season perennial bunchgrass with an extensive deep coarse fibrous root system (Reynolds and Fraley 1989). Clumps may reach up to 2 meters in height (Cronquist et al. 1994). Basin wildrye does not tolerate long periods of inundation; it prefers cycles of wet winters and dry summers and is most commonly found in deep soils with high water holding capacities or seasonally high water tables (Cronquist et al. 1994, Perryman and Skinner 2007).

The ecological sites in this DRG have high resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Long-term disturbance response may be influenced by small differences in landscape topography. Concave areas receive run-in from adjacent landscapes and consequently retain more moisture to support the growth of deep-rooted perennial grasses (i.e. basin wildrye) whereas convex areas where runoff occurs are slightly less resilient and may have more shallow-rooted perennial grasses (i.e. bluegrasses (*Poa* spp.) and prairie junegrass (*Koeleria macrantha*)). North slopes are also more resilient than south slopes because lower soil surface temperatures keep moisture content higher on northern exposures. Three possible alternative stable states have been identified for this DRG.

Fire Ecology:

Fire is believed to be the dominant disturbance force in big sagebrush communities. Several authors suggest pre-settlement fire return intervals in mountain big sagebrush communities varied from 15 to 25 years (Burkhardt and Tisdale 1969, Houston 1973, and Miller et al. 2000). Kitchen and McArthur (2007) suggest a mean fire return interval of 40 to 80 years for mountain big sagebrush communities. The range from 15 to 80 years is probably more accurate and reflects the differences in elevation and precipitation where mountain big sagebrush communities occur. On a landscape scale, multiple seral stages were represented in a mosaic, reflecting periodic reoccurrence of fire and other disturbances (Crawford et al 2004). Post-fire hydrologic recovery and resilience is primarily influenced by pre-fire site conditions, fire severity, and post-fire weather and land use that relate to vegetation recovery. Fire adaptation by herbaceous species is generally superior to the dominant shrubs, which are typically killed by fire. Sites with low abundances of native perennial grasses and forbs typically have reduced resiliency following disturbance and are less resistant to invasion or increases in cheatgrass (Miller et al 2013). If fire frequency decreases, sagebrush will increase and with inappropriate grazing management, the perennial bunchgrasses and forbs may be reduced.

Mountain big sagebrush is killed by fire (Neunschwander 1980, Blaisdell et al. 1982) and does not resprout (Blaisdell 1953). Post-fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and may reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). Mountain big sagebrush may return to pre-burn density and cover within 15 to 20 years following fire, but establishment after severe fires may proceed more slowly (Bunting et al. 1987).

With fire, sprouting shrubs may become dominant in the community for a period of time before sagebrush is able to recolonize the site. Pre-fire condition and fire severity influences the growth of most of these species. Douglas' rabbitbrush (*Chrysothamnus viscidiflorus*) and rubber rabbitbrush (*Ericameria nauseosa*) are both top-killed by fire, but can resprout after fire and can also quickly re-establish from seed (Young 1983, Kuntz 1982, Akinsoji 1988). Snowberry has been noted to regenerate from rhizomes and can exceed pre-burn biomass in the third season after a fire (Merrill et al. 1982, Noste and Bushey 1987). Spineless horsebrush readily sprouts and survives after being top-killed by fire (Evans and Young 1978, Pyle and Crawford 1996, Ellsworth and Kauffman 2017).

Antelope bitterbrush is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, Clements and Young 2002), however sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires may allow for bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006). Similarly, currant (*Ribes spp.*) can increase after fire but this result is not guaranteed (Young and Bailey 1975).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Young 1983, Wright 1971).

Broad-leaved grasses like western needlegrass are relatively tolerant of fire (Blaisdell 1953; Wright and Klemmedson 1965, Wright 1971, Bunting et al. 1987). Western needlegrass decreased the first year after an August wildfire in northeastern California, but increased by the third post-fire year, nearly doubling in basal area (Countryman and Cornelius 1957). Emergence of western needlegrass seeds was shown to significantly improve with additions of smoke and burned soil (Blank and Young 1996).

Basin wildrye is relatively resistant to fire, particularly dormant season fire, as plants sprout from surviving root crowns and rhizomes (Zschaechner 1985). Miller et al. (2013) reported increased total shoot and reproductive shoot densities in the first year following fire, although by year two there was little difference between burned and control treatments.

If fire-tolerant species such as balsamroot (*Balsamorhiza* spp.), lupine (*Lupinus* spp.), mule-ears (*Wyethia amplexicaulis*) and phlox (*Phlox* spp.) are common before fire, these forbs will increase after fire. The increase in species such as silvery lupine in mountain big sagebrush communities has been attributed to both resprouting and reproduction from seed (Goergen and Chambers 2009). Because these species are relatively unpalatable, they may also increase with heavy grazing.

Wildlife/Livestock Grazing Interpretations:

This site is suitable for grazing. Grazing management considerations include timing, duration, frequency, and intensity of grazing. Overgrazing leads to an increase in mountain big sagebrush and a decline in deep-rooted perennial bunchgrasses. Shallow-rooted bluegrasses will increase with further degradation. Reduced bunchgrass vigor or density provides an opportunity for expansion of bluegrass species in interspaces. Sandberg bluegrass and similar low-growing grasses increase under grazing pressure (Tisdale and Hironaka 1981). A combination of overgrazing and prolonged drought may lead to soil redistribution, increased bare ground and a loss in plant production.

Despite low palatability, mountain big sagebrush is eaten by sheep, cattle, goats, and horses. Chemical analysis indicates that the leaves of big sagebrush equal alfalfa meal in protein, have a higher carbohydrate content, and yield twelvefold more fat (USDA 1988). Many wildlife species are dependent on the sagebrush ecosystem including the greater sage grouse, sage sparrow, pygmy rabbit and the sagebrush vole. Dobkin and Sauder (2004) identified 61 species, including 24 mammals and 37 birds, associated with the shrub-steppe habitats of the Intermountain West. Antelope bitterbrush is an important shrub species to a variety of animals, such as domestic livestock, antelope, deer, and elk. Bitterbrush is critical browse for mule deer, as well as domestic livestock, antelope, and elk (Wood 1995, Clements and Young 2002). Antelope bitterbrush is most commonly found on soils that provide minimal restriction to deep root penetration such as coarse textured soil, or finer textured soil with high stone content (Driscoll 1964). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison 1953).

Western needlegrass is slow to mature and remains green through most of the growing season. Since it can remain green into fall, it is higher quality forage compared to other species that have senesced by then (USDA Forest Service 1988). For livestock, this grass has good forage value, and it has fair forage value for wildlife (Stubbendieck et al. 1992). Seeds of this grass are avoided by grazing animals but are not necessarily injurious. Since seeds are avoided by grazing animals, a large amount of the seed produced grows to maturity (USDA Forest Service 1988).

The early growth and abundant production of basin wildrye make it a valuable source of forage for livestock. It is important forage for cattle and is readily grazed by cattle and horses in early spring and fall. Though coarse-textured during the winter, basin wildrye may be utilized more frequently by livestock and wildlife when snow has covered low shrubs and other grasses. Basin wildrye is used often as a winter feed for livestock and wildlife; not only providing roughage above the snow but also cover in the early spring months (Majerus 1992). Inadequate rest and recovery from defoliation causes a decrease in basin wildrye and an increase in sagebrush and rubber rabbitbrush (Young et al. 1976, Roundy 1985). Spring defoliation of basin wildrye and/or consistent, heavy grazing during the growing season has been found to significantly reduce basin wildrye production and density (Krall et al. 1971). Additionally, basin wildrye suffers from low seed viability and low seedling vigor (Young and Evans 1981). Roundy (1985) found that although basin wildrye is adapted to seasonally dry soils, high and frequent spring precipitation is necessary to establish it from seed. This suggests that establishment of basin wildrye seedlings occurs only during years of unusually high precipitation.

Long-term disturbance response may be influenced by small differences in landscape topography. Concave areas receive and hold more moisture and may retain deep-rooted perennial grasses whereas convex areas are slightly less resilient and may lose deep-rooted perennial grasses more rapidly.

State and Transition Model Narrative for Group 13

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 13.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. The reference state has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
Mountain big sagebrush and perennial bunchgrasses co-dominate. Western needlegrass is the dominant grass species, however there may be several grass species present. Grass, shrub, and forb diversity is high.

Ashy Slope 14-16" (R026XY0108NV) Phase 1.1 T.K. Stringham, July 2015

Ashy Slope 14-16” (R026XY108NV) Phase 1.1 D. Snyder, September 2017

Community Phase Pathway 1.1a, from phase 1.1 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and allow perennial bunchgrasses and forbs to dominate the site. Fires are small, high-severity, stand replacement fires that typically occur from April through October. Patchy fires create a sagebrush/grass mosaic. High severity fire significantly reduces sagebrush cover and leads to an early- to mid-seral community, dominated by grasses and forbs.

Community Phase Pathway 1.1b, from phase 1.1 to 1.3:
Time and lack of disturbance such as fire or drought allow for an increase in mountain big sagebrush. Excessive herbivory and/or long-term drought may also reduce perennial understory.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early- to mid-seral community. Western needlegrass, bluegrass and other perennial grasses dominate. Sprouting shrubs such as green rabbitbrush (*Chrysothamnus viscidiflorus*), snowberry (*Symphoricarpos oreophilus),* green ephedra (*Ephedra viridis*), spineless horsebrush *(Tetradymia canescens)* may be a significant component*.* Mountain big sagebrush is a minor component. Forbs may be a significant component.

Ashy Mountain Shoulders 16-20" (R026XF059CA) Phase 1.2, T.K. Stringham, June 2016

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Time and lack of disturbance allows sagebrush to reestablish.

Community Phase 1.3:
Mountain big sagebrush becomes dominant in the absence of disturbance. Western needlegrass and other perennial grasses are reduced. Bluegrass may increase. Singleleaf pinyon and/or Utah juniper may be present.

Ashy Loamy Slope 16-20" (R026XF058CA) Phase 1.3 T.K. Stringham, June 2016

Community Phase Pathway 1.3a, from phase 1.3 to 1.1:
Low severity fire kills some sagebrush and results in a patchwork of shrubs and grasses.

Community Phase Pathway 1.3b, from phase 1.3 to 1.2:
High severity fire significantly reduces sagebrush cover, leading to early- to mid-seral community.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass, mustard and Russian thistle (*Salsola* spp.).

Slow variables: Over time, the annual non-native plants will increase within the community decreasing organic matter inputs from deep-rooted perennial bunchgrasses resulting in reductions in soil water availability for perennial bunchgrasses.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

T2A: Transition from Reference State 1.0 to Shrub State 3.0:

Trigger: Inappropriately managed, long-term grazing of perennial bunchgrasses during the growing season would favor shrubs and initiate transition to Community Phase 3.1. Fire would cause a transition to Community Phase 3.2.

Slow variables: Long-term decrease in deep-rooted perennial grass density resulting in a decrease in organic matter inputs and subsequent soil water decline.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution and reduces soil organic matter.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate and adaptations for seed dispersal. Additionally, the presence of highly flammable, non-native species reduces State resilience because these species can promote fire where historically fire has been infrequent leading to positive feedbacks that further the degradation of the system.

Community Phase 2.1:
Mountain big sagebrush and perennial bunchgrasses co-dominate. Western needlegrass is the dominant grass species; however, there may be several grass species present. Grass, shrub, and forb diversity is high. Annual non-native species present.

Community Phase Pathway 2.1a, from phase 2.1 to 2.2:
Fire would decrease or eliminate the overstory of sagebrush and allow perennial bunchgrasses and forbs to dominate the site. Fires would typically be small, high-severity, stand replacing, and patchy due to fine fuel loads. Patchy fires create a sagebrush/grass mosaic. High severity fire

significantly reduces sagebrush cover and leads to an early- to mid-seral community, dominated by grasses and forbs.

Community Phase Pathway 2.1b, from phase 2.1 to 2.3:
Time, long-term drought, grazing management that favors shrubs or combinations of these allows the sagebrush overstory to increase and dominate the site, causing a reduction in perennial bunchgrasses.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early- to mid-seral community. Western needlegrass, bluegrass and other perennial grasses dominate. Sprouting shrubs such as green rabbitbrush (*Chrysothamnus viscidiflorus*), snowberry (*Symphoricarpos oreophilus),* green ephedra (*Ephedra viridis*), spineless horsebrush *(Tetradymia canescens)* may be a significant component*.* Mountain big sagebrush is a minor component. Forbs may be a significant component. Annual non-native species are present.

Community Phase Pathway 2.2a, from phase 2.2 to 2.1:
Absence of disturbance over time allows the sagebrush to recover. This may be combined with grazing management that favors shrubs.

Community Phase 2.3:
Mountain big sagebrush increases and the perennial understory is reduced. Squirreltail and bluegrasses may increase. Annual non-native species are present.

Community Phase Pathway 2.3a, from phase 2.3 to 2.1:
Low severity fire kills some sagebrush and results in a patchwork of shrubs and grasses. Other disturbances/practices include brush management with minimal soil disturbance to reduce sagebrush cover.

Community Phase Pathway 2.3b, from phase 2.3 to 2.2
High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: Inappropriately managed, long-term grazing of perennial bunchgrasses during the growing season would favor shrubs and initiate transition to Community Phase 3.1. Fire would cause a transition to Community Phase 3.2.

Slow variables: Long-term decrease in deep-rooted perennial grass density resulting in a decrease in organic matter inputs and subsequent soil water decline.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter.

Shrub State 3.0:

This state has two community phases: a mountain big sagebrush dominated phase and a rabbitbrush dominated phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Squirreltail and bluegrasses will increase with a reduction in deep-rooted perennial bunchgrass competition and become the dominant grass. Sagebrush dominates the overstory and rabbitbrush may be a significant component. Sagebrush canopy cover is high and sagebrush may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory and shallow-rooted understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1:
Mountain big sagebrush dominates the overstory. Western needlegrass and other deep-rooted perennial grasses are reduced or missing. Bluegrasses may dominate the understory. Bare ground may be significant. Annual non-native species are present.

Community Phase Pathway 3.1a, from phase 3.1 to 3.2:
Fire reduces or eliminates the overstory of sagebrush.

Community Phase 3.2:
Bluegrasses dominate the site. Rabbitbrush, bitterbrush, horsebrush, ephedra, and/or snowberry may be sprouting. Mountain big sagebrush is a minor component. Annual non-native species increasing and may be co-dominant in the understory.

Community Phase Pathway 3.2a, from phase 3.2 to 3.1:
Absence of disturbance over time allows sagebrush and other shrubs to recover.

Potential Resilience Differences with Other Sites:

Ashy Slope 14-16" (R026XY108NV)

This site is very similar to the modal site, but with Letterman needlegrass and mountain brome as the dominant grasses. Pinyon and juniper are not present in the Reference state. The annual production for a normal year is 500 lbs/acre.

Gravelly Mountain Shoulders 16+ (R026XY075NV)

This site occurs on slopes of 15 to 50 percent on north-facing high mountain shoulders and backslopes. The soils contain high amounts of rock fragments and have a low available water capacity. Snow accumulation of the site lasts well into the summer, limiting the potential plant growth period. Slowly melting snow provides moisture to plants through the growing season. Runoff is medium to high on these sites. The dominant grasses include spike fescue and Letterman's needlegrass. Oceanspray is present in areas of snow accumulation within rock outcrops. The annual production for a normal year is 700 lbs/acre. Pinyon and juniper are not present in the Reference state.

South Slope 16+ (R026XY056NV)

This site occurs on southern facing slopes ranging from 30 to 50 percent slope. The soils contain 15 to 50 percent rock fragments, and have a moderate to high available water capacity. Runoff is medium to high. The dominant grass is spike fescue, and antelope bitterbrush is a significant shrub on the site. The annual production for a normal year is 700 lbs/acre.

Shallow Loam 16+ (R026XY052NV)

This site occurs on north facing slopes with slope gradients of 15 to 50 percent being typical. The elevation range for this site is 9000 to over 10000 feet. These soils remain cool and moist due to snow accumulation and slow melting snow. Throughout the soil profile there is a large amount of rock fragments. Runoff is medium. Spike fescue, dunhead sedge, Ross' sedge, and prairie junegrass dominate the site. Slender eriogonum is a significant shrub on site as well. The annual production for a normal year is 700 lbs/acre, and pinyon and juniper are not present on the Reference state.

Mountain Shoulders 16+ (R026XY076NV)

This site is similar to the modal site, but with slopes of 2 to 15 percent being typical. The soils are deep, well drained, and have a depth of 20+ inches. The available water capacity is low to moderate. The site is dominated by Letterman's needlegrass and sedges. The annual production for a normal year is 600 lbs/acre, and pinyon and juniper are not present in the Reference state.

Loamy Slope 16+" (R026XY109NV)

This site is very similar to the modal, but with spike fescue and western needlegrass as significant components. The annual production for a normal year is 1000 lbs/acre, and pinyon and juniper are not present in the Reference state.

Ashy Pocket (R026XY112NV)

This site occurs on north-facing sideslopes ranging from 30 to 50 percent slope. Elevations range from 8000 to 8800 feet. The soils on this site formed in colluvium derived from andesite or tuff breccia with eolian volcanic ash additions. Throughout the soil profile there are high amounts of rock fragments, vitric volcanic ash, and glass. They are moderately deep, well drained, and have a low available water capacity. The vegetation on the site is very similar to the modal site, but with sedge as a codominant grass. There is also no pinyon or juniper in the Reference state. The annual production for a normal year is 600 lbs/acre.

Gravelly South Slope 16+ (R026XY110NV)

This site is very similar to the modal but occurs on southern aspects with 15 to 30 percent slope being typical. Antelope bitterbrush and mountain snowberry are significant shrubs on site. The annual production for a normal year is 1200 lbs/acre, and pinyon and juniper are not present in the Reference state.

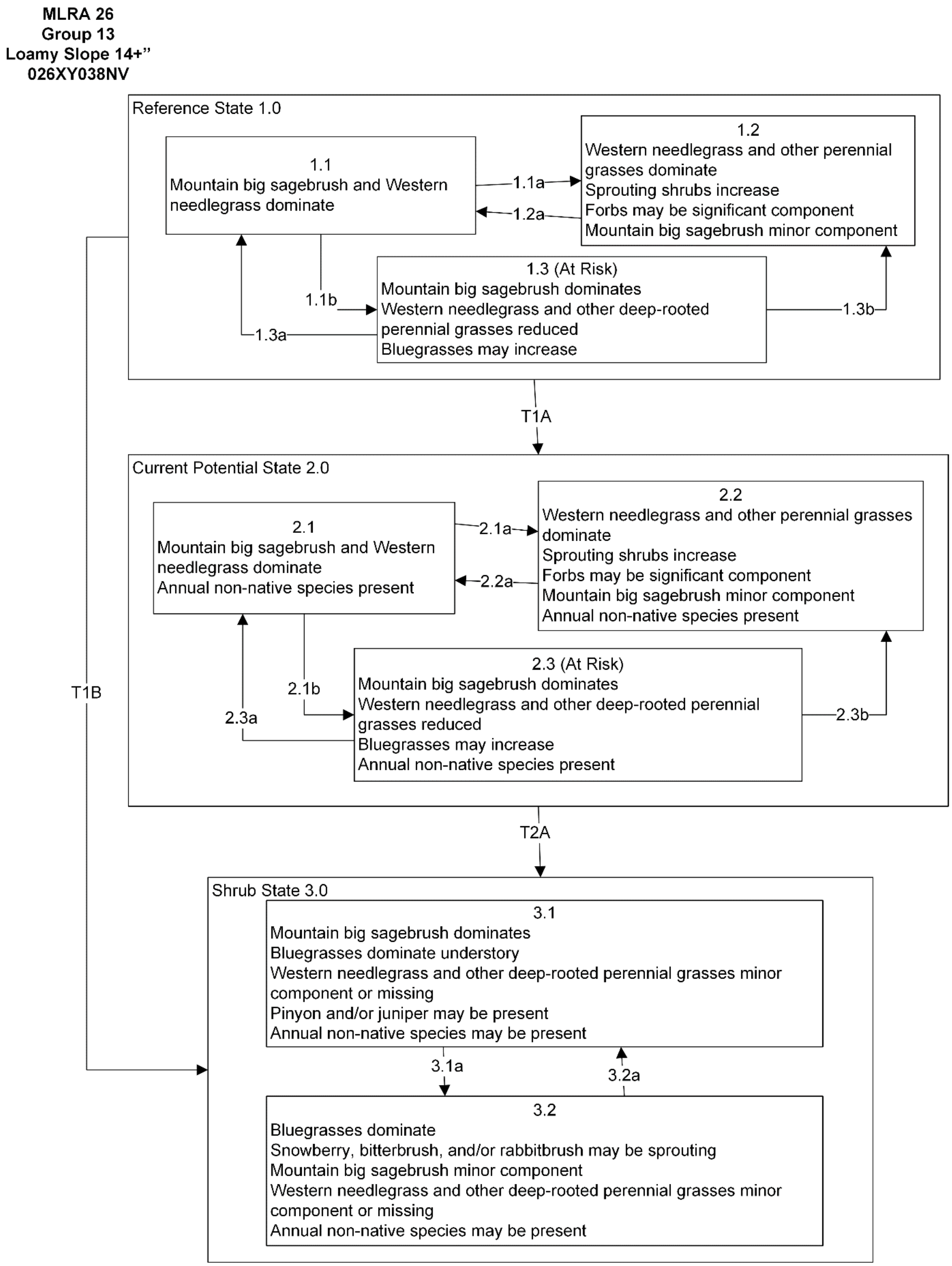
Ashy Mountain Shoulders 16-20" (R026XF059CA)

This site is similar to the modal with very deep and well drained soils. The soil has a large amount of volcanic glass. A mollic epipedon occurs from the soil surface to 18+ inches deep. Prairie junegrass is significant on the site, with Letterman’s and western needlegrass being dominant. Pinyon and juniper are not present in the Reference state. The annual production for a normal year is 600 lbs/acre.

Ashy Loamy Slope 16-20" (R026XF058CA)

This site is very similar to the modal with deep and well-drained soils. The soils have a mollic epipedon to more than 40 inches, and significant amounts of volcanic glass. Prairie junegrass and basin wildrye are significant grasses. Golden current and roundleaf snowberry are significant shrubs on the site. The annual production for a normal year is 1600 lbs/acre. Pinyon and juniper are not on the Reference state.

Modal State and Transition Model for Group 13 in MLRA 26:



MLRA 26
Group 13
Loamy Slope 14+"
026XY038NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

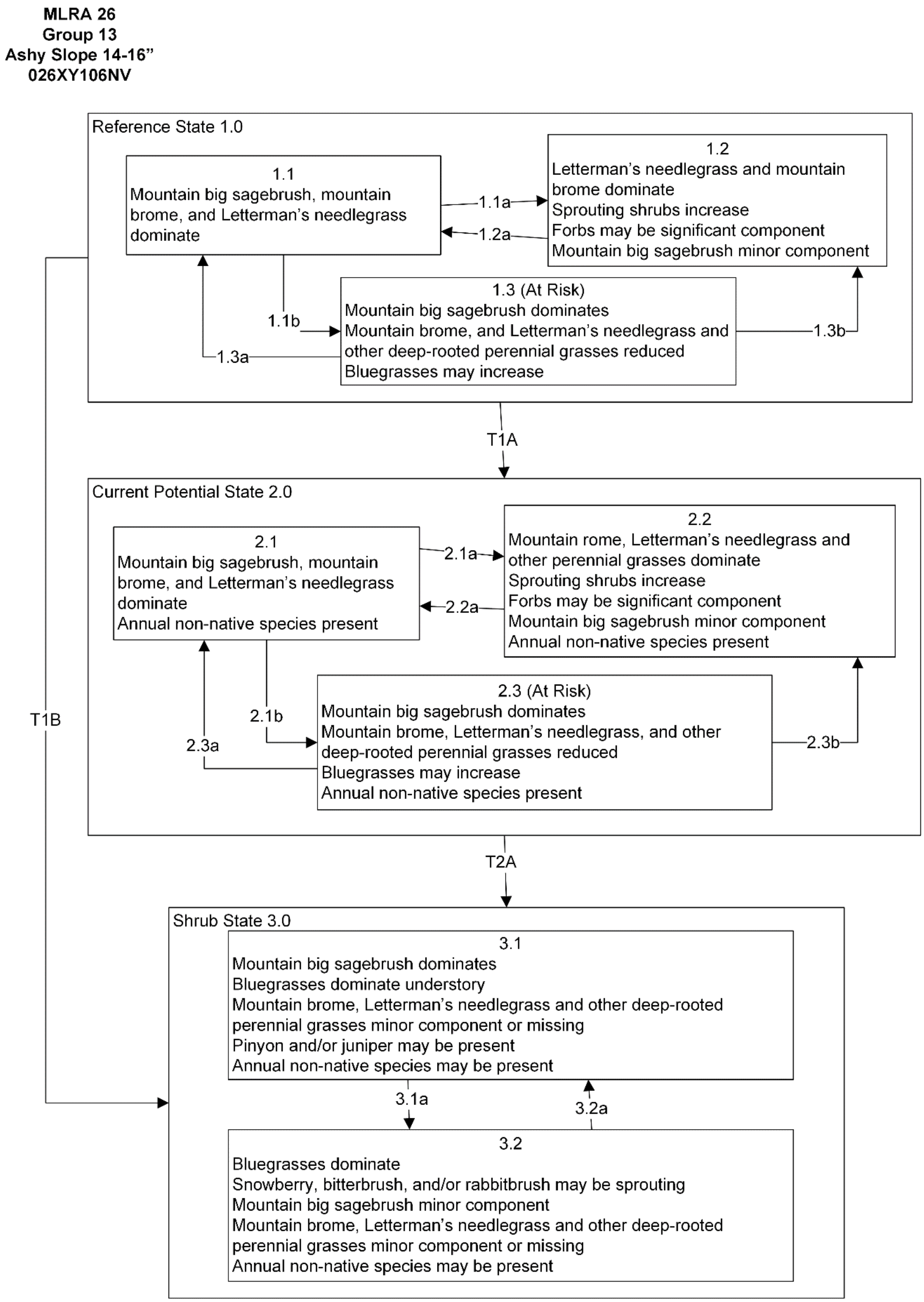
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

Additional State and Transition Models for Group 13 in MLRA 26:



MLRA 26
Group 13
Ashy Slope 14-16"
026XY106NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

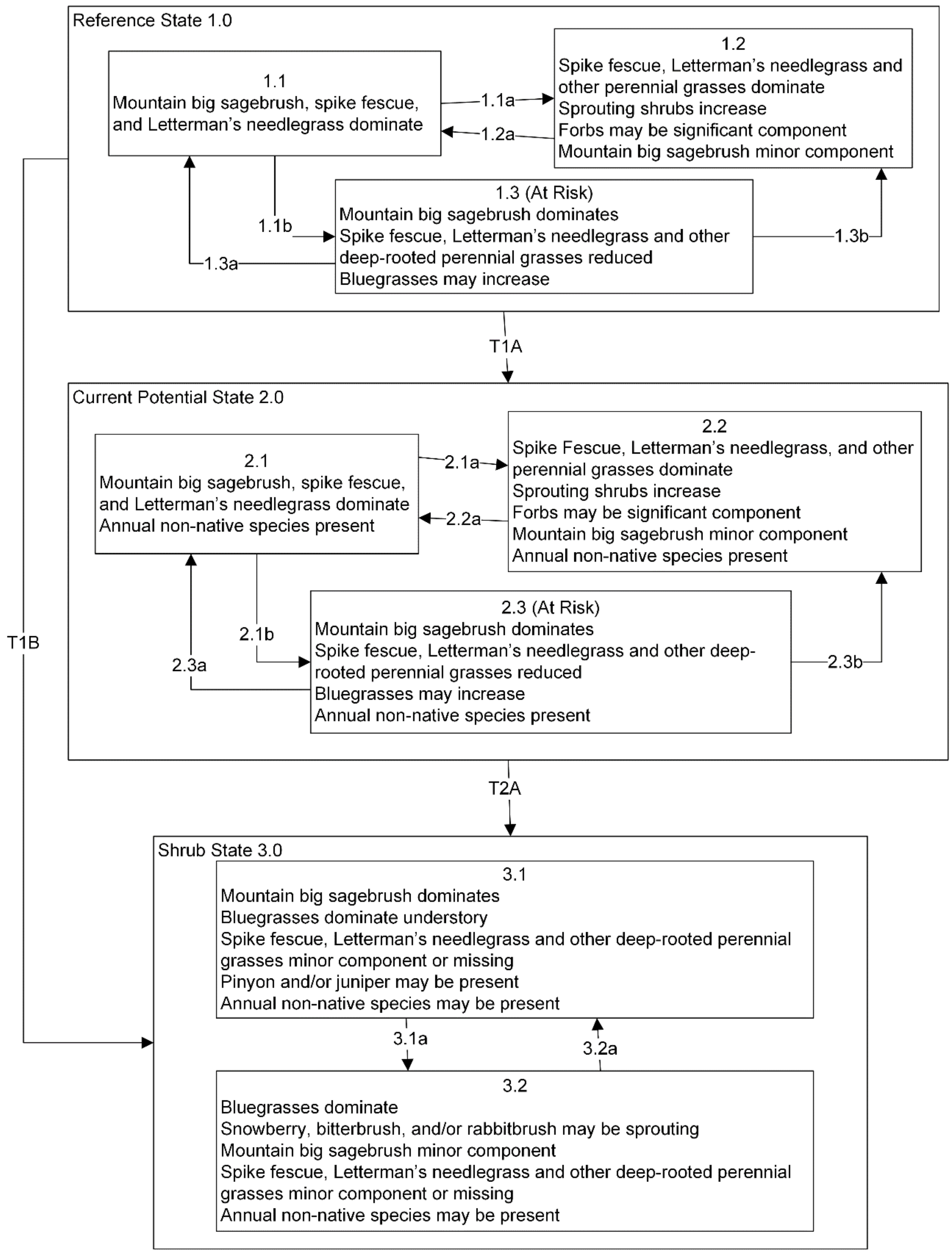
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

MLRA 26
Group 13
Gravelly Mountain Shoulders 16+”
026XY075NV



MLRA 26
Group 13
Gravelly Mountain Shoulders 16+”
026XY075NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

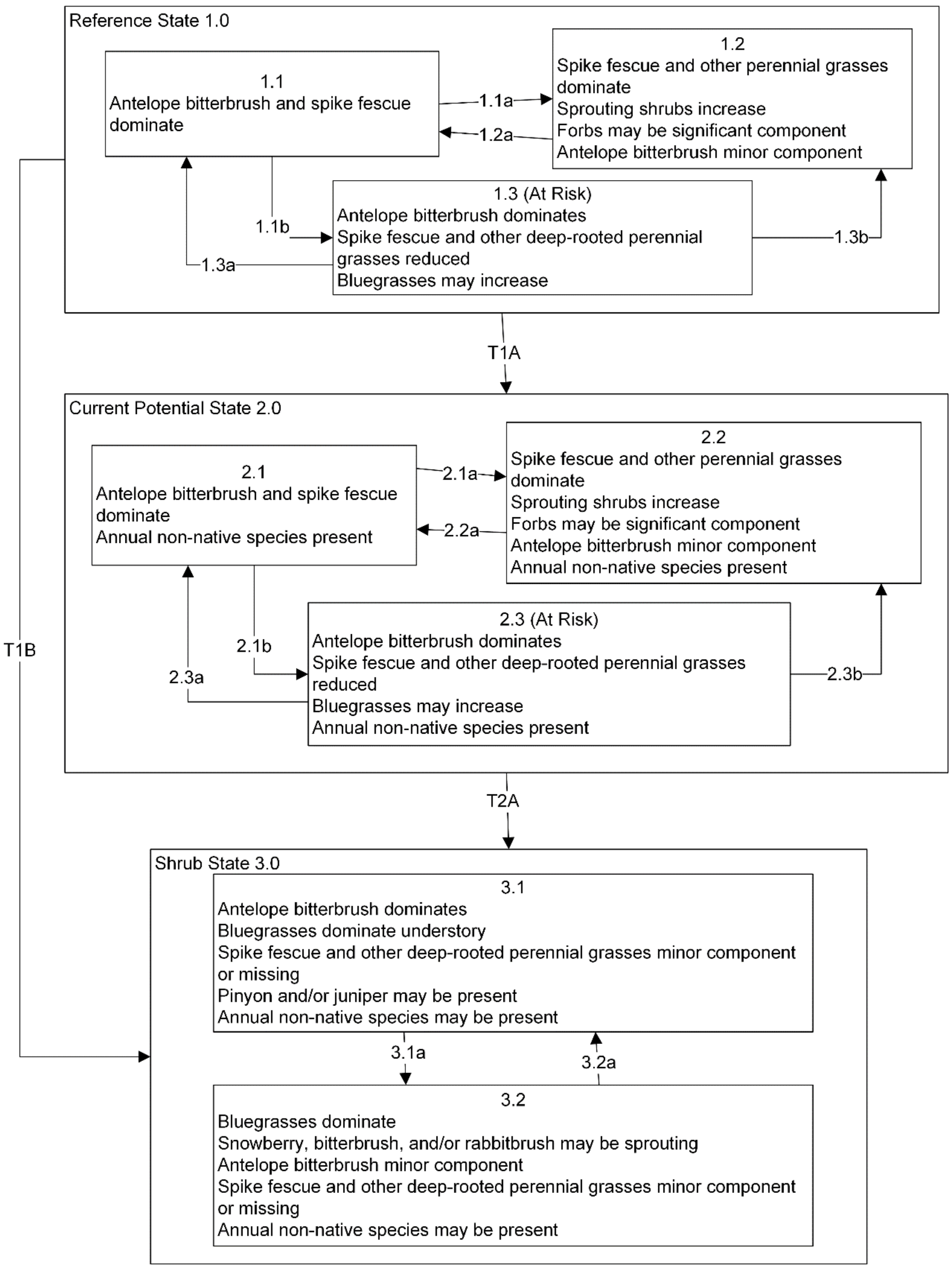
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

MLRA 26
Group 13
South Slope 16+"
026XY056NV



MLRA 26
Group 13
South Slope 16+"
026XY056NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates shrub/grass mosaic; high severity fire significantly reduces shrub cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates shrub/grass mosaic.
1.3b: High severity fire significantly reduces shrub cover leading to early/mid-seral community.

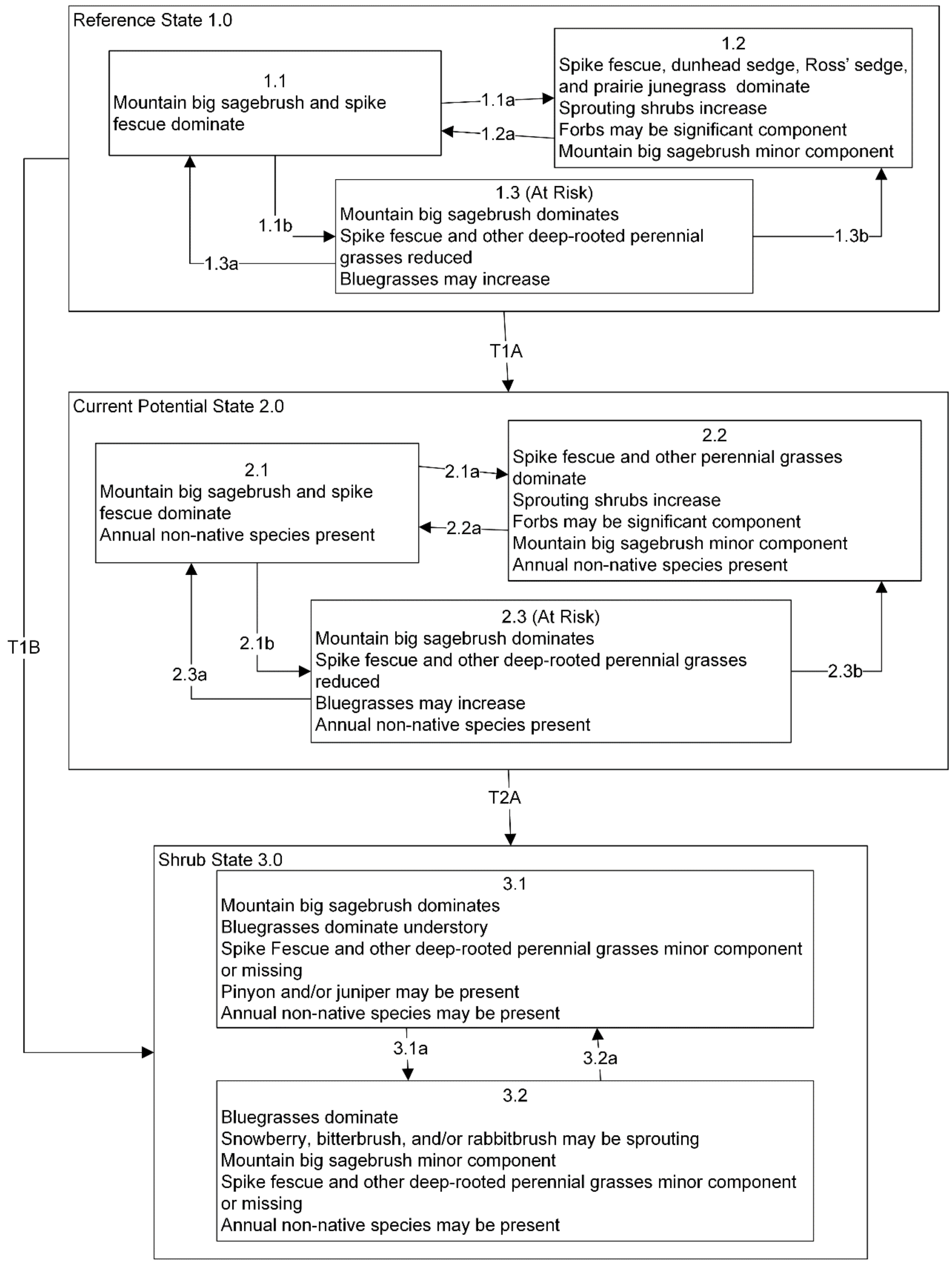
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates shrub/grass mosaic; high severity fire significantly reduces shrub cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of shrub.
2.3a: Low severity fire creates shrub/grass mosaic.
2.3b: High severity fire significantly reduces shrub cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

MLRA 26
Group 13
Shallow Loam 16+"
026XY052NV



MLRA 26
Group 13
Shallow Loam 16+"
026XY052NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

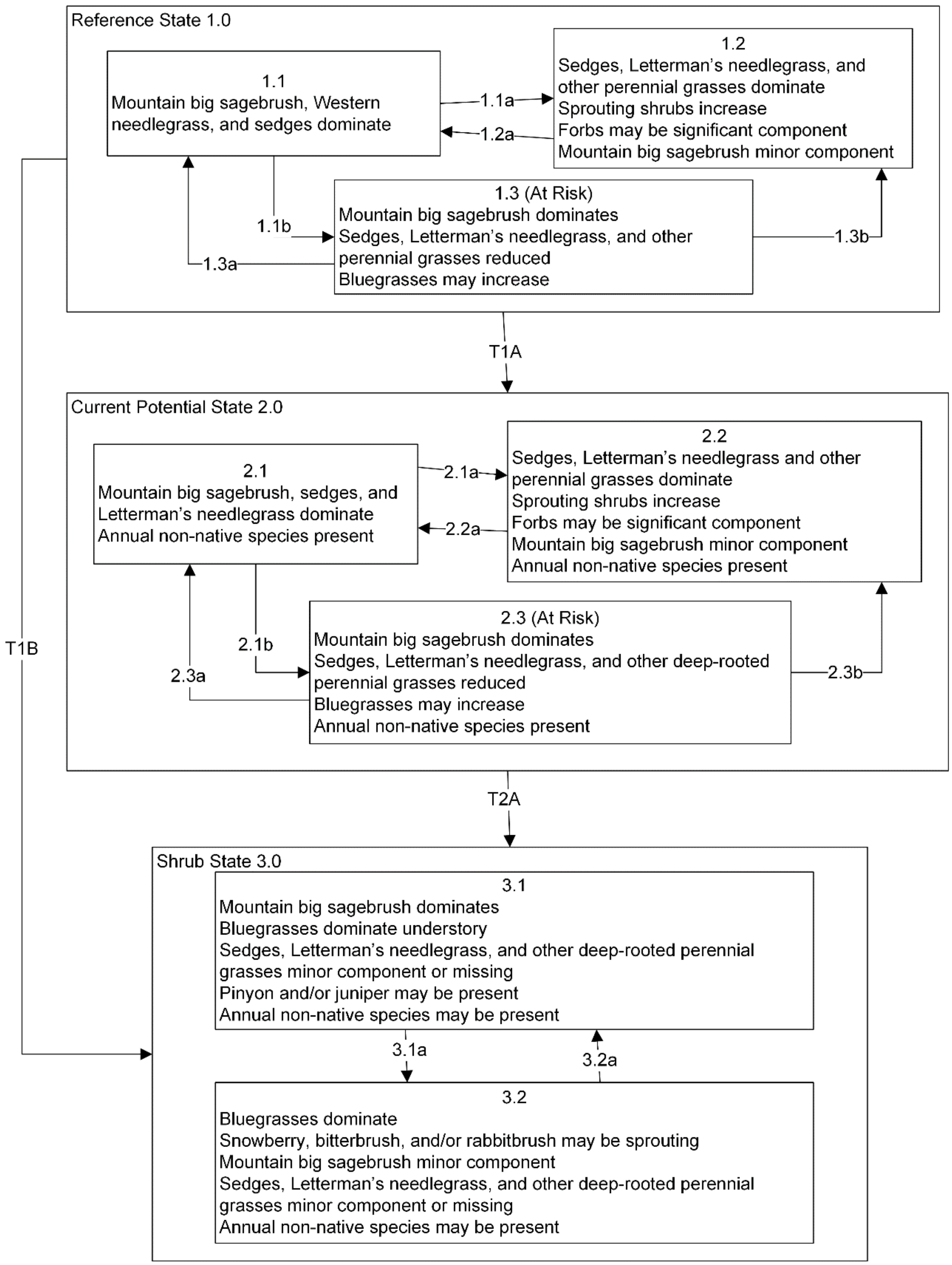
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

MLRA 26
Group 13
Mountain Shoulders 16+"
026XY076NV



MLRA 26
Group 13
Mountain Shoulders 16+”
026XY076NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

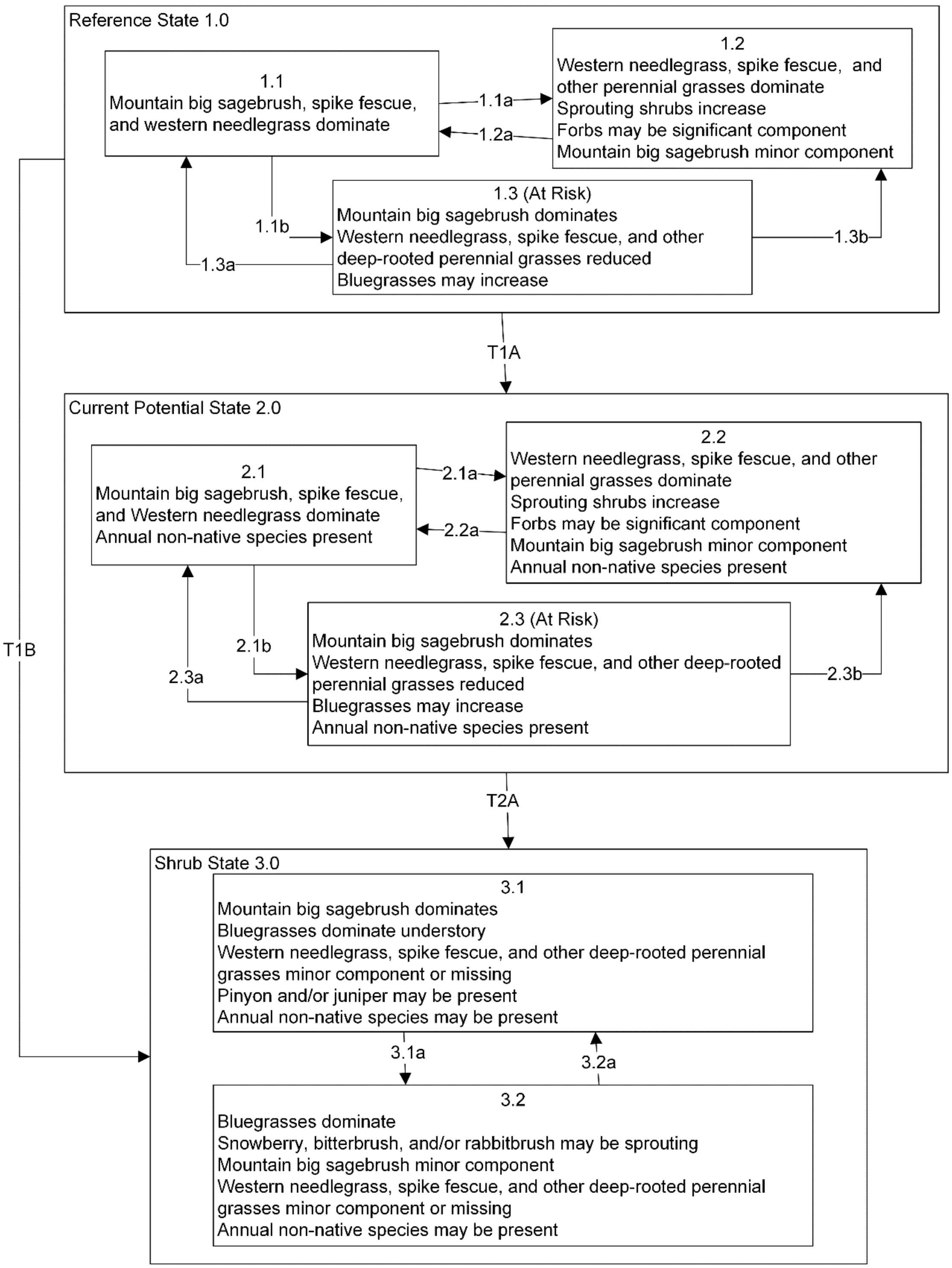
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

MLRA 26
Group 13
Loamy Slope 16+"
026XY1098NV



MLRA 26
Group 13
Loamy Slope 16+"
026XY109NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

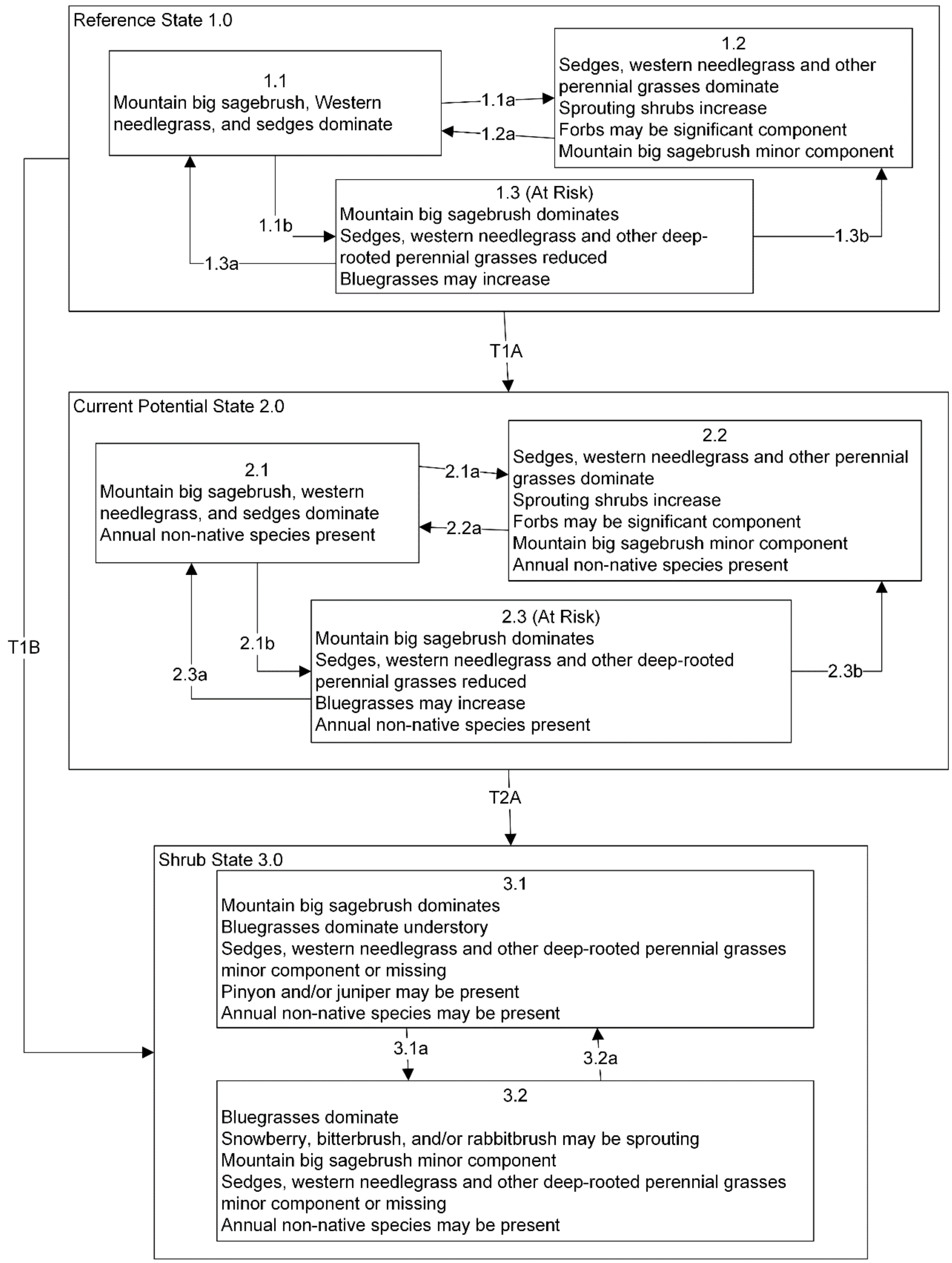
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

MLRA 26
Group 13
Ashy Pocket
026XY112NV



MLRA 26
Group 13
Ashy Pocket
026XY112NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

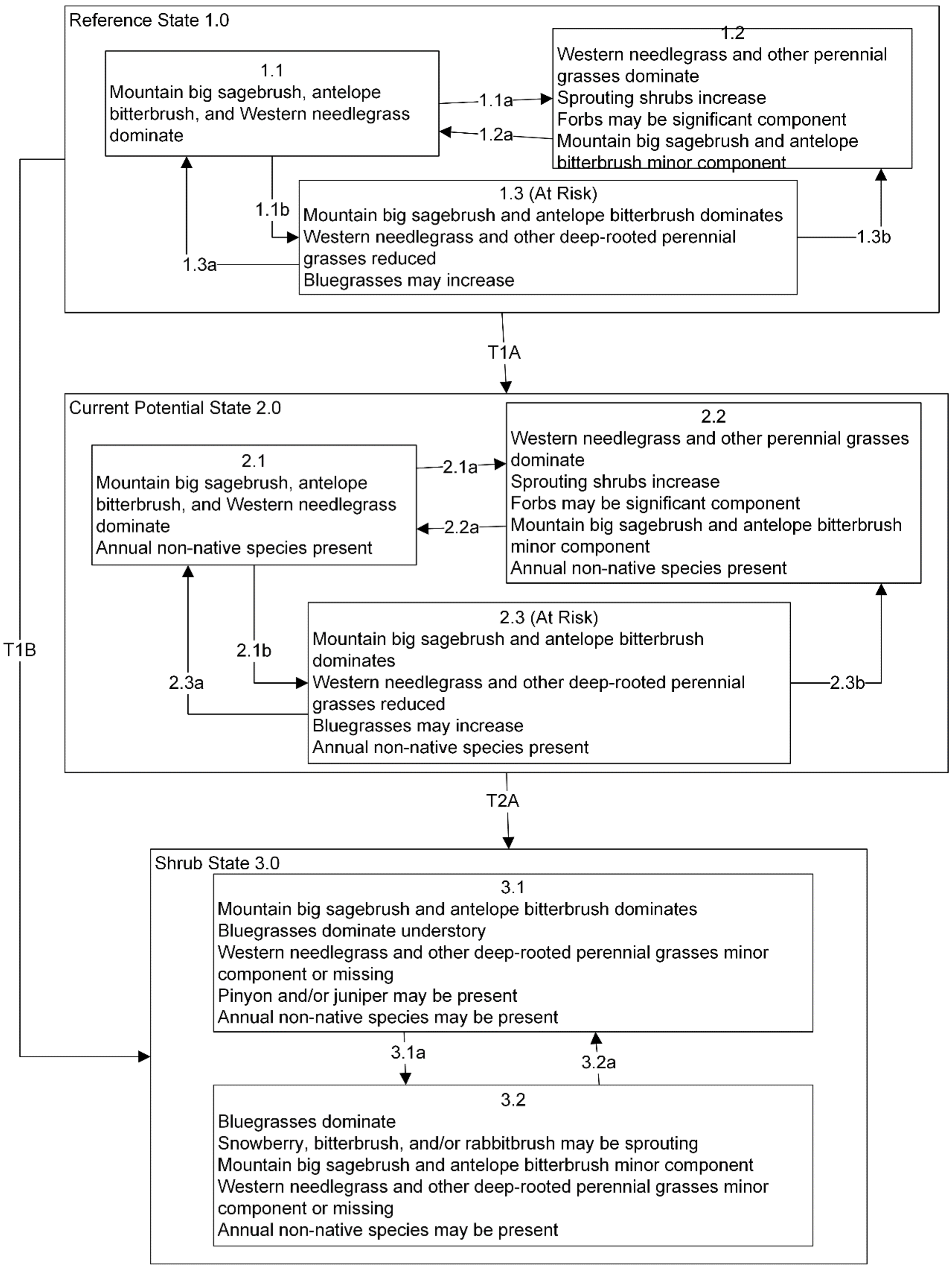
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

MLRA 26
Group 13
Gravelly South Slope 16+"
026XY110NV



MLRA 26
Group 13
Gravelly South Slope 16+”
026XY110NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

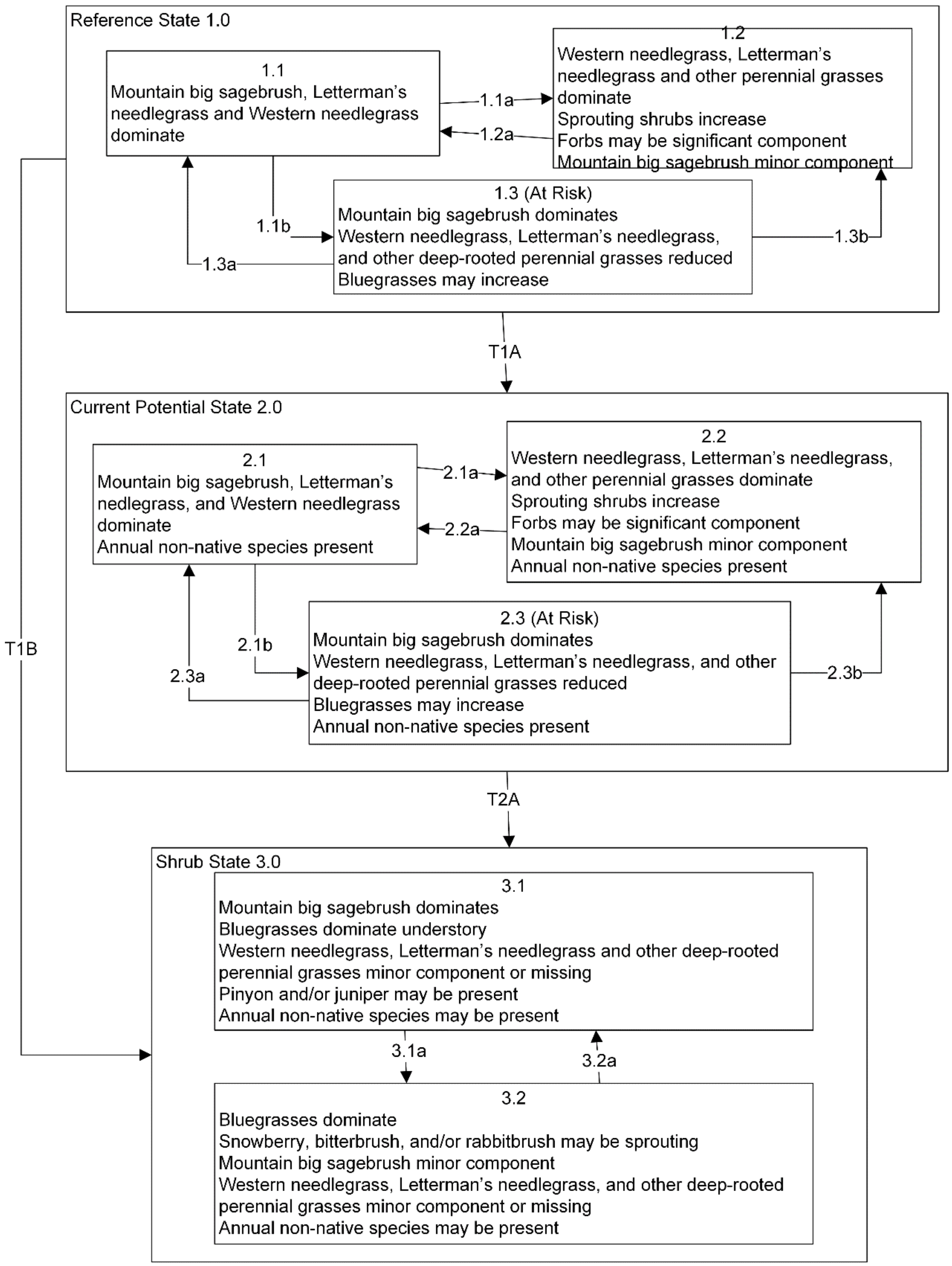
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

MLRA 26
Group 13
Ashy Mountain Shoulders 16-20”
R026XF059CA



MLRA 26
Group 13
Ashy Mountain Shoulders 16-20”
R026XF059CA
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire creates sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

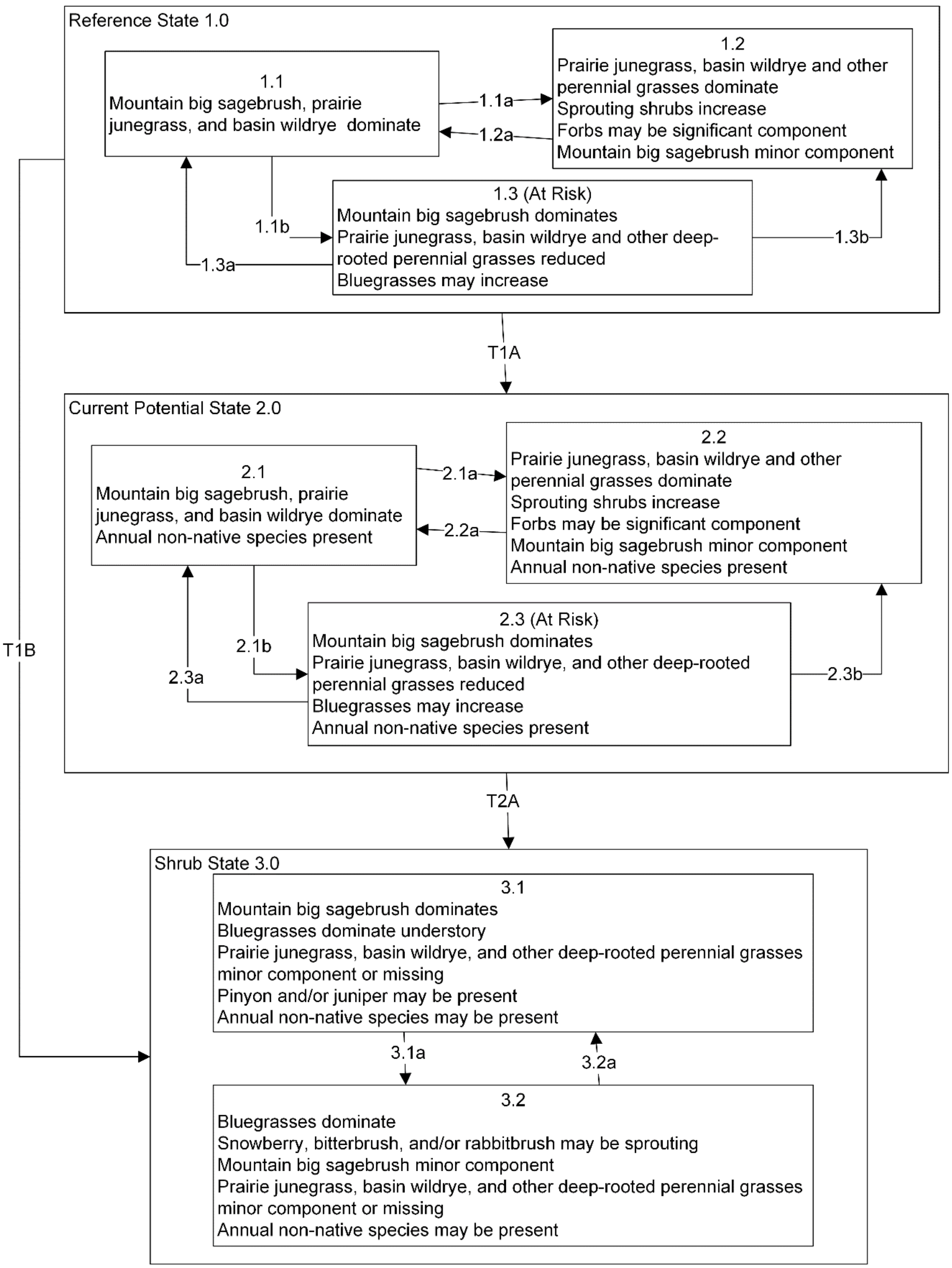
Transition T1A: Introduction of non-native annual species.
Transition T2B: Inappropriate grazing management (from 1.3 to 3.1).

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance. Inappropriate grazing management and/or long-term drought may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

MLRA 26
Group 13
Ashy Loamy Slope 16-20”
R026XY058CA



MLRA 26
Group 13
Ashy Loamy Slope 16-20"
R026XY058CA
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire creates sagebrush/grass mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory and/or long-term drought may also reduce perennial understory.
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Current Potential State 2.0 Community Phase Pathways
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2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (to 3.1), or high severity fire (from 2.3 to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire.
3.2a: Time and lack of disturbance.

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MLRA 26 Group 14: Black greasewood alluvial flats and bolsons

Description of MLRA 26 Disturbance Response Group 14

Disturbance Response Group (DRG) 14 consists of three ecological sites. These sites are found primarily on stream floodplains, alluvial flats, and bolsons. These areas are characterized by deep, fine-textured, salt-affected soils. Plant growth is controlled by a fluctuating shallow water table, soil pH, and natural ponding and crusting of the soil surface. Seasonal flooding is common. Precipitation for these sites ranges from 5 to 10 inches, however most of the plant-available moisture occurs as shallow groundwater. Slopes range from 0 to 4 percent but slopes from 0 to 2 percent are most typical. Elevations range from 3,500 to 5,500 feet. These sites are dominated by black greasewood (*Sarcobatus vermiculatus*). Understory grasses include basin wildrye (*Leymus cinereus*), inland saltgrass (*Distichlis spicata*), and alkali sacaton (*Sporobolus airoides*). Torrey's saltbush (*Atriplex torreyi*) and shadscale (*Atriplex confertifolia*) are other important species. Average annual production ranges from 500 to 1500 lbs/ac in normal years.

Disturbance Response Group 14 Ecological Sites:

Sodic Flat – Modal Site	R026XY021NV
Sodic Floodplain	R026XY013NV
Saline Bottom	R026XY004NV

Modal Site:

Sodic Flat ecological site (R026XY021NV) is the modal site for this group. While it does not have the greatest amount of mapped acres, it was the only site in this group visited during fieldwork for this project. This site occurs along axial-stream floodplains, alluvial plains and alluvial flats. Slopes range from 0 to 2 percent. Elevations range from 3,500 to 5,000 feet. Annual production ranges from 300 to 600 lbs/ac, with 500 lbs/ac in a normal year. Soils on this site have a surface layer that can be strongly affected by sodium and will naturally form a crust upon drying, which can inhibit water infiltration and seedling emergence. This site is a groundwater-dependent ecosystem, with plants accessing a water table that can fluctuate dramatically. Black greasewood (*Sarcobatus vermiculatus*) is able to root to great depths and can take advantage of the deep water table well into the summer. Some areas are subject to ponding for brief periods, due mainly to run-in from adjacent areas. Runoff is slow and potential for rill and sheet erosion is slight. The overstory of the plant community is dominated by black greasewood, while basin wildrye (*Leymus cinereus*) and inland saltgrass (*Distichlis spicata*) dominate the understory. This site does not support significant amounts of grass. Shadscale (*Atriplex confertifolia*), rubber rabbitbrush (*Chrysothamnus viscidiflorus*), seepweed (*Sueda* spp.), alkali sacaton (*Sporobolus airoides*), and bottlebrush squirreltail (*Elymus elymoides*) are also commonly found on this site.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter, salt content), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al 2013). Biotic factors that that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Periodic drought regularly influences sagebrush ecosystems, and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historic precipitation patterns have the greatest potential to alter ecosystem function and productivity (Snyder et al. 2019). Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006). The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition or can increase resource pools by the decomposition of dead plant material following disturbance.

Black greasewood is classified as a phreatophyte, meaning it relies on access to groundwater rather than precipitation for survival (Meinzer 1927, Eddleman 2002, Naumberg et al. 2005). Its distribution is well correlated with the distribution of shallow groundwater (Meinzer 1927, Mozingo 1987). Black greasewood stands develop best where moisture is readily available, either from surface or subsurface runoff (Brown 1971). It is commonly found on floodplains that are either subjected to periodic flooding, have a high water table at least part of the year, or have a water table less than 34 feet deep (Harr and Price 1972, Blauer et al. 1976, Branson et al. 1976, Blaisdell and Holmgren 1984, Eddleman 2002). Romo (1984) found water tables ranging from 3.5 to 15 m under black greasewood dominated communities in Oregon. Black greasewood is usually a deep-rooted shrub, but has some shallow roots near the soil surface; the maximum rooting depth can be determined by the depth to a saturated zone (Harr and Price 1972).

Black greasewood is adapted to areas with shallow groundwater: it is tolerant of seasonal inundation but not continuous flooding, and its roots must have access to the water table for long-term survival. Ganskopp (1986) reported that water tables within 9.8 to 11.8 inches of the surface had no negative effect on black greasewood in Oregon. However, a study, conducted in California, found that black greasewood did not survive six months of continuous flooding (Groeneveld and Crowley 1988, Groeneveld 1990).

Black greasewood is capable of rooting to exceptional depths to access the water table in drought conditions. The taproots of black greasewood can penetrate from 20 to 57 feet below the surface (Meinzer 1927). However, other studies have found the maximum rooting depth to be closer to 12 feet (3.6 m), with effective use of water occurring at even shallower depths (Groeneveld 1990). Disturbances such as long-term drought and groundwater extraction that lower the water table beyond the rooting depths of these plants threaten communities of phreatophytic vegetation (Naumberg et al. 2005, Elmore et al. 2006). Recent remote sensing research in black greasewood and saltgrass communities shows a reduction in plant productivity over time with lowered water tables associated with groundwater pumping (Huntington et al. 2016). The exact groundwater level at which greasewood can no longer survive is not yet known (Devitt and Bird 2016). Lowering of the water table and subsequent loss of greasewood has been observed in other MLRAs. Death of phreatophytes in this system leaves the site open to invasion by non-native species (Devitt and Bird 2016, Provencher et al. 2020). Because of the high salt content of these soils, other more drought-tolerant native plants such as basin big sagebrush may be unlikely to colonize the site.

Basin wildrye is the dominant grass on this site. It is weakly rhizomatous and has been found to root to depths of up to 2 meters, and exhibits greater lateral root spread than many other grass species (Abbott et al. 1991, Reynolds and Fraley 1989). Basin wildrye is a large, cool-season perennial bunchgrass with an extensive deep coarse fibrous root system (Reynolds and Fraley 1989). Clumps may reach up to six feet in height (Ogle et al. 2012b). Basin wildrye does not tolerate long periods of inundation; it prefers cycles of wet winters and dry summers and is most commonly found in deep soils with high water holding capacities or seasonally high water tables (Ogle et al. 2012b, Perryman and Skinner 2007).

Seasonally high water tables have been found to be necessary for maintenance of site productivity and reestablishment of basin wildrye stands following disturbances such as fire, drought or excessive herbivory (Eckert et al. 1973). The sensitivity of basin wildrye seedling establishment to reduced soil water availability is increased as soil pH increases (Stuart et al. 1971). Lowering of the water table through extended drought, channel incision or groundwater pumping will decrease basin wildrye production and establishment, while sagebrush, rabbitbrush, and invasive weeds increase.

Other grasses that occur on this site are warm-season grasses, which means they use the C_4 photosynthetic pathway. This adaptation makes these plants more efficient in their use of nitrogen and water (Taylor et al. 2009). These types of grasses can adjust their growth more quickly to drought or wet conditions when compared to C_3 grasses (Witwicki et al. 2016).

Inland saltgrass is a warm-season rhizomatous grass that is often indicative of shallow groundwater. It is tolerant of high concentrations of salt (Skougard et al. 1979). Where present, the water table tends to be within 8 to 12 feet of the soil surface even in dry periods (Meinzer 1927). Saltgrass is also adapted to low water conditions, as it can distribute water for long distances through its connected rhizomes (Alpert 1990).

Alkali sacaton, a minor component of this site, is a native, long-lived, warm-season, densely tufted perennial bunchgrass ranging from 20 to 40 inches in height. It usually grows on saline soils but is not restricted to saline soils and can be found on nonsaline soils, rocky sites, open plains, valleys and bottom lands (Dayton 1937). Marcum and Kopec (1997) found inland saltgrass more tolerant of increased levels of salinity than alkali sacaton, therefore dewatering and/or long term drought that cause increased levels of salinity would create environmental conditions more favorable to inland saltgrass over alkali sacaton. Alkali sacaton is considered a facultative species in this region; it is tolerant of drought and inundation (Brakie 2007).

These communities often exhibit the formation of microbiotic crusts within the interspaces. These crusts influence the soils on these sites and their ability to reduce erosion and increase infiltration, they may also alter the soil structure and possibly increase soil fertility (Fletcher and Martin 1948, Williams 1993). Finer textured soils such as silts tend to support more microbiotic cover than coarse textured soils (Anderson et al. 1982). Disturbance such as hoof action from inappropriate grazing and cheatgrass (*Bromus tectorum*) invasion can reduce biotic crust integrity (Anderson et al. 1982, Ponzetti et al. 2007) and increase erosion. Annual non-native species such as clasping pepperweed (*Lepidium perfoliatum*), crossflower (aka purple mustard, *Chorispora tenella)*, bur buttercup (*Ceratocephela testiculata)*, and cheatgrass invade these sites where competition from perennial species is decreased. Native annual forbs like western tansymustard (*Descurainia pinnata)* can also become weedy on this site. Density of western tansymustard increases with supplemental water (Gutierrez and Whitford 1987); it may become a dominant understory plant in years with favorable moisture regimes. With increased production and density, these annual species increase the risk of fire in this community.

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. Primary disturbances on these sites include excessive livestock grazing, lowering of the water table, and conversion to agricultural land and urban development. Four possible stable states have been identified for this DRG.

Fire Ecology:

Fire is a rare disturbance in these plant communities, likely occurring in years with above average production. Natural fire return intervals are estimated to vary between less than 35 years up to 100 years in salt desert ecosystems with basin wildrye (Paysen et al. 2000). Historically, black greasewood-saltbush communities had sparse understories and bare soil in interspaces, making these communities somewhat resistant to fire (Young 1983, Paysen et al. 2000). They may burn only during high fire hazard conditions; for example, years with high precipitation can result in almost continuous fine fuels, increasing fire hazard (West 1994, Paysen et al. 2000).

Black greasewood may be killed by severe fires but can resprout after low to moderate severity fires (Robertson 1983, West 1994). Sheeter (1968) reported that following a Nevada wildfire, black greasewood sprouts reached approximately 2.5 feet within 3 years. Grazing and other disturbance may result in increased biomass production due to sprouting and increased seed production, also leading to greater fuel loads (Sanderson and Stutz 1994). Higher production sites would have experienced fire more frequently than lower production sites.

Shadscale is intolerant of fire and can only regenerate through seed (Zielinski 1994). Increases in the fire return interval leads to increases in the shrub component of the plant community, potentially facilitating increases in bare ground, inland salt grass and invasive weeds. Lack of fire combined with excessive herbivory decreases or eliminates the herbaceous understory, favoring black greasewood and annual species. Therefore, fire can be detrimental to these communities, especially in the presence of fire tolerant, annual non-native species.

The effect of fire on grasses relates to culm density, culm-leaf morphology, rooting characteristics, and the size of the plant. The initial condition of grasses within the site, along with seasonality and intensity of the fire, all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface, which provides relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat, which is related to culm density, culm-leaf morphology, size of plant, and abundance of old growth (Wright 1971, Young 1983). However, season and severity of the fire will influence plant response. Plant response will vary depending on post-fire soil moisture availability.

Basin wildrye is relatively resistant to fire, particularly dormant season fire, as plants sprout from surviving root crowns and rhizomes (Zschaechner 1985). Miller et al. (2013) reports fall and spring burning increased total shoot and reproductive shoot densities in the first year, although live basal areas were similar between burn and unburned plants. By year two, there was little difference between burned and control treatments.

Inland saltgrass is tolerant of fire, as its rhizomatous roots are protected beneath the soil (Monsen et al. 2004). This plant reproduces primarily through vegetative spread from rhizomesand is a poor seed producer (Monsen et al. 2004).

Alkali sacaton is tolerant of, but not resistant to fire. Recovery of alkali sacaton after fire has been reported as 2 to 4 years (Bock and Bock 1978).

Livestock/ Wildlife Grazing Interpretations:

Black greasewood is typically not considered an important browse species for wildlife and livestock. However, in a study by Smith et al. (1992), utilization of new growth on greasewood shrubs by cattle was 77 percent in summer, and greasewood was found to have the highest amounts of crude protein when compared to perennial and annual grasses. Black greasewood plants have been found to contain high amounts of sodium and potassium oxalates which are toxic to livestock and caution should be taken when grazing these communities. These shrubs can be used lightly in the spring as long as there is a substantial amount of other preferable forage available (Benson et al. 2011). Black greasewood also provides good cover for wildlife species (Benson et al. 2011).

Shadscale is a valuable browse species for a wide variety of wildlife and livestock (Blaisdell and Holmgren 1984). The spinescent growth habit of shadscale lends to its browsing tolerance with no more than 15 to 20% utilization by sheep being reported (Blaisdell and Holmgren 1984) and significantly less utilization by cattle. Increased presence of shadscale within grazed versus ungrazed areas is generally a result of the decreased competition from more heavily browsed associates (Cibils et al. 1998). Reduced competition from more palatable species in heavily grazed areas may increase shadscale germination and establishment. Chambers and Norton (1993) found shadscale establishment higher under spring than winter browsing as well as heavy compared to light browsing ($p<0.01$). During years of below average precipitation, shadscale has been found very susceptible to grazing pressure regardless of season (Chambers and Norton 1993).

Spring defoliation of basin wildrye and/or consistent, heavy grazing during the growing season has been found to significantly reduce basin wildrye production and density (Krall et al. 1971). Basin wildrye is valuable forage for livestock (Ganskopp et al. 2007) and wildlife, but is intolerant of heavy, repeated, or spring grazing (Krall et al. 1971). Basin wildrye is used often as a winter feed for livestock and wildlife; not only providing roughage above the snow but also cover in the early spring months (Majerus 1992).

Inland saltgrass is not a preferred forage for livestock or native ungulates. Saltgrass is generally avoided by cattle unless it is late in the summer when other grasses have dried out (Monsen et al. 2004). It is resistant to trampling and is generally consider an “increaser” under heavy grazing (Parker 1975). This plant is an important plant within the salt marsh as it is a larval host plant for the Wandering Skipper butterflies, some of which are endangered (i.e. the Carson Wandering Skipper (*Pseudocopaeodes eunus obscurus))*. Saltgrass is a food source for ducks and rodents, and provides valuable cover for birds and insects.

Alkali sacaton has been found to be sensitive to early growing season defoliation, whereas late growing season and/or dormant season use allowed recovery of depleted stands (Hickey and Springfield 1966). Inadequate rest and recovery from defoliation can cause a decrease in basin wildrye and an increase in rabbitbrush, black greasewood, inland saltgrass, and non-native weeds (Young et al. 1976, Roundy 1985).

Urban/Agricultural Use:

Sites in this group exist in flat, accessible areas near water in western Nevada. Many of these areas have been developed for agriculture production and housing developments. There are few areas where sites in this group exist in an unmodified condition. Farming and subsequent abandonment may facilitate the creation of a vesicular crust on the soil surface, increase surface ponding, and reduce infiltration; which leads to dominance by sprouting shrubs and an annual understory. While sites exhibiting significant hydrologic alteration were not seen during field visits for this project, this dynamic is included in the STM narrative since it has been seen on similar sites in other MLRAs.

State and Transition Model Narrative for Group 14

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for MLRA 26 Disturbance Response Group 14.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. The Reference State has three general community phases: a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic long-term drought and/or insect or disease attack.

Community Phase 1.1:
This community is dominated by black greasewood. Shadscale and rubber rabbitbrush are also common. The herbaceous understory is dominated by basin wildrye and inland saltgrass. Squirreltail and alkali sacaton make up minor components.

Community Phase Pathway 1.1a, from phase 1.1 to 1.2:
A low severity fire would decrease the overstory of black greasewood and allow the understory perennial grasses to increase. Fires are typically low severity and rare due to low fuel loads, but would result in a mosaic pattern of shrubs and grasses. A fire following an unusually wet spring facilitating an increase in fine fuels may be more severe and reduce black greasewood cover to trace amounts.

Community Phase Pathway 1.1b, from phase 1.1 to 1.3:
Absence of disturbance over time, significant herbivory, long term drought, or combinations of these would allow the black greasewood overstory to increase and dominate the site. This will generally cause a reduction in basin wildrye. Inland saltgrass may increase in the understory depending on the timing and intensity of herbivory. Heavy spring utilization will favor an increase in black greasewood.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early-seral community phase. Basin wildrye dominates the community. Black greasewood will decrease but will likely sprout and return to pre-burn levels within a few years. Early colonizers such as rabbitbrush and inland saltgrass may increase.

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Time and lack of disturbance will allow shrubs to increase

Community Phase 1.3:
Black greasewood and shadscale increase in the absence of disturbance. Decadent shrubs dominate the overstory and basin wildrye is reduced either from competition with shrubs, herbivory, drought, or combinations of these.

Community Phase Pathway 1.3a, from phase 1.3 to 1.1:
Fire will decrease the overstory of black greasewood and allow for the perennial bunchgrasses to dominate the site. Fires will typically be high intensity in this phase due to the dominance of greasewood, resulting in removal of the overstory shrub community.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, mustards, halogeton, or Russian thistle.

Slow variables: Over time the annual non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0 with three similar community phases. Ecological function has not changed; however, the resilience of the state has been reduced by the presence of invasive weeds. Non-natives may increase in abundance but will not become dominant within this State. These non-natives can be highly flammable and can promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1. This community is dominated by black greasewood. Shadscale and rubber rabbitbrush are also common. The herbaceous understory is dominated by basin wildrye and inland saltgrass. Squirreltail and alkali sacaton make up minor components. Non-native annual species such as halogeton, Russian thistle and cheatgrass are present.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
A low severity fire would decrease the overstory of black greasewood and allow the understory perennial grasses to increase. Fires are typically low severity and rare due to low fuel loads, but would result in a mosaic pattern of shrubs and grasses. A fire following an unusually wet spring facilitating an increase in fine fuels may be more severe and reduce black greasewood cover to trace amounts. Brush treatments with minimal soil disturbance may also reduce black greasewood and allow for perennial bunchgrasses to increase. Annual non-native species are likely to increase after fire.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Absence of disturbance over time, significant herbivory, long term drought, or combinations of these would allow the black greasewood overstory to increase and dominate the site. Inappropriate grazing management reduces basin wildrye, and inland saltgrass may increase in the understory.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early-seral community phase. Basin wildrye dominates the community. Black greasewood will decrease but will likely sprout and return to pre-burn levels within a few years. Early colonizers such as rabbitbrush and inland saltgrass may increase. Annual non-native species are stable to increasing in the community.

Community Phase Pathway 2.2a, form Phase 2.2 to 2.1:
Absence of disturbance over time and/or grazing management that favors the establishment and growth of black greasewood allows the shrub component to recover.

Community Phase 2.3:
Black greasewood and shadscale increase in the absence of disturbance. Decadent shrubs dominate the overstory and basin wildrye is reduced either from competition with shrubs, herbivory, drought, or combinations of these. Annual non-native species are stable or increasing. This community is at risk of crossing a threshold to the Shrub State.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.2:
Grazing management that reduces shrubs will allow for the perennial bunchgrasses in the understory to increase. Heavy late-fall/winter grazing may cause mechanical damage to black greasewood promoting the perennial bunchgrass understory. Brush treatments with minimal soil disturbance will also decrease black greasewood and release the perennial understory. Annual non-native species are present and may increase in the community. Fire will decrease the overstory of black greasewood and allow for the perennial bunchgrasses to dominate the

site. Fires will typically be high intensity in this phase due to the dominance of greasewood, resulting in removal of the overstory shrub community.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: To Community Phase 3.1: Inappropriate cattle/horse grazing will decrease or eliminate deep rooted perennial bunchgrasses and favor shrub growth and establishment. To Community Phase 3.2: Severe fire will reduce and/or eliminate the black greasewood overstory. Soil disturbing brush treatments will reduce black greasewood and possibly increase non-native annual species. Lowering of the water table due to groundwater pumping will also decrease basin wildrye and black greasewood, and will allow rabbitbrush and other shrubs to increase.

Slow variables: Long term decline in perennial grass density.

Threshold: Loss of perennial grasses alters nutrient cycling, nutrient redistribution, and reduces soil organic matter. Loss of long-lived black greasewood changes the temporal and the spatial distribution of nutrient cycling depending on the replacement shrub.

Shrub State 3.0:

This state has two community phases, one that is characterized by a dominance of a black greasewood overstory and the other with a rabbitbrush overstory. This site has crossed a biotic and abiotic threshold and site processes are being controlled by shrubs. Bare ground has increased and pedestalling of grasses may be excessive.

Community Phase 3.1:
Black greasewood dominates the overstory. Perennial grasses have significantly declined and may be missing. Annual non-native species increase. Bare ground is significant; however, there may be occasional flushes of annual forbs with certain moisture conditions in winter and spring.

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Long term drought and/or lowering of water table by groundwater pumping would reduce black greasewood and allow rabbitbrush and other shrubs on the site to dominate. Severe fire would also reduce black greasewood overstory and allow for an increase in rabbitbrush.

Community Phase 3.2:
Rabbitbrush is a significant component. Native and non-native annual forbs (primarily mustards) present. Perennial bunchgrasses may be present but are a minor component. Bare ground may be significant in years with little moisture to support an annual community.

Sodic Flat (R026XY021NV) Phase 3.2, T. Stringham, May 2017

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Release from drought conditions may allow black greasewood to increase.

T3A: Transition from Shrub State 3.0 to Annual State 4.0:

Trigger: Fire, or moisture conditions that cause a sudden increase in density and production of annual plants. May be coupled with a lowering of the water table that reduces vitality of perennial species.

Slow variable: Increasing non-native annuals causes an increase of fine fuel loads over time. These fuel loads cause frequent fires, or build up over time until it causes a catastrophic fire.

Threshold: Annual forbs and/or grasses dominate the site. Loss of perennial grasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter. Non-native annual species increase in the seedbank and respond positively to fire.

Annual State 4.0:

This state has one community phase characterized by the dominance of annual native and non-native species such as western tansymustard and cheatgrass in the understory. Time since fire may facilitate the maturation of sprouting shrubs. Ecological dynamics are significantly altered in this state. Annual non-native species create a highly combustible fuel bed that shortens the fire return interval. Nutrient cycling is spatially and temporally truncated as annual plants contribute significantly less to deep soil carbon. Some perennial grasses may remain but they are a minor component. Without management, it is unlikely these plants will be able to recruit in the presence of dominant annual plants.

Community Phase 4.1:
Annual non-native species dominate. Black greasewood, other shrubs, and perennial bunchgrasses are a minor component or missing. Soil redistribution and erosion may be significant.

Sodic Flat (R026XY021NV) Phase 3.1, T. Stringham, May 2017

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Fire reduces shrub community and allows annuals to dominate.

Community Phase 4.2:
This is a post-fire community phase. Native and non-native annual forbs and grasses dominate. Black greasewood may be sprouting.

Potential Resilience Differences with other Ecological Sites:

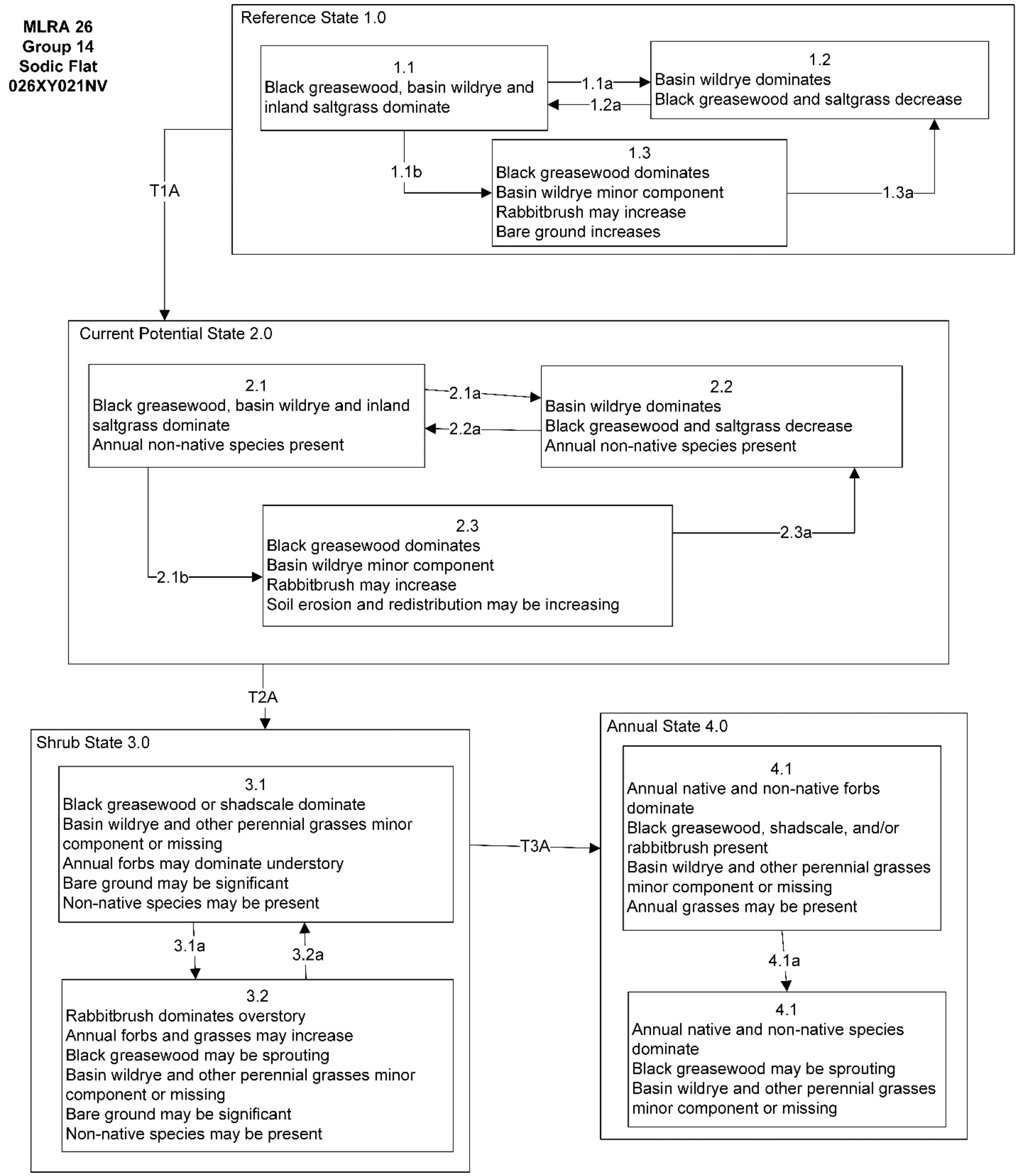
Sodic Floodplain (R026XY013NV)

This site is very similar to the modal site, but with alkali sacaton as the dominant grass and Torrey's quailbush as a secondary shrub. It is more productive with 700 lbs/ac in a normal year and receives 8-10" of precipitation annually. The soils are very deep and poorly drained with an available water capacity of moderate to high. On this site there is occasional overland flow causing it to be highly susceptible to gullying.

Saline Bottom (R026XY004NV)

This site is very similar to the modal site, but with a different potential vegetative composition. This site is potentially composed of 75% grasses, 20% shrubs, and 5% forbs. This causes the site to have much higher annual production at 1500 lbs/ac. Soils are deep and somewhat poorly drained, with an available water capacity of moderate. Unlike the modal site, this site has 3 stable states.

Modal State and Transition Model for Group 14 in MLRA 26:



MLRA 26
Group 14
Sodic Flat
026XY021NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Fire allows basin wildrye to dominate.
1.1b: Time and lack of disturbance, drought, herbivory or combinations of these.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Fire allows basin wildrye to dominate.

Transition T1A: Introduction of non-native annual species

Current Potential State 2.0 Community Phase Pathways
2.1a: Fire allows basin wildrye to dominate.
2.1b: Time and lack of disturbance, drought, herbivory or combinations of these.
2.2a: Time and lack of disturbance allows for shrub regeneration.
2.3a: Fire allows basin wildrye to dominate.

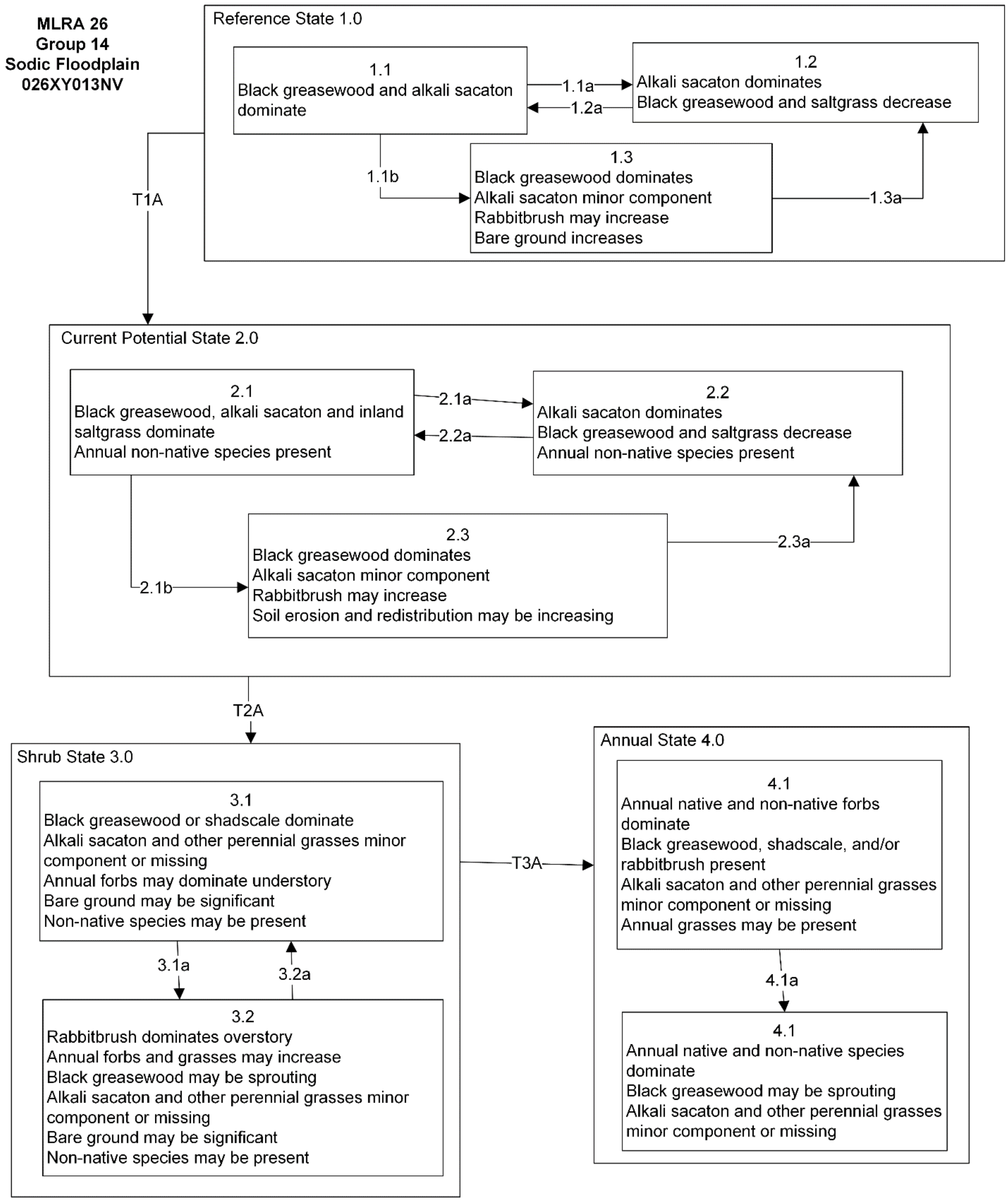
Transition T2A: Long-term inappropriate grazing management. May be coupled with a lowering of the water table and/or long term drought.

Shrub State 3.0 Community Phase Pathways
3.1a: Drought and/or lowering of the water table due to groundwater pumping and/or severe fire.
3.2a: Release of drought and/or grazing pressure may allow for black greasewood to increase.

Transition T3A: Long-term inappropriate grazing management coupled with moisture conditions that favor expansion of annual forbs and grasses. May be coupled with a lowering of the water table that reduces vitality of perennial species. Fire would lead to phase 4.2.

Annual State 4.0 Community Phase Pathways
4.1a: Fire.

Additional State and Transition Models for Group 14 in MLRA 26:



MLRA 26
Group 14
Sodic Floodplain
026XY013NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Fire allows basin wildrye to dominate.
1.1b: Time and lack of disturbance, drought, herbivory or combinations of these.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Fire allows basin wildrye to dominate.

Transition T1A: Introduction of non-native annual species

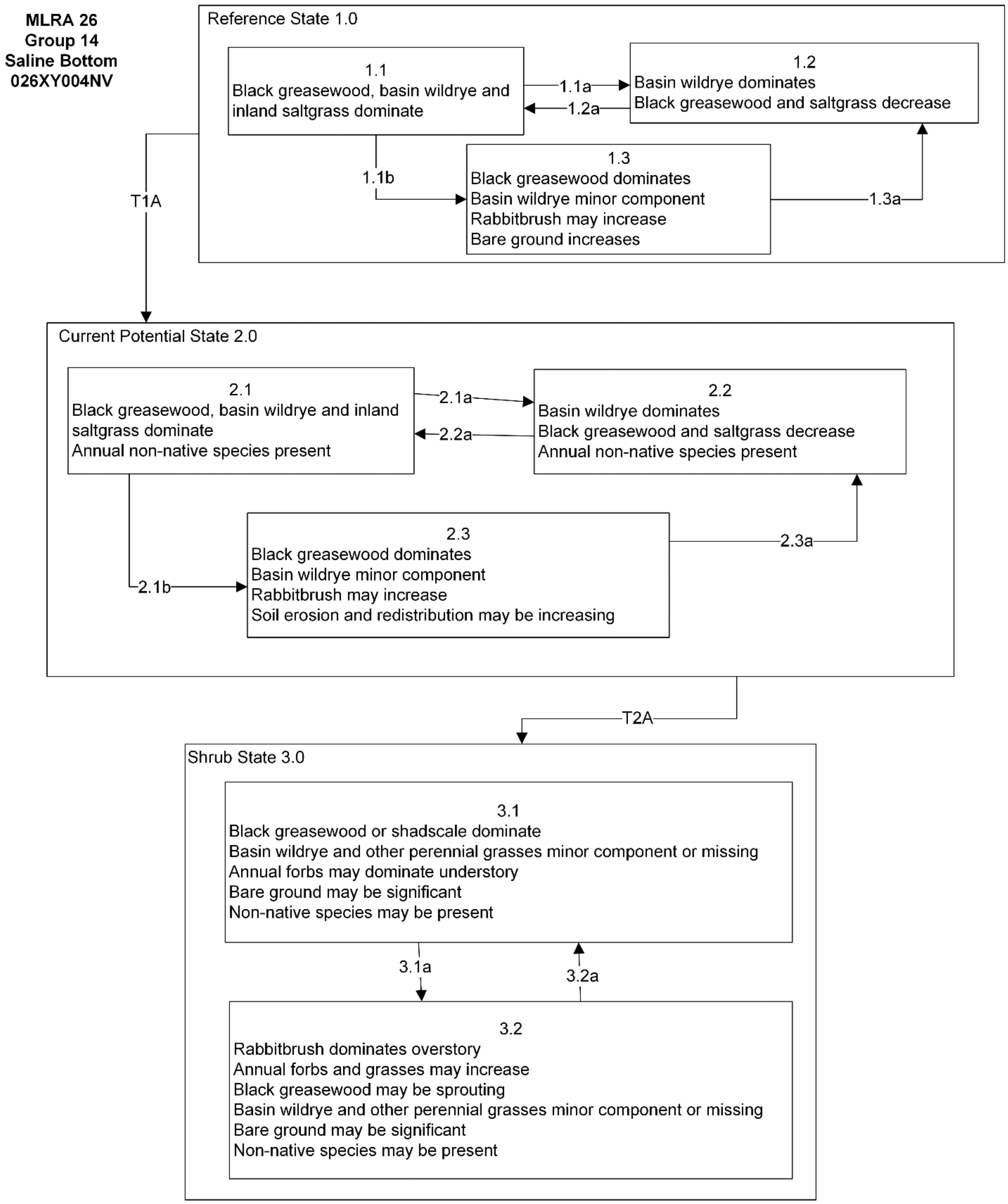
Current Potential State 2.0 Community Phase Pathways
2.1a: Fire allows basin wildrye to dominate.
2.1b: Time and lack of disturbance, drought, herbivory or combinations of these.
2.2a: Time and lack of disturbance allows for shrub regeneration.
2.3a: Fire allows basin wildrye to dominate.

Transition T2A: Long-term inappropriate grazing management. May be coupled with a lowering of the water table and/or long term drought.

Shrub State 3.0 Community Phase Pathways
3.1a: Drought and/or lowering of the water table due to groundwater pumping and/or severe fire.
3.2a: Release of drought and/or grazing pressure may allow for black greasewood to increase.

Transition T3A: Long-term inappropriate grazing management coupled with moisture conditions that favor expansion of annual forbs and grasses. May be coupled with a lowering of the water table that reduces vitality of perennial species. Fire would lead to phase 4.2.

Annual State 4.0 Community Phase Pathways
4.1a: Fire.


MLRA 26
Group 14
Saline Bottom
026XY004NV
Reference State 1.0
1.1
Black greasewood, basin wildrye and inland saltgrass dominate
1.1a
1.2a
1.2
Basin wildrye dominates
Black greasewood and saltgrass decrease
1.1b
1.3
Black greasewood dominates
Basin wildrye minor component
Rabbitbrush may increase
Bare ground increases
1.3a
T1A
Current Potential State 2.0
2.1
Black greasewood, basin wildrye and inland saltgrass dominate
Annual non-native species present
2.1a
2.2a
2.2
Basin wildrye dominates
Black greasewood and saltgrass decrease
Annual non-native species present
2.3
Black greasewood dominates
Basin wildrye minor component
Rabbitbrush may increase
Soil erosion and redistribution may be increasing
2.3a
2.1b
T2A
Shrub State 3.0
3.1
Black greasewood or shadscale dominate
Basin wildrye and other perennial grasses minor component or missing
Annual forbs may dominate understory
Bare ground may be significant
Non-native species may be present
3.1a
3.2a
3.2
Rabbitbrush dominates overstory
Annual forbs and grasses may increase
Black greasewood may be sprouting
Basin wildrye and other perennial grasses minor component or missing
Bare ground may be significant
Non-native species may be present

MLRA 26
Group 14
Saline Bottom
026XY004NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Fire allows basin wildrye to dominate.
1.1b: Time and lack of disturbance, drought, herbivory or combinations of these.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Fire allows basin wildrye to dominate.

Transition T1A: Introduction of non-native annual species

Current Potential State 2.0 Community Phase Pathways
2.1a: Fire allows basin wildrye to dominate.
2.1b: Time and lack of disturbance, drought, herbivory or combinations of these.
2.2a: Time and lack of disturbance allows for shrub regeneration.
2.3a: Fire allows basin wildrye to dominate.

Transition T2A: Long-term inappropriate grazing management. May be coupled with a lowering of the water table and/or long term drought.

Shrub State 3.0 Community Phase Pathways
3.1a: Drought and/or lowering of the water table due to groundwater pumping and/or severe fire.
3.2a: Release of drought and/or grazing pressure may allow for black greasewood to increase.

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MLRA 26 Group 15: Mahogany stands with a sagebrush and needlegrass understory

Description of MRLA 26 Disturbance Response Group 15:

Disturbance Response Group (DRG) 15 consists of two ecological sites. These sites are found on summits and upper sideslopes of mountains. The precipitation zone for these sites ranges from 14 to over 18 inches, and it is found at elevations from 6,000 to over 9,000 feet. Slopes range from 4 to 75 percent; however, 4 to 30 percent are typical. Soils on these sites range from shallow to very deep with available water capacity ranging from very low to low. These soils can be shallow to bedrock or have a high volume of rock fragments in deeper soils. Production in a normal year ranges from 3,500 to 7,000 lbs/ac for the group. The potential native plant community for these sites varies depending on precipitation, elevation and landform. Curl-leaf mountain mahogany (*Cercocarpus ledifolius*) is the dominant plant on these sites. Understory plants include mountain big sagebrush (*Artemisia tridentata* ssp*. vaseyana*), mountain snowberry (*Symphoricarpos oreophilis),* western needlegrass (*Achnatherum occidentale*), and Letterman's needlegrass (*Achnatherum lettermanii*). Other important grasses include bluegrass species (*Poa spp.*) and spike fescue (*Leucopoa kingii*).

Disturbance Response Group 15 Ecological Sites:

Mahogany Savanna – Modal Site	R026XY009NV
Mahogany Thicket	R026XY081NV

Modal Site:

The Mahogany Savanna ecological site is the modal site. This site occurs on mountain summits and upper side slopes on all exposures at elevations ranging from 6,000 to over 9,000 feet. Slopes generally range from 4 to 75 percent, but slopes of 4 to 30 percent are more typical. Average annual precipitation is 14 to over 18 inches. The soils of this site are shallow to very deep, with low available water capacity due to shallow depth to bedrock or a high volumes of rock in the soil profile. The soils may be slightly acidic or neutral. The plant community is dominated by curl-leaf mountain mahogany. Mountain big sagebrush, Letterman's needlegrass, and western needlegrass are important understory species. Other important plants include mountain snowberry (*Symphoricarpos oreophilus*), bush oceanspray (*Holodiscus discolor*), antelope bitterbrush (*Purshia tridentata*), muttongrass (*Poa fendleriana*), and Cusick's bluegrass (*Poa cusikii*). Total annual production ranges from 3,500 to 6,500 lbs/ac.

Ecological Dynamics and Disturbance Response

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The Great Basin vegetation communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The moisture resource supporting the greatest amount of plant growth is usually the water stored in the soil profile during the winter. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition, or increase resource uptake by the decomposition of dead plant material following disturbance. The invasion of cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007). Dobrowolski et al. (1990) cite multiple authors on the extent of the soil profile exploited by the competitive exotic annual cheatgrass. Specifically, the depth of rooting is dependent on the size the plant achieves; in competitive environments cheatgrass roots were found to penetrate only 15 cm, while isolated plants and pure stands were found to root up to 1.7 m. Mahogany stands are susceptible to drought, frost, and invasion by non-native species, especially cheatgrass. Cheatgrass affects mahogany seedling growth by competing for water resources and nutrients in an area (Ross 1999).

Periodic drought regularly influences Great Basin ecosystems, and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historic precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

Long-lived curl-leaf mountain mahogany, deep-rooted cool season perennial bunchgrasses, and long-lived shrubs (50+ years) with high root-to-shoot ratios dominate the ecological sites in this DRG. Curl-leaf mountain mahogany (hereafter, mahogany) is a widespread species in Nevada, occurring on mountain slopes spanning a wide elevation range, from the sagebrush and pinyon-juniper vegetation zones into the mountain shrub communities that border mixed conifer and even subalpine ecosystems (Tueller 1989). Mahogany is a multi-branched, evergreen shrub or tree reaching 3 to over 20 feet in height. Mahogany plants are long-lived; it is common to find plants over 200 years old, however there are some reports of plants over 1,000 years old (Ex et al. 2011, Schultz 1987, Schultz et al. 1990). As mahogany stands increase in average age, average canopy volume and height of the individuals present also increases. As average canopy height and volume increase, stand density declines (Schultz et al. 1991). Stands with a closed or nearly closed canopy often have little recruitment in the understory (Schultz et al. 1990, 1991), despite high seed density beneath trees (Russell and Schupp 1998, Ibáñez et al. 2002). Intraspecific competition reduces the growth rates of all age classes and may increase mortality in the younger plants.

The species plays an important role in biogeochemical cycles, since its roots can host nitrogen-fixing nodules (Youngberg and Hu 1972, Freund et al., 2018), possibly allowing for successional processes on poor soils in stressful environments (Kratsch and Graves, 2004). Seedlings of mahogany exhibit rapid root growth in relation to top growth, providing some resistance to drought and competition with invasive species (Dealy 1974). Dealy (1974) reported that curl-leaf mahogany seedlings have a mean taproot length of 0.97 m after 120 days, while the mean top height was slightly less than 2.5 cm. Ibáñez et al. (1999) and Schultz et al. (1996) found that mahogany seedlings germinate abundantly under the canopy of adult plants, but rarely successfully establish there due to shading and higher litter amounts. In addition, Schultz et al. (1996) found that seedlings had significantly higher long-term success in areas dominated by sagebrush canopy than in areas under mahogany canopy or in interspaces. The shading and hydraulic lift provided by adult sagebrush may create a microsite that facilitates mahogany recruitment (Gruell et al. 1985, Ibáñez et al. 1999).

Mountain big sagebrush is a minor component of this site. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance for this plant (Noy-Meir 1973). It is not tolerant of shade and may be missing in dense stands of mahogany.

Perennial bunchgrasses generally have shallower root systems than shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m and taper off more rapidly than shrubs. Letterman needlegrass, the dominant grass on the non-modal ecological site, is an erect, densely-tufted perennial bunchgrass that forms large clumps. It is found on dry soils in a variety of vegetation communities, including, high elevation meadows, subalpine grasslands, open areas underneath aspen, and in sagebrush communities. It grows best on loamy soils with greater than 20 cm depth (Dittberner and Olson 1983).

Western needlegrass is a strongly tufted perennial grass that grows up to 4 dm in height (Cronquist et al. 1994). It grows in dry, well-drained soils from upper foothills up into the higher areas of the mountains in the western United States (USDA Forest Service 1988). The roots of this grass are deep, fibrous and spreading, which allows it to be more resistant to trampling and drought (USDA Forest Service 1988).

Cusick’s bluegrass and/or muttongrass are found on this site. There is evidence that these two common names have been used interchangeably or are sometimes misidentified (Monsen et al. 2004), but they occupy similar ecological niches (Cronquist et al. 1972). Cusick’s bluegrass is a strongly tufted perennial grass but may be somewhat rhizomatous in loose soils (Cronquist et al. 1972). It begins growth very early in the season and may produce two crops of inflorescences in a growing season (Cronquist et al. 1972). Muttongrass persists well in open areas and under canopies of oak and other shrubs (Monsen et al. 2004). Muttongrass may be more shade tolerant than other perennial bunchgrasses and may persist in the understory as the canopy closes (Erdman 1970).

There is potential for infilling by singleleaf pinyon (*Pinus monophylla*) on these sites. Infilling may occur if the site is adjacent to woodland sites or other ecological sites with conifers present. Without disturbance, such as low-intensity fire, pinyon will eventually dominate and out-compete mahogany for water and sunlight. The authors have observed this phenomenon and there is ongoing research to evaluate this process. One study found that mahogany seedlings responded best to mechanical juniper removal compared to burning (O’Connor et al. 2013).

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, precipitation, and nutrient availability. Long-term disturbance response may be influenced by small differences in landscape topography. North slopes are more resilient than south slopes because lower soil surface temperatures operate to keep moisture content higher on northern exposures. Four possible alternative stable states have been identified for this DRG.

Fire Ecology:

The fire return interval in mahogany-dominated sites is not well documented, however a study by Arno and Wilson (1986) suggested mahogany with ponderosa pine communities had fire return intervals of 13 to 22 years before 1900. Fire frequency most likely depends on surrounding vegetation. Most often mahogany stands occur on warm, dry, rocky ridges or outcrops where fire would be an infrequent occurrence (USDA 1988). Dealy (1974) and Scheldt (1969) found that mahogany trees were larger and older on fire-resistant rocky sites and were the seed source if fire destroyed the non-rocky portion of the site. Mahogany is considered a weak sprouter, and is usually moderately to severely damaged by severe fires. Because of their thicker bark, mature trees can often survive low-severity fires (Gruell et al. 1985). The recovery time of these sites is variable; some measurements show that stands lack recruitment for up to 30 years post-fire (Gruell et al. 1985, Ross 1999). Mahogany seeds germinate and have the highest survival rates with moderate litter amounts; litter depths over 0.25 inches can impede recruitment (Gruell et al. 1985, Ibáñez et al. 2002, Ibáñez et al., 1999, Schultz et al. 1991, Schultz et al. 1990). Since these plants germinate well under the protection of adult mahogany and sagebrush, germination rates may be quite low immediately after fire (Schultz et al. 1996, Ross 1999).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses, the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat, which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). In addition, season and severity of the fire will influence plant response as will post-fire soil moisture availability.

Emergence of western needlegrass seeds was shown to significantly improve with additions of smoke and burned soil (Blank et al. 1996).

Mountain big sagebrush is killed by fire (Neuenschwander 1980, Blaisdell et al. 1982), and does not resprout (Blaisdell 1953). Post-fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and may reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). Mountain big sagebrush may return to pre-burn density and cover within 15-20 years following fire, but establishment after severe fires may proceed more slowly (Bunting et al. 1987).

Depending on fire severity, snowberry and other sprouting shrubs may increase after fire. Snowberry is top-killed by fire, but resprouts after fire from rhizomes (Leege and Hickey 1971, Noste and Bushey 1987). Snowberry has been noted to regenerate well and exceed pre-burn biomass in the third season after a fire (Merrill et al. 1982). Douglas rabbitbrush (*Chrysothamnus* viscidiflorus) is also found in these sites. It has a large taproot root system and is known to be shorter lived and less competitive than sagebrush. Seedling density, flower production, and shoot growth decline as competition from other species increases (McKell and Chilcote 1957, Miller et al. 2013). Douglas rabbitbrush is top-killed by fire, but sprouts vigorously after fire (Kuntz 1982, Akinsoji 1988).

Livestock/Wildlife Grazing Interpretations:

Mountain mahogany is an important cover and browse species for big game such as elk (*Cervus canadensis*), mule deer (*Odocoileus heminous*), pronghorn antelope (*Antilocarpra americana*), and bighorn sheep (*Ovis canadensis*) (Lanner 1984, Furniss et al. 1988, Sabo et al. 2005). Sampson and Jespersen (1963) state that mahogany is excellent browse for mule deer, and domestic livestock will browse this plant to varying degrees in all seasons except summer. It is not uncommon for these trees to develop a “hedged” appearance after years of regular browsing by wildlife. According to (Olsen 1992) mahogany is consumed widely by mule deer throughout the year. In fact, mule deer fecal pellets were observed to contain mahogany year-round, with the highest frequency of leaves found in winter (Gucker 2006). Mule deer will use mahogany for cover as well (Steele et al. 1981).

Despite low palatability, mountain big sagebrush is eaten in small amounts by sheep, cattle, goats, and horses. Chemical analysis indicates that the leaves of big sagebrush equal alfalfa meal in protein, have a higher carbohydrate content, and yield twelvefold more fat (USDA 1988).

Antelope bitterbrush is a small component of these sites, but is a critical browse species for mule deer, antelope and elk and is often utilized heavily by domestic livestock (Wood et al. 1995). Grazing tolerance is dependent on site conditions (Garrison 1953) and the shrub can be severely hedged during the dormant season for grasses and forbs.

Letterman’s needlegrass provides valuable forage for both livestock and wildlife (Taylor 2000). It begins growth early in the year and is available to be utilized when other grasses are not yet palatable. It is especially important fall forage for big game (Monsen et al. 2004). Letterman’s needlegrass appears to tolerate sheep grazing, however time and timing of grazing is not well documented for this species (Bowns and Bagley 1986). It also declines when grazing is excluded for a long time (Turner 1969).

Western needlegrass is slow to mature and remains green through most of the growing season. Since it can remain green into fall, it is higher quality forage compared to other species that have senesced by then (USDA Forest Service 1988). For livestock, this grass has good forage value, and it has fair forage value for wildlife (Stubbendieck et al. 1992). Seeds of this grass are avoided by grazing animals, but are not necessarily injurious. Since seeds are avoided by grazing animals, a large amount of the seed produced grows to maturity (USDA Forest Service 1988).

Cusick’s bluegrass was the most palatable and preferred grass compared to Thurber’s needlegrass and bluebunch wheatgrass in a 1975 grazing study, and was the most negatively affected by grazing (Rickard et al. 1975). Uresk and Rickard (1976) found Cusick’s bluegrass to be a highly preferred grass, especially in the spring, even when it is a minor component of the plant community.

Invasive Annual Grasses:

The species most likely to invade these sites is cheatgrass. Cheatgrass is a cool season annual grass that maintains an advantage over native plants for several reasons: it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead.

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass “die-off” provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but there is ongoing work to try to predict where they occur, in the hopes of aiding conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, are able to suppress cheatgrass growth when mature (Blank et al. 2020). Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, as only one year of data was reported.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of alderleaf mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz./ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

State and Transition Model Narrative for Group 15:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 15.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. The reference state has three general community phases; a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
This community is dominated by curl-leaf mountain mahogany. Mountain big sagebrush and snowberry make up the shrub components of the understory. Needlegrasses and bluegrasses are dominant perennial bunchgrasses. A diversity of other grasses and forbs exist in the understory.

Community Phase Pathway 1.1a from phase 1.1 to 1.2:
Fire will reduce the mahogany overstory and allow the understory species to dominate the site. Due to low fuel loads, fires will typically be low severity, resulting in a mosaic pattern.

Community Phase Pathway 1.1b from phase 1.1 to 1.3:
Time and lack of disturbance or fire, drought, herbivory, or combinations of these causes mountain mahogany to increase. The shrub and herbaceous understory components decline due to increased shading from the trees. Muttongrass increases with more shade.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early- to mid-seral plant community. Snowberry and rabbitbrush are sprouting. Perennial grasses and forbs dominate. Mahogany and mountain big sagebrush may be present, but only in patches.

Community Phase Pathway 1.2a from phase 1.2 to 1.1:
Time and lack of disturbance or fire, drought, herbivory, or combinations of these allows the mountain mahogany and sagebrush to increase.

Community Phase 1.3 (At-Risk):
Mahogany density will increase in the absence of disturbance. Shrubs and deep-rooted perennial bunchgrasses will be shaded out by the dense mahogany. Bluegrasses are more shade tolerant, however, and increase in the understory. Mahogany in dense stands will lose lower branches due to shading and/or herbivory, resulting in a more tree-like appearance.

Mahogany Savanna (R026XY009NV) Phase 1.3, T.K. Stringham, May 2016

Mahogany Savanna (R026XY009NV) Phase 1.3, T.K. Stringham, May 2016

Community Phase Pathway 1.3a fro, phase 1.3 to 1.2:
A low-severity or spot fire, snow loading, or insect damage will decrease the overstory and allow for the herbaceous plants in the understory to increase.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass, mustard and Russian thistle.

Slow variables: Over time, the annual non-native plants will increase within the community decreasing organic matter inputs from deep-rooted perennial bunchgrasses resulting in reductions in soil water availability for perennial bunchgrasses.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

T1B: Transition from Reference State 1.0 to Tree State 3.0:

Trigger: Time and lack of disturbance allows pinyon to increase and overtop the mountain mahogany. Litter increases while understory plants decrease.

Slow variables: Over time, abundance and size of singleleaf pinyon will increase.

Threshold: Pinyon dominate(s) ecological processes. Trees overtop and outcompete mountain mahogany and shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. This state has the same three general community phases. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross-pollinate and adaptations for seed dispersal. Additionally, the presence of highly flammable, non-native species reduces State resilience because these species can promote fire where historically fire has been infrequent leading to positive feedbacks that further the degradation of the system.

Community Phase 2.1:
This community is dominated by curl-leaf mountain mahogany. Mountain big sagebrush and snowberry make up the shrub components of the understory. Needlegrasses and bluegrasses are dominant perennial bunchgrasses. A diversity of other grasses and forbs exist in the understory. Annual non-native species like cheatgrass are present.

Community Phase Pathway 2.1a from phase 2.1 to 2.2:
Fire will decrease or eliminate the overstory of mahogany and allow the perennial bunchgrasses to dominate the site. Fires will typically be small and patchy due to low fuel loads.

Community Phase Pathway 2.1b from phase 2.1 to 2.3:
Time and lack of disturbance or fire, drought, herbivory, or combinations of these causes mountain mahogany to increase. The shrub and herbaceous understory components decline due to increased shading from the mahogany and/or pinyon pine. Muttongrass increases with more shade.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community phase. Needlegrasses and other perennial grasses dominate the site. Snowberry and/or rubber rabbitbrush may be sprouting. Mountain mahogany and mountain big sagebrush are patchy. Annual non-native species are present.

Community Phase Pathway 2.2a from phase 2.2 to 2.1:
Time and lack of disturbance or fire, drought, herbivory, or combinations of these allows the mountain mahogany and sagebrush to increase.

Community Phase Pathway 2.2b from phase 2.2 to 2.4:
Higher than normal spring precipitation favors annual non-native species such as cheatgrass. Non-native annual species will increase in production and density throughout the site. Perennial bunchgrasses may also increase in production. Fire may also play a part in this pathway.

Community Phase 2.3 (At-Risk):
Mahogany density will increase in the absence of disturbance. Shrubs and deep-rooted perennial bunchgrasses will be shaded out by the dense mahogany. Bluegrasses are more shade tolerant, however, and increase in the understory. Mahogany in dense stands will lose lower branches due to shading and/or herbivory, resulting in a more tree-like appearance. Pinyon pine may be present.

Mahogany Savanna (028AY059NV) Phase 2.3. T.K. Stringham, July 2012.
Similar site in MLRA 28A.

Calcareous Mahogany Savanna (028BY043NV) Phase 2.3. T.K. Stringham, September 2012.

Similar site in MLRA 28B.

Community Phase Pathway 2.3a from phase 2.3 to 2.2:
Fire reduces the shrub overstory and allows perennial bunchgrasses to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts. Annual non-native species are likely to increase after fire.

Community Phase Pathway 2.3b from phase 2.3 to 2.4:
Fall, winter, and spring precipitation and temperatures mediate the ability for annual grasses and perennial grasses to germinate and/or survive. Higher than normal spring precipitation creates high annual production of annual grasses (Bradley et al. 2016). Non-native annual species increase in production and density throughout the site. Perennial bunchgrasses may also increase in production.

Community Phase 2.4 (At-Risk):
This community is at risk of crossing into an annual state. Native bunchgrasses dominate; however, annual non-native species such as cheatgrass may be sub- or co-dominant in the understory. Annual production and abundance of these annuals may increase drastically in years with heavy spring precipitation. This site is susceptible to further degradation from grazing, drought, and fire. Pinyon pine may be present.

Stony Mahogany Savanna (028BY032NV) Phase 2.4. T.K. Stringham, July 2014.
Similar site in MLRA 28B.

T2A: Transition from Current Potential State 2.0 to Tree State 3.0:

Trigger: Time and lack of disturbance allows pinyon to increase and overtop the mountain mahogany. Litter increases while understory plants decrease.

Slow variables: Over time, abundance and size of pinyon will increase.

Threshold: Pinyon pine dominate(s) ecological processes. Trees overtop and outcompete mountain mahogany and shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Fire or a failed range seeding leads to plant community phase 4.1. Inappropriate grazing management that favors shrubs in the presence of non-native annual species leads to community phase 4.2.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Cheatgrass or other non-native annuals dominate understory.

Tree State 3.0:

This state has two community phases that are characterized by the dominance of singleleaf pinyon in the overstory. Mountain big sagebrush and perennial bunchgrasses may still be present, but they are no longer controlling site resources. Soil moisture, soil nutrients, soil organic matter distribution and nutrient cycling have been spatially and temporally altered.

Community Phase 3.1:
Pinyon pine and mountain mahogany dominate the site. Mountain big sagebrush and snowberry are minor component. Bluegrasses dominate understory. Annual non-native species may be present or dominant.

Landscape of mahogany overtopped by young singleleaf pinyon. Image is from the Pinenut Mountains. T. K. Stringham, May 2016.

Community Phase Pathway 3.1a from phase 3.1 to 3.2:
Time and lack of disturbance or fire, drought, inappropriate grazing management, or combinations of these allows for maturation of the pinyon/juniper community.

Community Phase 3.2:
Pinyon pine dominates the site. Mountain mahogany is decadent and the stand lacks recruitment. Bluegrasses are present. Understory is reduced overall. Annual non-native species may be present.

Dead and decadent mahogany among singleleaf pinyon. Image taken in a similar ecological site in the Desatoya Mountains. D.K. Snyder, August 2019.

T3A: Transition from Tree State 3.0 to Annual State 4.0:

Trigger: To community phase 4.1: Overgrazing in the presence of non-native annual species can cause a decrease in perennial bunchgrasses and an increase in annual species. Spring and/or fall moisture may also increase annual species. To community phase 4.2: Fire in the presence of annual invasive grasses.

Slow variables: Cover and production of annual non-native species increase in the understory.

Threshold: Loss of mahogany overstory, mountain big sagebrush, and deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter. Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires.

R3A: Restoration from Tree State 3.0 to Current Potential State 2.0:

Removal of pinyon from site will allow mountain mahogany to again become the dominant overstory.

Annual State 4.0:

This state has two community phases: one with annual invasive plants in the understory of an intact mahogany stand, and another post-fire phase where mahogany is a minor component or missing from the site. This state is characterized by the dominance of annual non-native species such as cheatgrass and/or tansy mustard in the understory. Ecological dynamics are significantly altered in this state. Annual non-native species create a highly combustible fuel bed that shortens the fire return interval. Nutrient cycling is spatially and temporally truncated as annual plants contribute significantly less to deep soil carbon. Because this is a productive site, some deep-rooted perennial grasses may remain, even in the annual state. Without management, it is unlikely these plants will be able to recruit in the presence of dominant annual grasses.

Community Phase 4.1:
Mountain mahogany dominates the overstory and annual non-native plants such as cheatgrass dominate the understory. Native perennial grasses and forbs are significantly reduced. Sagebrush and snowberry may or may not be present.

Community Phase Pathway 4.1a:
Catastrophic fire reduces the mountain mahogany overstory and allows annual species to dominate.

Community Phase 4.2:
Annual non-native species dominate the site. The open canopy may allow sprouting shrubs and bluegrasses to increase.

Stony Mahogany Savanna (028BY032NV) Phase 4.2. T.K. Stringham, July 2014.
Similar site in MLRA 28B.

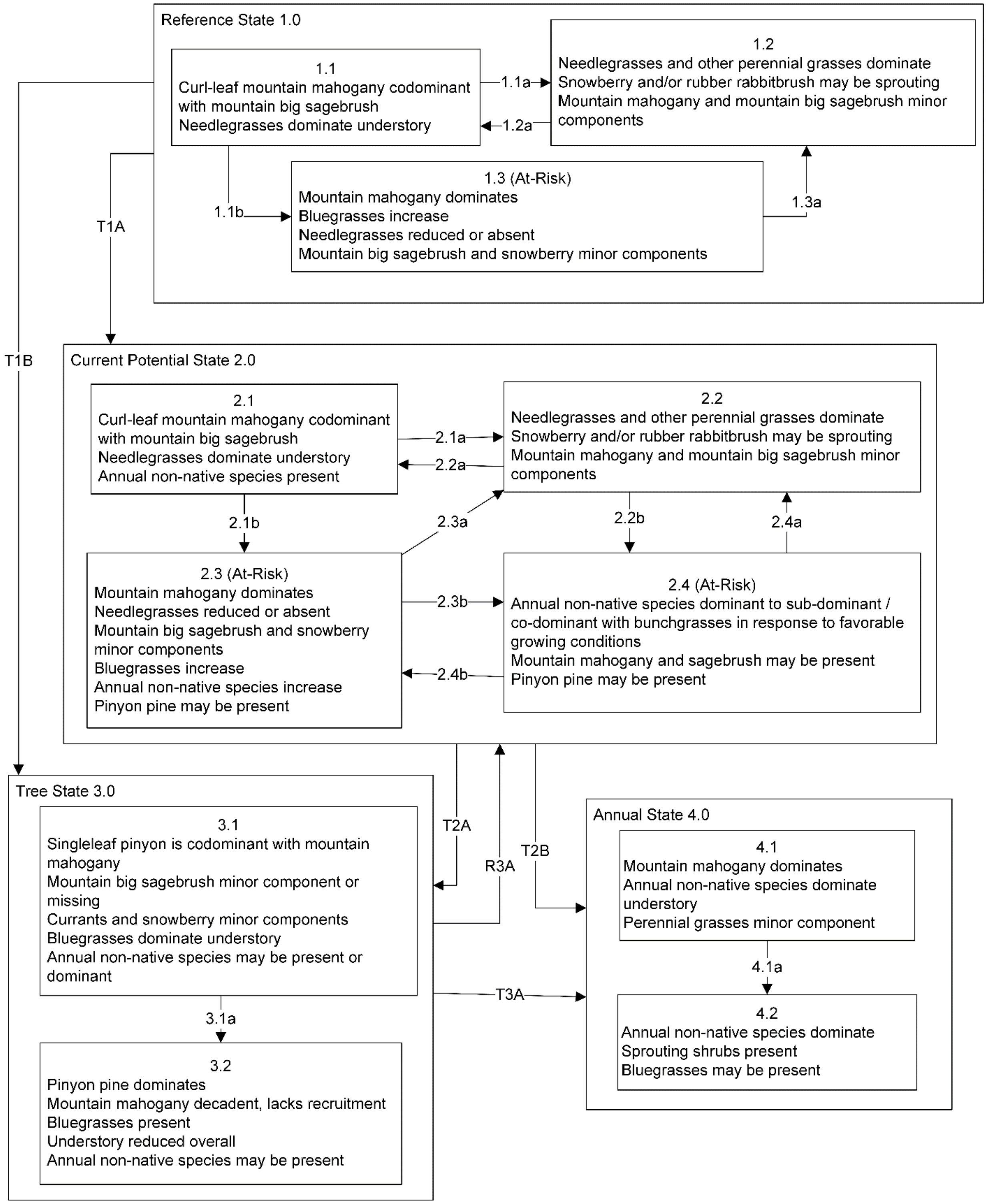
Potential Resilience Differences with other Ecological Sites:

Mahogany Thicket (R026XY081NV):

The Mahogany Thicket is found where snow accumulates on mountain sideslopes. This site is significantly more productive than the modal site. It can support an average of 7,000 lbs/ac in normal years. Canopy cover of mahogany is higher, ranging from 50 to 80 percent. Because of the high mahogany cover, understory production is lower, however, at 350 lbs/ac in normal years. Snowberry may be more common in the understory than sagebrush, because it is more tolerant of shade.

Modal State and Transition Model for Group 15 in MRLA 26:

MLRA 26
Group 15
Mahogany Savanna
026XY009NV



MLRA 26
Group 15
Mahogany Savanna
026XY009NV
KEY

Reference State 1.0 Community Pathways
1.1a: Low severity fire creates mosaic pattern of shrubs and grasses.
1.1b: Time and lack of disturbance or fire, drought, herbivory, or combinations of these. Muttongrass increases with more shade.
1.2a: Time and lack of disturbance or fire, drought, herbivory, or combinations of these.
1.3a: Low severity fire creates mosaic pattern.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and lack of disturbance allows pinyon to increase and overtop mahogany. Litter increases while understory plants decrease.

Current Potential State 2.0 Community Pathways
2.1a: Low severity fire, snow loading, or insect damage reduces mahogany.
2.1b: Time and lack of disturbance allows mahogany to reach peak canopy cover. Cusick's bluegrass increases with more shade.
2.2a: Time and lack of disturbance.
2.2b: Late spring moisture that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and may be a transitory plant community.
2.3a: Low severity fire, snow loading, or insect damage reduces mahogany.
2.3b: Late spring moisture that favors the germination and production of non-native, annual grasses. May be a transitory plant community. Effect may be exacerbated by long-term excessive herbivory.
2.4a: Rainfall pattern favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Rainfall pattern favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance allows pinyon to increase and overtop mahogany. Litter increases while understory plants decrease.
Transition T2B: Inappropriate grazing in the presence of non-native annual species (4.1) Catastrophic fire (4.2).

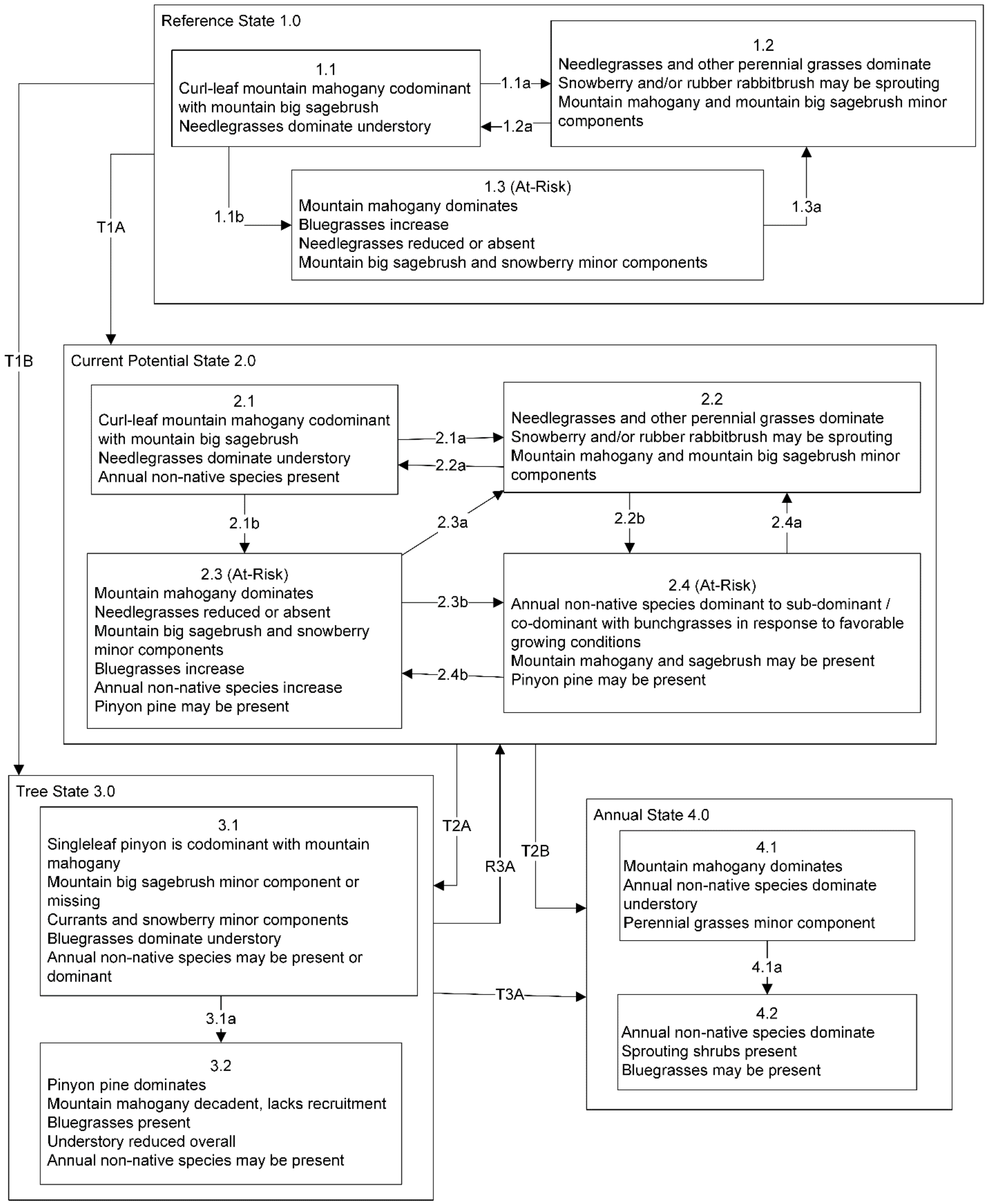
Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance or fire, drought, inappropriate grazing management, or combinations of these allows for maturation of the pinyon/juniper community.

Transition T3A: Fire (to state 4.2.)
Restoration Pathway R3A: Removal of pinyon from site will allow mountain mahogany to again become the dominant overstory.

Annual State 4.0 Community Pathways
4.1a: Catastrophic fire.

Additional State and Transition Models for Group 15 in MRLA in 26:

MLRA 26
Group 15
Mahogany Thicket
026XY081NV



MLRA 26
Group 15
Mahogany Thicket
026XY081NV
KEY

Reference State 1.0 Community Pathways
1.1a: Low severity fire creates mosaic pattern of shrubs and grasses.
1.1b: Time and lack of disturbance or fire, drought, herbivory, or combinations of these. Muttongrass increases with more shade.
1.2a: Time and lack of disturbance or fire, drought, herbivory, or combinations of these.
1.3a: Low severity fire creates mosaic pattern.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and lack of disturbance allows pinyon to increase and overtop mahogany. Litter increases while understory plants decrease.

Current Potential State 2.0 Community Pathways
2.1a: Low severity fire, snow loading, or insect damage reduces mahogany.
2.1b: Time and lack of disturbance allows mahogany to reach peak canopy cover. Cusick's bluegrass increases with more shade.
2.2a: Time and lack of disturbance.
2.2b: Late spring moisture that favors the germination and production of non-native, annual grasses. Pathway typically occurs 3 to 5 years post-fire and may be a transitory plant community.
2.3a: Low severity fire, snow loading, or insect damage reduces mahogany.
2.3b: Late spring moisture that favors the germination and production of non-native, annual grasses. May be a transitory plant community. Effect may be exacerbated by long-term excessive herbivory.
2.4a: Rainfall pattern favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Rainfall pattern favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance allows pinyon to increase and overtop mahogany. Litter increases while understory plants decrease.
Transition T2B: Inappropriate grazing in the presence of non-native annual species (4.1) Catastrophic fire (4.2).

Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance or fire, drought, inappropriate grazing management, or combinations of these allows for maturation of the pinyon/juniper community.

Transition T3A: Fire (to state 4.2.)
Restoration Pathway R3A: Removal of pinyon from site will allow mountain mahogany to again become the dominant overstory.

Annual State 4.0 Community Pathways
4.1a: Catastrophic fire.

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MLRA 26 Group 16: Silty soils with winterfat

Description of MLRA 26 Disturbance Response Group 16

Disturbance Response Group (DRG) 16 consists of one ecological site, Silty 8-10” (R026XY031NV). This site occurs on lower piedmont slopes and basin floors at slopes ranging from 0 to 15 percent. Elevations range from 5,000 to 5,200 feet. The soils on these sites are typically very deep and well to somewhat excessively drained with surface layers that will crust and bake upon drying due to their high silt content. The water holding capacity can range from moderate to high. The potential native plant community of these sites is dominated by winterfat (*Krascheninnikovia lanata*) and Indian ricegrass (*Achnatherum hymenoides*). Sandberg bluegrass (*Poa secunda*), bottlebrush squirreltail (*Elymus elymoides*), and fourwing saltbush (*Atriplex canescens*) are commonly found on these sites.

This site was seen once during fieldwork for this project. It is limited in extent in MLRA 26 with only 3 map units. This site is primarily mapped on private lands and much of it has been converted to farmland. For this reason, much of this report is adapted from similar ecological sites in MLRA 28A and 28B. Edits to this model may be warranted.

Disturbance Response Group 16 Ecological Sites:

Silty 8-10"   026XY031NV

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site’s resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Winterfat is a long-lived, drought tolerant, native shrub typically about 30 cm tall (Mozingo 1987). It has a woody base from which annual branchlets grow (Welsh et al. 1987). The most common variety is a low growing dwarf form (less than 38.1 cm), which is most often found on desert valley floors (Stevens et al. 1977). Total winter precipitation is a primary growth driver and lower than average spring precipitation can reverse the impact of plentiful winter precipitation. While summer rainfall has a limited impact, heavy August-September rain can cause a second flowering in winterfat (West and Gasto 1978).

Winterfat reproduces from seed and primarily pollinates via wind (Stevens et al. 1977). Seed production, especially in desert regions, is dependent on precipitation (West and Gasto 1978) with good seed years occurring when there is appreciable summer precipitation and little browsing (Stevens et al. 1977). Winterfat has multiple dispersal mechanisms: diaspores are shed in the fall or winter, dispersed by wind, rodent-cached, or carried on animals (Majerus 2003). Diaspores take advantage of available moisture, tolerating freezing conditions as they progress from imbibed seeds to germinants to nonwoody seedlings (Booth 1989). Under some circumstances, the degree of reproduction may be dependent on mature plant density (Freeman and Emlen 1995).

These communities often exhibit the formation of microbiotic crusts within the interspaces between shrubs. These crusts influence the soils on these sites and their ability to reduce erosion and increase infiltration; they may also alter the soil structure and possibly increase soil fertility (Fletcher and Martin 1948, Williams 1993). Finer textured soils such as silts tend to support more microbiotic cover than coarse texture soils (Anderson 1982). Disturbance such as hoof action from inappropriate grazing and cheatgrass (*Bromus tectorum*) invasion can reduce biotic crust integrity (Anderson 1982, Ponzetti et al. 2007) and increase erosion.

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Drought and/or inappropriate grazing will initially favor shrubs but prolonged drought can cause a decrease in the winterfat, and other shrubs while bare ground increases. Squirreltail may maintain or also decline within the community. Repeated spring and early summer grazing will have an especially detrimental effect on winterfat. Cheatgrass and other non-native annual weeds increase with excessive grazing. Abusive grazing during the winter may lead to soil compaction and reduced infiltration. Prolonged abusive grazing during any season leads to abundant bare ground, desert pavement and active wind and water erosion. Repeated, frequent fire will promote cheatgrass dominance and elimination of the native plant community. These sites frequently attract recreational use, primarily by off highway vehicles (OHV). Annual non-native species increase where surface soils have been disturbed. Five alternative stable states have been identified for this site.

Fire Ecology:

Winterfat tolerates environmental stress, extremes of temperature and precipitation, and competition from other perennials but not the disturbance of fire or overgrazing (Ogle et al. 2001). Fire is rare within these communities due to low fuel loads. There are conflicting reports in the literature about the response of winterfat to fire. In one of the first published descriptions, Dwyer and Pieper (1967) reported that winterfat sprouts vigorously after fire. This observation was frequently cited in subsequent literature, but recent observations have suggested that winterfat can be completely killed by fire (Pellant and Reichert 1984). The response is dependent on fire severity. Winterfat is able to sprout from buds near the base of the plant. However, if these buds are destroyed, winterfat will not sprout. Research has shown that winterfat seedling growth is depressed in growth by at least 90% when growing in the presence of cheatgrass (*Bromus tectorum*) (Hild et al. 2007). Repeated, frequent fires will increase the likelihood of conversion to a non-native, annual plant community with trace amounts of winterfat.

Fourwing saltbush is the most widely distributed shrubby saltbush in North America (Meyer 2003). It is highly variable across landscapes and even within populations (McArthur et al. 1983, Petersen et al. 1987). Its ability to sprout following fire may depend on the population and fire severity. A study by Parmenter (2008) showed 58% mortality rate of fourwing saltbush following fire in New Mexico, the surviving shrubs produced sprouts shortly after fire.

Indian ricegrass is the dominant grass on this ecological site. It is a hardy, cool-season, densely tufted, native perennial bunchgrass that grows from 4 to 24 inches in height (Blaisdell and Holmgren 1984). Indian ricegrass has been found to reestablish on burned sites through seed dispersed from adjacent unburned areas (Young 1983). Thus the presence of surviving, seed producing plants is necessary for reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

Bottlebrush squirreltail, another cool-season, native perennial bunchgrass is common to this ecological site. Bottlebrush squirreltail is considered more fire tolerant than Indian ricegrass due to its small size, coarse stems, and sparse leafy material (Britton et al. 1990). Post-fire regeneration occurs from surviving root crowns and from on- and off-site seed sources.

Livestock/Wildlife Grazing Interpretations:

Winterfat is a valuable forage species with an average of 10% crude protein during winter when there are few nutritious options for livestock and wildlife (Welch 1989). However, excessive grazing throughout the west has negatively impacted survival of winterfat stands (Hilton 1941, Statler 1967, Stevens et al. 1977). Time of grazing is critical for winterfat with the active growing period being most critical (Romo 1995). Stevens et al. (1977) found that both vigor and reproduction of winterfat were reduced in Steptoe Valley, Nevada by improper season of use. Stevens et al. (1977) recommended no more than 25% utilization during periods of active growth and up to 75% utilization during dormant season use. Rasmussen and Brotherson (1986) found significantly greater foliar cover and density of winterfat in areas ungrazed for 26 years versus winter grazed areas in Utah. In exclosures protected from grazing for between 5 and 16 years, Rice and Westoby (1978) found that winterfat increased in foliar cover but not in density where it was dominant, and in both foliar cover and density in shadscale-perennial grass communities where it was not dominant.

In addition to grazing by cattle, winterfat is browsed by rabbits, antelope, and other wildlife species (Stevens et al. 1977, Ogle et al. 2001). Winterfat and perennial grasses average 80% of jackrabbits' diet in southeastern Idaho, with shrubs being grazed in fall and winter particularly (Johnson and Anderson 1984). Pronghorn and rabbits browse stems, leaves, and seed stalks of winterfat year round, especially during periods of active growth (Stevens et al. 1977). Management of wildlife browse is difficult and browse may be harmful to winterfat reestablishment as seed production and regrowth are curtailed if grazing occurs as the plant begins to grow (Eckert 1954).

Spiny hopsage is palatable to livestock, especially sheep, during the spring and early summer (Phillips et al. 1996). However, the shrub goes to seed and loses its leaves in July and August so its usefulness in the fall and winter is limited (Sanderson and Stutz 1992). Two studies showed little to no utilization by sheep during the winter (Harrison and Thatcher 1970, Green et al. 1951). Some scientists are concerned about the longevity of the species. One study showed no change in cover or density when excluded from livestock and wildlife grazing for 10+ years (Rice and Westoby 1978), while another seldom observed seedling establishment (Daubenmire 1970). With poor recruitment rates, some are concerned that with repeated fires and overgrazing, local populations of spiny hopsage may be lost (Simmons and Rickard 2003).

Fourwing saltbush is one of the most important forage shrubs in arid sites. Its importance is due to its abundance, accessibility, size, large volume of forage, evergreen habit, high palatability and nutritive value. The palatability rates from fairly good to good for cattle, and as good for sheep and goats, deer usually relish it as a winter browse (USDA 1988). It has similar protein, fat, and carbohydrate levels as alfalfa (*Medicago sativa*) (Catlin 1925). It is especially valuable as winter forage. It was noted in a study by Otsyina et al. (1982) that sheep readily grazed fourwing saltbush when introduced into a new pasture.

Heavy spring grazing has been found to sharply reduce the vigor of Indian ricegrass and decrease the stand (Cook and Child 1971). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1965). Cook and Child (1971) found significant reduction in plant cover after 7 years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended.

Bottlebrush squirreltail has the ability to produce large numbers of highly germinable seeds, with relatively rapid germination (Young and Evans 1977) when exposed to the correct environmental cues. Early spring growth and ability to grow at low temperatures contribute to the persistence of bottlebrush squirreltail among cheatgrass dominated ranges (Hironaka and Tisdale 1973). Squirreltail generally increases in abundance when moderately grazed or protected (Hutchings and Stewart 1953). In addition, moderate trampling by livestock in big sagebrush rangelands of central Nevada enhanced bottlebrush squirreltail seedling emergence compared to untrampled conditions. Heavy trampling however was found to significantly reduce germination sites (Eckert et al. 1987). Squirreltail is more tolerant of grazing than Indian ricegrass but all bunchgrasses are sensitive to over utilization within the growing season.

Reduced bunchgrass vigor or density provides an opportunity for cheatgrass and other invasive species to occupy interspaces. This can lead to increased fire frequency and potentially an annual plant community.

Annual Invasive Grasses:

The species most likely to invade these sites is cheatgrass. Cheatgrass is a cool season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983; Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead.

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass “die-off” provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but there is ongoing work to try to predict where they occur, in the hopes of aiding conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, as only one year of data was reported.

In considering pre-emergent herbicide for invasive annual grass control, it is important to assess the soil for characteristics that may reduce effectiveness. Imazapic, for example, is less effective in soils with high contents of sand; on the other hand, clay soils allow for excessive leaching (Inoue et al. 2009). Imazapic may be minimally effective on calcareous soils because the chemical binds to particles of organic matter more readily at high pH (Inoue et al. 2009, Tu et al. 2001). Effects on non-target plants should also be considered. Imazapic is readily adsorbed through foliage and roots (Tu et al. 2001) and can have negative effects on desirable plants, however most established perennial grasses remain unaffected (Applestein et al. 2018). Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated. Grasses drill-seeded after imazapic application displayed improved establishment rates, indicating that careful seeding can lead to restoration success, at least for the species studied (Morris et al. 2007).

After a wildfire, there is opportunity to intervene with seeding to establish perennial plants that will compete with cheatgrass. To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, are able to suppress cheatgrass growth when mature (Blank et al. 2020). Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al. 2015).

State and Transition Model Narrative – Group 16

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition Model for the MLRA 26 Disturbance Response Group 16.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. This state has two community phases: one co-dominated by shrubs and grass, and the other dominated by shrubs. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. This site is very stable, with little variation in plant community composition. Plant community changes would be reflected in production in response to drought or abusive grazing. Wet years will increase grass production, while drought years will reduce production. Shrub production will also increase during wet years; however, recruitment of winterfat is episodic.

Community Phase 1.1:
This community is dominated by winterfat and Indian ricegrass. Fourwing saltbush is another important species on this site. Community phase changes are primarily a function of chronic drought. Fire is infrequent and patchy due to low fuel loads.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Long term drought and/or herbivory. Fires would also decrease vegetation on these sites but would be infrequent and patchy due to low fuel loads.

Community Phase 1.2:
Drought will favor shrubs over perennial bunchgrasses. However, long-term drought will result in an overall decline in the plant community, regardless of functional group.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Time, lack of disturbance and recovery from drought would allow the vegetation to increase and bare ground would eventually decrease.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual plants, such as halogeton and cheatgrass.

Slow variables: Over time the annual non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. This state has the same two general community phases. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. Non-natives may increase in abundance but will not become dominant within this State. These non-natives can be highly flammable and can promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community is dominated by winterfat and Indian ricegrass. Community phase changes are primarily a function of chronic drought. Fire is infrequent and patchy due to low fuel loads. Non-native annual species are present.

Silty 8-10 (028BY013NV) Phase 2.1 T.K. Stringham, July 2014
This is a similar site in MLRA 28B.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Long term drought will favor shrubs over perennial bunchgrasses. However, long-term drought will result in an overall decline in the plant community, regardless of functional group. Inappropriate grazing of winterfat will reduce this shrub and allow fourwing and spiny hopsage to increase.

Community Phase 2.2:
This community is dominated by winterfat. The perennial grass component is significantly reduced.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Release from long term drought and/or growing season grazing pressure allows recovery of bunchgrasses, winterfat, and bud sagebrush.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during the growing season and/or long term drought will favor shrubs and initiate a transition to Community Phase 3.1.

Slow variables: Long term decrease in deep-rooted perennial grass density.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Severe fire/ multiple fires, long term inappropriate grazing and/or soil disturbing treatments such as plowing.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs truncates, spatially and temporally, nutrient capture and cycling within the community. Increased, continuous fine fuels from annual non-native plants modify the fire regime by changing intensity, size and spatial variability of fires.

Shrub State 3.0:

This state consists of two community phases. The site in this phase has crossed a biotic threshold and site processes are being controlled by shrubs. Winterfat or sprouting shrubs like fourwing saltbush and spiny hopsage dominate the overstory. Indian ricegrass and other perennial bunchgrasses are reduced. Rabbitbrush may be a significant component. The shrub overstory dominates site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1:

Perennial bunchgrasses, like Indian ricegrass are significantly reduced and the site is dominated by winterfat. Annual non-native species may be increasing. Bare ground has increased and there may be evidence of soil movement.

Silty 8-10" (028AY030NV) Phase 3.1 T.K. Stringham, April 2013

This is a similar site in MLRA 28A.

Community Phase Pathway 3.1a, from phase 3.1 to 3.2:
Inappropriate grazing management that reduces winterfat viability gives spiny hopsage and fourwing saltbush a competitive edge. Winterfat is eventually pushed out of the system.

Community Phase 3.2:
Spiny hopsage and fourwing saltbush dominate the site. Winterfat, Indian ricegrass, and other perennial bunchgrasses are minor components and may be missing. Annual non-native species may be present.

Silty 8-10" (R026XY031NV) Phase 3.2, P. Novak-Echenique, April 2015

T3A: Transition from Shrub State 3.0 to Annual State 4.0:

Trigger: Severe fire/multiple fires, long term inappropriate grazing, and/or soil disturbing treatments such as plowing.

Slow variables: Increased production and cover of non-native annual species.

Threshold: Increased, continuous fine fuels modify the fire regime by changing intensity, size and spatial variability of fires. Changes in plant community composition and spatial variability of vegetation due to the loss of perennial bunchgrasses and sagebrush truncate energy capture spatially and temporally thus impacting nutrient cycling and distribution.

T3B: Transition from Shrub State 3.0 to Eroded State 5.0:

Trigger: Contiguous inappropriate grazing management and/or soil disturbance that concentrates runoff of water.

Slow variables: Increased bare ground.

Threshold: Headcutting and subsequent gullies alter the hydrology of the site. Loss of hydraulic connectivity alters the potential vegetation and truncates, spatially and temporally, nutrient capture and cycling within the community.

Annual State 4.0:

This state consists of one community phase. This community is characterized by the dominance of annual non-native species such as halogeton and cheatgrass. Rabbitbrush, fourwing saltbush, spiny hopsage, and other sprouting shrubs may dominate the overstory.

Community Phase 4.1:
This community is dominated by annual non-native species. Trace amounts of winterfat and other shrubs may be present, but are not contributing to site function. Bare ground may be abundant, especially during low precipitation years. Ecological dynamics are significantly altered in this state. Annual non-native species create a highly combustible fuel bed that shortens the fire return interval. Nutrient cycling is spatially and temporally truncated as annual plants contribute significantly less to deep soil carbon. Because this is a productive site, some deep-rooted perennial grasses may remain, even in the annual state. Without management, it is unlikely these plants will be able to recruit in the presence of dominant annual grasses. Soil erosion, soil temperature and wind are driving factors in site function.

Silty 8-10" (028BY013NV) Phase 4.1 T.K. Stringham, April 2013
This is a similar site in MLRA 28B.

T4A: Transition from Annual State 3.0 to Eroded State 5.0:

Trigger: Contiguous inappropriate grazing management and/or soil disturbance that concentrates runoff of water.

Slow variables: Increased bare ground.

Threshold: Headcutting and subsequent gullies alter the hydrology of the site. Loss of hydraulic connectivity alters the potential vegetation and truncates, spatially and temporally, nutrient capture and cycling within the community.

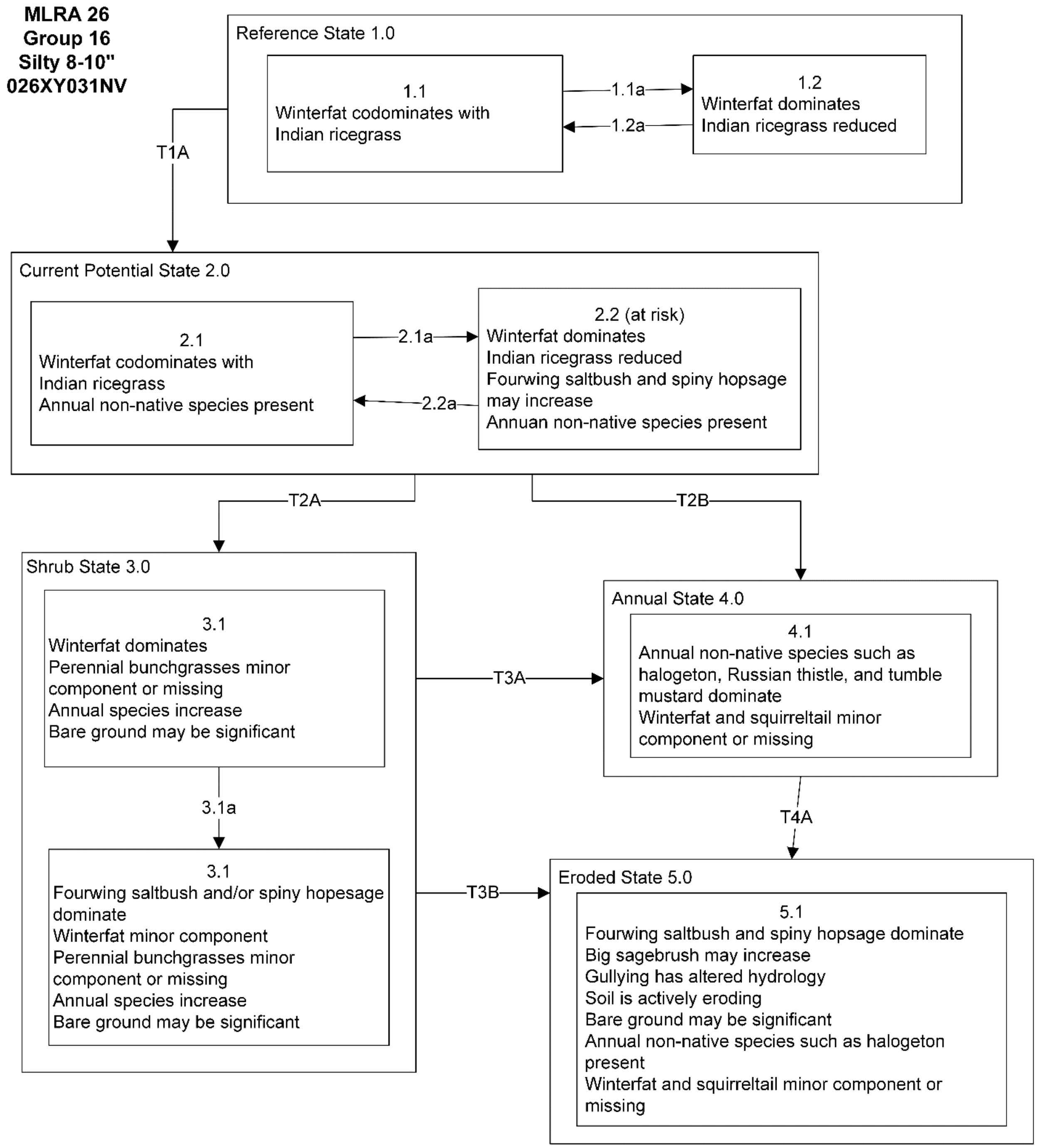
Eroded State 5.0:

This site consists of one community phase. Abiotic factors including soil redistribution and erosion, soil temperature, soil crusting and sealing are primary drivers of ecological condition within this state. Soil moisture, soil nutrients and soil organic matter distribution and cycling are severely altered due to degraded soil surface conditions and reduced seasonal flooding.

Community Phase 5.1:
Big sagebrush, fourwing saltbush, and spiny hopsage dominate this phase. Winterfat and grasses are minor components and may be entirely missing from the site. Gullying and active soil erosion are occurring. Bare ground may be significant. Hydrology has been altered at this site due to significant soil loss. Annual non-native species such as halogeton and annual mustards may be present.

Silty 8-10" (028BY013NV) Phase 5.1 T.K. Stringham, July 2014
This is a similar site in MLRA 28B.

Modal State and Transition Model for Group 16 in MLRA 26



MLRA 26
Group 16
Silty 8-10"
026XY031NV
Key

Reference State 1.0 Community Phase Pathways
1.1a: Drought and/or excessive herbivory favors a reduction in perennial bunchgrasses. Fire was infrequent but would be patchy due to low fuel loads.
1.2a: Time and lack of disturbance and/or release from drought.

T1A: Introduction of non-native species such as cheatgrass and halogeton.

Current Potential State 2.0 Community Phase Pathways
2.1a: Drought and/or inappropriate grazing management.
2.2a: Time and lack of disturbance and/or release from drought .

T2A: Inappropriate grazing management in the presence of non-native species.
T2B: Catastrophic fire and/or multiple fires, inappropriate grazing management and/or soil disturbing treatments.

Shrub State 3.0 Community Phase Pathways
3.1a: Inappropriate grazing management that reduces winterfat.

T3A: Catastrophic fire and/or multiple fires, inappropriate grazing management and/or soil disturbing treatments.
T3B: Loss of understory coupled with concentrated soil disturbance such as trailing. Headcutting and subsequent gullies alter hydrology of the site.

Annual State 4.0 Community Phase Pathways
None.

T4A: Loss of understory coupled with concentrated soil disturbance such as trailing. Headcutting and subsequent gullies alter hydrology of the site.

Eroded State 5.0 Community Phase Pathways
None.

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<u>MLRA 26 Group 17: Sand-sheet juniper with sagebrush and needlegrass understory</u>

Description of MLRA 26 Disturbance Response Group 17:

Disturbance Response Group (DRG) 17 consists of one ecological site dominated by Utah juniper, Wyoming big sagebrush, Indian ricegrass, and needle-and-thread (JUOS/ARTRW8/ACHY-HECO26 (F026XY063NV). This forest site occurs on sand sheets that cover summits and sideslopes of upper fan piedmonts and rock pediments. This site is dominated by old growth Utah juniper *(Juniperus osteosperma)* with Wyoming big sagebrush *(Artemisia tridentata ssp. wyomingensis)* as the principal understory shrub. Other shrubs on the site include currant *(Ribes ssp.)*, green ephedra *(Ephedra viridis)*, and Douglas rabbitbrush *(Chrysothamnus viscidiflorus)*. The dominant understory grasses are Indian ricegrass *(Achnatherum hymenoides*) and needleandthread *(Hesperostipa comata)*. Other understory grasses include desert needlegrass *(Achnatherum speciosum)*, bottlebrush squirreltail *(Elymus elymoides)*, and Sandberg bluegrass *(Poa secunda)*. An overstory canopy cover of 10 to 20 percent was assumed to be representative of tree dominance for a mature forest in the Reference State for this model. Wildfire is recognized as a natural disturbance that strongly influenced the structure and composition of the Reference State. The Reference plant community is dominated by Utah juniper with Wyoming big sagebrush and Indian ricegrass dominant in the understory. Few tree seedling and saplings would be present in the Reference State.

Under medium canopy cover (11-20%), understory production (plants under 4.5 feet in height) ranges from 100 to 350 lbs/ac on this site. This site is found from 6,500 to 7,500 feet elevation. Slopes range from 2 to 15 percent, but are typically 2 to 8 percent. Average annual precipitation is about 8 to 12 inches. The soils on this site are shallow and well drained. The surface is covered with a mantle of aeolian sand that strongly influences the understory vegetation. The subsurface soils are usually skeletal with 35 to over 50 percent gravels, cobbles, or stones, by volume, distributed throughout the soil profile. Available water capacity is low, but trees and shrubs extend their roots into fractures in the underlying material, allowing them to utilize deep moisture. Some soils have high amounts of gravel on the soil surface that can provide a stabilizing effect on surface erosion conditions. Runoff is slow to medium to rapid and the potential for sheet and rill erosion is moderate to severe depending on the slope. Potential for wind erosion is high.

Disturbance Response Group 17 Ecological Site:

JUOS WSG: 0S0402	JUOS/ARTRW8/ACHY-HECO26	F026XY063NV

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regimes (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Pinyon and juniper dominated plant communities in the cold desert of the Intermountain West occupy over 18 million ha (44,600,000 acres) (Miller and Tausch 2001). In the mid to late 1900's, the number of pinyon and juniper trees establishing per decade began to increase compared to the previous several hundred years. The substantial increase in conifer establishment is attributed to a number of factors. These factors include: (1) cessation of the aboriginal burning (Tausch 1999), (2) change in climate with rising temperatures (Heyerdahl et al. 2008), (3) the reduced frequency of fire likely driven by the introduction of domestic livestock, (4) a decrease in wildfire frequency along with improved wildfire suppression efforts, and (5) potentially increased CO2 levels favoring woody plant establishment (Tausch 1999, Bunting 1994). Miller et al. (2008) found pre-settlement tree densities averaged 2 to 11 trees/acre in six woodlands studied across the Intermountain West. Current stand densities range from 80 to 358 trees/ac. In Utah, Nevada, and Oregon, trees establishing prior to 1860 account for only two percent or less of the total population of pinyon and juniper (R. Miller et al. 1999, Miller and Tausch 2001, Miller et al. 2008). The research strongly suggests that for over 200 years prior to settlement, woodlands in the Great Basin were relatively low density with limited rates of establishment (Miller and Tausch 2001, Miller et al. 2008). Tree canopy cover of 10 to 20 percent may be more representative of these sites in pristine condition (USDA 1997). Increases in pinyon and juniper densities post-settlement were the result of both infill in mixed age tree communities and expansion into shrub-steppe communities. However, the proportion of old-growth can vary depending on disturbance regimes, soils, and climate. Some ecological sites are capable of supporting persistent woodlands, likely due to specific soils and climate resulting in infrequent stand-replacing disturbances. In the Great Basin, old-growth trees have been found to typically grow on rocky shallow or sandy soils that support little understory vegetation to carry a fire (Burkhardt and Tisdale 1976, Holmes et al. 1986, West et al. 1998, Miller and Rose 1995, USDA 1997).

Utah juniper is a long-lived tree species with wide ecological amplitudes (Tausch et al. 1981, West et al. 1998, Weisberg and Ko 2012). Maximum ages of juniper exceed 1000 years, and stands with maximum age classes are only found on steep rocky slopes with no evidence of fire (West et al. 1975). Juniper growth is dependent mostly upon soil moisture stored from winter precipitation, mainly snow. Much of the summer precipitation is ineffective, being lost in runoff after summer convection storms or by evaporation and interception (Tueller and Clark 1975). Juniper is highly resistant to drought, which is common in the Great Basin. Taproots of juniper have a relatively rapid rate of root elongation and are thus able to persist until precipitation conditions are more favorable (Emerson 1932).

Infilling by younger trees increases canopy cover and causes a decline in understory perennial vegetation because of increased competition for water and sunlight. There is also some evidence that phenolic compounds in juniper litter may have allelopathic effects on grass (Jameson 1970). Infilling shifts stand level biomass from ground fuels to canopy fuels, which has the potential to significantly impact fire behavior. The more tree-dominated juniper woodlands become, the less likely they are to burn under moderate conditions, resulting in infrequent high intensity fires (Gruell 1999, Miller et al. 2008). As the understory vegetation declines in vigor, the ability of native perennial plants to recover after fire is reduced (Urza et al. 2017). The increase in bare ground allows for the invasion of non-native annual species such as cheatgrass (*Bromus tectorum*), and with intensive wildfire, the potential for conversion to annual exotics is a serious threat (Tausch 1999, Miller et al. 2008).

Specific successional pathways after disturbance in juniper stands are dependent on a number of variables such as plant species present at the time of disturbance and their individual responses to disturbance, past management, type and size of disturbance, available seed sources in the soil or adjacent areas, and site and climatic conditions throughout the successional process.

A fungus called juniper pocket rot (*Pyrofomes demidoffi*), also known as white trunk rot (Eddleman et al. 1994, Durham 2014) can kill Utah juniper. Pocket rot enters the tree through any wound or opening that exposes the heartwood. In an advanced stage, this fungus can cause high mortality (Durham 2014). Dwarf mistletoe (*Phorandendron* spp.), a parasitic plant, may also affect Utah juniper and without treatment or pruning, may kill the tree 10 to 15 years after infection. Seedlings and saplings are most susceptible to the parasite (Christopherson 2014). Other diseases affecting juniper are: dwarf mistletoe (*Arceuthobium* spp.) that may weaken trees; leaf rust (*Gymnosporangium* sp.) on leaves and young branches; and juniper blight (*Phomopsis* sp.). Flat-head borers (*Chrysobothris* sp.) attack the wood; long-horned beetles (*Methia juniper*, *Styloxus bicolor*) and round-head borers (*Callidium* spp.) girdle branches and can kill branches or entire trees (Tueller and Clark 1975).

The understory is dominated by deep-rooted, cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Dobrowolski et al. 1990).

The dominant perennial bunchgrasses on this site are Indian ricegrass and needle-and-thread. These species and other perennial bunchgrasses generally have somewhat shallower root systems than shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m of the soil profile. General differences in root depth distributions between grasses, shrubs, and trees results in resource partitioning in these shrub/grass systems.

In the Great Basin, the majority of annual precipitation is received during the winter and early spring. This continental semiarid climate regime favors growth and development of deep-rooted shrubs and herbaceous cool season plants using the C3 photosynthetic pathway (Comstock and Ehleringer 1992). Winter precipitation and slow melting of snow results in deeper percolation of moisture into the soil profile. Herbaceous plants, more shallow-rooted than shrubs, grow earlier in the growing season and thrive on spring rains, while the deeper rooted shrubs lag in phenological development because they draw from deeply infiltrating moisture from snowmelt the previous winter. Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

The ecological site in this DRG has low to moderate resilience to disturbance and resistance to invasion. Resilience increases with higher elevation, northerly aspect, increased precipitation, and nutrient availability. Three possible states have been identified for this DRG.

Annual Invasive Grasses:

The species most likely to invade these sites is cheatgrass, however the sandy surface decreases the probability of cheatgrass dominance. Cheatgrass is a cool-season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983, Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead. Bradley and Mustard (2005) utilized Landsat and Advanced Very High Resolution Radiometer to estimate the areal extent of cheatgrass dominance in the Great Basin. Their results suggest cheatgrass dominated over 4.9 million acres in 2005. In addition, they found cheatgrass was 26% more likely to be found within 450 feet of areas occupied by cheatgrass in 1973, with cultivation, power lines and roads identified as primary vectors of spread (Bradley and Mustard 2006).

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass "die-off" provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but there is ongoing work to try to predict where they occur, in the hopes of aiding conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, are able to suppress cheatgrass growth when mature (Blank et al. 2020). Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, as only one year of data was reported.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz./ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Utah juniper is usually killed by fire, and is most vulnerable to fire when it is under four feet tall (Bradley et al. 1992). Larger trees, because they have foliage farther from the ground and thicker bark, can survive low severity fires but mortality occurs when 60% or more of the crown is scorched (Jameson 1966). With the low production of the understory vegetation, high severity fires within this plant community were not likely and rarely became crown fires (Bradley et al. 1992, Miller and Tausch 2001). Tree density on this site increases with grazing management that favors the removal of fine fuels and management focused on fire suppression. With an increase of cheatgrass in the understory, fire severity is likely to increase. Utah juniper reestablishes by seed from nearby seed source or surviving seeds. Utah juniper begins to produce seed at about 30 years old (Bradley et al. 1992). Seeds establish best through the use of a nurse plant such as sagebrush and rabbitbrush (*Chrysothamnus* spp. or *Ericameria* spp). (Everett and Ward 1984, Tausch and West 1988, Bradley et al. 1992). Utah juniper woodlands reach mature stage between 85 to 150 years after fire (Barney and Frischknecht 1974, Tausch and West 1988).

Large fires were and continue to be rare on this site due to large interspaces and low levels of fine fuels (Miller and Heyerdahl 2008). Lightning-ignited fires were likely common but typically did not affect more than a few individual trees. Replacement fires were uncommon to rare (100 to 600 years) and occurred primarily during extreme fire behavior conditions. Spreading, low-intensity surface fires had a very limited role in molding stand structure and dynamics (Miller at al. 2019). Surface spread was more likely to occur in more productive areas with moderately deep to deep soils, which favors the dominance of herbaceous vegetation and sagebrush (Miller and Heyerdahl 2008, Romme et al. 2009, Miller et al. 2019). The open structure of woodlands is the result of limited seedling establishment, natural thinning processes such as drought and pests, or competition from herbaceous vegetation (Miller et al. 2019). Pre-settlement fire return intervals in the Great Basin National Park, Nevada were found to have a mean range between 50 to 100 years with north-facing slopes burning every 15 to 20 years and rocky landscapes with sparse understory very infrequently (Gruell 1999). Results were less conclusive in a similar study in the Bodie Hills, however it was apparent that old (300+ yr) pinyon primarily survived in protected, low-fuel areas. Woodland dynamics are largely attributed to long-term climatic shifts (temperature, amounts and distribution of precipitation) and the extent and return intervals of fire (Miller and Tausch 2001, Miller et al. 2019). Limited data exists that describes fire histories across woodlands in the Great Basin. Both the infilling of younger trees into old-growth stands and the expansion of trees into surrounding sagebrush communities has increased the risk of loss of pre-settlement trees through the increased landscape level continuity of fuels (Miller et al. 2008).

Wyoming big sagebrush is killed by fire and only regenerates from seed. Recovery time for Wyoming big sagebrush may require 50-120 or more years (Baker 2006, Baker 2011). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses, the growing points are located at or below the soil surface which provides relative protection from disturbances that decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983).

Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below-ground root crowns. Vallentine (1989) cites several studies in the sagebrush zone that classified Indian ricegrass as being slightly damaged from late summer burning. Indian ricegrass has also been found to reestablish on burned sites through seed dispersed from adjacent unburned areas (Young 1983, West 1994). Thus, the presence of surviving, seed producing plants facilitates the reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

Needle-and-thread, a fine-leaved grass, is considered sensitive to fire (Akinsoji 1988, Bradley et al. 1992, Miller et al. 2013). In a study by Wright and Klemmedson (1965), season of burn rather than fire intensity seemed to be the crucial factor in mortality for needle-and-thread grass. Early spring season burning was seen to kill the plants while August burning had no effect. Thus, under wildfire scenarios needle-and-thread is often present in the post-burn community.

Desert needlegrass may increase after burning. In a summation of 13 studies, Abella (2009) found that desert needlegrass increased in abundance (derived from cover, density, or frequency depending on the source of publication) on burned to unburned sites. Thatcher and Hart (1974) observed an increase in desert needlegrass in areas which appeared to have burned on a relict site, however they attributed this to soil type rather than species response.

Bottlebrush squirreltail is considered more fire tolerant than Indian ricegrass due to its small size, coarse stems, and sparse leafy material (Britton et al. 1990). Postfire regeneration occurs from surviving root crowns and from on- and off-site seed sources. Bottlebrush squirreltail has the ability to produce large numbers of highly germinable seeds with relatively rapid germination (Young and Evans 1977) when exposed to the correct environmental cues. Early spring growth and ability to grow at low temperatures contribute to the persistence of bottlebrush squirreltail among cheatgrass dominated ranges (Hironaka and Tisdale 1973).

The grass likely to invade this site is cheatgrass. These invasive grasses displace desirable perennial grasses, reduce livestock forage, and accumulate large fuel loads that foster frequent fires (Davies and Svejcar 2008). Invasion by annual grasses can alter the fire cycle by increasing fire size, fire season length, rate of spread, numbers of individual fires, and likelihood of fires spreading into native or managed ecosystems (D'Antonio and Vitousek 1992, Brooks et al. 2004). While historical fire return intervals are estimated at 15 to 100 years, areas dominated with cheatgrass are estimated to have a fire return interval of 3-5 years (Whisenant 1990). The mechanisms by which invasive annual grasses alter fire regimes likely interact with climate. For example, cheatgrass cover and biomass vary with climate (Chambers et al. 2007) and are promoted by wet and warm conditions during the fall and spring. Invasive annual species have been shown able to take advantage of high nitrogen availability following fire through higher growth rates and increased seedling established relative to native perennial grasses (Monaco et al. 2003).

Livestock/Wildlife Grazing Interpretations:

This ecological site is suitable for grazing. Grazing management considerations include timing, duration and intensity of grazing along with other disturbances that may have changed the resiliency and resistance of the ecological site. In addition, old growth juniper stands provide habitat for a variety of plant and animal species. Bird surveys indicate that the highest abundance and diversity of songbirds occur in shrub steppe communities adjacent to old-growth stands (Reinkensmeyer et al. 2007) but may decline when understory complexity is lost in canopy closure (Miller 2005).

The literature is unclear as to the palatability of Wyoming big sagebrush. Generally, Wyoming sagebrush is the least palatable of the big sagebrush taxa (Bray et al. 1991, Sheehy and Winward 1981), however, it may receive light or moderate use depending upon the amount of understory herbaceous cover (Tweit and Houston 1980). Personius et al. (1987) found Wyoming big sagebrush and basin big sagebrush to be intermediately palatable to mule deer when compared to mountain big sagebrush (most palatable) and black sagebrush (least palatable).

Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton et al. (1990) observed the effects of clipping date on basal area of five bunchgrasses in eastern Oregon and found grazing from August to October (after seed set) has the least impact. Heavy grazing during the growing season will reduce perennial bunchgrasses and increase sagebrush. Abusive grazing by cattle or horses will likely increase Wyoming big sagebrush, rabbitbrush and deep-rooted perennial forbs. Non-native weedy species such as cheatgrass and mustards, and potentially medusahead may invade.

Indian ricegrass is a preferred forage species for livestock and wildlife (Cook 1962, Booth et al. 2006). This species is often heavily utilized in winter because it cures well (Booth et al. 2006). It is also readily utilized in early spring, being a source of green feed before most other perennial grasses have produced new growth (Quinones 1981). Booth et al. (2006) note that the plant does well when utilized in winter and spring. Cook and Child (1971), however, found that repeated heavy grazing reduced crown cover, which may reduce seed production, density, and basal area of these plants. Additionally, heavy early spring grazing reduces plant vigor and stand density (Stubbendieck 1985). In eastern Idaho, productivity of Indian ricegrass was at least 10 times greater in undisturbed plots than in heavily grazed ones (Pearson 1965). Cook and Child (1971) found significant reduction in plant cover after 7 years of rest from heavy (90%) and moderate (60%) spring use. The seed crop may be reduced where grazing is heavy (Bich et al. 1995). Tolerance to grazing increases after May, thus spring deferment may be necessary for stand enhancement (Pearson 1964, Cook and Child 1971); however, utilization of less than 60% is recommended.

Bottlebrush squirreltail generally increases in abundance when moderately grazed or protected (Hutchings & Stewart, 1953). In addition, moderate trampling by livestock in big sagebrush rangelands of central Nevada enhanced bottlebrush squirreltail seedling emergence compared to untrampled conditions. Heavy trampling however was found to significantly reduce germination sites (Eckert, Peterson, & Emmerich, 1987). Squirreltail is more tolerant of grazing than Indian ricegrass, but all bunchgrasses are sensitive to over utilization within the growing season.

Needlegrasses in general are valuable forage for both livestock and wildlife. They are grazed closely when the leaves are green in early spring, but are usually avoided once seed has matured (Sampson et al. 1951). Desert needlegrass is a compact bunchgrass with considerable basal leafage. The young herbage is palatable to all classes of livestock. When mature the fine basal leaves, intermingled with the coarse stems and flowering stalks, are grazed some by cattle and horses, but little by sheep (Sampson et al. 1951). Desert needlegrass is palatable to wildlife such as bighorn sheep and feral burros when young. Desert needlegrass tolerates light grazing but overgrazing may eliminate it from an ecological site. It is best to graze it before seed develops because the seed has a sharp callus that can injure the eyes and mouths of grazing animals (Perkins and Ogle, 2008).

Needle-and-thread is not grazing tolerant and will be one of the first grasses to decrease under heavy grazing pressure (Smoliak et al. 1972, Tueller & Blackburn 1974). Heavy grazing is likely to reduce basal area of these plants (Smoliak et al. 1972). With the reduction in competition from deep rooted perennial bunchgrasses, shallower rooted grasses such as bottlebrush squirreltail may increase (Smoliak et al. 1972).

State and Transition Model Narrative Group 17:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 17.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability of this site under pristine conditions. The reference state has four general community phases: an old-growth phase, a shrub-herbaceous phase, an immature tree phase, and an infilled tree phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought, and/or insect or disease attack. Fires within this community are infrequent and likely small and patchy due to low fuel loads; i.e. single tree death due to lightning strike. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community Phase 1.1:
Widely dispersed old-growth juniper trees with a dominant understory of sagebrush and perennial bunchgrass, characterize this phase. The visual aspect is dominated by Utah juniper with canopy cover of 10 to 20 percent (USDA-NRCS 1985, USDA 1997). Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Wyoming big sagebrush is the primary understory shrub along with Indian ricegrass and needle-and-thread as the most prevalent understory grasses. Forbs, such as lupine *(Lupinus ssp.)* and milkvetch *(Astragalus ssp.)* are minor components. Overall, the understory is sparse with production ranging between 100 to 350 lbs/ac.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
A high-severity crown fire will reduce or eliminate the Utah juniper overstory.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual infilling of juvenile Utah juniper.

Community Phase 1.2:
This phase is characterized by a post-fire shrub and herbaceous community. Indian ricegrass and other perennial grasses dominate. Forbs may increase after a fire but will likely return to pre-burn levels within a few years. Juniper seedlings/saplings up to 4 feet in height may be present. Sprouting shrubs, may increase. Wyoming big sagebrush may be present in unburned patches. Burned tree skeletons may be present; however, these have little or no effect on the understory vegetation.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.3:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of the Utah Juniper component. Wyoming big sagebrush reestablishes. Excessive herbivory may also reduce perennial grass understory.

Community Phase 1.3:
This community phase is characterized by an immature woodland, with juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation consists of smaller tree seedling and saplings, however perennial bunchgrasses and big sagebrush dominate.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of Utah juniper. Infilling by younger trees continues. Excessive herbivory may also reduce perennial bunchgrass understory.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase 1.4 (at-risk):
This phase is dominated by Utah juniper. The stand exhibits mixed age classes and canopy cover exceeds 25%. The density and vigor of the Wyoming big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. This community is at risk of crossing a threshold; without proper management or natural disturbance this phase will transition to the Infilled Tree State 3.0. This community phase is typically described as *early* Phase II woodland (Miller et al. 2008).

Community Phase Pathway 1.4a, from Phase 1.4 to 1.1:
Low intensity fire, insect infestation, or disease kills individual trees within the stand, reducing canopy cover to less than 20%. Over time, young trees mature to replace and maintain the old-growth woodland. The big sagebrush and perennial bunchgrass community increases in density and vigor because of increased availability of light and water resources.

Community Phase Pathway 1.4b, from Phase 1.4 to 1.2:
A high-severity crown fire will eliminate or reduce the Utah juniper overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: Introduction of non-native annual species.

Slow variables: Over time the annual non-native plants will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

T1B: Transition from Reference State 1.0 to Infilled Tree State 3.0:

Trigger: Time and a lack of disturbance allow trees to dominate site resources; may be coupled with inappropriate herbivory that favors shrub and tree dominance.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Juniper canopy cover is greater than 25%. Little understory vegetation remains due to competition with trees for site resources.

Current Potential State 2.0:

This state is similar to the Reference State 1.0, with four general community phases: an old-growth tree phase, a shrub-herbaceous phase, an immature tree phase, and an infilled tree phase. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of non-native species. These non-natives, particularly cheatgrass, can be highly flammable and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal. Fires within this community with the small amount of non-native annual species present are likely still small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community Phase 2.1:
This phase is characterized by a widely dispersed old-growth juniper trees with a big sagebrush and perennial bunchgrass understory. The visual aspect is dominated by Utah juniper with canopy cover of 10 to 20 percent (USDA-NRCS 1985, USDA 1997). Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Wyoming big sagebrush is the primary understory shrub. Indian ricegrass is the most prevalent perennial understory grass. Forbs such as lupin and milkvetch are minor components. Overall, the understory is sparse with production ranging between 100 to 350 lbs/ac.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
A high-severity crown fire will eliminate or reduce the Utah juniper overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual infilling of Utah juniper.

Community Phase 2.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Indian ricegrass and other perennial grasses dominate. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Juniper seedlings up to 4 feet in height may be present. Wyoming big sagebrush may be present in unburned patches. Burned tree skeletons may be present; however, these have little or no effect on the understory vegetation. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.3:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of the Utah Juniper component. Big sagebrush reestablishes. Excessive herbivory may also reduce perennial grass understory.

Community Phase 2.3:
This community phase is characterized by an immature woodland, with juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation consists of smaller tree seedling and saplings, however perennial bunchgrasses and big sagebrush dominate. Annual non-native species are present.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of Utah juniper. Infilling by younger trees continues. Excessive herbivory may also reduce perennial grass understory.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase 2.4 (at-risk):
This phase is dominated by Utah juniper. The stand exhibits mixed age classes and canopy cover exceeds 25 percent. The density and vigor of the big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs may increase. Annual non-native species are present, primarily under tree canopies. This community is at risk of crossing a threshold, without proper management this phase will transition to the Infilled Tree State 3.0. This community phase is typically described as *early* Phase II woodland (Miller et al. 2008).

Community Phase Pathway 2.4a, from Phase 2.4 to 2.1:
Low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 20 percent. Over time young trees mature to replace and maintain the old-growth woodland. The big sagebrush and perennial bunchgrass community increases in density and vigor. Annual non-natives present in trace amounts.

Community Phase Pathway 2.4b, from Phase 2.4 to 2.2:
A high-severity crown fire will eliminate or reduce the Utah juniper overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site. Annual non-native grasses typically respond positively to fire and may increase in the post-fire community.

T2A: Transition from Current Potential State 2.0 to Infilled Tree State 3.0:

Trigger: Time and a lack of disturbance allow trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Utah juniper canopy cover is greater than 25%. Little understory vegetation remains due to competition with trees for site resources.

Infilled Tree State 3.0:

This state has two community phases that are characterized by the dominance of Utah juniper in the overstory. This state is identifiable by greater than 25 percent cover of Utah juniper. This stand exhibits a mixed age class. Older trees are at maximal height and upper crowns may be flat-topped or rounded. Younger trees are typically cone- or pyramidal-shaped. Understory vegetation is sparse due to increasing shade and nutrient competition from trees.

Community Phase 3.1:
Utah juniper dominate the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and big sagebrush skeletons are as common as live shrubs due to tree competition for soil water, overstory shading, and duff accumulation. Tree canopy cover is greater than 25 percent. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent and increasing. This community phase is typically described as a Phase II woodland (Miller et al. 2008).

JUOS/ARTRW8/ACHY-HECO26 (F026XY063NV), Phase 3.1. D. Snyder, September 2017

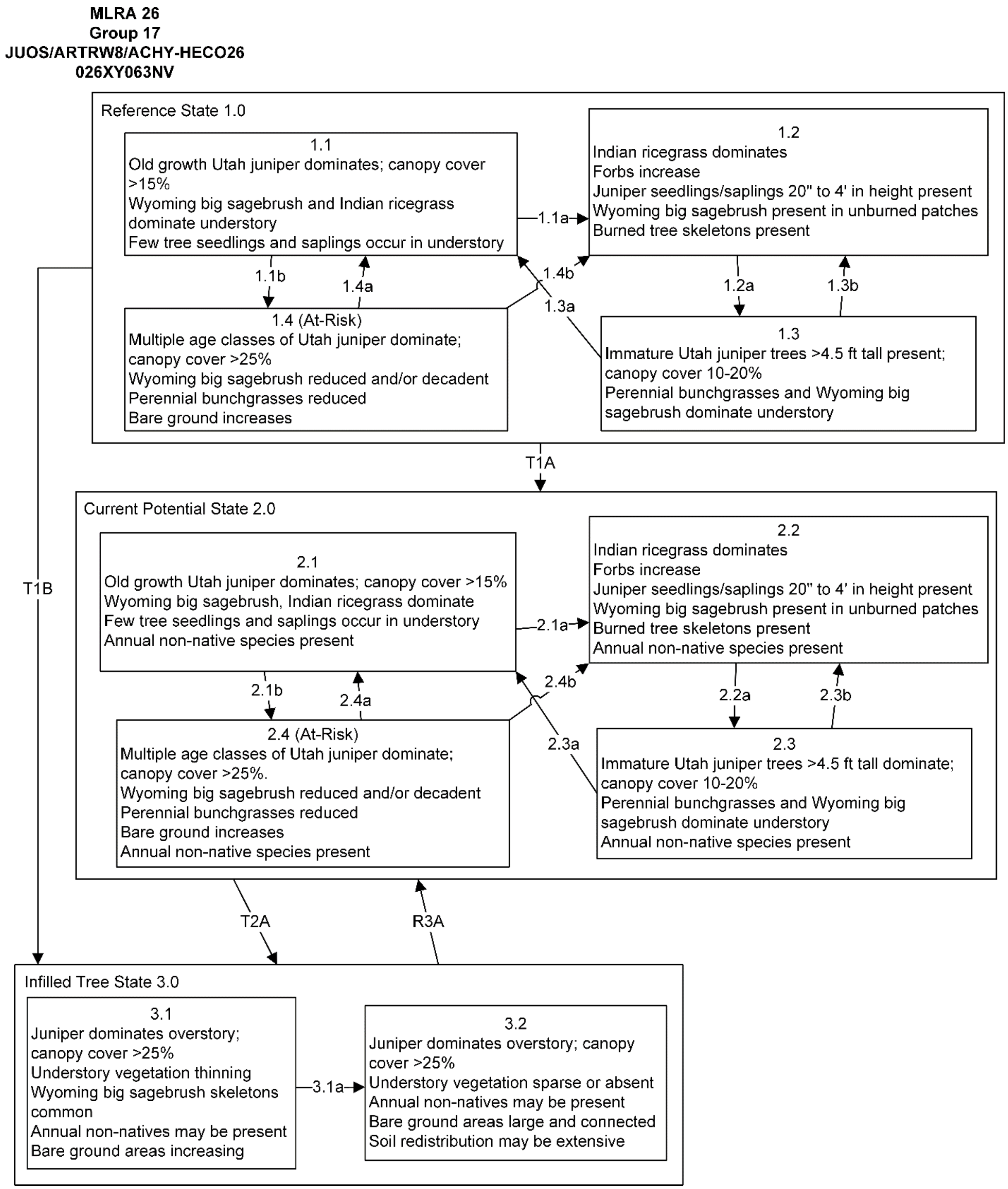
Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of Utah juniper. Infilling by younger trees continues.

Community Phase 3.2 (at risk):
Utah juniper dominates the visual aspect. Tree canopy cover exceeds 25 percent and may be as high as 35 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses, if present, exist in the drip line or under the canopy of trees. Wyoming big sagebrush skeletons are common or the sagebrush has been extinct long enough that only scattered limbs remain. Mat-forming forbs or Sandberg bluegrass may dominate interspaces. Annual non-native species are present and are typically found under the trees. Bare ground areas are large and interconnected. Soil redistribution may be extensive. This community phase is typically described as a Phase III woodland (Miller et al. 2008).

R3A: Restoration from Infilled Tree state 3.0 to Current Potential State 2.0:

Manual or mechanical thinning of trees coupled with seeding. Probability of success is highest from community phase 3.1.

Modal State and Transition Model for Group 17 MLRA 26:



MLRA 26
Group 17
JUOS/ARTRW8/ACHY-HECO26
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KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

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MLRA 26 Group 18: Pinyon and juniper with sagebrush and needlegrass understory

Description of MLRA 26 Disturbance Response Group 18:

Disturbance Response Group (DRG) 18 consists of four ecological sites. The group falls in the 8 to 14 inch precipitation zone. Elevations range from 4,500 to 8,000 feet and these sites are found on slopes ranging from 2 to 75 percent. The soils in this group are typically shallow to very shallow and available water holding capacity is low. These soils usually have high amounts of rock fragments at the soil surface which help to reduce evaporation and provide a stabilizing effect on erosion conditions. This group is dominated by singleleaf pinyon (*Pinus monophylla*) and/or Utah juniper (*Juniperus osteosperma*) with Wyoming big sagebrush *(Artemisia tridentata ssp. wyomingensis)* or low sagebrush (*Artemisia arbuscula*) as the primary understory shrub. Other shrubs in the group include antelope bitterbrush *(Purshia tridentata)*, Douglas rabbitbrush *(Chrysothamnus viscidiflorus),* green ephedra *(Ephedra viridis*), and currant *(Ribes* spp.). The dominant understory grass of the group is Thurber's needlegrass (*Achnatherum thurberianum)*. Other understory grasses include muttongrass (*Poa fendleriana*), Sandberg bluegrass *(Poa secunda)*, and Indian ricegrass *(Achnatherum hymenoides*). Under medium canopy cover (11 to 30 percent, dependent on ecological site), understory production ranges from 75 to 400 lbs/ac.

Disturbance Response Group 18 Ecological Sites:

PIMO-JUOS WSG: 0R0502 – Modal Site	PIMO-JUOS/ARTRW8/ACTH7	F026XY062NV
PIMO-JUOS WSG: 0D0503	PIMO-JUOS/ARAR8-PUTR2/ACTH7	F026XY064NV
JUOS WSG: 0X0403	JUOS/ARAR8/ACTH7-POA	F026XY092NV
PIMO WSG: 0X0603	PIMO/ARAR8/POFE-ACTH7	F026XY093NV

Modal Site:

The ecological site dominated by singleleaf pinyon, Utah juniper, Wyoming big sagebrush and Thurber's needlegrass (F026XY062NV) is the modal site which represents this group as it has the most acres mapped. This forest site occurs summits and sideslopes of hills and lower elevation mountains on all aspects. The site is found from 5,000 to 6,500 feet elevation on slopes that range from 15 to 50 percent. Average annual precipitation is 10 to 12 inches. The soils are typically shallow and well drained. These soils are skeletal, with 35 to over 50 percent gravels, cobbles or stones, by volume, distributed throughout their profile. Available water capacity is low, but trees and shrubs can extend their roots into fissures within the underlying material allowing them to utilize deep moisture. Runoff is medium to rapid and potential for sheet and rill erosion is moderate to severe depending on slope. Coarse fragments on the soil surface provide a stabilizing effect on surface erosion conditions.

An overstory canopy cover of 20 to 30 percent is assumed to be representative of tree dominance for a mature woodland in the Reference State. However, current research indicates a canopy cover of 10 to 20 percent is likely more appropriate to represent this site condition in pre-European contact condition (Miller et al. 2008). Wildfire is recognized as a natural disturbance that strongly influenced the structure and composition of the Reference State. The Reference State is dominated by singleleaf pinyon and Utah juniper in the overstory. Wyoming big sagebrush and Thurber's needlegrass dominate the understory. Few saplings occur in the understory. Phlox (*Phlox* spp.) and buckwheat *(Eriogonum ssp.)* are common understory forbs. Overstory tree canopy composition is about 50 to 85 percent singleleaf pinyon and 15 to 50 percent Utah juniper. Average understory production ranges from 200 to 400 pounds per acre under medium canopy cover (20 to 30 percent). Understory production includes the total annual production of all species within 4½ feet of the ground surface.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Pinyon and juniper dominated plant communities in the cold desert of the Intermountain West occupy over 18 million ha (44,600,000 acres) (Miller and Tausch 2001). In the mid to late 1900's, the number of pinyon and juniper trees establishing per decade began to increase compared to the previous several hundred years. The substantial increase in conifer establishment is attributed to a number of factors the most important being (1) cessation of the aboriginal burning (Tausch 1999), (2) change in climate with rising temperatures (Heyerdahl et al. 2006), (3) the reduced frequency of fire likely driven by the introduction of domestic livestock, (4) a decrease in wildfire frequency along with improved wildfire suppression efforts and (5) potentially increased CO_2 levels favoring woody plant establishment (Tausch 1999, Bunting 1994). Miller et al. (2008) found pre-settlement tree densities averaged 2 to 11 per acre in six woodlands studied across the Intermountain West. Current stand densities range from 80 to 358 trees/ac. The research strongly suggests that for over 200 years prior to settlement, woodlands in the Great Basin were relatively low density with limited rates of establishment (Miller et al. 2008, Miller and Tausch 2001). This evidence strongly suggests that tree canopy cover of 10 to 20 percent may be more representative of these sites in pristine condition (USDA 1997). Increases in pinyon and juniper densities post-settlement were the result of both infill in mixed age tree communities and expansion into shrub-steppe communities. Pre-settlement trees accounted for less than 2 percent of the stands sampled in Nevada, Oregon, and Utah (Miller et al. 2008, Miller and Tausch 2001, Miller et al. 1999). However, the proportion of old-growth can vary depending on disturbance regimes, soils and climate. Some ecological sites are capable of supporting persistent woodlands, likely due to specific soils and climate resulting in infrequent stand replacement disturbance regimes. In the Great Basin, old-growth trees have been found to typically grow on rocky shallow or sandy soils that support little understory vegetation to carry a fire (Holmes et al. 1986, Miller and Rose 1995, West et al. 1998, USDA 1997).

Singleleaf pinyon and Utah juniper are long-lived tree species with wide ecological amplitudes (Tausch et al 1981, Weisberg and Dongwook 2012, West et al 1998). Maximum ages of pinyon and juniper exceed 1000 years and stands with maximum age classes are only found on steep rocky slopes with no evidence of fire (West et al 1975). Pinyon is slow-growing and very intolerant to shade with the exception of young plants, usually first year seedlings (Tueller and Clark 1975). Singleleaf pinyon seedling establishment is episodic. Population age structure is affected by drought, which reduces seedling and sapling recruitment more than other age classes. The ecotones between singleleaf pinyon woodlands and adjacent shrublands and grasslands provide favorable microhabitats for singleleaf pinyon seedling establishment since they are active zones for seed dispersal, nurse plants are available, and singleleaf pinyon seedlings are only affected by competition from grass and other herbaceous vegetation for a couple of years.

The pinyon jay (*Gymnorhinus cyanocephalus)* and other members of the seed caching corvids play an important role in pinyon pine regeneration. These birds cache the seeds in the soil for future use. Those seeds that escape harvesting by the birds and rodents have the opportunity to germinate under favorable soil and climatic conditions (Lanner 1981). A mutualistic relationship exists between the trees that produce food and the animals that disperse the seeds, thereby insuring perpetuation of the trees. Large crops of seeds may stimulate reproduction in birds, especially the pinyon jay (Ligon 1974).

Pinyon and juniper growth is dependent mostly upon soil moisture stored from winter precipitation, mainly snow. Much of the summer precipitation is ineffective, being lost in runoff after summer convection storms or by evaporation and interception (Tueller and Clark 1975). Pinyon and juniper are highly resistant to drought which is common in the Great Basin. Tap roots of pinyon and juniper have a relatively rapid rate of root elongation and are thus able to persist until precipitation conditions are more favorable (Emerson 1932).

Infilling by younger trees increases canopy cover and causes a decline in understory perennial vegetation because of increased competition for water and sunlight. There is also some evidence that phenolic compounds in juniper litter may have allelopathic effects on grass (Jameson 1970). Infilling shifts stand level biomass from ground fuels to canopy fuels, which has the potential to significantly impact fire behavior. The more tree-dominated pinyon and juniper woodlands become, the less likely they are to burn under moderate conditions, resulting in infrequent high intensity fires (Gruell 1999, Miller et al. 2008). As the understory vegetation declines in vigor, the ability of native perennial plants to recover after fire is reduced (Urza et al. 2017). The increase in bare ground allows for the invasion of non-native annual species such as cheatgrass (*Bromus tectorum*), and with intensive wildfire, the potential for conversion to annual exotics is a serious threat (Tausch 1999, Miller et al. 2008).

Specific successional pathways after disturbance in pinyon-juniper stands are dependent on a number of variables such as plant species present at the time of disturbance and their individual responses to disturbance, past management, type and size of disturbance, available seed sources in the soil or adjacent areas, and site and climatic conditions throughout the successional process.

Utah juniper can be killed by a fungus called Juniper Pocket Rot (*Pyrofomes demidoffi*), also known as white trunk rot (Eddleman et al. 1994 and Durham 2014). Pocket rot enters the tree through any wound or opening that exposes the heartwood. In an advanced stage, this fungus can cause high mortality (Durham 2014). Dwarf mistletoe (*Phorandendron* spp.) a parasitic plant, may also affect Utah juniper and without treatment or pruning, may kill the tree 10-15 years after infection. Seedlings and saplings are most susceptible to the parasite (Christopherson 2014). Other diseases affecting juniper are: dwarf mistletoe (*Arceuthobium* spp.) that may weaken trees; leaf rust (*Gymnosporangium* sp.) on leaves and young branches; and juniper blight (*Phomopsis* sp.). Flat-head borers (*Chrysobothris* sp.) attack the wood; long-horned beetles (*Methia juniper*, *Styloxus bicolor*) girdle limbs and twigs; and round-head borers (*Callidium* spp.) attack twigs and limbs (Tueller and Clark 1975).

Phillips (1909) recognized that the pinyons are more resistant to disease than most of the conifers with which it associates. Hepting (1971) lists several diseases affecting pinyon including: foliage diseases, a tarspot needle cast, stem diseases such as blister rust and dwarf mistletoe, root diseases and trunk rots, red heart rot, and but rot. The pinyon ips beetle *(Ips confuses*) and pinyon needle scale (*Matsucoccus acalyptus*) are both native insects to Nevada that attack pinyon pines throughout their range. The pinyon needle scale weakens trees by killing needles older than 1 year. Sometimes small trees are killed by repeated feeding and large trees are weakened to the point that they are attacked by the pinyon ips beetle. The beetle typically kills weak and damaged trees (Phillips 2014). During periods of chronic drought the impact of these two insects on singleleaf pinyon can be substantial.

In the Great Basin, the majority of annual precipitation is received during the winter and early spring. This continental semiarid climate regime favors growth and development of deep-rooted shrubs and herbaceous cool season plants using the C3 photosynthetic pathway (Comstock and Ehleringer 1992). Winter precipitation and slow melting of snow results in deeper percolation of moisture into the soil profile. Herbaceous plants, more shallow-rooted than shrubs, grow earlier in the growing season and thrive on spring rains, while the deeper rooted shrubs lag in phenological development because they draw from deeply infiltrating moisture from snowmelt the previous winter. Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

The ecological sites in this DRG are dominated by an overstory of long-lived coniferous trees and understory of deep-rooted, cool season, perennial bunchgrasses, and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Dobrowolski et al. 1990).

Wyoming big sagebrush, the most drought tolerant of the big sagebrush's, is generally long-lived; therefore it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir, 1973). Survival of the seedlings is depended on adequate moisture conditions.

Low sagebrush, which is dominant on three sites in this group, is fairly drought tolerant but also tolerates perched water tables during some portion of the growing season. Both Wyoming big and low sagebrush are susceptible to the sagebrush defoliator, Aroga moth (*Aroga websteri*). While Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975), research is inconclusive of the damage sustained by low sagebrush populations.

Thurber's needlegrass has a somewhat shallower root system than Wyoming big sagebrush and low sagebrush, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m. However, Thurber's needlegrass root densities taper off more rapidly than shrubs. Differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems.

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Four possible alternative stable states have been identified for this DRG.

Annual Invasive Grasses:

The species most likely to invade these sites is cheatgrass, however the sandy surface decreases the probability of cheatgrass dominance. Cheatgrass is a cool-season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983, Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead. Bradley and Mustard (2005) utilized Landsat and Advanced Very High Resolution Radiometer to estimate the areal extent of cheatgrass dominance in the Great Basin. Their results suggest cheatgrass dominated over 4.9 million acres in 2005. In addition, they found cheatgrass was 26percent more likely to be found within 450 feet of areas occupied by cheatgrass in 1973, with cultivation, power lines and roads identified as primary vectors of spread (Bradley and Mustard 2006).

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass "die-off" provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but there is ongoing work to try to predict where they occur, in the hopes of aiding conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, are able to suppress cheatgrass growth when mature (Blank et al. 2020). Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100percent control of ventenata and medusahead and greater than 95percent control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, as only one year of data was reported.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz./ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Large fires were and continue to be rare on this site due to large interspaces and low levels of fine fuels (Miller and Heyerdahl 2008). Lightning-ignited fires were likely common but typically did not affect more than a few individual trees. Replacement fires were uncommon to rare (100-600 years) and occurred primarily during extreme fire behavior conditions. Spreading, low-intensity surface fires had a very limited role in molding stand structure and dynamics (Miller at al. 2019). Surface spread was more likely to occur in more productive areas with moderately deep to deep soils, which favors the dominance of herbaceous vegetation and sagebrush (Miller and Heyerdahl 2008, Romme et al. 2009, Miller et al. 2019). The open structure of woodlands is the result of limited seedling establishment, natural thinning processes such as drought and pests, or competition from herbaceous vegetation (Miller et al. 2019). Pre-settlement fire return intervals in the Great Basin National Park, Nevada were found to have a mean range between 50 to 100 years with north-facing slopes burning every 15 to 20 years and rocky landscapes with sparse understory very infrequently (Gruell 1999). Results were less conclusive in a similar study in the Bodie Hills, however it was apparent that old (300+ yr) pinyon primarily survived in protected, low-fuel areas. Woodland dynamics are largely attributed to long-term climatic shifts (temperature, amounts and distribution of precipitation) and the extent and return intervals of fire (Miller and Tausch 2001, Miller et al. 2019). Limited data exists that describes fire histories across woodlands in the Great Basin. Both the infilling of younger trees into old-growth stands and the expansion of trees into surrounding sagebrush communities has increased the risk of loss of pre-settlement trees through the increased landscape level continuity of fuels (Miller et al. 2008).

Utah juniper is usually killed by fire, and is most vulnerable to fire when it is under four feet tall (Bradley et al. 1992). Larger trees, because they have foliage farther from the ground and thicker bark, can survive low severity fires but mortality does occur when 60percent or more of the crown is scorched (Bradley et al. 1992). Singleleaf pinyons are also most vulnerable to fire when less than four feet tall, however mature trees do not self-prune their dead branches allowing for accumulated fuel in the crowns. This characteristic and the relative flammability of the foliage make individual mature trees susceptible to fire (Bradley et al. 1992). With the low production of the understory vegetation and low density of trees per acre, high severity fires within this plant community were not likely and rarely became crown fires (Bradley et al. 1992, Miller and Tausch 2001).

Singleleaf pinyon and juniper reestablish by seed from nearby seed sources or surviving seeds. Junipers have a long-lived seed bank due to delayed germination by impermeable seed coats, immature or dormant embryos and germination inhibitors (Chambers et al. 1999). Singleleaf pinyon trees have relatively short-lived seeds with little innate dormancy that form only temporary seed banks with most seeds germinating the spring following dispersal (Meewig and Bassett 1983). Density of pinyon seeds in the seed bank is dependent upon the current year’s cone crop. Singleleaf pinyon are known to have favorable cone production every two to three years thus the potential for a large temporary seed bank is high during mast years and likely low during non-mast years (Chambers et al. 1999). The role of nurse plant requirements between the two tree species is important to post-fire establishment. Chambers et al. (1999) found that singleleaf pinyon seedlings rarely establish in interspaces or open environments. In contrast, Utah juniper seedlings were found capable of establishing in interspace microhabitats as frequently as under sagebrush. Therefore, fire that removes both trees and understory shrubs in pinyon-juniper woodlands may have a relatively greater effect on the establishment of pinyon than juniper.

Initial response of native understory species following fire correlates closely with percent crown cover. In general, research indicates that understory response to disturbance is most productive when crown cover is at or below 20 percent while beyond 30 percent there is a rapid decline in understory species and soil seed reserves (Huber et al. 1999). The reference community understory vegetation of Wyoming big sagebrush and Thurber's needlegrass further supports the evidence of a pre-settlement community with an open overstory and infrequent ground fire.

Wyoming big sagebrush is killed by fire and only regenerates from seed. Recovery time for Wyoming big sagebrush may require 50 to 120 or more years (Baker 2006). However, the introduction and expansion of cheatgrass has dramatically altered the fire regime (Balch et al. 2013) and restoration potential of Wyoming big sagebrush communities.

Low sagebrush is killed by fire and does not sprout (Young 1983). Establishment after fire is from seed, generally blown in and not from the seed bank (Bradley et al. 1992). Fire risk is greatest following a wet, productive year when there is greater production of fine fuels (Beardall and Sylvester 1976). Recovery time of low sagebrush following fire is variable (Young 1983). After fire, if regeneration conditions are favorable, low sagebrush recovers in 2 to 5 years, however on harsh sites where cover is low to begin with and/or erosion occurs after fire, recovery may require more than 10 years (Young 1983). Slow regeneration may subsequently worsen erosion (Blaisdell et al. 1982).

Antelope bitterbrush, the second most abundant shrub on sites in this group, is moderately fire tolerant (McConnell & Smith, 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however, sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low-intensity fires may allow for bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006). If cheatgrass is present, bitterbrush seedling success is much lower. The factor that most limits establishment of bitterbrush seedlings is competition for water resources with the invasive species cheatgrass (Clements and Young 2002).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses, the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). However, season and severity of the fire will influence plant response. Plant response will also vary depending on post-fire soil moisture availability.

Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk, Cline, & Rickard, 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber's needlegrass (Carlton M. Britton, Guy R. McPherson, & Forrest A. Sneva, 1990). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influenced the response and mortality of Thurber's needlegrass, smaller bunch sizes were less likely to be damaged by fire (Wright and Klemmedson 1965). Fall prescribed burns did not significantly affect cover of Thurber's needlegrass over the course of two years, indicating that fall fire is not detrimental to this plant (Davies and Bates, 2008). Thurber's needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Britton et al. 1990, Koniak 1985). Reestablishment on burned sites has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and may preclude reestablishment (Evans and Young, 1978). Thurber's needlegrass was shown to decrease in density following a spring fire, but it produced more reproductive culms the year after a fall fire (Ellsworth and Kauffman 2010). Thurber's needlegrass is tolerant to barley yellow dwarf virus and shows no adverse symptoms when infected (Ingwell and Bosque-Perez, 2015).

Muttongrass, a minor component in this group, is top killed by fire but will sprout after low to moderate severity fires. A study by Vose and White (1991) in an open saw timber site found minimal difference in overall effect of burning on mutton grass.

Livestock/ Wildlife Grazing Interpretations:

The history of livestock grazing in the pinyon-juniper ecosystem goes back to more than 200 years, depending on the particular locality within the ecosystem (Hurst 1975). Historically, pinyon-juniper woodlands were much more open, and they supported a diverse understory that provided forage for both livestock and wildlife. Historic livestock overuse and increased stand densities have reduced the carrying capacity of these pinyon-juniper stands and many current stands only provide shade and shelter for livestock.

Generally, Wyoming big sagebrush is the least palatable of the big sagebrush taxa (Bray et al. 1991, Sheehy and Winward 1981), however, it may receive light or moderate use depending upon the amount of understory herbaceous cover (Tweit and Houston 1980). Personius et al. (1987) found Wyoming big sagebrush and basin big sagebrush to be intermediately palatable to mule deer when compared to mountain big sagebrush (most palatable) and black sagebrush (least palatable).

Domestic sheep and, to a much lesser degree, cattle, consume low sagebrush particularly during the spring, fall, and winter (Sheehy and Winward 1981). Heavy dormant season grazing by sheep will reduce sagebrush cover and increase grass production (Laycock 1967). Severe trampling damage to supersaturated soils could occur if sites are used in early spring when there is abundant snowmelt. Trampling damage, particularly from cattle or horses, in sagebrush habitat types is greatest when high clay content soils are wet. In drier areas with more gravelly soils, no serious trampling damage occurs, even when the soils are wet (Hironaka et al. 1983).

Antelope bitterbrush is critical browse for mule deer (*Odocoileus heminous*), as well as domestic livestock, pronghorn (*Antilocapra americana*), and elk (*Cervus canadensis)* (Wood et al. 1995). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison 1953). Cattle tend to graze bitterbrush in higher areas than sheep or deer and take off newer twig growth, keeping them shorter. Palatability varies between plants and stages of growth, degree of use, and location. Pronghorn usually graze bitterbrush in the spring and summer, mule deer in the winter, and livestock in the summer. It is rather shade intolerant (Hormay 1943). Antelope bitterbrush initiates growth in the spring and finishes by late summer. It grows large ephemeral leaves in the spring and then small overwintering leaves in the late summer. Antelope bitterbrush recovers vigorously with new growth after defoliation from grazing, and potential growth remains the same or is enhanced by browsing. Antelope bitterbrush will allocate additional resources to new growth to recover from browsing (Bilbrough and Richards 1993).

Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton et al. (1990) observed the effects of clipping date on basal area of five bunchgrasses in eastern Oregon, and found grazing from August to October (after seed set) has the least impact. Heavy grazing, year after year during the growing season, will reduce perennial bunchgrasses and increase sagebrush. Abusive grazing by cattle or horses will likely increase sagebrush, rabbitbrush and deep-rooted perennial forbs such as arrowleaf balsamroot *(Balsamorhiza* spp.) Annual non-native weedy species such as cheatgrass and mustards, and potentially medusahead may invade.

Thurber’s needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber’s needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp, 1988). Thurber’s needlegrass may increase in crude protein content after grazing (Dave et al. 2007).

Reduced bunchgrass vigor or density due to inappropriate grazing provides an opportunity for Sandberg bluegrass, mat forming forbs, and/or cheatgrass and other invasive species to occupy interspaces. Sandberg bluegrass, a minor component in this group, increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer, and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management. Field surveys indicate native mat-forming forbs may also increase with decreased bunchgrass density.

Pinyon-juniper woodlands provide a diversity of habitat for wildlife. Although the foliage of pinyon and juniper varies in palatability among fauna, the pinyon nuts and juniper berries are preferred food for many species. The understory species provide fruits and browse for large ungulates, small mammals, birds and beaver (Wildlife Action Plan Team 2012).

Ungulates will use pinyon and juniper trees for cover and graze the foliage. The understory species also provide critical browse for deer. The trees provide important cover for mule deer, elk*,* wild horses, mountain lion (*Puma concolor*), bobcat (*Lynx rufus*) and pronghorn (Gottfried and Severson 1994, Coates and Schemnitz 1994, Logan and Irwin 1985, Evans 1988).

Mule deer is considered the dominant big game species in the pinyon-juniper woodland and depend heavily on these woodlands for cover, shelter, and emergency forage during severe winters (Frischknecht 1975). Mule deer will eat singleleaf pinyon and juniper foliage, using the foliage moderately in winter, spring, and summer (Kufeld et al. 1973). Deep snows in higher elevation forest zones force mule deer and elk down into pinyon-juniper habitats during winter. This change in habitat allows mule deer and elk to browse the dwarf trees and shrubs (Gottfried and Severson 1994).

The diet of pronghorn varies considerably; however, singleleaf pinyon was shown to comprise 1 to 2 percent of winter diet of pronghorn that occur in pinyon-juniper habitat. Desert bighorn sheep (*Ovis nelson*) may utilize pinyon-juniper habitat, but only where the terrain is rocky and steep (Gottfried et al. 2000). Gray foxes, bobcats (*Lynx rufus*), coyotes (*Canis latran*s), weasels (*Mustela frenata*), skunks (*Mephitis* spp.), badgers (*Taxidea taxus*), and ringtail cats *(Bassariscus astutus*) search for prey in pinyon-juniper habitat woodlands (Short and McCulloch 1977).

Juniper "berries" or berry-cones are eaten by black-tailed jackrabbits (*Lepus californicus*) and coyotes (Gese et al. 1988, Kitchen et al. 2000). A study by Kitchen et al (1999) conducted in juniper-pinion habitat found vegetation in coyote scats was mainly grass seeds or juniper berries. Jackrabbits are a major dispenser of juniper seeds (Schupp et al. 1999). The pinyon mouse *(Peromyscus truei*) is a pinyon-juniper obligate and uses the woodlands for cover and food (Hoffmeister 1981). Other small mammals include the porcupine (*Hystricomorph hystricidae*), desert cottontail (*Sylvilagus audubonii*), Nuttall's cottontail (*S. nuttallii*), deer mouse (*Peromyscus maniculatus*), Great Basin pocket mouse (*Perognathus parvus*), chisel-toothed kangaroo rat (*Dipodomys microps*) and desert woodrat (*Neotoma lepida*) (Turkowski and Watkins 1976).

Many bird species are associated with the pinyon-juniper habitat; some are permanent residents, some summer residents, and some winter residents, depending upon location. For birds and bats, the woodland provides structure for nesting and roosting, and locations for foraging. Singleleaf pinyon provides a number of cavities and the stringy, fibrous bark provides quality nesting material as well as the food provided by the tree's seeds and berries (Short and McCulloch 1977). Many bird species depend on juniper berry-cones and pine nuts for fall and winter food (Balda and Masters 1980). Several bird species are obligates including (gray flycatcher (*Epidonax wrightii),* scrub jay (*Aphelocoma californica)*, plain titmouse (*Parus inornatus ridgwayi*), and gray vireo (*Vireo vicinior)* and several species are semi-obligates including black-chinned hummingbird (*Archilochus alexandri*), ash-throated flycatcher (*Myiarchus cinerascens*), pinion jay (*Gymnorhinus cyanocephalus*), American bushtit (*Psaltriparus minimus*), Bewick's wren (*Thryomanes bewickii*), Northern mockingbird (*Mimus polyglottos*), blue-gray gnatcatcher (*Polioptila caerulea*), black-throated gray warbler (*Dendroica nigrescens*), house finch (*Haemorhous mexicanus*), spotted towhee (*Pipilo maculatus*), lark sparrow (*Chondestes grammacus*) and black-chinned sparrow (*Zonotrichia atricapilla)* (Balda and Masters 1980). Ferruginous hawk (*Buteo regalis*), a conservation priority species due to recent population declines in Nevada, nest in older trees of sufficient size and structure to support their large nest platforms. (Holechek 1981).

Diurnal reptiles include the sagebrush swift (*Sceloporus graciosus)*, the blue-bellied lizard (*Sceloporus elongates)* the western collard lizard, the Great Basin rattlesnake, the Great Basin gopher snake (*Pituophis catenifer*) and horned lizard, also occur in Utah juniper habitat (Frischknecht 1975). However, the distribution of most of herpetofauna present in pinyon-juniper woodlands is poorly understood and more research and management are needed.

State and Transition Model Narrative for Group 18:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 disturbance response group 18.

Reference State 1.0:

The Reference State 1.0 is representative of the natural range of variability under pristine conditions. This reference state has four general community phases: an old-growth tree phase, a shrub-herbaceous phase, an immature tree phase, and an infilled tree phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought, and/or insect or disease attack. Fires within this community are infrequent and likely small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community Phase 1.1:
This phase is characterized by widely dispersed old-growth pinyon and juniper trees with an understory of Wyoming big sagebrush And perennial bunchgrasses. The visual aspect is dominated by singleleaf pinyon and Utah juniper with approximately 15 percent canopy cover (USDA-NRCS 1979, USDA 1997). Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Thurber's needlegrass is the most prevalent grass in the understory. Wyoming big sagebrush is the primary understory shrub. Forbs such as phlox, and buckwheat are minor components. Overall, the understory is sparse with production ranging between 200 to 400 pounds per acre.

PIMO/ARARL3/POFE-ACTH7 (F026XY093NV), Phase 1.1. D. Snyder, June 2016.
Lahontan sagebrush was present on this site instead of low sagebrush as the ESD describes.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual infilling of singleleaf pinyon and Utah juniper.

Community Phase 1.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass and other perennial grasses dominate. Forbs may increase after a fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 4 feet in height may be present. Wyoming big sagebrush may be present in unburned patches. Burned tree skeletons may be present; however, these have little or no effect on the understory vegetation.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.3:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Wyoming big sagebrush reestablishes. Excessive herbivory may also reduce perennial grass understory.

Community Phase 1.3:
This community phase is characterized by an immature woodland, with pinyon and juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation is dominated by Wyoming big sagebrush and perennial bunchgrasses as well as smaller tree seedling and saplings.

Community Phase Pathway 1.3a, from 1.3 to 1.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues. Excessive herbivory may also reduce the perennial grass understory.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase 1.4 (at-risk):
This phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover may be 30 percent or greater. The density and vigor of the Wyoming big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs such as phlox may increase. This community is at risk of crossing a threshold; without proper management this phase will transition to the infilled tree state 3.0. This community phase is typically described as early Phase II woodland (Miller et al. 2008).

Community Phase Pathway 1.4a, from Phase 1.4 to 1.1:
Low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 30 percent. Over time young trees mature to replace and maintain the

old-growth woodland. The Wyoming big sagebrush and perennial bunchgrass community increases in density and vigor.

Community Phase Pathway 1.4b, from Phase 1.4 to 1.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: Introduction of non-native annual species.

Slow variables: Over time the annual non-native plants will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

T1B: Transition from Reference State 1.0 to Infilled Tree State 3.0

Trigger: Time and a lack of disturbance allow trees to dominate site resources; may be coupled with inappropriate herbivory that favors shrub and tree dominance.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Pinyon and juniper canopy cover is greater than 40 percent. Little understory vegetation remains due to competition with trees for site resources.

Current Potential State 2.0:

This state is similar to the Reference State 1.0, with four general community phases: an old-growth tree phase, a shrub-herbaceous phase, an immature tree phase, and an infilled tree phase. Ecological function has not changed; however the resiliency of the state has been reduced by the presence of non-native species. These non-natives, particularly cheatgrass, can be highly flammable and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal. Fires within this community with the small amount of non-native annual species present are likely still small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community Phase 2.1:
This phase is characterized by a widely dispersed old-growth pinyon and juniper trees with a Wyoming big sagebrush perennial bunchgrass understory. The visual aspect is dominated by

singleleaf pinyon and Utah juniper with canopy cover of 15 percent or more (USDA-NRCS 1979, USDA 1997). Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Thurber's needlegrass is the most prevalent grass in the understory. Wyoming big sagebrush is the primary understory shrub. Forbs such as phlox and buckwheat are minor components. Overall, the understory is sparse with production ranging between 200 to 400 lbs. per acre.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual infilling of singleleaf pinyon and Utah juniper.

Community Phase 2.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass and other perennial grasses dominate. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Pinyon and juniper seedlings up to 4 feet in height may be present. Wyoming big sagebrush may be present in unburned patches. Burned tree skeletons may be present; however, these have little or no effect on the understory vegetation. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.3:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of the singleleaf pinyon and Utah Juniper component. Wyoming big sagebrush reestablishes. Excessive herbivory may also reduce perennial grass understory.

Community Phase 2.3:
This community phase is characterized by an immature woodland, with pinyon and juniper trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation is dominated by Wyoming big sagebrush and perennial bunchgrasses as well as smaller tree seedling and saplings. Annual non-native species are present.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.4:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase 2.4 (at-risk):
This phase is dominated by singleleaf pinyon and Utah juniper. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the Wyoming big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs may increase. Annual non-native species are present primarily

under tree canopies. This community is at risk of crossing a threshold, without proper management this phase will transition to the infilled tree state 3.0. This community phase is typically described as early Phase II woodland (Miller et al. 2008).

Community Phase Pathway 2.4a, from Phase 2.4 to 2.1:
Low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 30 percent. Over time young trees mature to replace and maintain the old-growth woodland. The Wyoming big sagebrush and perennial bunchgrass community increases in density and vigor. Annual non-natives present in trace amounts.

Community Phase Pathway 2.4b, from Phase 2.4 to 2.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon and Utah juniper overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site. Annual non-native grasses typically respond positively to fire and may increase in the post-fire community.

T2A: Transition from Current Potential State 2.0 to Infilled Tree State 3.0:

Trigger: Time and a lack of disturbance allow trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Singleleaf pinyon and Utah juniper canopy cover is greater than 40 percent. Little understory vegetation remains due to competition with trees for site resources.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Catastrophic crown fire facilitates the establishment of non-native, annual weeds.

Slow variables: Increase in tree crown cover, loss of perennial understory and an increase in annual non-native species.

Threshold: Cheatgrass or other non-native annuals dominate understory. Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter. Increased canopy cover of trees allows severe stand-replacing fire. The increased seed bank of non-native, annual species responds positively to post-fire conditions facilitating the transition to an Annual State.

Infilled Tree State 3.0:

This state has two community phases that are characterized by the dominance of Utah juniper and singleleaf pinyon in the overstory. This state is identifiable by over 40 percent cover of Utah juniper and singleleaf pinyon, exhibiting a mixed age class. Older trees are at maximal height and upper crowns may be flat-topped or rounded. Younger trees are typically cone- or pyramidal-shaped. Understory vegetation is sparse due to increasing shade and competition from trees.

Community Phase 3.1:
Singleleaf pinyon and Utah juniper dominate the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and Wyoming big sagebrush skeletons are as common as live shrubs due to tree competition for soil water, overstory shading, and duff accumulation. Tree canopy cover is greater than 40 percent. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent. This community phase is typically described as a Phase II woodland (Miller et al. 2008).

PIMO-JUOS/ARTRW8/ACTH7 (F026XY062NV), Phase 3.1. D. Snyder September 2017

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Time without disturbances such as fire, drought, or disease will allow for the gradual maturation of singleleaf pinyon and Utah juniper. Infilling by younger trees continues.

Community Phase 3.2 (at risk):
Singleleaf pinyon and Utah juniper dominate the aspect. Tree canopy cover exceeds 40 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses, if present exist in the drip line or under the canopy of trees. Wyoming big sagebrush skeletons are common or the sagebrush has been extinct long enough that only scattered limbs remain. Mat-forming forbs or Sandberg bluegrass (*Poa secunda*) may dominate interspaces. Annual non-native species are present and are typically found under the trees. Bare ground areas are large and interconnected. Soil redistribution may be extensive. This community phase is typically described as a Phase III woodland (Miller et al. 2008).

T3A: Transition from Infilled Tree State 3.0 to Annual State 4.0:

Trigger: Canopy fire reduces the pinyon and juniper overstory and facilitates the annual non-native species in the understory to dominate the site.

Slow variables: Over time, cover, production and seed bank of annual non-native species increases.

Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes temporal and spatial nutrient capture and cycling within the community. Increase in canopy cover of trees increases rainfall interception and reduces soil moisture for understory species. Increased canopy cover of trees increases the risk for severe stand-replacing crown fire. The increased seed bank of non-native, annual species responds positively to post-fire conditions facilitating the transition to an Annual State.

R3A: Restoration from Infilled Tree state 3.0 to Current Potential State 2.0:

Manual or mechanical thinning of trees coupled with seeding. Probability of success is highest from community phase 3.1.

Annual State 4.0:

This state has one community phase that is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard in the understory. Time since fire may facilitate the maturation of sprouting shrubs such as rabbitbrush. Ecological dynamics are significantly altered in this state. Annual non-native species create a highly combustible fuel bed that shortens the fire return interval. Nutrient cycling is spatially and temporally truncated as annual plants contribute significantly less to deep soil carbon. This state was not seen in MLRA 26 during field work for this project, however it is possible given increased fire activity in these sites and their proximity to known annual states of sagebrush ecological sites. We refer the reader to the report for Disturbance Response Group 21 for MLRA 28A and 28B.

Community Phase 4.1:
Cheatgrass, mustards and other non-native annual species dominate the site. Trace amounts of perennial bunchgrasses may be present. Sprouting shrubs may increase. Burned tree skeletons present.

Potential Resilience Differences with Other Ecological Sites:

PIMO-JUOS/ARAR8-PUTR2/ACTH7 (F026XY064NV):

This site is very similar to the modal site but with low sagebrush as the dominant shrub. Antelope bitterbrush is another important component of the understory. The subdominant grass on this site is Indian ricegrass. It occurs on upper piedmont slopes on soils with a clay subsoil horizon. Elevations range from 6,200 to 8,000 feet. The site, in its reference state, has a lower pinyon-juniper canopy understory of about 20 percent. It is less productive than the modal site with 150 lbs/ac in a normal year and has more precipitation at 10-14 inches per year.

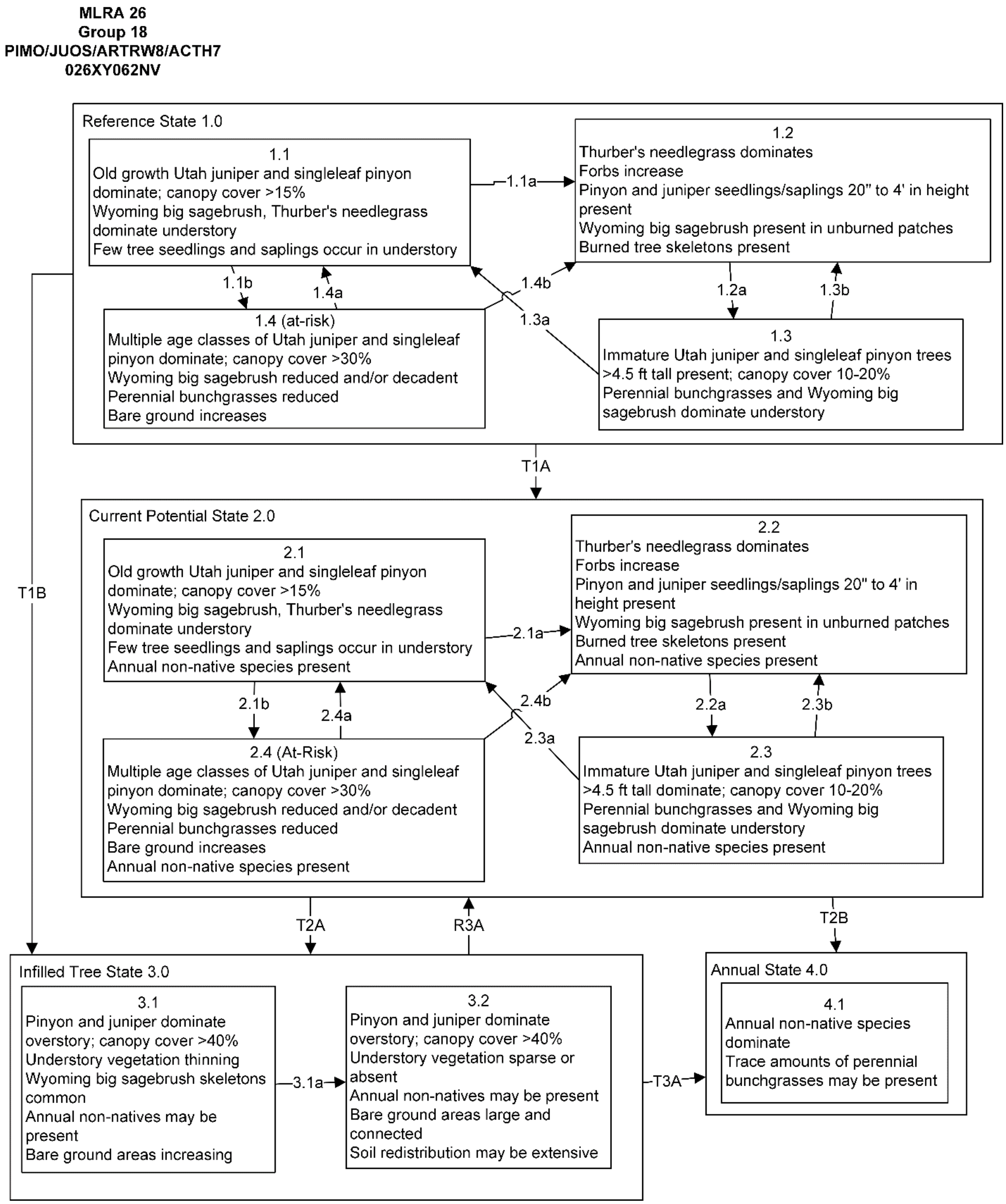
JUOS/ARAR8/ACTH7-POA (F026XY092NV):

This site is very similar to the modal site but with low sagebrush as the dominant shrub and a clay textured subsoil It occurs on plateaus and lower mountain sideslopes on all aspects with areas of rock outcrop or talus. It is at a slightly lower elevation of 4500 to 6000 feet. The site, in its reference state, has a much lower pinyon-juniper canopy overstory of 10 to 15 percent. It is less productive than the modal site with 150 lbs/ac in a normal year and has less precipitation at 8-12 inches per year.

PIMO/ARAR8/POFE-ACTH7 (F026XY093NV):

This site is very similar to the modal site but with low sagebrush as the dominant shrub and a clay textured subsoil The dominant grass is mutton grass and Sandberg’s bluegrass is subdominant. It occurs on lower mountain summits and sideslopes, typically associated with rock outcrops The site, in its reference state, has a much lower pinyon-juniper canopy overstory of 10 to 15 percent. It has the same amount of production as the modal site with 300 lbs/ac in a normal year and has more precipitation at 10 to 14 inches per year.

Modal State and Transition Model for MLRA 26 Group 18:



MLRA 26
Group 18
PIMO/JUOS/ARTRW8/ACTH7
026XY062NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

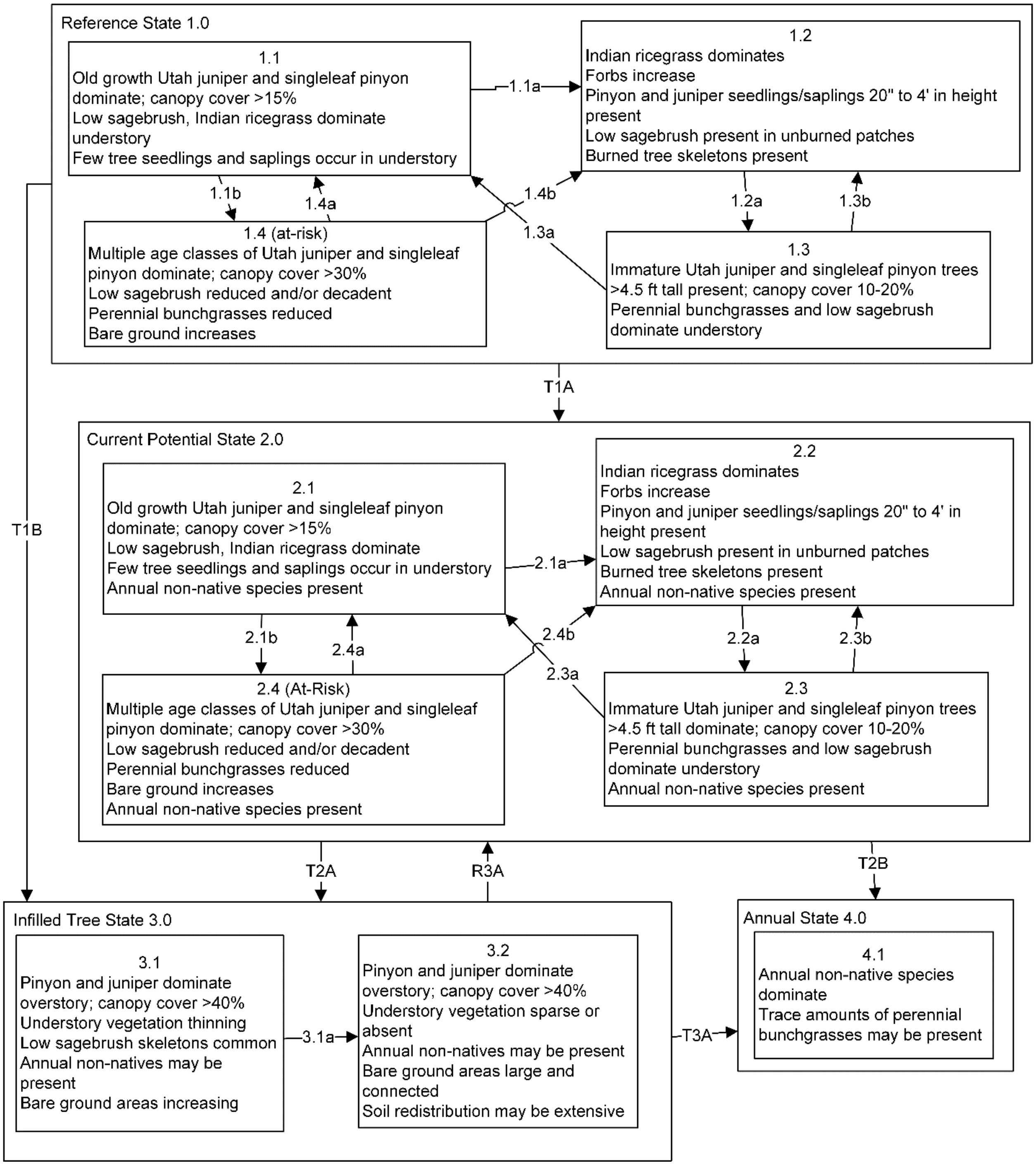
Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

Additional State and Transition Models for MLRA 26 Group 18:

MLRA 26
Group 18
PIMO-JUOS/ARAR8-PUTR2/ACTH7
F026XY064NV



MLRA 26
Group 18
PIMO-JUOS/ARAR8-PUTR2/ACTH7
F026XY064NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

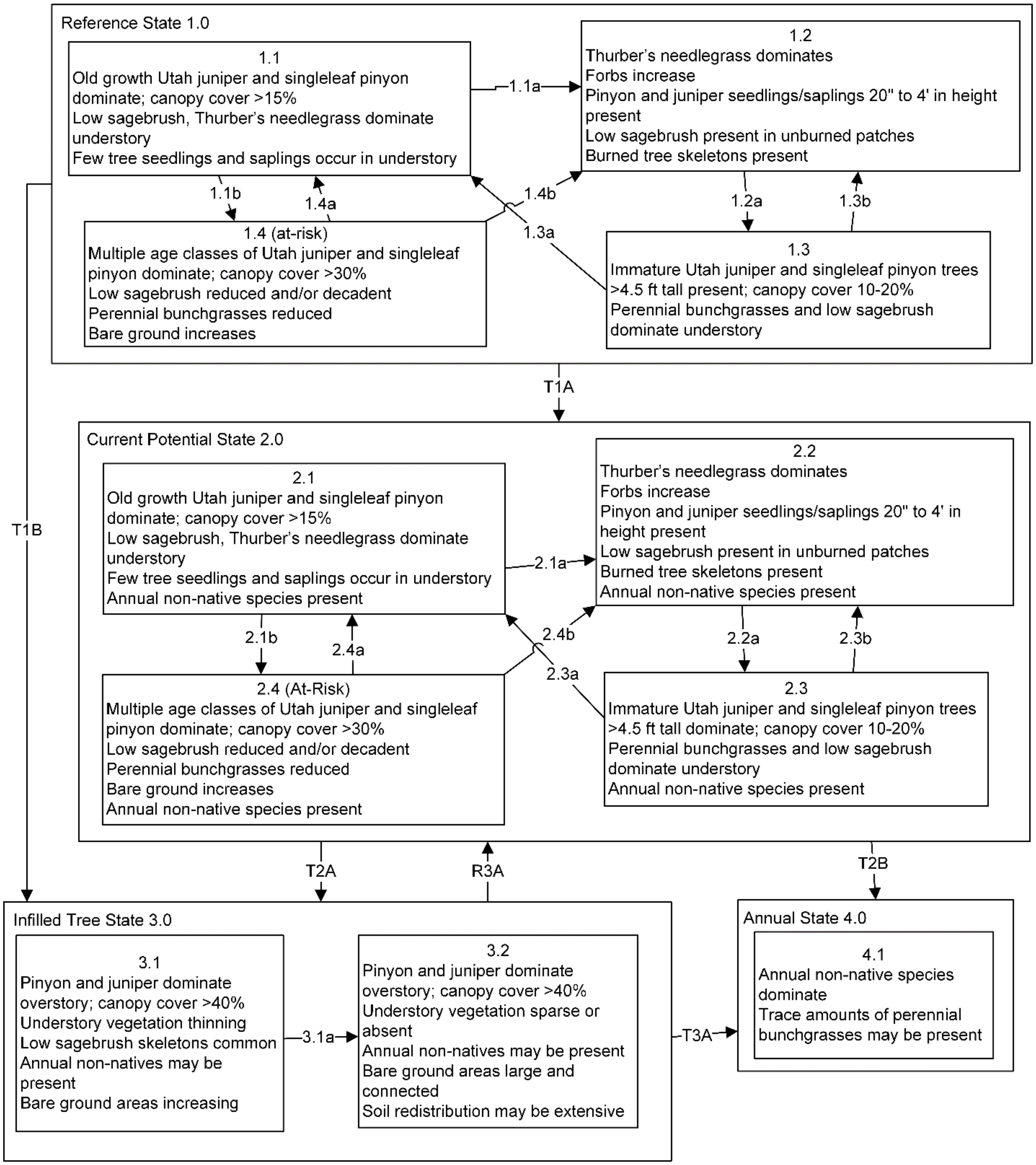
Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

MLRA 26
Group 18
JUOS/ARAR8/ACTH7-POA
F026XY092NV



MLRA 26
Group 18
JUOS/ARAR8/ACTH7-POA
F026XY092NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

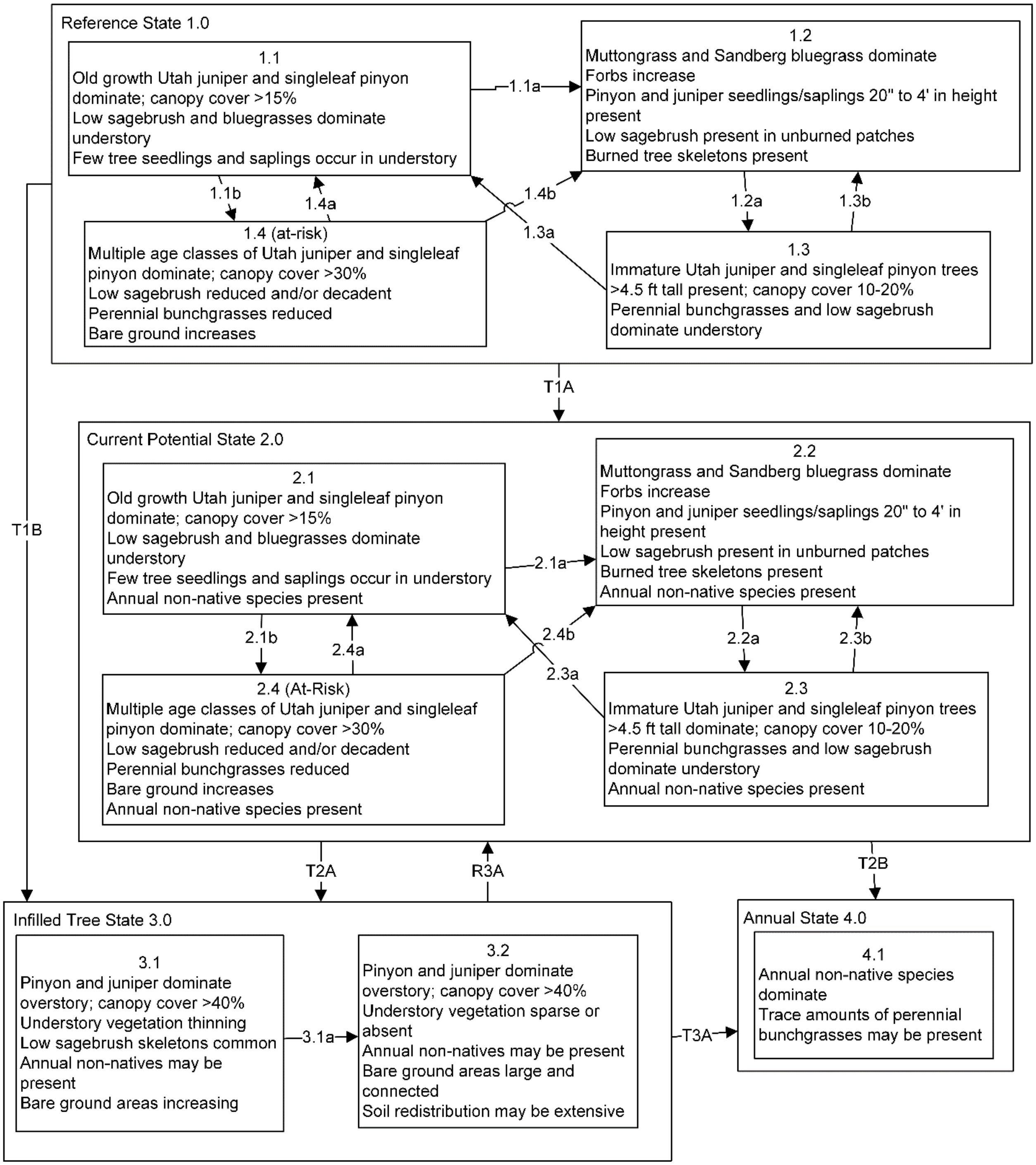
Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

MLRA 26
Group 18
PIMO/ARAR8/POFE-ACTH7
F026XY093NV



MLRA 26
Group 18
PIMO/ARAR8/POFE-ACTH7
F026XY093NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

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MLRA 26 Group 19: Singleleaf pinyon with a needlegrass understory

Description of MLRA 26 Disturbance Response Group 19:

Disturbance Response Group (DRG) 19 consists of six ecological sites. This group receives 10 to 14 inches of precipitation each year. Elevations range from 5,000 to 9,000 while slopes range from 15 to 75 percent. The soils are typically shallow to moderately deep and well drained and the water holding capacity is low to moderate. The soils are generally skeletal with 35 to 50 percent gravels, cobbles, or stones, by volume, distributed throughout the soil profile. This group is dominated by singleleaf pinyon (*Pinus monophylla*) with mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) as the primary understory shrub. Utah juniper (*Juniperus osteosperma*) and curl-leaf mountain mahogany (*Cercocarpus ledifolius*) are minor components. Other subdominant shrubs in the group include Wyoming big sagebrush *(Artemisia tridentata* ssp. *wyomingensis)* and antelope bitterbrush *(Purshia tridentata)*. The dominant understory grass is Thurber's needlegrass (*Achnatherum thurberianum) or* desert needlegrass *(Achnatherum speciosum)*. Other grasses in the group include muttongrass (*Poa fendleriana*) and prairie junegrass *(Koeleria macrantha)*. Under medium canopy cover (20 – 30 percent), understory production ranges from 200 to 450 pounds per acre in a normal year.

Disturbance Response Group 19 Ecological Sites:

PIMO WSG: 0R0601 – Modal Site	PIMO/ARTRV/ACTH7	F026XY060NV
PIMO WSG: 1R0601	PIMO/ARTRV/POFE-ACTH7	F026XY044NV
PIMO WSG: 0R0602	PIMO/ARTRV/ACSP12-ACTH7	F026XY061NV
PIMO WSG: 0R0601	PIMO/ARTRV/POFE	F026XY069NV
PIMO WSG: 1R1	PIMO/ARTRV/ACSP12	F026XY104NV
PIMO WSG: 1R0601	PIMO/ARTRV/POFE	F026XY071NV

Modal Site:

The forest ecological site dominated by pinyon pine, mountain big sagebrush, and Thurber's needlegrass (F026XY060NV) is the modal site chosen to represent this group as it has the most acres mapped. This woodland site occurs on mountain sideslopes on all aspects. Slopes range from 15 to over 75 percent, but are typically 30 to 50 percent. Elevations are 5,000 to 8,000 feet. Average annual precipitation is 10 to 14 inches. Soils are very shallow to shallow and well drained. Some soils are skeletal, with 35 to over 50 percent gravels, cobbles or stones by volume, distributed throughout the profile. Available water holding capacity is low, but trees and shrubs extend their roots into fractures in the bedrock allowing them to utilize deep moisture. High amounts of rock fragments are present at the soil surface, occupying plant growing space, yet helping to reduce evaporation and conserve soil moisture. Coarse fragments on the surface provide a stabilizing effect on surface erosion conditions. Runoff is rapid and potential for sheet and rill erosion is moderate to high depending on slope.

This site is dominated by singleleaf pinyon. An overstory canopy of 20 to 35 percent is assumed to be representative of tree dominance in the Reference State. However, current research indicates a canopy cover of 10 to 20% is likely more appropriate to represent this site condition in pre-European contact condition (Miller et al. 2008). The tree canopy of this site may contain up to 15% Utah juniper. Mountain big sagebrush is the principal understory shrub. Other shrubs on the site include antelope bitterbrush and Wyoming big sagebrush. Thurber's needlegrass is the dominant understory grass. Other grasses on the site include desert needlegrass, muttongrass, and Sandberg's bluegrass *(Poa secunda).* Average understory production ranges from 200 to 500 lbs/ac under medium canopy cover (20 to 35 percent). Understory production includes the total annual production of all woody and herbaceous plants within 4½ feet of the ground surface.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2003). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Pinyon and juniper dominated plant communities in the cold desert of the Intermountain West occupy over 18 million ha (44.6 million ac) (Miller and Tausch 2001). In the mid to late 1900's, the number of pinyon and juniper trees establishing per decade began to increase compared to the previous several hundred years. The substantial increase in conifer establishment is attributed to a number of factors the most important being (1) cessation of the aboriginal burning (Tausch 1999), (2) change in climate with rising temperatures (Heyerdahl et al. 2006), (3) the reduced frequency of fire likely driven by the introduction of domestic livestock, (4) a decrease in wildfire frequency along with improved wildfire suppression efforts and (5) potentially increased CO_2 levels favoring woody plant establishment (Tausch 1999, Bunting 1994). Miller et al. (2008) found pre-settlement tree densities averaged 2 to 11 per acre in six woodlands studied across the Intermountain West. Current stand densities range from 80 to 358 trees/ac. In Utah, Nevada, and Oregon, trees establishing prior to 1860 accounted for only two percent or less of the total population of pinyon and juniper (Miller et al. 2008). The research strongly suggests that for over 200 years prior to settlement, woodlands in the Great Basin were relatively low density with limited rates of establishment (Miller et al. 2008, Miller and Tausch 2001). This evidence suggests that tree canopy cover of 10 to 25 percent may be more representative of these sites in pristine condition (USDA 1997). Increases in pinyon and juniper densities post-settlement were the result of both infill in mixed age tree communities and expansion into shrub-steppe communities. Pre-settlement trees accounted for less than two percent of the stands sampled in Nevada, Oregon and Utah (Miller et al. 2008, Miller and Tausch 2001, Miller et al. 1999). However, the proportion of old-growth can vary depending on disturbance regimes, soils and climate. Some ecological sites are capable of supporting persistent woodlands, likely due to specific soils and climate resulting in infrequent stand replacement disturbance regimes. In the Great Basin, old-growth trees have been found to typically grow on rocky shallow or sandy soils that support little understory vegetation to carry a fire (Holmes et al. 1986, Miller and Rose 1995, West et al. 1998, USDA 1997).

Singleleaf pinyon and Utah juniper are long-lived tree species with wide ecological amplitudes (Tausch et al 1981, Weisberg and Dongwook 2012, West et al 1998). Maximum ages of pinyon and juniper exceed 1000 years and stands with maximum age classes are only found on steep rocky slopes with no evidence of fire (West et al 1975). Singleleaf pinyon is slow-growing and very intolerant to shade with the exception of young plants, usually first year seedlings (Tueller and Clark 1975). Singleleaf pinyon seedling establishment is episodic. Population age structure is affected by drought, which reduces seedling and sapling recruitment more than other age classes. The ecotones between singleleaf pinyon woodlands and adjacent shrublands and grasslands provide favorable microhabitats for singleleaf pinyon seedling establishment since they are active zones for seed dispersal, nurse plants are available, and singleleaf pinyon seedlings are only affected by competition from grass and other herbaceous vegetation for a couple of years.

The pinyon jay (*Gymnorhinus cyanocephalus)* and other members of the seed caching corvids play an important role in pinyon pine regeneration. These birds cache the seeds in the soil for future use. Those seeds that escape harvesting by the birds and rodents have the opportunity to germinate under favorable soil and climatic conditions (Lanner 1981). A mutualistic relationship exists between the trees that produce food and the animals that disperse the seeds, thereby insuring perpetuation of the trees. Large crops of seeds may stimulate reproduction in birds, especially the pinyon jay (Ligon 1974).

Pinyon and juniper growth is dependent mostly upon soil moisture stored from winter precipitation, mainly snow. Much of the summer precipitation is ineffective, being lost in runoff after summer convection storms or by evaporation and interception (Tueller and Clark 1975). Pinyon and juniper are highly resistant to drought which is common in the Great Basin. Tap roots of pinyon and juniper have a relatively rapid rate of root elongation and are thus able to persist until precipitation conditions are more favorable (Emerson 1932).

Infilling by younger trees increases canopy cover and causes a decline in understory perennial vegetation because of increased competition for water and sunlight. There is also some evidence that phenolic compounds in juniper litter may have allelopathic effects on grass (Jameson 1970). Infilling shifts stand level biomass from ground fuels to canopy fuels, which has the potential to significantly impact fire behavior. The more tree-dominated pinyon and juniper woodlands become, the less likely they are to burn under moderate conditions, resulting in infrequent high intensity fires (Gruell 1999, Miller et al. 2008). As the understory vegetation declines in vigor, the ability of native perennial plants to recover after fire is reduced (Urza et al. 2017). The increase in bare ground allows for the invasion of non-native annual species such as cheatgrass (*Bromus tectorum*), and with intensive wildfire, the potential for conversion to annual exotics is a serious threat (Tausch 1999, Miller et al. 2008).

Specific successional pathways after disturbance in pinyon-juniper stands are dependent on a number of variables, such as plant species present at the time of disturbance and their individual responses to disturbance, past management, type and size of disturbance, available seed sources in the soil or adjacent areas, and site and climatic conditions throughout the successional process.

There are several insects, fungi, mosses, and mistletoe that affect singleleaf pinyon and/or juniper. The impacts of diseases and pests are moderated by factors including ecological site characteristics, drought, and tree density (Greenwood and Weisberg 2008, Miller et al. 2019).

Hepting (1971) and Miller et al. (2019) list several diseases affecting pinyon including: foliage diseases, a tarspot needle cast, stem diseases such as blister rust and dwarf mistletoe, root diseases and trunk rots, red heart rot, and but rot. Defoliation from native and nonnative insects is a primary driver of pinyon damage. The pinyon ips beetle *(Ips confuses*) and pinyon needle scale (*Matsucoccus acalyptus*) are both native insects to Nevada that attack pinyon pines throughout their range. Pinyon needle scale weakens trees by killing two-year-old needles. Heavy defoliations reduce growth and sometimes cause mortality; outbreaks can affect several thousand acres at a time (Phillips 2020). The pinyon ips beetle typically kills weak and damaged trees (Phillips 2014). Dwarf mistletoe (*Phorandendron* spp.) a parasitic plant, affects both pinyon and juniper. While mistletoe may not kill the trees, it weakens the trees and makes them susceptible to other diseases and pests (Christopherson 2014, Phillips 2020).

Utah juniper can be killed by a fungus called Juniper Pocket Rot (*Pyrofomes demidoffi*), also known as white truck rot (Eddleman et al. 1994 and Durham 2014). Pocket rot enters the tree through any wound or opening that exposes the heartwood. In an advanced stage, this fungus can cause high mortality (Durham 2014). Other diseases affecting juniper are: dwarf mistletoe (*Arceuthobium* spp.) that may weaken trees; leaf rust (*Gymnosporangium* sp.) on leaves and young branches; and juniper blight (*Phomopsis* sp.). Flat-head borers (*Chrysobothris* sp.) attack the wood; long-horned beetles (*Methia juniper*, *Styloxus bicolor*) girdle limbs and twigs; and round-head borers (*Callidium* spp.) attack twigs and limbs (Tueller and Clark 1975).

In the Great Basin, the majority of annual precipitation is received during the winter and early spring. This continental semiarid climate regime favors growth and development of deep-rooted shrubs and herbaceous cool season plants using the C3 photosynthetic pathway (Comstock and Ehleringer 1992). Winter precipitation and slow melting of snow results in deeper percolation of moisture into the soil profile. Herbaceous plants, more shallow-rooted than shrubs, grow earlier in the growing season and thrive on spring rains, while the deeper rooted shrubs lag in phenological development because they draw from deeply infiltrating moisture from snowmelt the previous winter. Periodic drought regularly influences sagebrush ecosystems and drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

The ecological sites in this DRG are dominated by deep-rooted, cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Dobrowolski et al. 1990).

Mountain big sagebrush and antelope bitterbrush are generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions. Antelope bitterbrush is most commonly found on soils which provide minimal restriction to deep root penetration such as coarse textured soil, or finer textured soil with high stone content (Driscoll 1964, Clements and Young 2002).

The perennial bunchgrasses that are co-dominant with shrubs in this group generally have shallower root systems than the shrubs. Root densities are often as high as or higher than those of shrubs in the upper 0.5 m but taper off more rapidly than shrubs. Differences in root depth distributions between grasses and shrubs result in resource partitioning in these shrub/grass systems.

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. Four possible alternative stable states have been identified for this DRG.

Invasive Annual Grasses:

The species most likely to invade these sites is cheatgrass, however the sandy surface decreases the probability of cheatgrass dominance. Cheatgrass is a cool season annual grass that maintains an advantage over native plants in part because it is a prolific seed producer, can germinate in the autumn or spring, tolerates grazing, and increases with frequent fire (Klemmedson and Smith 1964, Miller et al. 1999). Cheatgrass originated from Eurasia and was first reported in North America in the late 1800s (Mack and Pyke 1983, Furbush 1953). Pellant and Hall (1994) found 3.3 million acres of public lands dominated by cheatgrass and suggested that another 76 million acres were susceptible to invasion by winter annuals including cheatgrass and medusahead. Bradley and Mustard (2005) utilized Landsat and Advanced Very High Resolution Radiometer to estimate the areal extent of cheatgrass dominance in the Great Basin. Their results suggest cheatgrass dominated over 4.9 million acres in 2005. In addition, they found cheatgrass was 26percent more likely to be found within 450 feet of areas occupied by cheatgrass in 1973, with cultivation, power lines and roads identified as primary vectors of spread (Bradley and Mustard 2006).

Recent modeling and empirical work by Bradford and Lauenroth (2006) suggests that seasonal patterns of precipitation input and temperature are also key factors determining regional variation in the growth, seed production, and spread of invasive annual grasses. The phenomenon of cheatgrass “die-off” provides opportunities for restoration of perennial and native species (Baughman et al. 2016, Baughman et al. 2017). The causes of these events are not fully understood, but there is ongoing work to try to predict where they occur, in the hopes of aiding conservation planning (Weisberg et al. 2017, Brehm 2019).

Methods to control cheatgrass include herbicide, fire, targeted grazing, and seeding. Mapping potential or current invasion vectors is a management method designed to increase the cost effectiveness of control methods. Spraying with herbicide (Imazapic or Imazapic + glyphosate) and seeding with crested wheatgrass and Sandberg bluegrass has been found to be more successful at combating cheatgrass (and medusahead) than spraying alone (Sheley et al. 2012). To date, most seeding success has occurred with non-native wheatgrass species. Perennial grasses, especially crested wheatgrass, are able to suppress cheatgrass growth when mature (Blank et al. 2020). Where native bunchgrasses are missing from the site, revegetation of annual grass invaded rangelands has been shown to have a higher likelihood of success when using introduced perennial bunchgrasses such as crested wheatgrass (Clements et al. 2017, Davies et al. 2015). Butler et al. (2011) tested four herbicides (Imazapic, Imazapic + glyphosate, rimsulfuron, and sulfometuron + Chlorsulfuron) for suppression of cheatgrass, medusahead and ventenata (North Africa grass, *Ventenata dubia*) within residual stands of native bunchgrass. Additionally, they tested the same four herbicides followed by seeding of six bunchgrasses (native and non-native) with varying success (Butler et al. 2011). Herbicide-only treatments appeared to remove competition for established bluebunch wheatgrass by providing 100% control of ventenata and medusahead and greater than 95% control of cheatgrass (Butler et al. 2011). Caution in using these results is advised, as only one year of data was reported.

In considering the combination of pre-emergent herbicide and prescribed fire for invasive annual grass control, it is important to assess the tolerance of desirable brush species to the herbicide being applied. Vollmer and Vollmer (2008) tested the tolerance of mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush, and multiple sagebrush species to three rates of Imazapic with and without methylated seed oil as a surfactant. They found a cheatgrass control program in an antelope bitterbrush community should not exceed Imazapic at 8 oz./ac with or without surfactant. Sagebrush, regardless of species or rate of application, was not affected. However, many environmental variables were not reported in this study and managers should install test plots before broad scale herbicide application is initiated.

Fire Ecology:

Large fires were and continue to be rare on this site due to large interspaces and low levels of fine fuels (Miller and Heyerdahl 2008). Lightning-ignited fires were likely common but typically did not affect more than a few individual trees. Replacement fires were uncommon to rare (100-600 years) and occurred primarily during extreme fire behavior conditions. Spreading, low-intensity surface fires had a very limited role in molding stand structure and dynamics (Miller at al. 2019). Surface spread was more likely to occur in more productive areas with moderately deep to deep soils, which favors the dominance of herbaceous vegetation and sagebrush (Miller and Heyerdahl 2008, Romme et al. 2009, Miller et al. 2019). The open structure of woodlands is the result of limited seedling establishment, natural thinning processes such as drought and pests, or competition from herbaceous vegetation (Miller et al. 2019). Pre-settlement fire return intervals in the Great Basin National Park, Nevada were found to have a mean range between 50 to 100 years with north-facing slopes burning every 15 to 20 years and rocky landscapes with sparse understory very infrequently (Gruell 1999). Woodland dynamics are largely attributed to long-term climatic shifts (temperature, amounts and distribution of precipitation) and the extent and return intervals of fire (Miller and Tausch 2001, Miller et al. 2019). Limited data exists that describes fire histories across woodlands in the Great Basin. Both the infilling of younger trees into old-growth stands and the expansion of trees into surrounding sagebrush communities has increased the risk of loss of pre-settlement trees through the increased landscape level continuity of fuels (Miller et al. 2008).

Utah juniper is usually killed by fire, and is most vulnerable to fire when it is under four feet tall (Bradley et al. 1992). Larger trees, because they have foliage farther from the ground and thicker bark, can survive low severity fires but mortality does occur when 60% or more of the crown is scorched (Bradley et al. 1992). Singleleaf pinyons are also most vulnerable to fire when less than four feet tall, however mature trees do not self-prune their dead branches allowing for accumulated fuel in the crowns. This characteristic and the relative flammability of the foliage make individual mature trees susceptible to fire (Bradley et al. 1992). With the low production of the understory vegetation and low density of trees per acre, high severity fires within this plant community were not likely and rarely became crown fires (Bradley et al. 1992, Miller and Tausch 2001).

Singleleaf pinyon and juniper reestablish by seed from nearby seed sources or surviving seeds. Junipers have a long-lived seed bank due to delayed germination by impermeable seed coats, immature or dormant embryos and germination inhibitors (Chambers et al. 1999). Singleleaf pinyon trees have relatively short-lived seeds with little innate dormancy that form only temporary seed banks with most seeds germinating the spring following dispersal (Meewig and Bassett 1983). Density of pinyon seeds in the seed bank is dependent upon the current year's cone crop. Singleleaf pinyon are known to have favorable cone production every two to three years thus the potential for a large temporary seed bank is high during mast years and likely low during non-mast years (Chambers et al. 1999). The role of nurse plant requirements between the two tree species is important to post-fire establishment. Chambers et al. (1999) found that singleleaf pinyon seedlings rarely establish in interspaces or open environments. In contrast, Utah juniper seedlings were found capable of establishing in interspace microhabitats as frequently as under sagebrush. Therefore, fire that removes both trees and understory shrubs in pinyon-juniper woodlands may have a relatively greater effect on the establishment of pinyon than juniper.

Initial response of native understory species following fire correlates closely with percent crown cover. In general, research indicates that understory response to disturbance is most productive when crown cover is at or below 20% while beyond 30% there is a rapid decline in understory species and soil seed reserves (Huber et al. 1999).

Infilling shifts stand level biomass from ground fuels to canopy fuels, which has the potential to significantly impact fire behavior. The more tree-dominated pinyon and juniper woodlands become, the less likely they are to burn under moderate conditions, resulting in infrequent high intensity fires (Gruell 1997, Miller et al. 2008). As the understory vegetation declines in vigor, the ability of native perennial plants to recover after fire is reduced (Urza et al. 2017). The increase in bare ground allows for the invasion of non-native annual species such as cheatgrass (*Bromus tectorum*), and with intensive wildfire, the potential for conversion to annual exotics is a serious threat (Tausch 1999, Miller et al. 2008).

Mountain big sagebrush is killed by fire (Neuenschwander 1980, Blaisdell et al. 1982), and does not resprout (Blaisdell 1953). Post fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and may reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). Mountain big sagebrush may return to pre-burn density and cover within 15-20 years following fire, but establishment after severe fires may proceed more slowly and can take up to 50 years (Bunting et al. 1987, Ziegenhagen 2003, Miller and Heyerdahl 2008, Ziegenhagen and Miller and Rose 2009). The introduction of annual weedy species, like cheatgrass (*Bromus tectorum*) may cause an increase in fire frequency and eventually lead to an annual dominated community. Conversely, without fire, big sagebrush will increase and the potential for re-establishment of pinyon and juniper also increases. Without fire or changes in management, pinyon and juniper will dominate the site and mountain big sagebrush will be severely reduced. The herbaceous understory will also be reduced; however, muttongrass and Sandberg bluegrass may be found in trace amounts. The potential for soil erosion increases as the juniper woodland matures and the understory plant community cover declines. Catastrophic wildfire in pinyon-juniper controlled sites may lead to an annual weed dominated state.

Antelope bitterbrush is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires may allow for bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006). If cheatgrass is present, bitterbrush seedling success is much lower. The factor that most limits establishment of bitterbrush seedlings is competition for water resources with cheatgrass (Clements and Young 2002).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). However, season and severity of the fire will influence plant response. Plant response will vary depending on post-fire soil moisture availability.

Thurber's needlegrass is moderately resistant to wildfire (Smith and Busby 1981), but can be severely damaged and have high mortality depending on season and severity of fire. Burning has been found to decrease the vegetative and reproductive vigor of Thurber's needlegrass (Uresk et al. 1976). Fire can cause high mortality, in addition to reducing basal area and yield of Thurber's needlegrass (Britton et al. 1990). The fine leaves and densely tufted growth form make this grass susceptible to subsurface charring of the crowns (Wright and Klemmedson 1965). Although timing of fire highly influenced the response and mortality of Thurber's needlegrass, smaller bunch sizes were less likely to be damaged by fire (Wright and Klemmedson 1965). Thurber's needlegrass often survives fire and will continue growth or regenerate from tillers when conditions are favorable (Koniak 1985, Britton et al. 1990). Post-fire regeneration usually occurs from seed thus reestablishment has been found to be relatively slow due to low germination and competitive ability (Koniak 1985). Cheatgrass has been found to be a highly successful competitor with seedlings of this needlegrass and may preclude reestablishment (Evans and Young 1978).

Desert needlegrass may increase after burning. In a summation of 13 studies, Abella (2009) found that desert needlegrass increased in abundance (derived from cover, density, or frequency depending on the source of publication) on burned to unburned sites. Thatcher and Hart (1974) observed an increase in desert needlegrass in areas which appeared to have burned on a relict site, however they attributed this to soil type rather than species response. Muttongrass is top-killed by fire but will resprout after low to moderate severity fires. A study by Vose and White (1991) in an open saw timber site found minimal difference in overall effect of burning on mutton grass.

Sandberg bluegrass, a minor component of this group, has been found to increase following fire likely due to its low stature and productivity (Daubenmire 1975). Sandberg bluegrass may retard reestablishment of deeper rooted bunchgrasses.

Livestock/Wildlife Grazing Interpretations:

The history of livestock grazing in the pinyon-juniper ecosystem goes back to more than 200 years, depending on the particular locality within the ecosystem (Hurst 1975). Historically, pinyon-juniper woodlands were much more open and supported a diverse understory that provided forage for both livestock and wildlife. Historic livestock overuse of fine fuels and increased stand densities have reduced the carrying capacity of these pinyon-juniper stands and many current stands only provide shade and shelter for livestock and wildlife.

Pinyon-juniper woodlands provide a diversity of habitat for wildlife. Although the foliage of pinyon and juniper varies in palatability among fauna, the pinyon nuts and juniper berries are preferred by many species. The understory species provide fruits and browse for large ungulates, small mammals, birds and beaver (Wildlife Action Plan Team 2012).

Ungulates will use pinyon and juniper trees for cover and graze the foliage. The understory species also provide critical browse for deer. The trees provide important cover for mule deer (*Odocoileus heminous*), elk (*Cervus canadensis)* wild horses, mountain lion (*Puma concolor*), bobcat (*Lynx rufus*) and pronghorn (*Antilocapra americana*) (Gottfried and Severson 1994, Coates and Schemnitz 1994, Logan and Irwin 1985, Evans 1988).

Mule deer depend heavily on these woodlands for cover, shelter, and emergency forage during severe winters (Frischknecht 1975). Mule deer will eat singleleaf pinyon and juniper foliage, using the foliage moderately in winter, spring, and summer (Kufeld et al. 1973). Deep snows in higher elevation forest zones force mule deer and elk down into pinyon-juniper habitats during winter. This change in habitat allows mule deer and elk to browse the dwarf trees and shrubs (Gottfried and Severson 1994).

The diet of pronghorn antelope varies considerably; however, singleleaf pinyon was shown to comprise 1 to 2 percent of winter diet of pronghorn antelope that occur in pinyon-juniper habitat. Desert bighorn sheep (*Ovis nelson*) may utilize pinyon-juniper habitat, but only where the terrain is rocky and steep (Gottfried et al. 2000). Gray foxes, bobcats (*Lynx rufus*), coyotes (*Canis latran*s), weasels (*Mustela frenata*), skunks (*Mephitis* spp.), badgers (*Taxidea taxus*), and ringtail cats *(Bassariscus astutus*) search for prey in pinyon-juniper habitat woodlands (Short and McCulloch 1977).

Juniper "berries" or berry-cones are eaten by black-tailed jackrabbits, *Lepus californicus*, and coyotes (Gese et al. 1988, Kitchen et al. 2000). A study by Kitchen et al (1999) conducted in juniper-pinion habitat found vegetation in coyote scats was mainly grass seeds or juniper berries. Jackrabbits are a major dispenser of juniper seeds (Schupp et al. 1999). The pinyon mouse *(Peromyscus truei*) is a pinyon-juniper obligate and uses the woodlands for cover and food (Hoffmeister 1981). Other small mammals include the porcupine (*Hystricomorph hystricidae*), desert cottontail (*Sylvilagus audubonii*), Nuttall's cottontail (*S. nuttallii*), deer mouse (*Peromyscus maniculatus*), Great Basin pocket mouse (*Perognathus parvus*), chisel-toothed kangaroo rat (*Dipodomys microps*) and desert woodrat (*Neotoma lepida*) (Turkowski and Watkins 1976).

Many bird species are associated with the pinyon-juniper habitat; some are permanent residents, some summer residents, and some winter residents, depending upon location. For birds and bats, the woodland provides structure for nesting and roosting, and locations for foraging. Singleleaf pinyon provides a number of cavities and the stringy, fibrous bark provides quality nesting material as well as the food provided by the tree's seeds and berries (Short and McCulloch 1977). Many bird species depend on juniper berry-cones and pine nuts for fall and winter food (Balda and Masters 1980). Several bird species are obligates including (gray flycatcher (*Epidonax wrightii)* scrub jay (*Aphelocoma californica)*, plain titmouse (*Parus inornatus ridgwayi*), and gray vireo (*Vireo vicinior)* and several species are semi-obligates including black-chinned hummingbird (*Archilochus alexandri*), ash-throated flycatcher (*Myiarchus cinerascens*), pinion jay (*Gymnorhinus cyanocephalus*), American bushtit (*Psaltriparus* *minimus*), Bewick's wren (*Thryomanes bewickii*), Northern mockingbird (*Mimus polyglottos*), blue-gray gnatcatcher (*Polioptila caerulea*), black-throated gray warbler (*Dendroica nigrescens*), house finch (*Haemorhous mexicanus*), spotted towhee (*Pipilo maculatus*), lark sparrow (*Chondestes grammacus*) and black-chinned sparrow (*Zonotrichia atricapilla)* (Balda and Masters 1980). Ferruginous hawk (*Buteo regalis*), a conservation priority species due to recent population declines in Nevada, nest in older trees of sufficient size and structure to support their large nest platforms. (Holechek 1981).

Diurnal reptiles include the sagebrush swift (*Sceloporus graciosus)*, the blue-bellied lizard (*Sceloporus elongates)* the western collard lizard, the Great Basin rattlesnake, the Great Basin gopher snake (*Pituophis catenifer*) and horned lizard, also occur in Utah juniper habitat (Frischknecht 1975). However, the distribution of most of herpetofauna present in pinyon-juniper woodlands is poorly understood and more research and management are needed.

Inappropriate grazing management during the growing season, for multiple years, will cause a decline in understory plants such as Thurber's needlegrass. Thurber's needlegrass is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds are apparently not injurious, grazing animals avoid them when they begin to mature. Sheep, however, have been observed to graze the leaves closely, leaving stems untouched (Eckert and Spencer 1987). Heavy grazing during the growing season has been shown to reduce the basal area of Thurber's needlegrass (Eckert and Spencer 1987), suggesting that both seasonality and utilization are important factors in management of this plant. A single defoliation, particularly during the boot stage, was found to reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988). Thurber's needlegrass may increase in crude protein content after grazing (Dave Ganskopp et al 2007).

Desert needlegrass is a compact bunchgrass with considerable basal leafage. The young herbage is palatable to all classes of livestock. When mature the fine basal leaves, intermingled with the coarse stems and flowering stalks, are grazed some by cattle and horses, but little by sheep (Sampson et al. 1951). Desert needlegrass is palatable to wildlife such as bighorn sheep and feral burros when young. Desert needlegrass tolerates light grazing but overgrazing may eliminate it from an ecological site. It is best to graze it before seed develops because the seed has a sharp callus that can injure the eyes and mouths of grazing animals (Perkins and Ogle 2008).

Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass, mat forming forbs and/or cheatgrass and other invasive species to occupy interspaces. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often dominates (Daubenmire 1970). Thus, depending on the season of use, the grazer and site conditions, either Sandberg bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management. Field surveys indicate native, mat-forming forbs may also increase with decreased bunchgrass density.

Mountain big sagebrush is a relatively palatable shrub. Fecal samples from ungulates in Montana showed that big horn sheep, mule deer, and elk all consumed mountain big sagebrush in small amounts in winter, while cattle had no sign of sagebrush use. D. P. Sheehy and A. Winward (1981) studied preferences of mule deer and sheep in a controlled experiment: several different varieties of sagebrush (basin big sagebrush, black sagebrush, bolander silver sagebrush, foothill big sagebrush, low sagebrush, mountain big sagebrush, wyoming big sagebrush) were brought into a pen and the animals preferences were measured. Deer showed the most preference for low sagebrush, mountain and foothill sagebrush, and Bolander silver sagebrush and least preference for black sagebrush. Sheep showed highest preference for low sagebrush, medium preference for black sagebrush, and least preference for Wyoming and basin big sagebrush. In a study by Personius et al (1987), mountain big sagebrush was the most preferred taxon by mule deer.

Antelope bitterbrush is critical browse for mule deer (*Odocoileus heminous*), as well as domestic livestock, pronghorn (*Antilocapra americana*), and elk (*Cervus canadensis)* (M. K. Wood, Bruce A. Buchanan, & William Skeet, 1995). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison, 1953). Cattle tend to graze bitterbrush in higher areas than sheep or deer and take off newer twig growth, keeping them shorter. Palatability varies between plants and stages of growth, degree of use, and location. Columbian black-tailed deer and antelope usually graze it in the spring and summer, mule deer in the winter, and livestock in the summer. It is rather shade intolerant (Hormay, 1943). Antelope bitterbrush initiates growth in the spring and finishes by late summer. It grows large ephemeral leaves in the spring and then small overwintering leaves in the late summer. Antelope bitterbrush recovers vigorously with new growth after defoliation from grazing, and potential growth remains the same or is enhanced by browsing. Antelope bitterbrush will allocate additional resources to new growth to recover from browsing (Bilbrough and Richards 1993).

State and Transition Model Narrative for Group 19:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 disturbance response group 19.

Reference State 1.0:

The Reference State 1.0 is representative of the natural range of variability under pristine conditions. This Reference State has four general community phases: an old-growth woodland phase, a shrub-herbaceous phase, an immature tree phase, and an infilled tree phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic long-term drought, and/or insect or disease attack. Fires are typically small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community Phase 1.1:
This phase is characterized by widely dispersed old-growth singleleaf pinyon trees with an understory of mountain big sagebrush and perennial bunchgrasses. The visual aspect is dominated by singleleaf pinyon with 15 percent or greater canopy cover (USDA-NRCS 1988, USDA 1997). Utah juniper may be present. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Thurber's needlegrass and bluegrasses are the most prevalent grasses in the understory. Mountain big sagebrush is the primary understory shrub. Forbs such as arrowleaf balsamroot (*Balsamorhiza sagittat*a) and tapertip hawksbeard (*Crepis acuminata*) are minor components. Utah juniper may be present.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.4:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual infilling of singleleaf pinyon.

Community Phase 1.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass, bluegrasses, and other perennial grasses dominate. Thurber's needlegrass can experience high mortality from fire and may be reduced in the community for several years. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Singleleaf pinyon seedlings up to 4 feet in height may be present. Mountain big sagebrush may be present in unburned patches. Burned tree skeletons may be present; however, these have little or no effect on the understory vegetation.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.3:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of the singleleaf pinyon component. Mountain big sagebrush reestablishes. Excessive herbivory may also reduce perennial grass understory.

Community Phase 1.3
This community phase is characterized as an immature woodland with singleleaf pinyon trees averaging over 4.5 feet in height. Pinyon canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation consists of smaller tree seedling and saplings, as well as perennial bunchgrasses and sagebrush.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.2:
Fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.1:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of singleleaf pinyon. Excessive herbivory may also reduce perennial grass understory.

Community Phase 1.4 (at-risk):
This phase is dominated by singleleaf pinyon. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the mountain big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs may increase. Utah juniper may be present. This community is at risk of crossing a threshold; without proper management this phase will transition to the infilled woodland state 3.0. This community phase is typically described as early Phase II woodland (Miller et al. 2008).

Community Phase Pathway 1.4a, from Phase 1.4 to 1.1:
Low intensity fire, insect infestation, or disease kills individual trees within the stand reducing canopy cover to less than 35 percent. Over time young trees mature to replace and maintain the

old-growth woodland. The mountain big sagebrush and perennial bunchgrass community increases in density and vigor.

Community Phase Pathway 1.4b, from Phase 1.4 to 1.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: Introduction of non-native annual species.

Slow variables: Over time the annual non-native plants will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

T1B: Transition from Reference State 1.0 to Infilled Tree State 3.0:

Trigger: Time and a lack of disturbance allow trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Singleleaf pinyon canopy cover is greater than 50 percent. Little understory vegetation remains due to competition with trees for site resources.

Current Potential State 2.0:

This state is similar to the Reference State 1.0, with four general community phases: an old-growth woodland phase, a shrub-herbaceous phase, an immature tree phase, and an infilled tree phase. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of non-native species. These non-natives, particularly cheatgrass, can be highly flammable and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal. Fires within this community with the small amount of non-native annual species present are likely still small and patchy due to low fuel loads. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state.

Community Phase 2.1:
This phase is characterized by a widely dispersed old-growth singleleaf pinyon trees with an understory of mountain big sagebrush and perennial bunchgrasses. The visual aspect is dominated by singleleaf pinyon with 15 percent or greater canopy cover (USDA-NRCS 1988,

USDA 1997). Utah juniper may be present. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Thurber's needlegrass and bluegrasses are the most prevalent grasses in the understory. Mountain big sagebrush is the primary understory shrub. Forbs such as arrowleaf balsamroot and tapertip hawksbeard are minor components. Utah juniper may be present.

PIMO/ARTRV/ACTH7 (F026XY060NV) Phase 2.1, P. Novak-Echenique July 2017

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon overstory and the shrub component. This allows for the perennial bunchgrasses to dominate the site.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.4:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual infilling of singleleaf pinyon.

Community Phase 2.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Thurber's needlegrass, bluegrass, and other perennial grasses dominate. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Pinyon seedlings up to 4.5 feet in height may be present. Mountain big sagebrush may be present in unburned patches. Burned tree skeletons may be present; however, these have little or no effect on the understory vegetation. Annual non-native species generally respond well after fire and may be stable or increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.3:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of the singleleaf pinyon component. Mountain big sagebrush reestablishes. Excessive herbivory may also reduce perennial grass understory.

Community Phase 2.3:
This community phase is characterized by an immature woodland, with singleleaf pinyon trees averaging over 4.5 feet in height. Tree canopy cover is between 10 to 20 percent. Tree crowns are typically cone- or pyramidal-shaped. Understory vegetation consists of smaller tree seedling

and saplings, as well as perennial bunchgrasses and shrubs. Annual non-native species are present.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.2:
Fire reduces or eliminates tree canopy, allowing perennial grasses to dominate the site.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.1:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of singleleaf pinyon. Excessive herbivory may also reduce the perennial grass understory.

Community Phase 2.4 (at-risk):
This phase is dominated by singleleaf pinyon and Utah juniper may be present. The stand exhibits mixed age classes and canopy cover exceeds 30 percent. The density and vigor of the mountain big sagebrush and perennial bunchgrass understory is decreased. Bare ground areas are likely to increase. Mat-forming forbs may increase. Annual non-native species are present primarily under tree canopies. Utah juniper may be present. This community is at risk of crossing a threshold, without proper management this phase will transition to the Infilled Tree State 3.0. This community phase is typically described as early Phase II woodland (Miller et al. 2008).

Community Phase Pathway 2.4a, from Phase 2.4 to 2.1:
Low intensity fire, insect infestation, or disease kills individual trees within the stand, reducing canopy cover to less than 35 percent. Over time young trees mature to replace and maintain the old-growth woodland. The mountain big sagebrush and perennial bunchgrass community increases in density and vigor. Annual non-natives present in trace amounts.

Community Phase Pathway 2.4b, from Phase 2.4 to 2.2:
A high-severity crown fire will eliminate or reduce the singleleaf pinyon overstory and the shrub component which will allow for the perennial bunchgrasses to dominate the site. Annual non-native grasses typically respond positively to fire and may increase in the post-fire community.

T2A: Transition from Current Potential State 2.0 to Infilled Tree State 3.0:

Trigger: Time and a lack of disturbance allow trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Pinyon canopy cover is greater than 30%. Little understory vegetation remains due to competition with trees for site resources.

T2B: Transition from Current Potential State 2.0 to Annual State 4.0:

Trigger: Catastrophic crown fire facilitates the establishment of non-native, annual weeds.

Slow variables: Increase in tree crown cover, loss of perennial understory and an increase in annual non-native species.

Threshold: Cheatgrass or other non-native annuals dominate understory. Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter. Increased canopy cover of trees allows severe stand-replacing fire. The increased seed bank of non-native, annual species responds positively to post-fire conditions facilitating the transition to an Annual State.

Infilled Tree State 3.0:

This state has two community phases that are characterized by the dominance of singleleaf pinyon in the overstory. This state is identifiable by greater than 50 percent cover of singleleaf pinyon and a mixed age class. Older trees are at maximal height and upper crowns may be flat-topped or rounded. Younger trees are typically cone- or pyramidal-shaped. Understory vegetation is sparse due to increasing shade and competition from trees.

Community Phase 3.1:
Singleleaf pinyon dominates the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and mountain big sagebrush skeletons are as common as live shrubs due to tree competition for soil water, overstory shading, and duff accumulation. Tree canopy cover is greater than 50 percent. Utah juniper may be present. Annual non-native species are present or co-dominate in the understory. Bare ground areas are prevalent and soil redistribution is evident. This community phase is typically described as a Phase II woodland (Miller et al. 2008).

PIMO/ARTRV/POFE-ACTH7 (F026XY044NV) Phase 3.1. T. Stringham, August 2015.

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Time without disturbance such as fire, long-term drought, or disease will allow for the gradual maturation of singleleaf pinyon. Infilling by younger trees continues.

Community Phase 3.2:
Singleleaf pinyon dominates the aspect and Utah juniper may be present. Tree canopy cover exceeds 50 percent. Utah juniper may be present. Understory vegetation is sparse to absent. Perennial bunchgrasses, if present exist in the dripline or under the canopy of trees. Mountain

sagebrush skeletons are common or the sagebrush has been extinct long enough that only scattered limbs remain. Mat-forming forbs or Sandberg's bluegrass may dominate interspaces. Annual non-native species are present and are typically found under the trees. Bare ground areas are large and interconnected. Soil redistribution may be extensive. This community phase is typically described as a Phase III woodland (Miller et al. 2008).

T3A Transition from Infilled Tree State 3.0 to Annual State 4.0:

Trigger: Catastrophic fire reduces the tree overstory and allows for the annual non-native species in the understory to dominate the site. Soil disturbing treatments such as slash and burn may also reduce tree canopy and allow for non-native annual species to increase.

Slow variables: Over time, cover and production of annual non-native species increases.

Threshold: Loss of deep-rooted perennial bunchgrasses and shrubs changes temporal and spatial nutrient capture and cycling within the community. Increased, continuous fine fuels modify the fire regime by increasing frequency, size, and spatial variability of fires.

R3A Restoration from Infilled Tree State 3.0 to Current Potential State 2.0:

Manual or mechanical thinning of trees coupled with seeding. Probability of success is highest from community phase 3.1.

Annual State 4.0:

This community is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard in the understory. Rabbitbrush or other sprouting shrubs may dominate the overstory. Annual non-native species dominate the understory. Ecological dynamics are significantly altered in this state. Annual non-native species create a highly combustible fuel bed that shortens the fire return interval. Nutrient cycling is spatially and temporally truncated as annual plants contribute significantly less to deep soil carbon. This state was not seen in MLRA 26 during field work for this project, however it is possible given increased fire activity in these sites and their proximity to known annual states of sagebrush ecological sites. We refer the reader to the report for Disturbance Response Group 21 for MLRA 28A and 28B.

Community Phase 4.1:
Cheatgrass, mustards and other non-native annual species dominate the site. Trace amounts of perennial bunchgrasses may be present. Sprouting shrubs may increase. Burned tree skeletons present.

Potential Resilience Differences with other Ecological Sites:

PIMO/ARTRV/POFE-ACTH7 (F026XY044NV):

This site is very similar to the modal site but with antelope bitterbrush as the subdominant shrub instead of Wyoming sagebrush. The dominant grass on this site is muttongrass, and Thurber's needlegrass is subdominant. It occurs on mid- to upper mountain sideslopes in a slightly higher elevation range of 6,000 to 9,000 feet. This site also receives more precipitation with 12 to 16 inches annually, and is more productive than the modal site with 450 lbs/ac of forage produced in a normal year under medium canopy (26-35%). This site is sometimes found with up to 15% Utah juniper or curl-leaf mountain mahogany canopy.

PIMO/ARTRV/ACSP12-ACTH7 (F026XY061NV):

This site is very similar to the modal site but with desert needlegrass as the dominant grass. It occurs on hills to mid- to lower mountain slopes as a slightly lower elevation of 5,000 to 7,500 feet. This site is less productive than the modal site with on 200 lbs/ac of forage produced in a normal year under medium canopy (21-35%). This site is sometimes found with up to 15% Utah juniper canopy.

PIMO/ARTRV/POFE (F026XY069NV):

This site is very similar to the modal site but with antelope bitterbrush as the subdominant shrub. The dominant grass on this site is muttongrass with prairie junegrass subdominant. It occurs on mid- to upper mountain sideslopes at a slightly higher elevation of 6,500 to 8,500 feet. This site also receives more precipitation with 12 to 18 inches annually and is slightly more productive than the modal site with 350 lbs/ac of forage produced in a normal year under medium canopy (21-35%). This site is sometimes found with up to 15% Utah juniper or curl-leaf mountain mahogany canopy.

PIMO/ARTRV/ACSP12 (F026XY104NV):

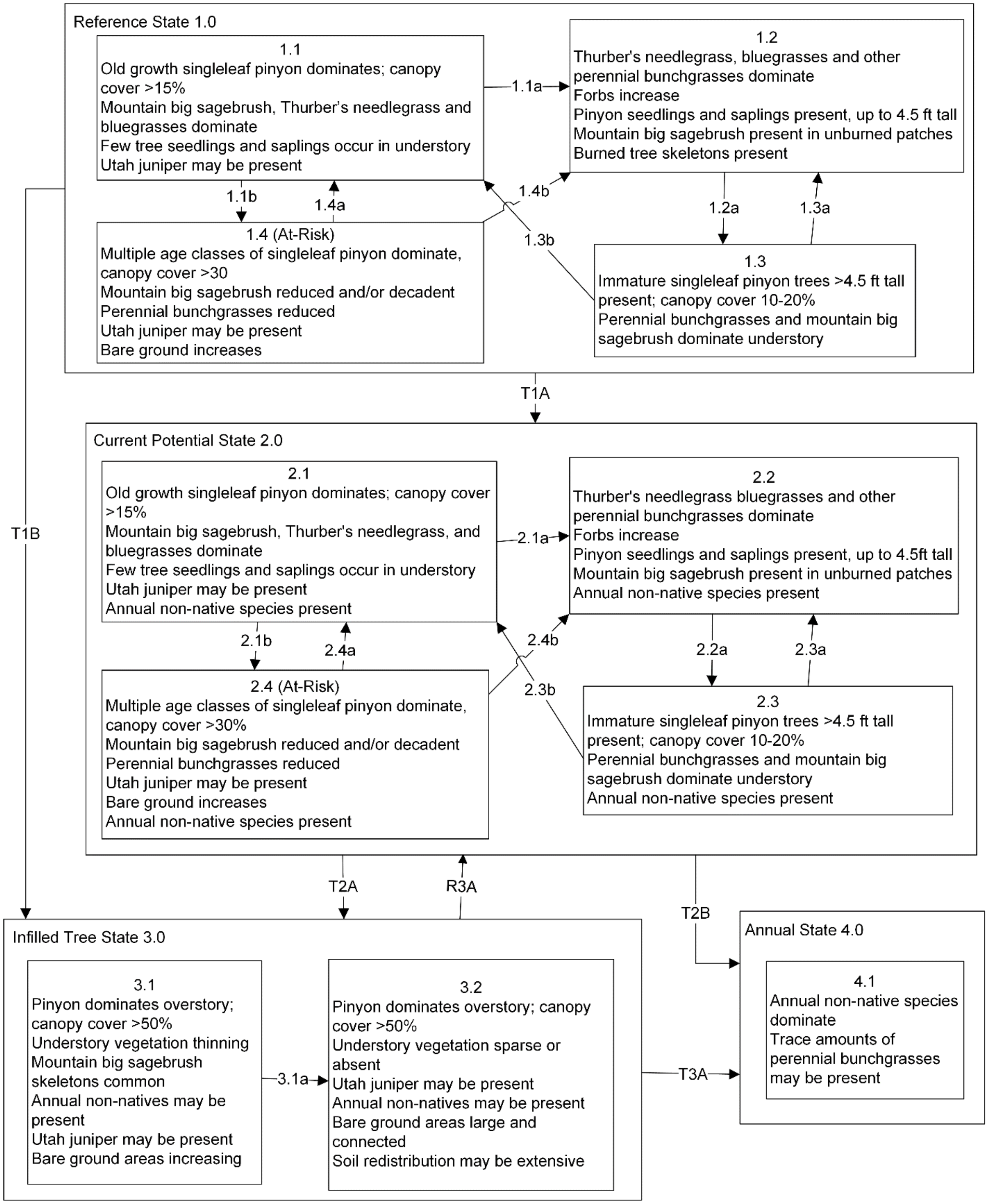
This site is very similar to the modal site but with antelope bitterbrush as the subdominant shrub. Desert needlegrass is the dominant grass. It occurs on hills and mid- to lower mountain sideslopes at a slightly higher elevation of 6,000 to 8,500 feet. This site also receives more precipitation with 16 to 24 inches annually and is less productive than the modal site with 200 lb/ac of forage produced in a normal year under medium canopy (21-35%). This site is sometimes found with up to 15% Utah juniper canopy.

PIMO/ARTRV/POFE (F026XY071NV):

This site is very similar to the modal site but with antelope bitterbrush as the subdominant shrub. The dominant grass on this site is muttongrass with Thurber's needlegrass subdominant. It occurs on mid- to upper mountain sideslopes in a slightly higher elevation range of 6,000 to 9,000 feet. This site also receives more precipitation with 14 to 18 inches annually and is more productive than the modal site with 450 lbs/ac of forage produced in a normal year under medium canopy (26-35%). This site is sometimes found with up to 10% Utah juniper, Sierra juniper (*Juniperus grandis*), Jeffrey pine (*Pinus jeffreyi*), or curl-leaf mountain mahogany canopy.

Modal State and Transition Model for Group 19 MLRA 26:

MLRA 26
GROUP 19
PIMO/ARTRV/ACTH7
026XY060NV



MLRA 26
GROUP 19
PIMO/ARTRV/ACTH7
026XY060NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Fire.
1.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.3a: Fire.
2.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

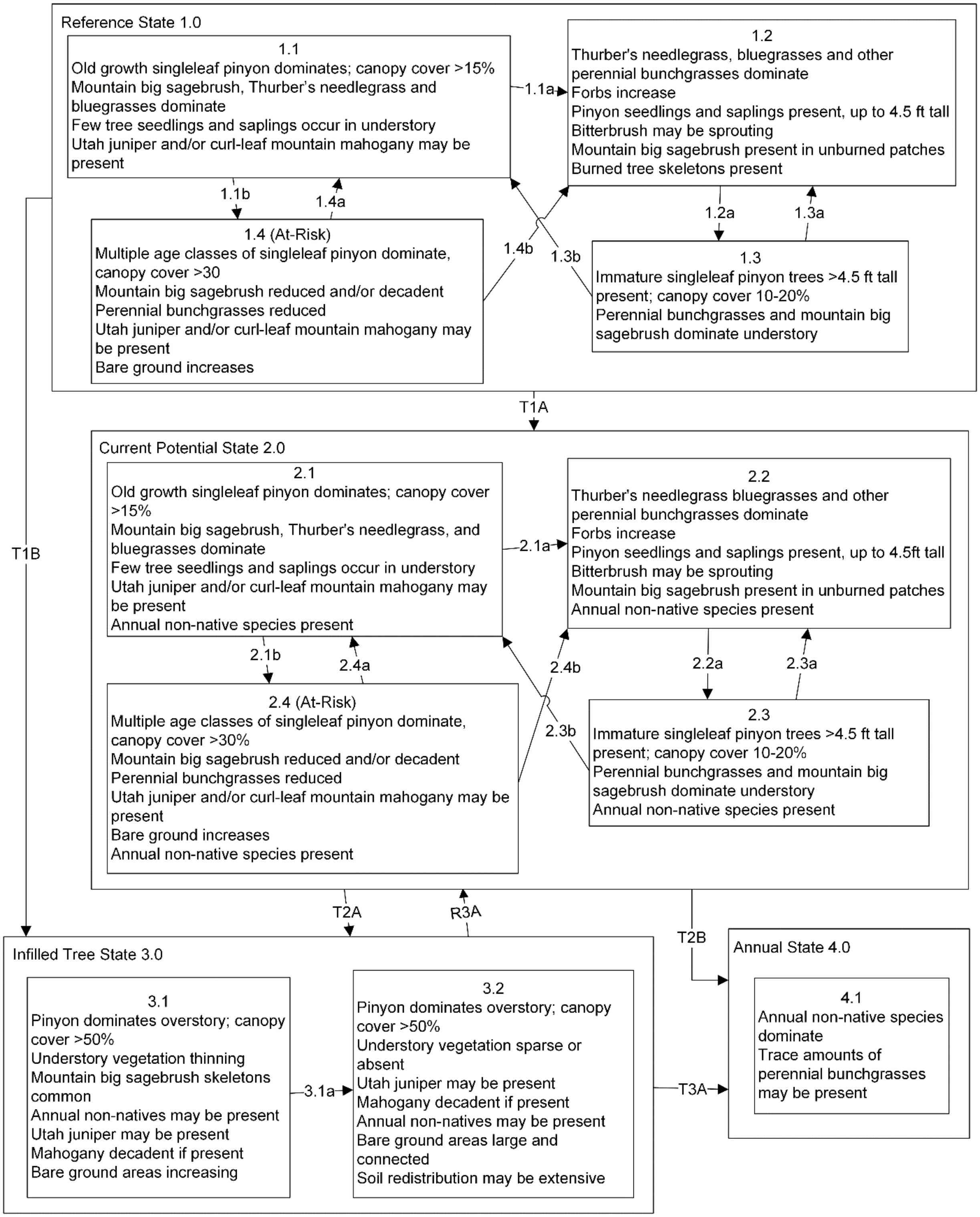
Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

Additional State and Transition Models for Group 19 MLRA 26:

MLRA 26
GROUP 19
PIMO/ARTRV/POFE-ACTH7
026XY044NV



MLRA 26
GROUP 19
PIMO/ARTRV/POFE-ACTH7
026XY044NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Fire.
1.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.3a: Fire.
2.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

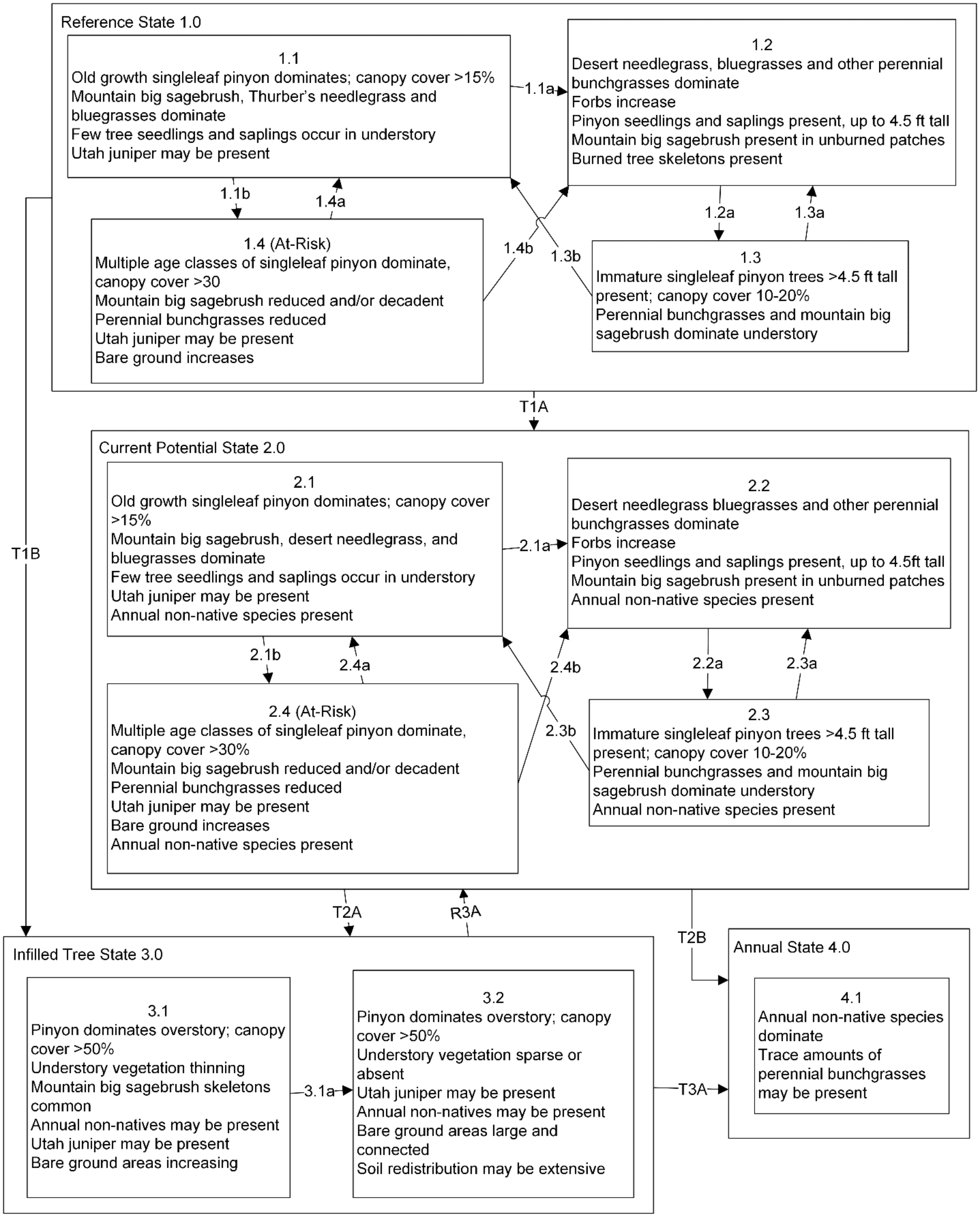
Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

MLRA 26
GROUP 19
PIMO/ARTRV/ACSP12-ACTH7
026XY061NV



MLRA 26
GROUP 19
PIMO/ARTRV/ACSP12-ACTH7
026XY061NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Fire.
1.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.3a: Fire.
2.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

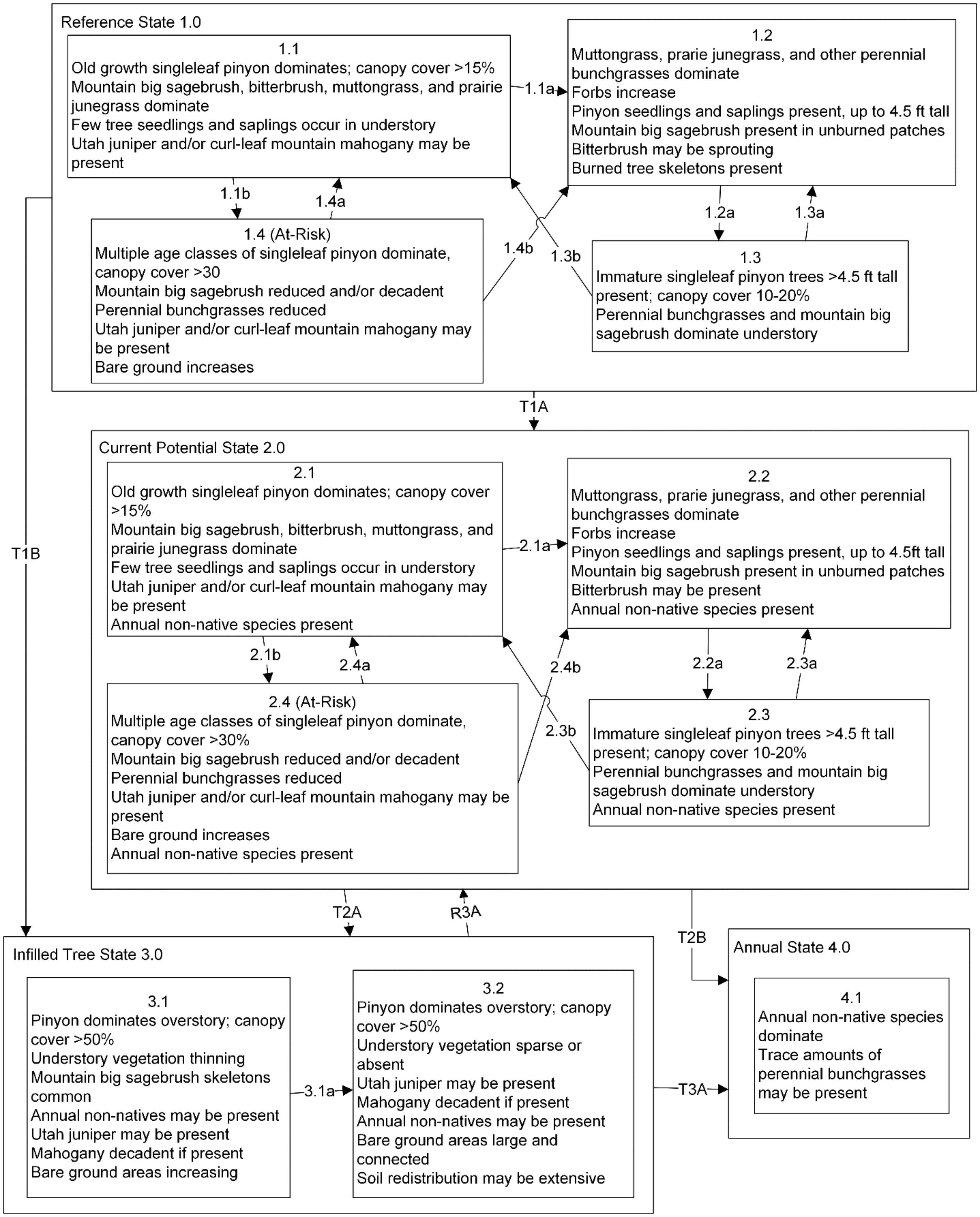
Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

MLRA 26
GROUP 19
PIMO/ARTRV/POFE
026XY069NV



MLRA 26
GROUP 19
PIMO/ARTRV/POFE
026XY069NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Fire.
1.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.3a: Fire.
2.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

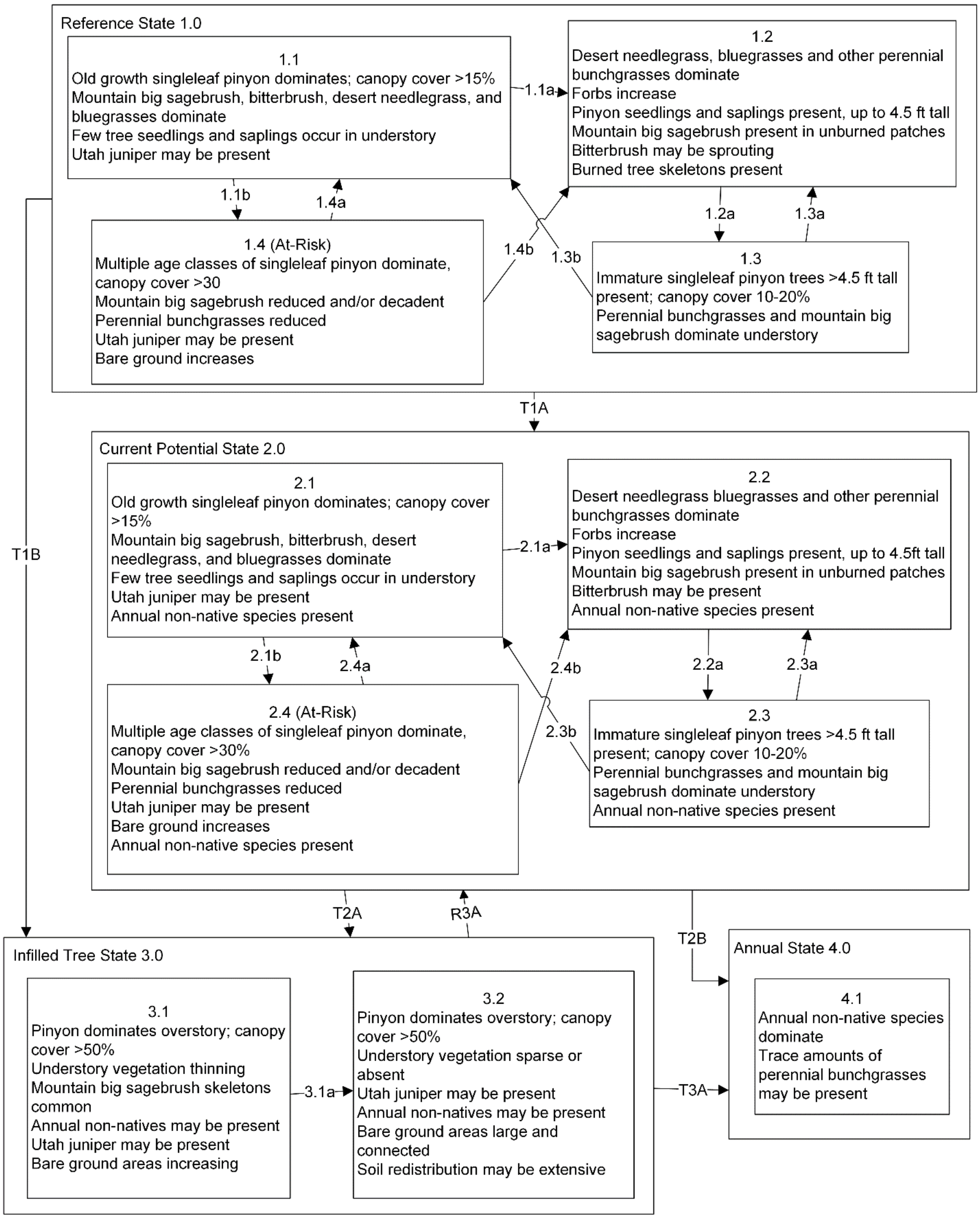
Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

MLRA 26
GROUP 19
PIMO/ARTRV/ACSP12
026XY104NV



MLRA 26
GROUP 19
PIMO/ARTRV/ACSP12
026XY104NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Fire.
1.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.3a: Fire.
2.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

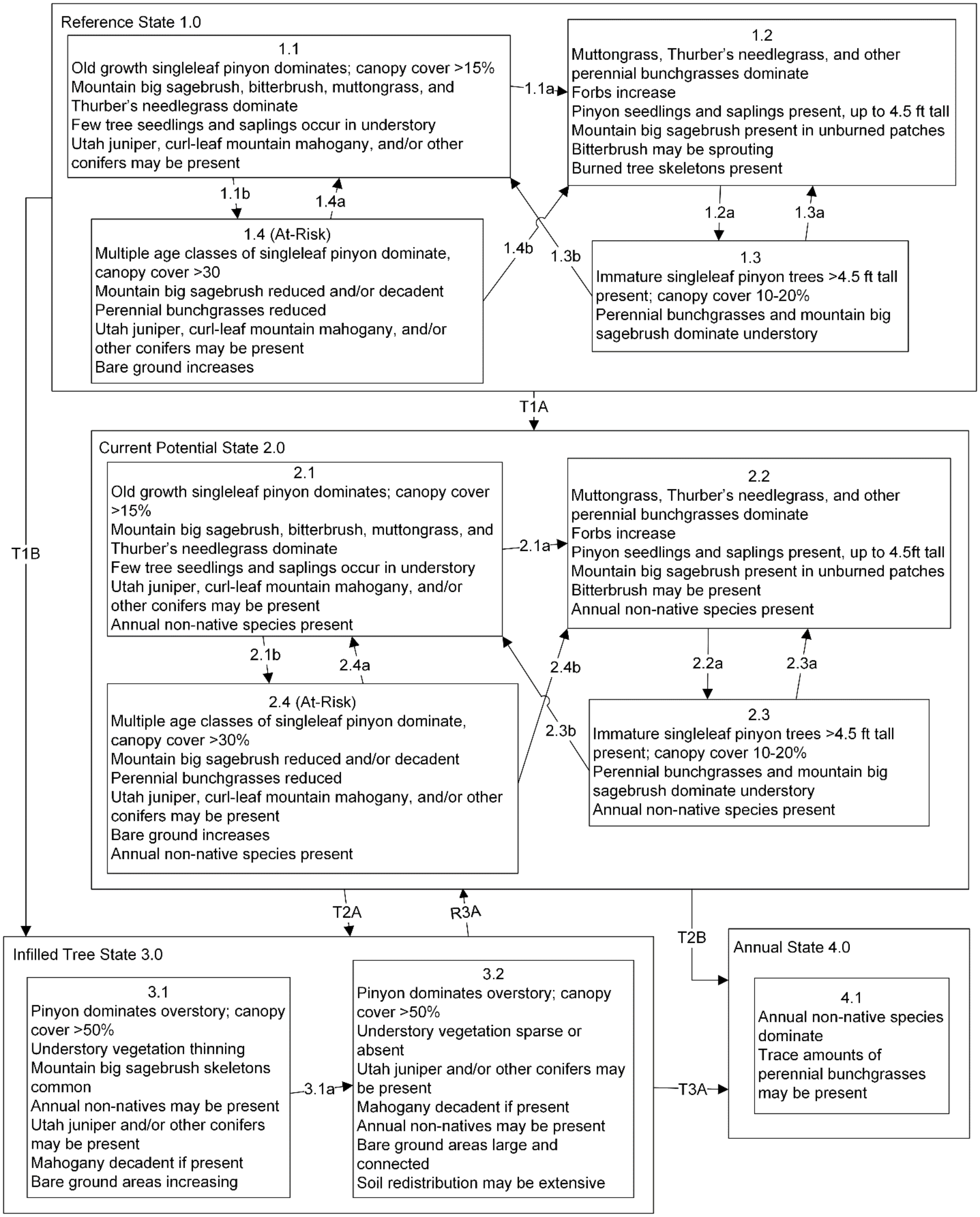
Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

MLRA 26
GROUP 19
PIMO/ARTRV/POFE
026XY071NV



MLRA 26
GROUP 19
PIMO/ARTRV/POFE
026XY071NV
KEY

Reference State 1.0 Community Pathways
1.1a: High severity crown fire reduces or eliminates tree cover.
1.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
1.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.3a: Fire.
1.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also reduce perennial grass understory.
1.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
1.4b: High severity crown fire reduces or eliminates tree cover.

Transition T1A: Introduction of non-native annual species.
Transition T1B: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.
2.2a: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.3a: Fire.
2.3b: Time and lack of disturbance such as fire or drought. Excessive herbivory or inappropriate grazing may also reduce perennial grass understory.
2.4a: Low severity fire, insect infestation, or disease removes individual trees and reduces total tree cover.
2.4b: High severity crown fire reduces or eliminates tree cover.

Transition T2A: Time and a lack of disturbance allows for trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.
Transition T2B: Catastrophic fire.

Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill.

Transition T3A: Catastrophic fire.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Annual State 4.0 Community Pathways
None.

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MLRA 26 Group 20: Quaking aspen

Description of MLRA 26 Disturbance Response Group 20:

Disturbance Response Group (DRG) 20 consists of four ecological sites. The precipitation zone for these sites ranges from 14 to over 20 inches. The elevation range for this group is from 6,500 to 10,000 ft. Slopes range from 0 to 50 percent. The soils in this site are moderately deep to very deep and somewhat well drained to moderately well-drained. These soils have a thick, dark, medium-textured surface horizon. Available water capacity is moderate to high. These aspen sites are associated with either riparian areas and stream terraces, or concave mountain sideslopes that accumulate snow that persists late into spring and early summer. In both cases, the sites receive additional moisture inputs when compared to adjacent upland sites. Sites in this group are dominated by an overstory of quaking aspen (*Populus tremuloides*). The shrub component includes mountain snowberry (*Symphoricarpos oreophilus*), Woods' rose (*Rosa woodsii*), and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*). The herbaceous understory is dominated by mountain brome (*Bromus marginatus*), needlegrasses (*Achnatherum spp.*), slender wheatgrass (*Elymus trachycaulus*), and a variety of perennial forbs. The average annual understory production in years with normal precipitation ranges from 600 to 1,600 lbs/ac depending on the level of canopy cover.

Disturbance Response Group 20 – Ecological Sites:

POTRT WSG: 1A1707 – Modal Site	POTRT/ARTRV/BRMA4-ELTR7	F026XY086NV
POTRT WSG: 2W1710	POTRT/PONE3-ELTR7-CAREX	F026XY068NV
POTR5 WSG: 1R1707	POTRT/SYOR2/BRMA4-ELTR7	F026XY066NV
Aspen Thicket	POTRT/ACHNA-ELTR7	R026XF056CA

Modal Site:

The forest ecological site dominated by aspen, mountain big sagebrush, mountain brome and slender wheatgrass (F026XY086NV) is the modal site for this group, as it has the most acres mapped. This forest site occurs on cool, stream terraces on the margin of perennial stream floodplains. Slopes range from 0 to 15 percent. Elevations range from 6,000 to 8,000 feet. Average annual precipitation is 16 to 20 inches. Available water capacity is moderate to high. Some soils have cobbles or boulders on the surface. Soils are wet in the rooting zone of quaking aspen during the early part of the growing season for short periods. The plant community is dominated by quaking aspen in the overstory, with an understory of mountain big sagebrush, mountain snowberry, mountain brome, and slender wheatgrass. Understory annual production on a normal year ranges from 900 to 1,300 lbs/ac depending on canopy cover.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Quaking aspen is the most widely distributed tree in North America, and in the West it is the only upland hardwood tree (Monsen et al. 2004). Aspen is a fire-adapted species that can sprout prolifically after fire (Shinneman et al. 2013). Aspen is typically found in nearly pure stands. Mature aspen stands (80 to 100 years) can reach heights up to 100 feet depending on the site. Most stands contain a variety of medium-high shrubs and tall herbs in the understory (DeByle and Winokur 1985). Cryer and Murray (1992) found that stable aspen stands occurred only on soils with a mollic horizon. Lateral roots may extend over 30 meters, with vertical sinker roots nearly 3 meters deep. Entire stands are often produced as a single clone from root sprouts or suckers. Individual "trees" are known as ramets. Aspen can establish from seed, however, reproduction is primarily by root sprouts that develop within 10 meters of the parent stem. Growth from primordia (root tissue) is suppressed until the tree is top-killed by fire or another disturbance, however, just girdling the trees does not promote root sprouts (Perala 1990). Individual trees are short lived (<150 years) and rely on regular disturbances to regenerate (Bartos and Mueggler 1981, Shepperd and Smith 1993). Aspen is shade intolerant, which promotes even-aged ramets. Stands of uneven-aged trees only form under stable conditions where the overstory gradually dies off with disease or age, and is replaced by aspen suckers (Perala 1990).

Common disturbances in aspen stands include fire, insect and disease outbreaks, wind storms, and avalanches. Aspen stands have also shown some sensitivity to drought (Hogg et al. 2008, Hanna and Kulakowski 2012). Increased fire suppression, excessive browse pressure, and conifer encroachment threaten the structure of western aspen stands. It is projected that the Western United States may see increased summer temperatures, lower total annual precipitation, and increased extreme weather in coming years due to climate change (Morelli and Carr 2011). These changes and others may exacerbate climate- and weather-induced mortality in aspen (Romme et al. 2001, Morelli and Carr 2011).

Conifer Dynamics:

Shading by conifer trees limits aspen regeneration (Bartos and Campbell 1998, Stringham et al. 2015). If the aspen stand exists near or is intermixed with conifers like white fir (*Abies concolor)*, spruce (*Picea* spp.), pine (*Pinus* spp.) or juniper (*Juniperus* spp.), the clone is at risk of being overtopped and killed from competition and shading over time (Wall et al. 2001). Aspen stands in the northwestern Great Basin have widespread encroachment by western juniper (*Juniperus occidentalis)*; as juniper cover increases in these areas, aspen tree density, recruitment, and herbaceous understory production declines (Wall et al. 2001, Miller et al. 2000). The increase in conifers can be attributed to both fire suppression and grazing pressure by both livestock and wildlife (Potter 2005, Strand et al. 2009b, Bartos and Campbell 1998). Using a habitat model Strand et al. (2009) computed aspen occurrence probability across the landscape of the Owyhee Plateau. They visited 41 sites where they modeled aspen occurrence; 37% had dead aspen stems with no aspen regeneration, 51% had scattered aspen ramets and aspen was regenerating in forest gaps, and in 12% there was no evidence that aspen had ever occurred on or near the site. Their aspen successional model theorized that non-producing aspen stands can be permanently converted to a conifer stand and the aspen clone can be lost. They estimated that over 60% of aspen woodlands have been, or are in the process of being, converted to conifer woodlands. It is unknown how long an aspen stand can survive in a non-reproductive state under conifer canopy closure (Strand et al. 2009).

Overstory clearing, whether in small gaps or in large openings, provides the needed light for aspen suckers to sprout (Shepperd et al. 2006, Berrill et al. 2017). A limited aspen root system resulting from previous conifer dominance and/or persistent shading from surrounding uncut trees may require additional disturbance to initiate suckering. Additional management actions such as root ripping may be needed to stimulate root suckering (Shepperd et al. 2006). Prescribed fire is an effective tool for removing western juniper and releasing aspen stands; fall burning was most effective in removing juniper (Bates and Davies 2018a), however spring burning had more desirable effects on the understory (Bates and Davies 2018b). Other studies have explored this technique for releasing aspen and have seen success (Bartos and Mueggler 1981, Brown and DeByle 1989, DeByle 1985, Walker 1993). Limiting browse impacts is crucial to allow aspen regeneration after disturbance (See Livestock Interpretations section below).

There are many environmental factors that can contribute to stand decline or die-off. The major underlying cause can be attributed to tree and/or stand stress. Drought, low soil oxygen, and cold soil temperatures all limit soil water uptake and can contribute to xylem cavitation. Cavitation causes much of the aspen die-off but the created stress can also leave the stand open to secondary factors such as wood boring insects and fungal pathogens (Frey et al. 2004). Drought has been attributed to the decline and death of aspen trees, but also contributes to secondary factors such as insects (Frey et al. 2004, Hanna and Kulakowski 2012, Dudley et al. 2015).

Aspen stands possess three characteristics that provide suitable sites for invasive plants: 1) deep, rich soils, 2) proximity to moist meadows and riparian areas with open water, 3) their dependency on disturbance and open light. This site has moderate resilience to disturbance and resistance to invasion. Human disturbance associated with recreation and animal (domestic and wildlife) disturbance may lead to the spread of invasive species such as Kentucky bluegrass (*Poa pratensis*), common dandelion (*Taraxacum officinale*) and thistles (*Cirsium spp*.).

The ecological sites contained within this DRG are moderately resilient and resistant due to productive soils, additional soil moisture and aspens ability to sprout following fire or other stand or tree removal processes. Three stable states have been identified for this DRG.

Fire Ecology:

Wildfire is recognized as a natural disturbance that influences the structure and composition of the vegetation of the Reference State. Periodic wildfires prevent over-mature aspen stands and maintain a naturally stratified mosaic of even-aged aspen communities in various stages of successional development (Strand et al. 2009b, Shinneman et al. 2013). Wall et al. (2001) found a pattern of even-aged aspen stands that indicated there were stand-replacing fires roughly every 16-17 years on average. Aspen can regrow even when subjected to fires only 3 years apart (Perala 1990). Although aspen stands rely on fire for successful regeneration, aspen stands don’t readily carry fire alone (Fechner and Barrows

1976, Debyle and Winokur 1985, Debyle et al. 1987, Monsen et al. 2004, Shinneman et al. 2013). At least 80% top-kill may be necessary to promote suckering (Brown 1985). Bates and Davies (2018a) used cut and dried juniper to carry prescribed fire through experimental aspen stands. Aspen is extremely fire sensitive (Baker 1925); with its thin bark most individual ramets are killed by fire, and those left with scarring are usually killed within the next growing season from rot and disease (Bradley et al. 1992, Davidson et al. 1959, Meinecke 1929). However, fires that kill the aspen overstory usually stimulate abundant suckering and enhance the long-term health of the clone (DeByle and Winokur 1985, Bartos and Mueggler 1981, Turner et al. 2003, Brewen et al. 2021).

It is hypothesized that many of the fires that maintained these communities were set by the Native American population to manage plant communities for human benefit (Kay 1997). Specific fire intervals are dependent upon surrounding vegetation communities. Reduced fire intervals in the last 100-150 years threaten survival of existing aspen stands; fire suppression is a factor in reducing aspen recruitment (Hessl 2002). Historic heavy grazing has been attributed to the reduction of fine fuels within stands; without the fuels to burn, fires seldom occur within aspen forests (DeByle and Winokur 1985). While wild or prescribed fire can be a tool to promote aspen regeneration and clone health, it is important to manage browse impacts or the beneficial effects of fire may be negated (Smith et al. 2016).

Many of the species associated with aspen stands are adapted to survive wildfire. Woods' rose sprouts following fire unless the shallow root crown is damaged (Monsen et al. 2004). Mountain snowberry is top-killed by fire, but sprouts after fire from rhizomes (Leege and Hickey 1971, Noste and Bushey 1987). Snowberry has been noted to regenerate well and exceed pre-burn biomass in the third season after fire (Merrill et al. 1982). Currant, a minor component of this site, is known as a weak sprouter from the root crown but usually regenerates from soil stored seeds after fire. It is susceptible to fire kill and rarely survives fire (Crane and Fischer 1986). Utah serviceberry (*Amelanchier utahensis)* sprouts after fire (Conrad 1987) and grows more rapidly than some other serviceberry species (Plummer et al. 1968). If balsamroot (*Balsamorhiza* spp.) or mule-ears (*Wyethia* spp.) is common before fire, these plants will increase after fire or with heavy grazing (Wright 1985).

Mountain big sagebrush, a minor component on these sites, is killed by fire (Neuenschwander 1980, Blaisdell et al. 1982), and does not sprout (Blaisdell 1953). Post-fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and may reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). Mountain big sagebrush may return to pre-burn density and cover within 15 to 20 years following fire, but establishment after severe fires may proceed more slowly and can take up to 50 years (Bunting et al. 1987, Ziegenhagen 2003, Miller and Heyerdahl 2008, Ziegenhagen and Miller 2009).

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface, providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983).

Mountain brome, the dominant grass found on this site is a robust, coarse-stemmed, short-lived perennial bunchgrass that can grow from 1 to 5 feet in height (USDA 1988, Tilley et al. 2004). Mountain brome significantly decreases after burning (Nimir and Payne 1978), but is commonly seeded after wildfires in high elevation areas, due to its ability to establish quickly from seed and reduce erosion (Tilley et al. 2004). Slender wheatgrass, a sub-dominant grass on this site, may increase after fire. In a study by Nimir and Payne (1978) slender wheatgrass increased significantly more in burned than in non-burned sites, although the species did not appear in measurable quantities until mid-July after a spring (May) burn in the same year.

Livestock Grazing / Wildlife Browse Interpretations:

This site is valuable for livestock grazing and wild ungulate browse. Grazing considerations include timing, intensity, and duration of grazing. Domestic livestock, wild ungulates, rodents, and rabbits utilize aspen stands and can have a measurable impact (Kay and Bartos 2000). Cattle (*Bos taurus)* have a less injurious effect on aspen sprouts than sheep (*Ovis aries)*, who more readily browse twigs (Sampson 1919), however cattle and sheep still use aspen significantly less than deer (*Odocoileus hemionus)* and elk (*Cervus canadensis)* (Beck and Peek 2005). Browsing during the sapling stage reduces aspen growth, vigor and numbers (DeByle and Winokur 1985). Heavy browsing on aspen suckers may result in lower clone vigor to the point that suckering no longer takes place (Lindroth and St. Clair 2013). Browsing pressure may allow aspen to regenerate but prevent the development of trees, and the aspen will grow instead as a dense shrub (Bradley et al. 1992) or the aspen stand will consist only of old age classes with many dead stems (Hessl 2002). A study of aspen across Utah, Idaho, and Wyoming showed that only 2% of trees were less than 50 years old, indicating that the effect of increasing elk numbers along with effects of cattle and deer use have prevented recruitment over time (Mueggler 1989).

Snowberry is an important forage plant for sheep, deer, elk, and bighorn sheep (*Ovis canadensis)* (Guillon 1964). Snowberry is poor to fair browse for cattle but may be heavily used by domestic livestock on overgrazed ranges (Morris et al 1962). Utah serviceberry is considered a staple browse for deer and livestock, while the fruits are preferred by birds and small mammals (Conrad 1987). Utah serviceberry also constituted two percent of the stomach contents of a bighorn ram taken out of Clark County in 1952 (Guillion 1964). Some varieties of Woods' rose are grazed heavily, while others can form thickets that reduce the ability of ungulates to use the area (Monsen et al. 2004).

Mountain brome increases with grazing (Leege et al. 1981). A study by Mueggler (1967), found that with clipping, mountain brome increased in herbage production when clipped in June. When clipped in July, mountain brome increased due to reduced competition from forb species. The study also found that after three successive years of clipping mountain brome started to show adverse effects. Mountain brome is ranked as highly valuable as elk winter forage (Kufeld 1973).

Slender wheatgrass is a perennial bunchgrass that tends to be short lived, however it spreads well by natural reseeding (Monsen et al. 2004). It is widely used in restoration seedings (Monsen et al. 2004). Slender wheatgrass tends to persists for a longer time than other perennial grasses when subjected to heavy grazing (Monsen et al. 1996, Monsen et al. 2004). Slender wheatgrass is palatable and nutritious for livestock. It is also grazed by wild ungulates and used for cover by small birds and mammals (Tilley et al. 2011, Hallsten et al. 1987).

Wildlife Interpretations:

Aspen stands are valued for their ability to support greater plant, insect, and bird biodiversity compared to surrounding forests and shrublands (Chong et al. 2001, Griffis-Kyle and Beier 2003). This site provides valuable habitat for several species of wildlife. Quaking aspen is important forage for large mammals. Elk browse the bark, branches and sprouts of quaking aspen year-round throughout the West (DeByle 1979, Howard 1996). Mule deer use quaking aspen year-round especially if winters are mild, browsing leaves, buds, twigs, bark, and sprouts. New growth, after burns or clearcuts, are readily consumed by mule deer (Innes 2013). Black bear (*Ursus americanus*) will eat stems and leaves of quaking aspen; however, forbs and other plants found in quaking aspen understory are preferred (Beetle 1974, Wildlife Action Plan Team 2012). A study by Krebill (1972) found the majority of aspen decline within their study area was due to a combination of pathogenic fungi and insects which invade aspen trees damaged by big game (Krebill 1972).

Several lagomorphs use quaking aspen habitat. Although aspen groves are at elevations where desert cottontail (*Sylvilagus audubonii*) are not normally found; desert cottontail may use aspen habitat where aspen groves occur at lower elevations with sagebrush and shrubland (DeByle and Winokur 1985). Snowshoe hares (*Lepus americanus*) feed on quaking aspen in summer and spring and will continue to use quaking aspen habitat year-roundbut are more common in the associated coniferous forests (DeByle and Winokur 1985). A threatened species, the American Pika (*Ochotona princeps)* will utilize quaking aspen stands in higher elevation habitat and have been documented to feed on quaking aspen buds, twigs, and bark (Wildlife Action Plan Team 2012, Howard 1996).

Rodents utilize aspen habitat for food and cover. Pocket gophers, (*Thomomys monticola*) a fossorial rodent favors quaking aspen stands (Linzey and Hammerson 2008). Aspen soils rarely freeze which are ideal for burrowing. Forbs and aspen sprouts provide forage in the spring and summer (DeByle and Winokur 1985). Deer mice (*Peromyscous maniculatus*) and least chipmunks (*Tamias minimus*) occupy quaking aspen habitat (Debyle 1979). The deer mouse was trapped more than any other rodent, consistently throughout several years, in quaking aspen stands according to Andersen et al. (1980). The least chipmunk has been trapped at near equal density as the deer mouse in aspen habitat (DeByle and Winokur 1985, Andersen et al. 1980). The Inyo shrew (*Sorex tenellus*), Merriam's shrew (*Sorex merriami*), montane shrew (*Sorex monticolus*), and western jumping mouse (*Zapus princeps*) use the shrub and herbaceous cover within quaking aspen habitat for foraging and cover (Wildlife Action Plan Team 2012). The flying squirrel (*Glaucomys sabrinus*), although rarely seen because of its nocturnal habit, is estimated to be one of the most common mammal species found in aspen type forests (DeByle and Winokur 1985). Larger rodents, such as the North American porcupine (*Erethizon dorsatum*) will eat quaking aspen in winter and spring months. In winter, porcupine eat the smooth outer bark of the upper trunk and branches, in spring they eat the buds and twigs (Howard 1996, DeByle and Winokur 1985).

Beaver (*Castor canadensis*) use a large amount of aspen for building material to construct their dams. In fact, as many as 200 quaking aspen stems are required to support one beaver for a 1-year period. Beaver prefer the inner bark of aspen to that of other trees as food (Lanner 1984). They will consume the leaves, bark, twigs, and any diameters of quaking aspen branches (Innes 2013). Previous research has estimated that an individual beaver consumes 2 to 4 pounds (1-2 kg) of quaking aspen bark daily (DeByle and Winokur 1985).

Quaking aspen provide feed and cover for a variety of bird species in Nevada. The northern goshawk (*Accipiter gentilis*) and flammulated owl (*Psiloscops flammeolus*) use mature overstory for nesting (Wildlife Action Plan Team 2012). Bird species including orange-crowned and yellow-rumped warblers

(*Vermivora celata* and *Dendroica coronata*, respectively), broad-tailed hummingbirds (*Selasphorus platycercus*), robins (*Turdus migratorius*), house wrens (*Troglodytes aedon*), pewees (*Contopus sordidulus*), juncos (*Junco hyemalis*), and thrushes (*Catharus ustulatus*) nest and forage aspen stands. Furthermore, dead trees are used by downy woodpeckers (*Picoides pubescens*), flickers (*Colaptes auratus*) and Lewis's woodpeckers (*Melanerpes lewis*) (Lanner 1984, Wildlife Action Plan Team 2012). Birds such as the mountain bluebird (*Sialia currucoides*), tree swallow (*Tachycineta bicolor*), pine siskin, (*Spinus pinus*), and black-headed grosbeak (*Pheucticus melanocephalus*) can be found at the edges of aspen communities (Flack 1976). Even duck species, including Wood duck (*Aix sponsa*), common and barrow's goldeneye (*Bucephala clangula* and *Bucephala islandica*, respectively), bufflehead (*Bucephala albeola*), hooded and common merganser (*Lophodytes cucullatus* and *Mergus merganserall*, respectively) utilize aspen habitat (DeByle and Winokur 1985). Dusky grouse (*Dendragapus obscurus*), sooty grouse (*Dendragapus fuliginosus*), mountain quail (*Oreotoryz pictus*) and Rufous hummingbird (*Selasphorus rufus*) utilize the shrub and herbaceous cover provided by quaking aspen forests (Wildlife Action Plan Team 2012).

Several bat species occur within subalpine habitat, adding to the community's diversity. The fringed myotis (*Myotis thysanodes*), long-eared myotis (*myotis evotis*), hoary bat (*Lasiurus cinereus*), Silver-haired bat (*Lasionycteris noctivagans*), little brown myotis (*Myotis lucifugus*), and western small-footed myotis (*Myotis ciliolabrum*) all are documented as occurring in quaking aspen forests and meadows above 9,000 feet (Keinath 2003, Arroyo-Calbrales and Álvarez-Castañeda 2008, Warner and Czaplewski 1984, Sullivan 2009, Wildlife Action Plan Team 2012).

Habitat distribution of reptiles and amphibians is not as widely studied as other animals and few reptiles and amphibians are found at such elevations where quaking aspen trees occur. The Columbia spotted frog (*Rana luteiventris*) and Northern rubber boa (*Charina bottae*) favor downed quaking aspen trees as well as stored ground moisture maintained from dead, decomposing logs (Wildlife Action Plan Team 2012).

Threats and Management:

Problems contributing to the decline of aspen communities in Nevada include fire suppression, climate change, conifer encroachment, improper livestock grazing, and browsing by big game species (Wildlife Action Plan Team 2012, Phillips 2020). Long-term drought threatens aspen stands that are snowdrift-dependent, like the non-modal sites in this group (Kretchun et al. 2020). Hanna and Kulakowski (22012) found sudden aspen dieback was strongly associated with warm temperatures and the frequency of mortality was associated with multiple years of drought. Several fungi species cause the formation of large cankers on aspen trunks, roots and spots on leaves. (*Marssonina populi*) causes particular damage to the aspen in the form of blight and leaf spot, leaving brown leaves on quaking aspen mid-summer throughout large portions of their habitat; this issue worsens in wet summers (Lanner 1984, Phillips 2020).

State and Transition Model Narrative for Group 20

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 20.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. This site has four general community phases: a mature woodland phase, a sucker/sapling phase, an immature woodland phase, and an overmature woodland phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic long-term drought and/or insect or disease attack.

Community Phase 1.1:
The visual aspect and vegetal structure are dominated by single-storied aspen that have reached or are near maximal heights for the site. Tree heights range from 40 to 60 feet in the modal site. Tree canopy cover ranges from 30 to about 40 percent. Despite considerable understory forage production, the overstory trees compete with the understory plants for moisture, light, nutrients, and space. Vegetative shoots and/or saplings of aspen occur in the understory, but they are inconspicuous and have a high mortality rate. Where this site occurs in close proximity with western juniper or white fir communities, young conifer trees may begin to grow within the aspen stand in this phase.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Fire, insects, disease, or wind reduce the mature aspen and allow regeneration of suckers, saplings, and the herbaceous understory to increase.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.4:
Time and lack of disturbance will allow mature trees to age.

Community Phase 1.2:
Herbaceous vegetation dominates the site. Quaking aspen suckers are evident. If the aspen stand is healthy and free of browse pressure, this stage will only last from one to two years as the aspen mature rapidly. However, if competing brush and herbaceous plants grow for a full season before aspen suckers emerge, or with excessive herbivory from large ungulates such as elk, a reduction in growth and survival of aspen suckers may occur. Vegetation consists of grasses, forbs and sprouting shrubs in association with tree saplings.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.3:
Time and lack of disturbance allows the aspen suckers to mature. There must be low browse pressure during this period or this pathway will be slowed.

Community Phase 1.3:
This stage is characterized by rapid growth of the aspen trees, both in height and canopy cover. Aspen stands are self-thinning, especially at young ages. After the canopy closes, trees stratify into crown classes quickly, despite genetic uniformity within clones. There are periodic surges in

mortality, with a large number of trees dying within a short time. The visual aspect and vegetal structure are dominated by aspen mostly greater than 25 feet in height. Understory vegetation is moderately influenced by a tree overstory canopy of about 15 to 30 percent.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
Time and lack of disturbance allows the aspen suckers to mature. Release from herbivory will allow suckers to thrive and mature.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire, insects, disease or wind damage can reduce the aspen canopy and the subsequent competition with the understory, allowing the understory herbaceous community to increase. Excessive herbivory while trees are still within reach to browse may also reduce aspen growth.

Community Phase 1.4:
In the absence of wildfire or other naturally occurring disturbances, the tree canopy on this site can become very dense. This stage is normally dominated by aspen that have reached maximal heights and stem diameters for the site. Aspen trees may be decadent. In the absence of disturbance, over-mature, even-aged aspen trees/ramets slowly die. These ramets are prone to disease as well. As the upper canopy layer deteriorates, slow regeneration of suckers may occur, leading to an all age-stand. Tree canopy cover is commonly more than 50 percent. Understory production is strongly influenced by the overstory, as is species composition. Shade tolerant forbs and a few grasses will dominate the understory. Where these sites occur in close proximity with pinyon or juniper, these trees may comprise as much as 50 percent of the total tree canopy in this phase. Shade from conifers inhibits growth of suckers.

Community Phase Pathway 1.4a, from Phase 1.4 to 1.2:
Fire removes the mature aspen canopy and conifers if present, allows new suckers and saplings to develop.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native plants, such as Kentucky bluegrass, thistles, and common dandelion.

Slow variables: Over time the on-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Non-native species cannot be easily removed from the system.

T1B: Transition from Reference State 1.0 to Conifer State 3.0:

Trigger: Time with lack of disturbance allows nearby conifer trees to establish, grow, and mature.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Conifer canopy cover comprises greater than 50% of the stand and conifer height exceeds aspen height. Aspen are decadent and dying with little to no regeneration. Vitality of the aspen clone is significantly impacted. Little understory vegetation remains due to competition with trees for site resources.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however, the resiliency of the state is reduced by the presence of invasive weeds. This state has the same four general community phases. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads and retention of organic matter and nutrients. Positive feedbacks with non-native invasive plants decrease ecosystem resilience and stability of the state. These include the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts such as common dandelion, thistles, and cheatgrass (*Bromus tectorum)*. The visual aspect and vegetal structure are dominated by single-storied aspen that have reached or are near maximal heights for the site. Despite considerable understory forage production, the overstory trees compete with the understory plants for moisture, light, nutrients, and space. Vegetative shoots and/or saplings of aspen occur in the understory, but they are inconspicuous and have a high mortality rate. Where this site occurs in close proximity with western juniper or white fir communities, conifer trees may begin to grow within the aspen stand in this phase.

Community Phase Pathway 2.1a from Phase 2.1 to 2.2:
Fire, insects, disease, or wind reduce the mature aspen and allow suckers, saplings, and the herbaceous understory to increase. Harvesting or cutting will cause the same effect. Non-natives are likely to increase after fire.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.4:
Time and lack of disturbance will allow for the saplings of conifer trees in the understory to mature and dominate the site. Allows mature trees to age.

Community Phase 2.2:
Herbaceous vegetation dominates the site. Quaking aspen suckers are evident. If the aspen stand is healthy and free of browse pressure, this stage will only last from one to two years as the aspen mature rapidly. However, if competing brush and herbaceous plants grow for a full season before aspen suckers emerge, sucker survival and growth may be reduced. With excessive grazing from large ungulates such as elk and cattle, a reduction in growth and survival of aspen suckers may occur, this may last until season of grazing is changed, or grazing is reduced/excluded. Vegetation consists of grasses, forbs and a few shrubs in association with tree saplings. Non-native species are stable to increasing within the community.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.3:
Time and lack of disturbance, or release from herbivory will allow for the aspen suckers to mature. There must be low browse pressure during this period or this pathway will be slowed.

Community Phase 2.3:

This phase is characterized by rapid growth of the aspen trees, both in height and canopy cover. Aspen stands are self-thinning, especially at young ages. After the canopy closes, trees stratify into crown classes quickly, despite genetic uniformity within clones. The visual aspect and vegetal structure are dominated by aspen ranging from about 10 to 20 feet in height, and having a diameter at breast height of about 2 to 4 inches. Understory vegetation is moderately influenced by a tree overstory canopy of about 15 to over 30 percent. Non-native species are present but may be reduced as aspen mature.

POTRT/SYOR2/BRMA4-ELTR7 (F026XY066NV) Phase 2.3. T. Stringham, July 2015.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
Time and lack of disturbance, or release from browsing/grazing allows the aspen suckers to mature.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire, insects, disease, drought, or wind damage can reduce the aspen canopy and the subsequent competition with the understory, allowing the understory herbaceous community to increase. Inappropriate grazing, especially by sheep, and/or herbivory by large ungulates while trees are still within reach to browse may also reduce aspen growth.

Community Phase 2.4:
In the absence of wildfire or other naturally occurring disturbances, the tree canopy on this site can become very dense. Aspen that have reached maximal heights and stem diameters for the site dominate in this phase. Aspen trees have straight, clear stems with short, high-rounded crowns. In the absence of disturbance, over-mature, even-aged aspen trees/ramets slowly die. The aspen canopy opens up, and otherwise inconspicuous aspen suckers survive and grow in the openings. These suckers typically arise over a period of several years. Tree canopy cover is commonly more than 50 percent. Understory production is strongly influenced by the overstory, as is species composition. Shade tolerant forbs and a few grasses will dominate the understory. Where these sites occur in close proximity with pinyon or juniper, these trees may comprise as much as 50 percent of the total tree canopy in this phase. Shade from conifers inhibits growth of suckers. Non-native species are present.

Community Phase Pathway 2.4a, from Phase 2.4 to 2.2:
Fire removes the mature aspen canopy and allows new suckers and saplings to develop. The understory plant community increases.

T2A: Transition from Current Potential State 2.0 to Conifer State 3.0:

Trigger: Time with lack of disturbance allows nearby conifer trees to establish, grow, and mature.

Slow variables: Over time the abundance and size of trees will increase.

Threshold: Conifer canopy cover comprises greater than 50% of the stand and conifer height exceeds aspen height. Aspen are decadent and dying with little to no regeneration. Vitality of the aspen clone is significantly impacted. Little understory vegetation remains due to competition with trees for site resources.

Conifer State 3.0:

This state is characterized by one community phase dominated by shade-intolerant conifers such as singleleaf pinyon, juniper, white fir, or Jeffrey pine. Aspen may be present, however, trees are decadent and little to no regeneration is present. Understory vegetation is sparse. Negative feedbacks contribute to the stability of the state. These feedbacks include the dense canopy cover of conifer, which creates a shade-rich environment that facilitates the germination and establishment of conifers, while retarding the growth and suckering of aspen. Eventually the aspen clone may be so impacted by competition and shading that the clone dies. If this community burns in this state, aspen may not come back.

Community Phase 3.1:
Shade-intolerant coniferous trees dominate this phase. Mature aspen ramets/trees may be entirely lost, and there may be no regeneration. If present, aspen trees show decadence and are significantly reduced. Understory vegetation is reduced due to competition of the overstory canopy. Non-native species may be present.

R3A: Transition from Conifer State 3.0 to Current Potential 2.0:

Prescribed fire or mechanical removal of trees potentially coupled with root ripping to stimulate suckering. This restoration treatment should be completed before all evidence of aspen regeneration is lost. However, it is not known how long an aspen stand can remain dormant in a conifer state before the stand will not return (Strand et al. 2009b).

Potential Resilience Differences with Other Ecological Sites:

POTR5/PONE3-ELTR7-CAREX (F026XY068NV):

This site is found in gently sloping mountain basins and along mountain streams. The soils are more than 60 inches deep, and somewhat poorly drained. The water table is seasonally high, reaching 40 to 60 inches from the soil surface. These soils are susceptible to gullying. The common understory shrubs are woods' rose and willow. In addition to mountain brome and slender wheatgrass, Nevada bluegrass, sedges, groundsel, yarrow, and meadowrue are also associated with the site. Understory annual production on a normal year ranges from 1,100 to 1,700 lbs/ac depending on canopy cover. This site can be invaded by white fir (*Abies concolor*).

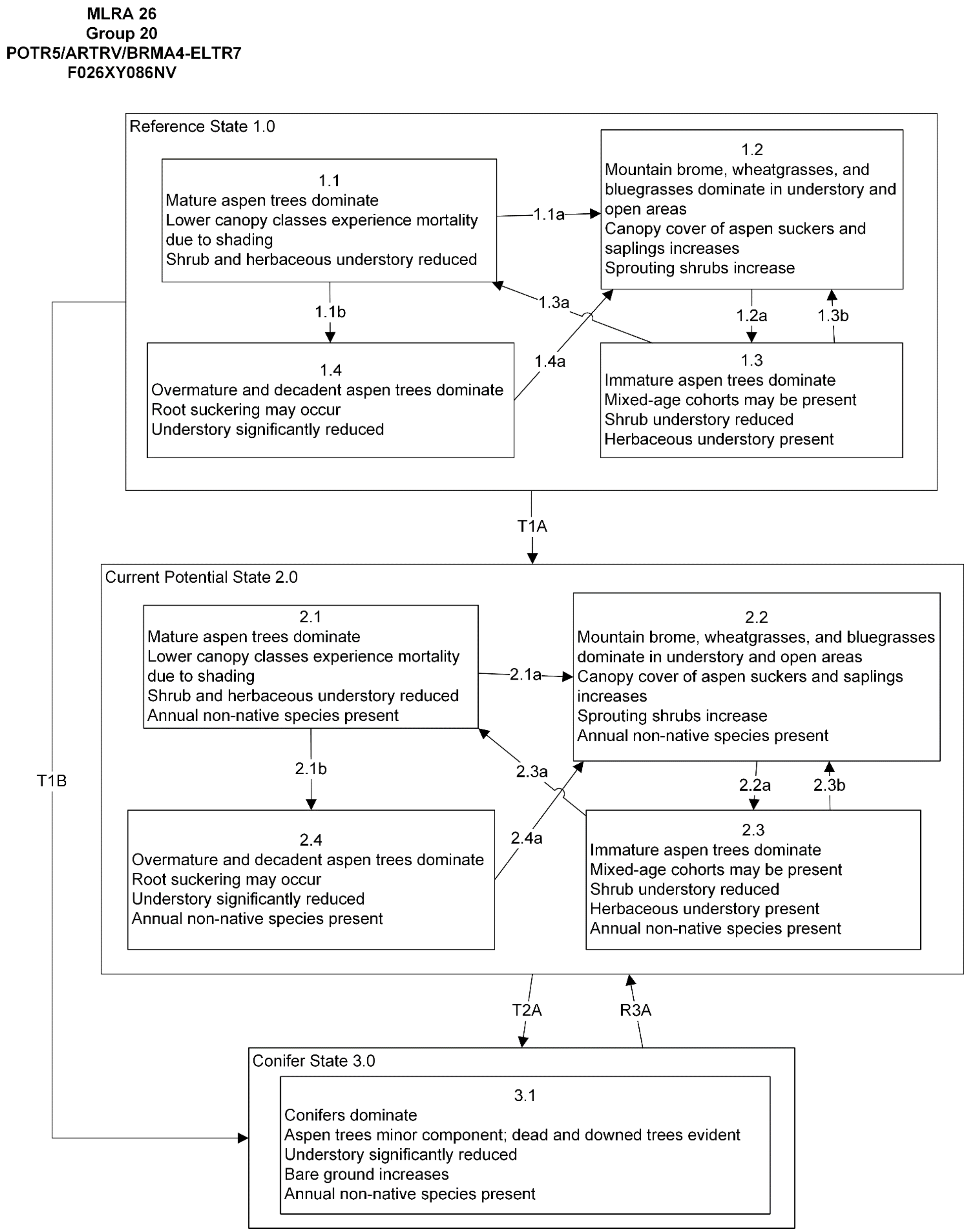
POTR5/SYOR2/BRMA4-ELTR7 (F026XY066NV):

This site occurs on smooth to concave, north-facing mountain sideslopes. In general, this site has a lower site index and lower production than the modal site. Slope gradients are typically 15 to 50 percent with elevations of 7,000 to over 9,500 feet. There is often a large volume of rock fragments through the soil profile. Mountain brome and slender wheatgrass are the dominant understory grasses. Idaho fescue and Ross' sedge are also common. Mountain snowberry, Utah serviceberry, and creeping barberry are the common understory shrubs. Understory annual production on a normal year ranges from 500 to 1,400 lbs/ac depending on canopy cover.

Aspen Thicket (R026XF056CA):

The Aspen Thicket plant community is dominated by dense stands of low-growing quaking aspen, generally less than 15-feet tall at maturity (locally known as "snowbank" aspen). Large rock fragments (cobbles and stones) are common throughout the soil profile. Stones may interfere with the lateral spread of shallow roots and can restrict the reproductive ability of aspen. A variety of forbs, Columbia needlegrass, western needlegrass, slender wheatgrass, and snowberry are important understory species associated with this site and are most prevalent on the periphery of the aspen overstory. This site has two stable states and does not have a conifer state.

Modal State and Transition Model for Group 20 in MRLA 26:



MLRA 26
Group 20
POTR5/PONE3-ELTR7-CAREX
F026XY068NV
Key

Reference State 1.0 Community Pathways
1.1a: Fire, insects, disease, drought, or wind storms remove aspen canopy.
1.1b: Time and lack of disturbance allows aspen to age.
1.2a: Time and lack of disturbance/herbivory allow aspen to mature.
1.3a: Time and lack of disturbance/herbivory allow aspen to mature.
1.3b: Fire, insects, disease, wind, or herbivory when young trees are within browsing reach.
1.4a: Fire.

T1A: Introduction of non-native species (i.e., Kentucky bluegrass, dandelion, thistles).
T1B: Time and lack of disturbance allows conifers to shade out aspen.

Current Potential State 2.0 Community Pathways
2.1a: Fire, insects, disease, drought, or wind storms remove aspen canopy. May also be achieved via harvesting/cutting but with slower results.
2.1b: Time and lack of disturbance allows aspen to age.
2.2a: Time and lack of disturbance/herbivory allow aspen to mature.
2.3a: Time and lack of disturbance/herbivory allow aspen to mature.
2.3b: Fire, insects, disease, wind, or herbivory when young trees are within browsing reach.
2.4a: Fire. May also be achieved via harvesting/cutting with slower results.

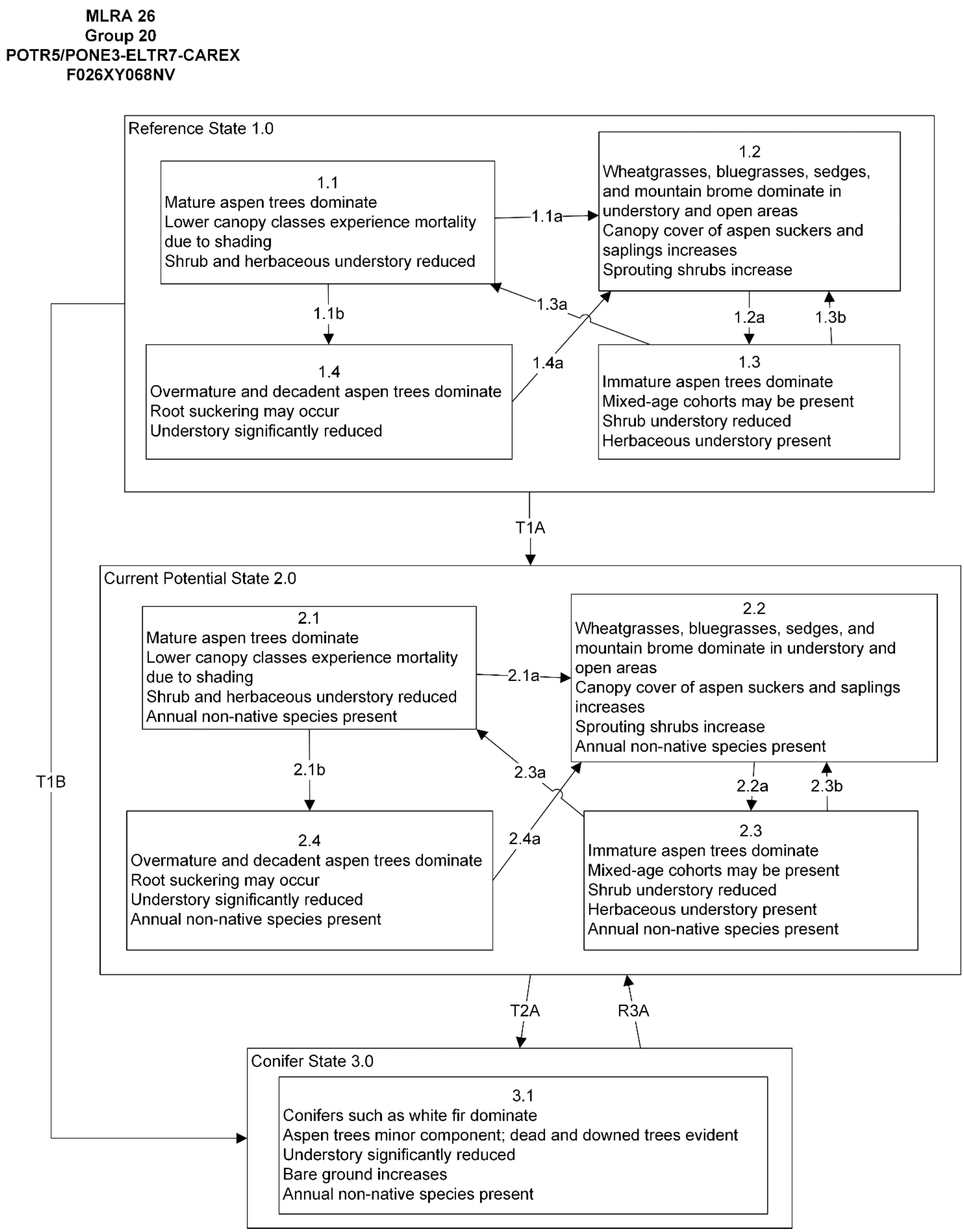
T2A: Time and lack of disturbance allows conifers to shade out aspen.

Conifer State 3.0 Community Pathways
None.

R3A: Prescribed fire or other conifer removal via harvesting/cutting. May be coupled with root ripping to stimulate suckering.

Notes: Fire intervals are dependent upon surrounding vegetation communities. Localized aspen death can occur from disease, insects, heavy snow loading, drought, windfall, etc.

Alternate State and Transition Models for Group 20 in MRLA 26:



MLRA 26
Group 20
POTR5/PONE3-ELTR7-CAREX
F026XY068NV
Key

Reference State 1.0 Community Pathways
1.1a: Fire, insects, disease, drought, or wind storms remove aspen canopy.
1.1b: Time and lack of disturbance allows aspen to age.
1.2a: Time and lack of disturbance/herbivory allow aspen to mature.
1.3a: Time and lack of disturbance/herbivory allow aspen to mature.
1.3b: Fire, insects, disease, wind, or herbivory when young trees are within browsing reach.
1.4a: Fire.

T1A: Introduction of non-native species (i.e., Kentucky bluegrass, dandelion, thistles).
T1B: Time and lack of disturbance allows conifers to shade out aspen.

Current Potential State 2.0 Community Pathways
2.1a: Fire, insects, disease, drought, or wind storms remove aspen canopy. May also be achieved via harvesting/cutting but with slower results.
2.1b: Time and lack of disturbance allows aspen to age.
2.2a: Time and lack of disturbance/herbivory allow aspen to mature.
2.3a: Time and lack of disturbance/herbivory allow aspen to mature.
2.3b: Fire, insects, disease, wind, or herbivory when young trees are within browsing reach.
2.4a: Fire. May also be achieved via harvesting/cutting with slower results.

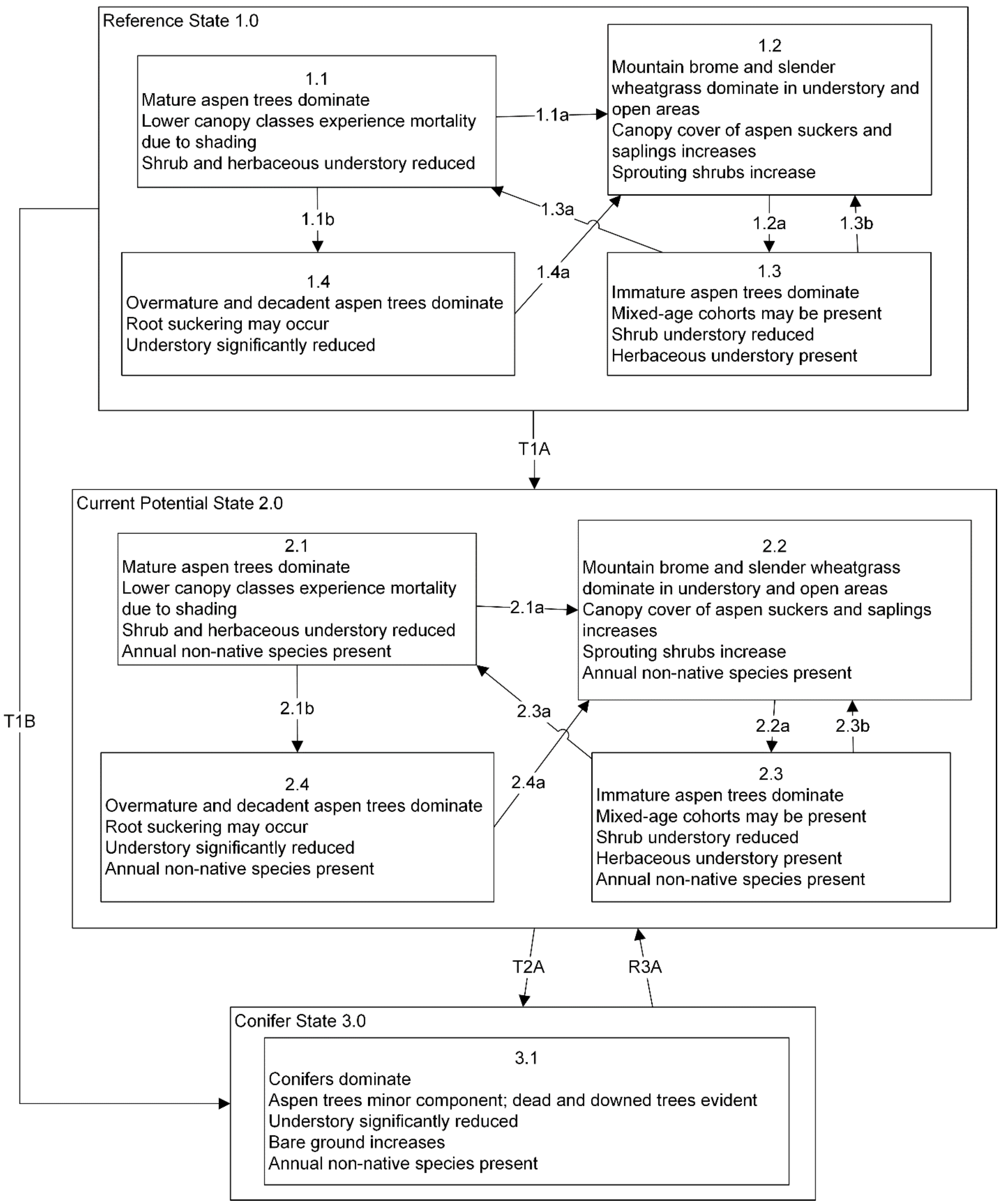
T2A: Time and lack of disturbance allows conifers to shade out aspen.

Conifer State 3.0 Community Pathways
None.

R3A: Prescribed fire or other conifer removal via harvesting/cutting. May be coupled with root ripping to stimulate suckering.

Notes: Fire intervals are dependent upon surrounding vegetation communities. Localized aspen death can occur from disease, insects, heavy snow loading, drought, windfall, etc.

MLRA 26
Group 20
POTR5/SYOR/BRMA4-ELTR7
F026XY066NV



MLRA 26
Group 20
POTR5/SYOR/BRMA4-ELTR7
F026XY066NV
Key

Reference State 1.0 Community Pathways
1.1a: Fire, insects, disease, drought, or wind storms remove aspen canopy.
1.1b: Time and lack of disturbance allows aspen to age.
1.2a: Time and lack of disturbance/herbivory allow aspen to mature.
1.3a: Time and lack of disturbance/herbivory allow aspen to mature.
1.3b: Fire, insects, disease, wind, or herbivory when young trees are within browsing reach.
1.4a: Fire.

T1A: Introduction of non-native species (i.e., Kentucky bluegrass, dandelion, thistles).
T1B: Time and lack of disturbance allows conifers to shade out aspen.

Current Potential State 2.0 Community Pathways
2.1a: Fire, insects, disease, drought, or wind storms remove aspen canopy. May also be achieved via harvesting/cutting but with slower results.
2.1b: Time and lack of disturbance allows aspen to age.
2.2a: Time and lack of disturbance/herbivory allow aspen to mature.
2.3a: Time and lack of disturbance/herbivory allow aspen to mature.
2.3b: Fire, insects, disease, wind, or herbivory when young trees are within browsing reach.
2.4a: Fire. May also be achieved via harvesting/cutting with slower results.

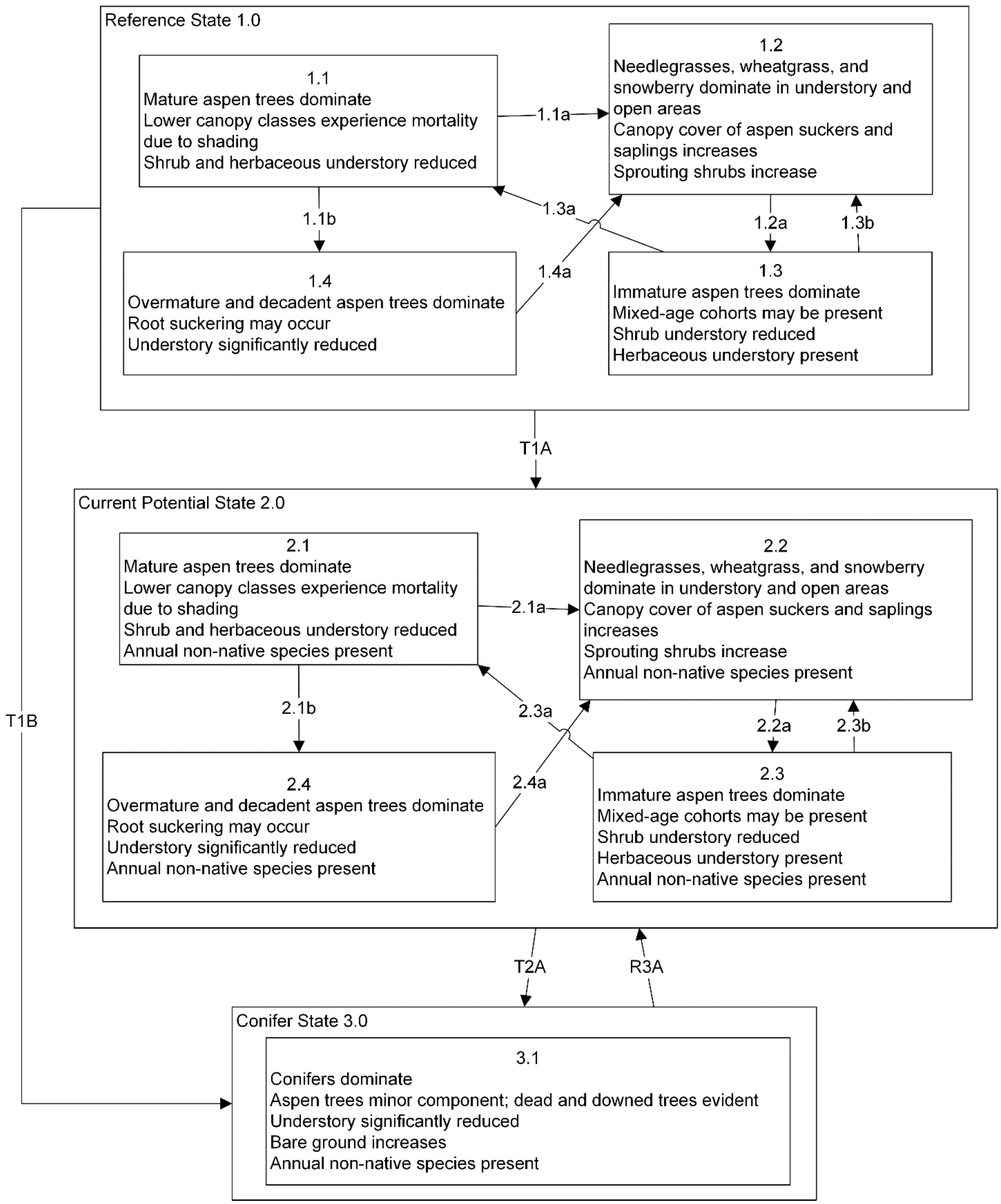
T2A: Time and lack of disturbance allows conifers to shade out aspen.

Conifer State 3.0 Community Pathways
None.

R3A: Prescribed fire or other conifer removal via harvesting/cutting. May be coupled with root ripping to stimulate suckering.

Notes: Fire intervals are dependent upon surrounding vegetation communities. Localized aspen death can occur from disease, insects, heavy snow loading, drought, windfall, etc.

MLRA 26
Group 20
Aspen Thicket
R026XF056CA



MLRA 26
Group 20
Aspen Thicket
R026XF056CA
Key

Reference State 1.0 Community Pathways
1.1a: Fire, insects, disease, drought, or wind storms remove aspen canopy.
1.1b: Time and lack of disturbance allows aspen to age.
1.2a: Time and lack of disturbance/herbivory allow aspen to mature.
1.3a: Time and lack of disturbance/herbivory allow aspen to mature.
1.3b: Fire, insects, disease, wind, or herbivory when young trees are within browsing reach.
1.4a: Fire.

T1A: Introduction of non-native species (i.e., Kentucky bluegrass, dandelion, thistles).
T1B: Time and lack of disturbance allows conifers to shade out aspen.

Current Potential State 2.0 Community Pathways
2.1a: Fire, insects, disease, drought, or wind storms remove aspen canopy. May also be achieved via harvesting/cutting but with slower results.
2.1b: Time and lack of disturbance allows aspen to age.
2.2a: Time and lack of disturbance/herbivory allow aspen to mature.
2.3a: Time and lack of disturbance/herbivory allow aspen to mature.
2.3b: Fire, insects, disease, wind, or herbivory when young trees are within browsing reach.
2.4a: Fire. May also be achieved via harvesting/cutting with slower results.

T2A: Time and lack of disturbance allows conifers to shade out aspen.

Conifer State 3.0 Community Pathways
None.

R3A: Prescribed fire or other conifer removal via harvesting/cutting. May be coupled with root ripping to stimulate suckering.

Notes: Fire intervals are dependent upon surrounding vegetation communities. Localized aspen death can occur from disease, insects, heavy snow loading, drought, windfall, etc.

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MLRA 26 Group 22: Seasonally flooded closed basins

Description of MLRA 26 Disturbance Response Group 22:

Disturbance Response Group (DRG) 22 consists of two related ecological sites: Wet Clay Basin (023XY036NV), and Wet Ashy Basin (023XF068CA). These sites are typically ponded during the early part of the growing season, sometimes throughout most of the growing season. A seasonally high water table is at or near the surface in most years; this plant community is therefore considered ephemeral, with cycles of ponding and drying. When dry, the soils are subject to extensive cracking that damages the root systems of many species of plants. The precipitation zone for these sites ranges from 8 to 12 inches. The elevation range for this group is from 5,500 to 7,500 ft. Slopes range from 0 to 4 percent. Soils of this site are generally very deep, dark colored, and clayey. The potential native plant community for these sites varies depending on precipitation, elevation, landform, and degree of seasonal ponding. In dry areas, the shrub component is dominated by silver sagebrush *(Artemisia cana)*. Shallow groundwater hydrology heavily influences both of these ecological sites.

Disturbance Response Group 22 Ecological Sites:

Wet Clay Basin – Modal Site	R026XY036NV
Wet Ashy Basin	R026XF068CA

Modal Site:

The Wet Clay Basin (023XY036NV) ecological site is the modal site for this group. This site occurs on nearly level enclosed basins, with slope gradients between 0 to 2 percent. This site is found between 5,000 to 6,000 feet. Average annual precipitation is 8 to 12 inches. A seasonally high water table is at or near the surface in most years and the soils are typically ponded through most of the growing season. The soils in this site are deep, dark colored and clayey. When dry, the soils are subject to extensive cracking that damages the root systems of many species of plants. The plant community is dominated by rhizomatous species that can tolerate seasonal ponding, including povertyweed (*Iva axillaris)*, largeleaf pondweed (*Potamogeton amplifolius*), mountain rush (*Juncus arcticus* ssp. *littoralis, also known as Baltic rush*), creeping spikerush (*Eleocharis* spp.), and sedges (*Carex spp*.). Mat muhly (*Muhlenbergia richardsonis*), creeping wildrye (also called beardless wildrye, *Leymus triticoides*), inland saltgrass (*Distichlis spicata*) and bluegrass (*Poa* spp.) are other important species. Silver sagebrush (*Artemisia cana*) may be present in dry areas. Production ranges from 0 lbs/ac in wet, ponded years, to 3,500 lbs/ac in drier years. Normal year annual production is 800 lbs/ac.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire,

herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Povertyweed is a slow-growing perennial with creeping roots, and is the dominant forb on this site. It can remain relatively dormant and can survive adverse weather conditions (Best 1975). It is considered an agricultural weed across North America, but is native to fine-textured moist sites (Montalvo et al. 2010). One study measured an extensive root system, with dense, fibrous roots reaching deeper than 1.8 m (5 ft 10 in) and may reach deeper than 2.5 m in certain conditions (Best 1975). Vegetative reproduction is the primary means of spread; in drought years, roots expand vertically and horizontally, able to exploit growing conditions that are unfavorable to most other plants (Best 1975). This plant thrives with disturbance, increasing in density and shoot height after cultivation (Best 1975). The rooting characteristics of povertyweed allow it to thrive in changing wet-dry conditions and the deep cracking that occurs on this ecological site.

Mountain rush is a cool season, sod-forming, rhizomatous, perennial graminoid – it is the most common rush found in the intermountain region. It has a low tolerance to drought, but can tolerate anoxic soil conditions during temporary flooding (Stevens et al. 2012). This species has been found with up to 1,800 grams of roots in just the top 10 cm of a single square meter of soil, which is second only to Nebraska sedge in terms of root mass (*Carex nebrascensis*) (Manning et al. 1989). Mountain rush primarily regenerates via rhizomes, but it can reproduce via seeds as well (Stubbendieck et al. 1992).

Mat muhly, a warm-season, strongly rhizomatous perennial grass that usually grows in loose clumps or mats (USDA 1988, Penskar and Higman 1999, Schultz 2002). Mat muhly reproduces by seed or rhizomes. Mat muhly can be found on dry to moist sites and often persists in an area for many years after hydrological modifications lower the water table (USDA 1988).

Inland saltgrass is a warm-season rhizomatous grass that is often indicative of shallow groundwater. It is tolerant of high concentrations of salt (Skougard et al. 1979). Where present, the water table tends to be within 8 to 12 feet of the soil surface even in dry periods (Meinzer 1927). Saltgrass is also adapted to low water conditions, as it can distribute water for long distances through its connected rhizomes (Alpert 1990).

Silver sagebrush is often found on deep, poorly drained, often flooded, alluvial soils high in clay, with a seasonally high water table. Silver sagebrush is an evergreen shrub that often forms colonies from a system of extensive rhizomes (Stubbendieck et al. 1992). The root system of silver sagebrush consists of a taproot with lateral roots and rhizomes, usually located within a few inches of the soil surface. Silver sagebrush is the most vigorous sprouter of all sagebrush (Wright et al. 1979); it is able to sprout from roots, rhizomes, and the root crown after disturbance (Ellison and Woolfolk 1937, Whitson et al. 1999, Blaisdell et al. 1982). It has been known to readily layer, meaning it can generate adventitious roots from branches touching soil (Blaisdell et al. 1982). Silver sagebrush is also capable of reproducing by seeds (Whitson 1999).

Silver sagebrush is a host species for the sagebrush defoliator, Aroga moth (*Aroga websteri*) (Henry 1961, Gates 1964, Hall 1965), but it remains unclear whether the moth causes significant damage or mortality to individual or entire stands of plants. Severe drought has been known to kill the crowns of entire stands of silver sagebrush, however, after release from drought it can rapidly regrow due to its vigorous sprouting ability (Ellison and Woolfolk 1937).

Periodic drought regularly influences sagebrush ecosystems. Drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity on this site can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006).

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation, both among years and within growing seasons. The Wet Clay Basin ecological site is subject to both periodic drought and flooding, which influence the vegetative community from year to year. Many of these sites have been altered since settlement times by water developments such as dams or dug-out "troughs." These impoundments and ditches alter the hydrology by changing the area in which water can be captured. If a dug-out lowers the water table, silver sagebrush will increase. If a dam captures more water than the natural site, there may be less vegetation on the site due to excessive ponding.

This ecological site has moderate resilience to disturbance and resistance to invasion. Significant year-to-year variation in ponding and depth to water table are primary drivers for above-ground biomass production. Surface alteration, prolonged drought, or prolonged flooding decreases resilience and increases the probability of annual or perennial weed invasion. Three possible alternative stable states have been identified for this ecological site. While this site was only seen in the reference state during field work for this project, a similar site in Major Land Resource Area 23 was documented in a drained condition and with non-native weeds. We have kept these concepts in this model because these threats exist in this MLRA as well.

Fire Ecology:

Fire likely was a rare occurrence on this ecological site. The fire return interval for this ecological site would be primarily a function the surrounding upland sagebrush sites capability to carry fire along with prior year rainfall and ponding duration effecting fine fuel production within the site. Fire return intervals are largely unknown for Lahontan and low sagebrush, but have been estimated at 100-200 years in the similar black sagebrush *(Artemisia nova)* ecosystem (Kitchen and McArthur 2007). Fires were probably historically patchy due to the low productivity of these sagebrush sites. Sites in this group are unlikely to burn in wet years, but the native vegetation is generally resistant to fire damage.

Little is known about the response of povertyweed to fire (Montalvo et al. 2010). Povertyweed possesses characteristics of early seral species capable of rapidly increasing within disturbed sites, including prolific seed production and ability to sprout from underground root systems (Whitson et al. 1999). Mat muhly (*Muhlenbergia richardsonis*) is resistant to damage from fire because its rhizome buds are insulated by soil (Benedict 1984). A few studies have observed that fire in the spring has stimulated flowering (Anderson and Bailey 1980, Pemble et al. 1981), however, there is little other documentation of this plant's fire response.

Creeping or beardless wildrye (*Leymus triticoides*), a minor component on this site, may increase after fire due to its aggressive creeping rhizomes (Monsen et al. 2004). Nevada bluegrass (*Poa nevadensis*) is generally not damaged by wildfire due to its short, tufted growth form and panicles lacking in density (Monsen et al. 2004). The lack of litter buildup within the grass plant, along with early dormancy, typically preclude extensive damage to the buds, however, early fires during dry years may be more damaging (Kearney et al. 1960). Cover of Nevada bluegrass may increase following wildfire (Blackburn et al. 1971). Similarly, Sandberg bluegrass (*Poa secunda*), a minor component of this site, has been found to increase following fire, likely due to its low stature and productivity (Daubenmire 1975). Overall, the grass components of this ecological site possess structural attributes suggesting high resiliency to fire.

Silver sagebrush has been found to be less sensitive to fire than other sagebrush species due to its ability to resprout. Silver sagebrush is capable of resprouting from roots and rhizomes when topgrowth is destroyed (Cronquist et al. 1994, Blaisdell et al. 1982, Whitson et al. 1999). Silver sagebrush also reproduces by seed. Seedling establishment can occur in the years after fire if the growing season is favorably wet (Wambolt et al. 1989). White and Currie (1983) found spring and fall burning both resulted in complete topkill of silver sagebrush regardless of fire intensity, however, spring burning when soil moisture was high and before plants began rapid stem growth resulted in low mortality and vigorous sprouting. Fall burning resulted in mortality of 40 to >70% of the silver sagebrush plants suggesting summer wildfires could cause substantial stand death. Post-fire recovery and resilience is primarily influenced by pre-fire site conditions, fire severity, and post-fire weather and land use that relate to vegetation recovery. Sites with low abundances of native perennial grasses and forbs typically have reduced resiliency following disturbance and are less resistant to invasion or increases in cheatgrass or other weedy species (Miller et al. 2013).

Livestock/Wildlife Grazing Interpretations:

The landscape position of the ecological sites in this group typically provides additional soil moisture for extended plant growth than the surrounding sagebrush landscape, increasing the attractiveness of these areas for animals seeking forage. There is potential for soil damage if grazing occurs during the time period when soils are saturated with water, generally in the spring.

Povertyweed is generally considered to be unpalatable: it increases under heavy grazing pressure, is not damaged by trampling, and has been reported to accumulate selenium at levels considered poisonous to some animals (Best 1975). However, there are some reports that sheep will consume this plant in the spring if concentrated in an area with it (Hanley and Hanley 1982).

Mountain rush is generally not eaten by cattle; it has low palatability due to a high lignin content (Stevens et al. 2012). Mat muhly withstands heavy grazing because of its sod-forming growth form (USDA 1988). It is a short-statured plant with stems typically 3 to 8 inches long and many basal and stem leaves between one-half and two or more inches long (USDA 1988).

In drier areas on these ecological sites, bluegrasses and creeping wildrye may be dominant. Nevada bluegrass is very palatable and is preferred by both domestic livestock and wildlife during the spring and early summer, with reported crude protein levels of over 17% (Monsen et al. 2004). Nevada bluegrass and Sandberg bluegrass are no longer differentiated taxonomically; however, the two grasses typically grow in different ecological niches. Nevada bluegrass is found in locations with greater soil moisture during the growing season. Sandberg bluegrass has been found to increase under grazing pressure due to its early dormancy and short stature (Tisdale and Hironaka 1981).

Silver sagebrush can provide an important source of browse and is used by livestock and big game when other food sources are scarce (Kufeld et al. 1973, Wasser 1982, Cronquist et al. 1994). In fall and winter feeding trials, silver sagebrush was among the most preferred sagebrush species for mule deer and sheep (Sheehy and Winward 1981). However, silver sagebrush is an aggressive colonizer and can occupy areas at high densities, due to its ability to resprout from the crown and to spread by rhizomes (Monsen et al. 2004). Therefore, silver sagebrush can increase significantly under inappropriate grazing management on this site.

In general, inappropriate grazing by domestic livestock or feral horses can cause Nevada bluegrass to decrease and mat muhly to initially increase. Continued deterioration leads to a decrease in mat muhly an increase in povertyweed and other annual and perennial weedy forbs along with silver sagebrush.

Hydrologic Modification:

This site receives additional moisture from runoff from adjacent sites. Hydrologic alteration impacts can occur from off-site or on-site activities. Years of extreme drought can also result in a lowered water table. Excessive large animal use during wet periods can cause pugging, root shear, hummock formation, an increase in bare ground and modification to infiltration rates. Modifications such as dams, dug-outs, or ditches lead to site drying, resulting in a loss of perennial grass-like plants and silver sagebrush, and an increase in weedy annual and perennial forbs.

State and Transition Model Narrative for Group 22:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 22.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. The reference state has three general community phases. State dynamics are primarily driven by changes in hydrology. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by cyclical drought and wet cycles.

Community Phase 1.1:
Povertyweed, mountain rush, spikerush, and other perennial forbs dominate the site. Silver sagebrush cannot tolerate excessive seasonal ponding and will be reduced in the wetter areas of this phase. The site is seasonally ponded, with vegetation coming in as the water dries up in the summer. Annual production increases in years when this site dries out early.

Wet Ashy Basin (026XF068CA) Phase 1.1. D. Snyder, September 2017

Community Phase Pathway 1.1a, from phase 1.1 to 1.2:
A wet winter and spring causes ponding that remains throughout the growing season, significantly reducing potential vegetative growth.

Community Phase Pathway 1.1b, from phase 1.1 to 1.3:
Extended drought facilitates an increase in flood-intolerant species like silver sagebrush, rabbitbrush, and mat muhly.

Community Phase 1.2:
Site is primarily covered in standing water through the growing season. Vegetative productivity is at or near 0 lbs/ac. Silver sagebrush may still be present in the driest areas around the perimeter of this site.

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Return to drought or normal-year moisture conditions allow rhizomatous forbs and grass-likes to dominate.

Community Phase 1.3:
Mat muhly and other grasses increase. Silver sagebrush and rabbitbrush will increase in cover as long as drought conditions persist. This phase may be at risk of becoming a shrub state if drought conditions persist, or with inappropriate management of grazing.

Wet Ashy Basin (026XF068CA) Phase 1.3 (At Risk) T. Stringham June 2016

Wet Ashy Basin (026XF068CA) Phase 1.3 (At Risk) T. Stringham June 2016

Community Phase Pathway 1.3a, from phase 1.3 to 1.2:
A winter with high amounts of precipitation returns the site to a ponded phase.

Community Phase Pathway 1.3b, from phase 1.3 to 1.1:
Release from extended drought conditions allow rhizomatous forbs and grasses to return to dominance.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0

Trigger: This transition is caused by the introduction of non-native annual weeds, such as cheatgrass, mustard (*Descurainia* sp.), and bur buttercup (or curveseed butterwort, *Ceratocephala testiculata*).

Slow variables: Over time the annual non-native plants will increase within the community, reducing availability of water and nutrients for native perennial plants.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

T1B: Transition from Reference State 1.0 to Shrub State 3.0

Trigger: Long-term drought, coupled with inappropriate grazing management, or surface alterations lower the water table.

Slow variables: Lowering of the water table allows silver sagebrush to dominate. A long-term decrease in deep-rooted herbaceous density results in a decrease in organic matter inputs and subsequent decline in soil water holding capacity.

Threshold: Loss of deep-rooted rhizomatous forbs and grasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter. The seedbank for understory forbs and grasses disappears.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed; however, the resiliency of the state has been reduced by the presence of invasive weeds. This state has three general community phases. State dynamics are primarily driven by changes in hydrology. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by cyclical drought and wet cycles. Positive feedbacks, such as the non-natives high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate and adaptations for seed dispersal decrease ecosystem resilience and stability of the state. The presence of nonnative grasses and forbs reduces resiliency because it reduces resource availability for native species.

Community Phase 2.1:
Povertyweed, mountain rush, spikerush, and other perennial forbs dominate the site. Silver sagebrush cannot tolerate excessive seasonal ponding and will be reduced in the wetter areas of this phase. The site is seasonally ponded, with vegetation coming in as the water dries up in the summer. Annual production increases in years when this site dries out early. Non-native annual/perennial weedy species present.

Community Phase Pathway 2.1a, from phase 2.1 to 2.2:
A wet winter and spring causes ponding that remains throughout the growing season, significantly reducing potential vegetative growth.

Community Phase Pathway 2.1b, from phase 2.1 to 2.3:
Extended drought facilitates an increase in flood-intolerant species like silver sagebrush, rabbitbrush, and mat muhly.

Community Phase 2.2:
Site is primarily covered in standing water through the growing season. Vegetative productivity is at or near 0 lbs/ac. Silver sagebrush may still be present in the driest areas around the perimeter of this site.

Community Phase Pathway 2.2a, from phase 2.2 to 2.1:
Return to drought or normal-year moisture conditions allow rhizomatous forbs and grass-likes to dominate.

Community Phase 2.3:
Mat muhly and other grasses increase. Silver sagebrush and rabbitbrush will increase in cover as long as drought conditions persist. This phase is at risk of becoming a shrub state if drought conditions persist, or with inappropriate management of grazing.

Community Phase Pathway 2.3a, from phase 2.3 to 2.2:
A winter with high amounts of precipitation returns the site to a ponded phase.

Community Phase Pathway 2.3b, from phase 2.3 to 2.1:
Release from extended drought conditions allow rhizomatous forbs and grasses to return to dominance.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0

Trigger: Long-term drought, coupled with inappropriate grazing management, or surface alterations lower the water table.

Slow variables: Lowering of the water table allows silver sagebrush to dominate. A long-term decrease in deep-rooted herbaceous density results in a decrease in organic matter inputs and subsequent decline in soil water holding capacity.

Threshold: Loss of deep-rooted rhizomatous forbs and grasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter. The seedbank for understory forbs and grasses disappears.

Shrub State 3.0:

This state is a product of altered hydrology, coupled with heavy grazing during time periods harmful to perennial bunchgrasses and grass-likes. Surface alterations that alter hydrology include severe trampling, dugout ponds for stock water, or trenches for water diversions. Nearby groundwater pumping may also have an effect on shallow groundwater hydrology. Silver sagebrush dominates the overstory and other shrubs may be a significant component. Sagebrush canopy cover is high and sagebrush may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. The shrub overstory dominates site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

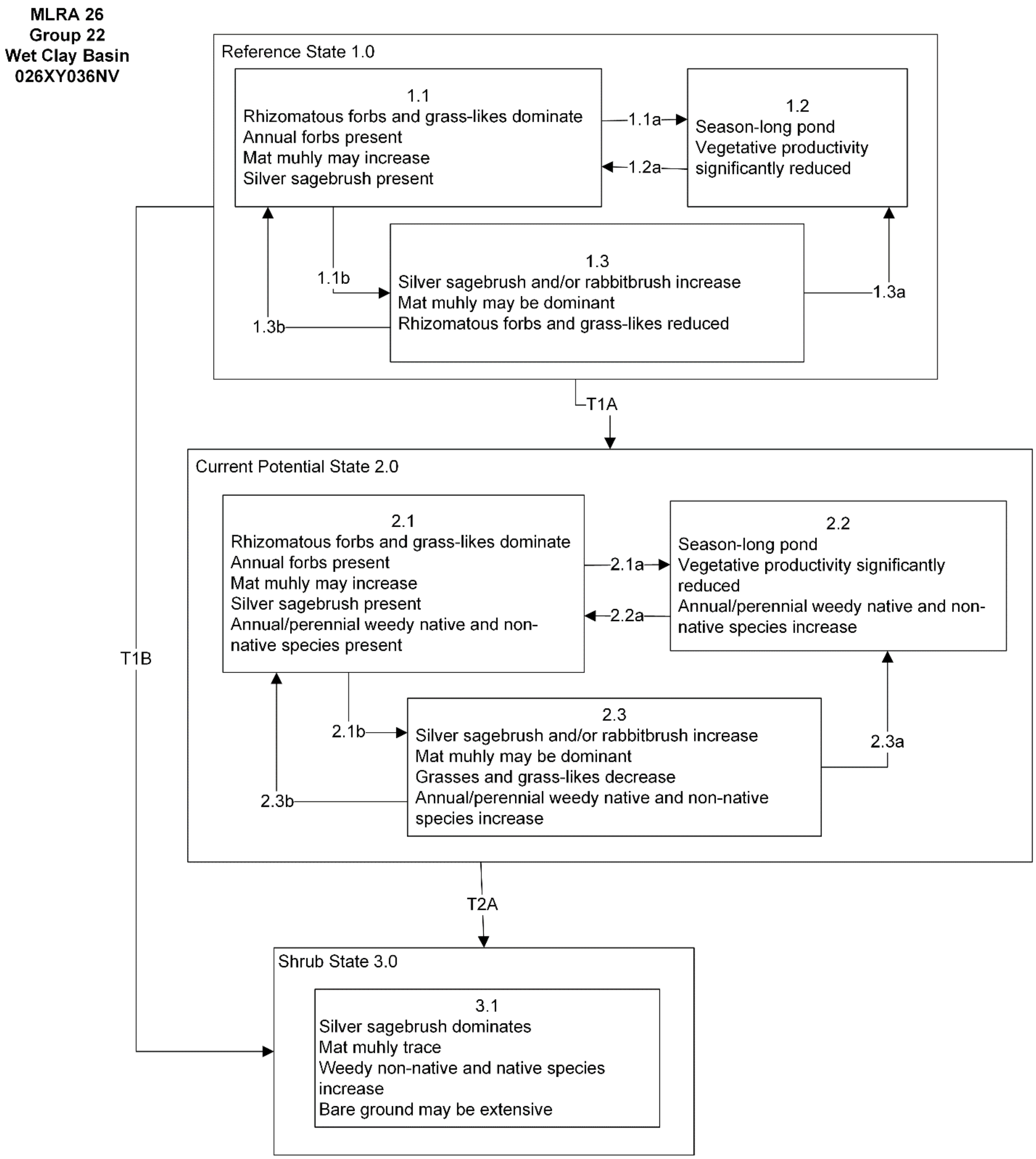
Community Phase 3.1:
Silver sagebrush dominates. Mat muhly may be present in trace amounts. Perennial grasses and forbs are minor components. Non-native weedy forbs may or may not be present. Bare ground is extensive.

Potential Resilience Differences with other Ecological Sites:

Wet Ashy Basin (R023XY068CA):

This site has similar plant community and ecological dynamics as the modal site that is mapped in Nevada. Tansyleaf evening primrose (*Camissonia tanacetifolia*) is a more important species on this site and may be dominant in phase 1.1 and 2.1. This site is found at higher elevations, between 7,000 and 8,500 feet. Soils on this site have high levels of volcanic ash.

Modal State and Transition Model for Group 22 in MRLA 26:



MLRA 26
Group 22
Wet Clay Basin
026XY036NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Ponding during years with high amounts of precipitation in winter and spring reduces productivity.
1.1b: Extended drought facilitates an increase in silver sagebrush, rabbitbrush and weedy species while all grasses decline in production.
1.2a: Years with less moisture allow forbs, sedges, and rushes to return to dominance.
1.3a: Release from long-term drought and a wetter-than-average winter allows site to return to ponded conditions.
1.3b: Release from long-term drought allows site to return to forb-dominated community.

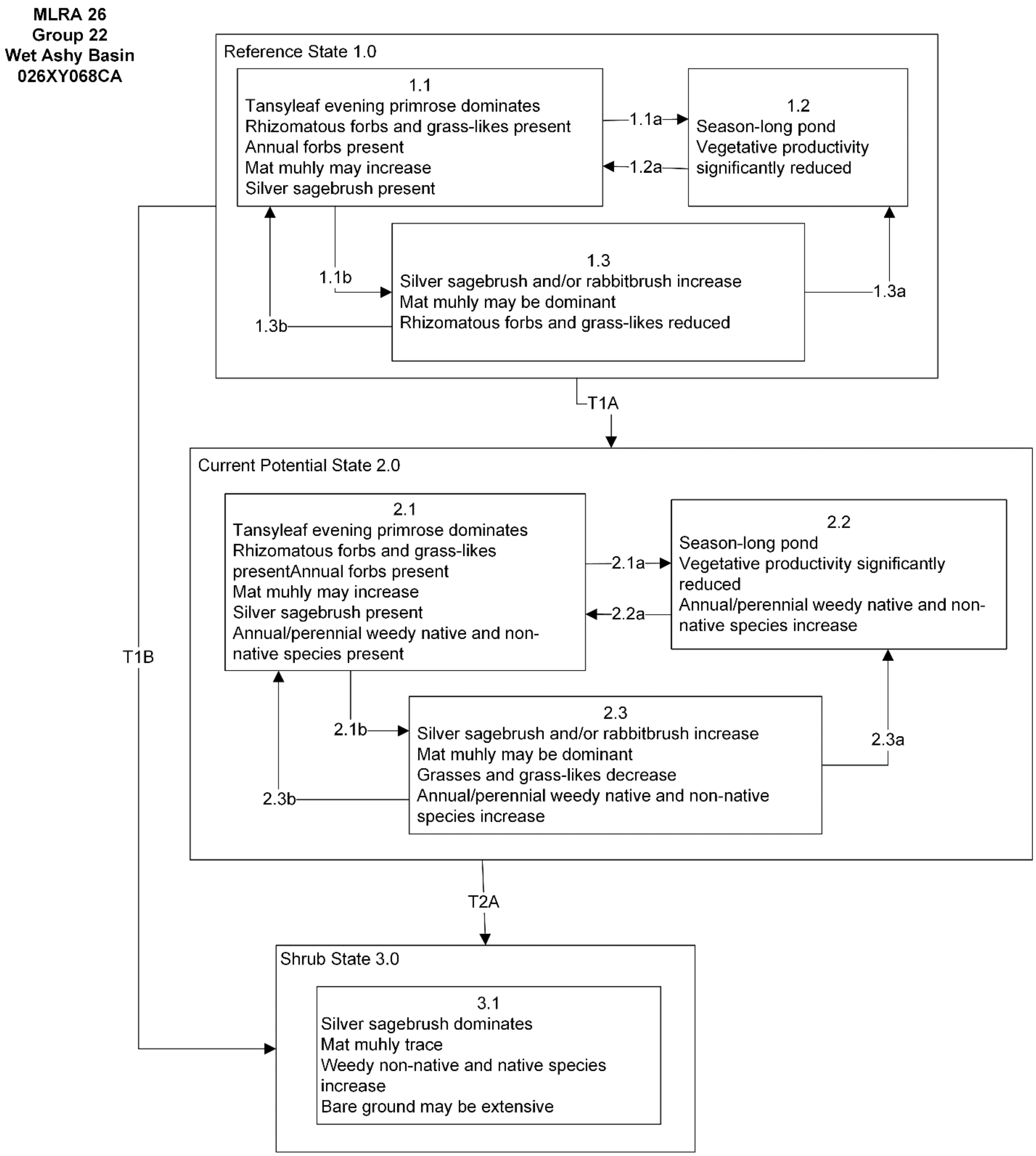
Transition T1A: Introduction of non-native species.
Transition T1B: Extended drought, inappropriate grazing management, or altered hydrology allows shrubs to dominate.

Current Potential State 2.0 Community Phase Pathways
2.1a: Ponding during years with high amounts of precipitation in winter and spring reduces productivity.
2.1b: Continued chronic drought coupled with inappropriate grazing management facilitates an increase in silver sagebrush, rabbitbrush and weedy species while all grasses decline in production.
2.2a: Years with less moisture allow forbs, sedges, and rushes to return to dominance.
2.3a: Release from long-term drought and a wetter-than-average winter allows site to return to ponded conditions.
2.3b: Fire, release from herbivory, and/or release from long-term drought allows site to return to forb-dominated community.

Transition T2A: Long term drought or otherwise altered hydrologic regime. May be coupled with inappropriate grazing management.

Shrub State 3.0 Community Phase Pathways
None.

Alternative State and Transition Models for Group 22 in MLRA 26:



MLRA 26
Group 22
Wet Ashy Basin
026XY068CA
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Ponding during years with high amounts of precipitation in winter and spring reduces productivity.
1.1b: Extended drought facilitates an increase in silver sagebrush, rabbitbrush and weedy species while all grasses decline in production.
1.2a: Years with less moisture allow forbs, sedges, and rushes to return to dominance.
1.3a: Release from long-term drought and a wetter-than-average winter allows site to return to ponded conditions.
1.3b: Release from long-term drought allows site to return to forb-dominated community.

Transition T1A: Introduction of non-native species.
Transition T1B: Extended drought, inappropriate grazing management, or altered hydrology allows shrubs to dominate.

Current Potential State 2.0 Community Phase Pathways
2.1a: Ponding during years with high amounts of precipitation in winter and spring reduces productivity.
2.1b: Continued chronic drought coupled with inappropriate grazing management facilitates an increase in silver sagebrush, rabbitbrush and weedy species while all grasses decline in production.
2.2a: Years with less moisture allow forbs, sedges, and rushes to return to dominance.
2.3a: Release from long-term drought and a wetter-than-average winter allows site to return to ponded conditions.
2.3b: Fire, release from herbivory, and/or release from long-term drought allows site to return to forb-dominated community.

Transition T2A: Long term drought or otherwise altered hydrologic regime. May be coupled with inappropriate grazing management.

Shrub State 3.0 Community Phase Pathways
None.

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MLRA 26 Group 23: High elevations with pines, sagebrush, currant and grass understory

Description of MRLA 26 Disturbance Response Group 23

Disturbance Response Group (DRG) 23 consists of one ecological site. This woodland community occurs on smooth to concave mountain sideslopes. The site is generally found on northerly aspects at lower elevations and on all aspects at higher elevations. Slopes range from 8 to over 75 percent but are typically 30 to 50 percent. Elevations are about 9,000 feet to over 10,000 feet. Average annual precipitation is over 20 inches. These soils are skeletal and typically have 35 to 50 percent gravels, cobbles, or stones, by volume, distributed throughout the soil profile. Available water capacity is moderate to high and the soils are well drained. Runoff is medium to rapid and the potential for sheet and rill erosion is moderate to severe depending on steepness of slope and amount of rock fragments on the soil surface. This site has an overstory tree canopy composition of 100 percent limber pine (*Pinus flexilis*). Canopy cover of limber pine on this site is about 20 to 35 percent. A variety of upland browse species are common in the understory although mountain big sagebrush (*Artemisia trientata ssp. vaseyana)* is the principal understory shrub. Spike fescue (*Leucopoa kingii*), prairie junegrass (*Koeleria macrantha*), dunhead sedge (*Carex phaeocephala*), Ross' sedges (*Carex rossii*) and Letterman's needlegrass (*Achnatherum lettermanii*) are the most prevalent understory grasses or grass-like plants. Understory production can range from 200 to 600 lbs/ac in normal years, depending on tree canopy levels.

This site was not seen during field work for this modeling effort. The site is mapped in the Wassuk Range south of Mount Grant.

Disturbance Response Group 23 Ecological Site:

PIFL2 WSG: 0R10001 PIFL2/ARTRV/LEKI2-KOMA-CAREX F026XY067NV

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Limber pine is a long-lived, five-needled white pine (of *Pinus* subgenus *Strobus*) that is found between 6,000 to 11,500 ft. in elevation. It has been found in 51 mountain ranges and 11 counties in Nevada. This pine has wingless seeds that are primarily dispersed by Clark's nutcrackers (*Nucifraga columbiana*) who tend to cache seeds in open burn sites (Coop and Schoettle 2009). Because of these caches, limber pines are often seen in clusters or groups after fire. Seed-caching by Clark's nutcrackers appears to be the only means of dispersal for this tree species (Lanner and Vander Wall 1980, Lanner 1985, Bradley et al. 1992).

Because of this continual seed-caching, stands of limber pine are typically multi-aged unless otherwise affected by disturbance such as fire.

Primary natural disturbance mechanisms affecting this ecological site are periodic long-term drought, infrequent wildfire, and insect-induced mortality. This site experiences an extended fire return interval due to lack of herbaceous understory and widely spaced trees.

Limber pine is affected by the native mountain pine beetle (*Dendroctonus ponderosae*). The beetle targets small-diameter trees, using phloem as a food source and sometimes introducing fungal pathogens; damage can sometimes be extensive enough to convert pine forest ecosystems to a shrub and grass phase (Phillips 2020). Limber pine is one of the five pines in North America that are susceptible to an introduced fungal pathogen called white pine blister rust that is responsible for >90% mortality of affected trees in some areas across western North America (Kendall and Kearne 2001). However, this does not seem to have major effects on populations in the Great Basin (Schoettle et al. 2014, Phillips 2020). This pathogen requires an alternate host species in order to complete its life cycle such as Indian paintbrush (*Castilleja* spp.), lousewort (*Pedicularis* spp.) and currant (*Ribes* spp.) (McDonald et al. 2006). In some parts of the Great Basin, limber pine is expanding its range upslope, above the current treeline in response to climate change (Millar et al. 2015, Smithers et al. 2018). More research is needed to understand factors that influence limber pine seedling establishment in order to implement best management practices.

Mountain big sagebrush and antelope bitterbrush are generally long-lived (50+ years); therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is dependent on adequate moisture conditions.

The limber pine community is stable and is minimally affected by non-native pests where it exists in this MLRA. Non-native plant species have not been found on this site, therefore this STM consists of one state: the reference state.

Fire Ecology:

Fire is very infrequent in high elevation forests dominated by limber pine, due to low herbaceous production and widely spaced trees (Bradley et al. 1992). Fires in these zones are more likely related to El Niño events and higher production years (Sherriff et al. 2001). In the more productive sites, limber pine may be dependent on infrequent stand replacing fires, which create open areas that promote regeneration (Coop and Schoettle 2009). Fire increases limber pine seedling establishment but the regeneration of this species is slow (Coop and Schoettle 2009) and depends on seed-caching by Clark's nutcracker (Bradley et al. 1992). The spread of wildfire from lightning is unlikely, but individual trees may ignite. As a thin-barked pine, limber pine is only able to survive low-severity fires.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983).

Post-fire regeneration occurs from surviving root crowns and from seed. Spike fescue is a broad-leaf grass and is relatively tolerant of fire and is generally known to increase after fire (Cook et al. 1994). It will reestablish by windblown seed from off-site seed sources (Bradley et al. 1992). Prairie junegrass is tolerant of low severity fire, likely due to its low stature and loosely tufted growth form, but may be killed by more severe fires (Young 1983). Ross' sedge survives fire through buried rhizomes, and its seeds are adapted to increase germination after exposure to heat (Bradley et al. 1992). This plant frequently increases production after fire.

Mountain big sagebrush is killed by fire (Neunschwander 1980, Blaisdell et al. 1982) and does not resprout (Blaisdell 1953). Post-fire regeneration occurs from seed and will vary depending on site characteristics, seed source, and fire characteristics. Mountain big sagebrush seedlings can grow rapidly and may reach reproductive maturity within 3 to 5 years (Bunting et al. 1987). Mountain big sagebrush may return to pre-burn density and cover within 15-20 years following fire, but establishment after severe fires may proceed more slowly (Bunting et al. 1987).

Antelope bitterbrush is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however, sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture, and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires may allow for bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006). If cheatgrass is present, bitterbrush seedling success is much lower. The factor that most limits establishment of bitterbrush seedlings is competition for water resources with the invasive species cheatgrass (Clements and Young 2002).

Snowberry has been noted to regenerate from rhizomes and can exceed pre-burn biomass in the third season after a fire (Merrill et al. 1982, Noste and Bushey 1987).

Livestock and Wildlife Interpretations:

Despite low palatability, mountain big sagebrush is eaten by sheep, cattle, goats, and horses. Chemical analysis indicates that the leaves of big sagebrush equal alfalfa meal in protein, have a higher carbohydrate content, and yield twelvefold more fat (USDA 1988). Many wildlife species are dependent on the sagebrush ecosystem including the greater sage grouse, sage sparrow, pygmy rabbit and the sagebrush vole. Dobkin and Sauder (2004) identified 61 species, including 24 mammals and 37 birds, associated with the shrub-steppe habitats of the Intermountain West. Antelope bitterbrush is an important shrub species to a variety of animals, such as domestic livestock, antelope, deer, and elk. Bitterbrush is critical browse for mule deer, as well as domestic livestock, antelope, and elk (Wood et al. 1995, Clements and Young 2002). Antelope bitterbrush is most commonly found on soils that provide minimal restriction to deep root penetration such as coarse textured soil, or finer textured soil with high stone content (Driscoll 1964). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison 1953).

Prairie junegrass is palatable to many wildlife species including deer, antelope, elk, bighorn sheep, small mammals and upland birds. It is valuable forage in the early spring as it develops earlier than most species and flowers in April to June. Letterman's needlegrass also provides valuable forage for wildlife (Taylor 2000). It begins growth early in the year and is available to be utilized when other grasses are not yet palatable, and is plant is especially important fall forage for big game. (Monsen et al. 2004).

State and Transition Model Narrative for Group 23:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 Disturbance Response Group 23.

Reference State 1.0:

The Reference State 1.0 represents of the natural range of variability under pristine conditions. The reference state has two general community phases: a dominant tree/shrub phase and a dominant shrub and grass/grass-like phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, insects, and/or periodic drought.

Community Phase 1.1:
This community is dominated by limber pine. Mountain big sagebrush, mountain snowberry, spike fescue, prairie junegrass, and sedges dominate the understory, which may be sparse. Large amounts of gravel and cobbles cover the soil surface and inhibit dense plant growth.

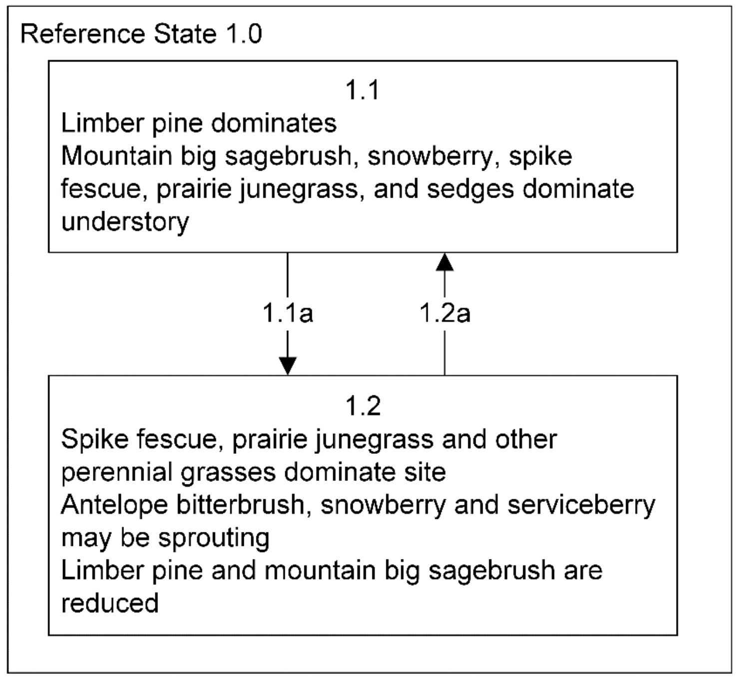
Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Low severity fire will kill limber pine and sagebrush, but allow for the perennial bunchgrasses to increase. Mortality caused by drought or insects may reduce limber pine but allow mountain big sagebrush to remain.

Community Phase 1.2:
This community is dominated by spike fescue, prairie junegrass, needlegrasses, and other perennial grasses and grass-likes. Limber pine and mountain big sagebrush are reduced after fire. Antelope bitterbrush, snowberry, and serviceberry may be sprouting.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Time and lack of disturbance will allow limber pine and/or mountain big sagebrush to increase. This pathway may be slow.

Modal State and Transition Model for Group 23 MLRA 26:

MLRA 26
Group 23
PIFL2/ARTRV/LEKI2-KOMA-CAREX
F026XY067NV



MLRA 26
Group 23
PIFL2/ARTRV/LEKI2-KOMA-CAREX
F026XY067NV
Key

Reference State 1.0 Community Phase Pathways:

1.1a: Low-severity fire or insect-induced mortality.
1.2a: Time and lack of disturbance.

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MLRA 26 Group 24: Ponderosa pine and altered andesite buckwheat

Description of MRLA 26 Disturbance Response Group 24

Disturbance Response Group (DRG) 24 consists of one ecological site: PIPO WSG: 2R1207 (F026XY065NV). This site occurs on the summits and steep side slopes of hills and lower elevation mountains on slopes ranging from 4 to over 75 percent, but slope gradients of 30 to 50 percent are most typical. Elevations range from 4,500 to 7,000 feet. The soils on this site are shallow to weathered bedrock and well drained. Soils are coarsely textured and have little horizonation. Soil material mixes with the underlying altered andesite parent material. The andesite base rock has been altered by chemical (hydrothermal) weathering with much of the mineral nutrients being leached from the soil. The available nitrogen and available phosphorous in these soils is extraordinarily low. These soils are acidic, with soil pH generally ranging between 3.5 and 5.5. Potential for sheet and rill erosion is moderate to severe depending on slope. The highly acidic soils, ranging from pH 3.5 to 5.5, are light tan to yellow in color; these conditions contrast starkly to neighboring soil types with neutral pH and higher productivity (Billings 1950, Billings 1992).

The plant community is dominated by ponderosa pine (*Pinus ponderosa*) with a sparse understory dominated by andesite buckwheat (*Eriogonum robustum*). Desert needlegrass (*Achnatherum speciosum*), sedges (*Carex* spp.), and bottlebrush squirreltail (*Elymus elymoides*) are also present in the community. Utah juniper (*Juniperus osteosperma*), ephedra (*Ephedra viridis*), and desert peach (*Prunus andersonii*) may be present but are minor components. The understory annual production on this site ranges from 10 to 200 lbs/ac, with 50 lbs/ac in normal years under medium canopy (11 to 20 percent).

Disturbance Response Group 24 Ecological Site:

PIPO WSG: 2R1207	PIPO/ERRO10/CAREX	F026XY065NV

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

In the Great Basin, the majority of annual precipitation is received during the winter and early spring. This continental semiarid climate regime favors growth and development of deep-rooted shrubs and herbaceous cool season plants using the C3 photosynthetic pathway (Comstock and Ehleringer 1992). Winter precipitation and slow melting of snow results in deeper percolation of moisture into the soil profile. Herbaceous plants, more shallow-rooted than shrubs, grow earlier in the growing season and thrive on spring rain and snowmelt. Deeper-rooted shrubs lag in phenological development because they draw from deeply infiltrating moisture from snowmelt. Periodic drought regularly influences Great

Basin ecosystems; drought duration and severity has increased throughout the 20th century in much of the Intermountain West. Major shifts away from historical precipitation patterns have the greatest potential to alter ecosystem function and productivity. Species composition and productivity can be altered by the timing of precipitation and water availability within the soil profile (Bates et al. 2006). Germination and establishment of all species on this site will be episodic because of this climactic variation (Korb et al. 2019).

Ponderosa pine and Jeffery pine, the two dominant woody species on this site, are typically found in the Sierra Nevada mountain range in areas that receive greater than 15 inches of precipitation per year. Where this ecological site exists, annual precipitation averages just 8-10 in per year, indicating that this ecological site may be a relic of past climate regimes that would have allowed for regeneration of ponderosa pine and other tree species more typical of Sierra Nevada ecosystems (Billings 1992). Billings (1992) posits that the Sierran species remain in these locations because sagebrush and pinyon-juniper vegetation is incapable of invading the nutrient poor, highly-acidic soil of the altered-andesite, leaving the area available to the trees and specialized herbaceous species that are adapted to these conditions (DeLucia et al. 1988, DeLucia and Schlesinger 1990, Billings 1992).

Altered andesite buckwheat is a distinctive species, endemic to these particular soils in the hills surrounding Reno and Virginia City, Nevada (Kuyper at al. 1997). This forb is recognized as “at-risk” in the state of Nevada and is listed as sensitive by both the Bureau of Land Management and the U.S. Forest Service (Nevada Division of Natural Heritage 2020). This plant has been previously classified under the name *Eriogonum lobbii* var*. robustum.*

Ponderosa pine is a deep-rooted tree when compared to other western conifer species (Fitzgerald 2005). It is theorized that the tap-rooted trees on this site are able to access deeper moisture in deep cracks in the bedrock, however, there are no known excavations to test this theory (DeLucia and Schlesinger 1990). There is some evidence that the altered andesite soils have greater soil moisture availability later into the summer than surrounding soil types (DeLucia and Schlesinger 1990). There are multiple age classes of ponderosa pine on these sites, indicating that while these plants are restricted to the altered andesite soils, there is recruitment to perpetuate the stand.

The ecological site in this DRG has moderate resilience to disturbance and resistance to invasion. Two stable states were identified for this site.

Fire Ecology:

Fire is not a regular occurrence for this ecological site. Low productivity and large interspaces keep fire risk relatively low. It is likely that this site only burns during wind-driven fires, fueled by neighboring sagebrush vegetation. There appears to be no research on the fire tolerance of altered andesite buckwheat, however some of the other “Sierran” species on this site do have fire adaptations.

Ponderosa pine has multiple adaptations that allows cone-bearing adults to survive both low- and high-intensity fires. At a young age, it develops a thick, corky bark that protects the cambium from fire (Hall 1980, Miller 2000, Fitzgerald 2005). The pine’s terminal buds are protected by thick bud scales and long needles with high moisture content fire (Miller 2000). A study in the Sierra Nevada mountains showed that even if the crown of Ponderosa pine is scorched, the tree often survives and “flushes” with new needles in the following growing season after (Hanson and North 2009). When estimating fire severity and post-fire mortality of both ponderosa and Jeffery pines, this survival should be taken into account. Post-fire conditions of bare mineral soil, increased soil moisture, and low canopy cover are favorable to seedling survival (Bradley et al. 1992, Flathers et al 2016). This community is not immune to negative effects of fire, however. In the seedling stage, ponderosa pine is readily killed by fire, and dense stands of this tree typically succumb to fire (Agee 1996). The cones are not serotinous and seeds are not long-lived in the soil, thus ponderosa pine will not return to dominance in large patches of high-severity fire (Korb et al. 2019).

The understory of this site is sparse and would be largely unaffected by wildfire. Antelope bitterbrush, desert peach, green ephedra, and Utah serviceberry may be present in small amounts; these shrubs all are capable of sprouting after fire and may increase in the understory. Desert peach sprouts reliably after fire, from lignotubers and an extensive network of underground stems (Evans and Young 1978). Desert peach relies on hoarding by rodents for seed dispersal and recruitment, and up to 75% of seeds may be carried away by various rodent species (Beck and Van Der Wall 2010). Germination and survival rates of seedlings are significantly higher for seeds buried 1 to 5 cm deep in rodent caches (Beck and Van Der Wall 2010). Germination and emergence increased with burial depth. Seedling survival through the first growing season may be 8% or less (Beck and Van Der Wall 2010). Its ability to sprout allows it to be easily propagated from hardwood or softwood stem cuttings (Everett et al. 1978) and containerized transplants have high survival rates (Everett 1980).

Antelope bitterbrush is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1982), however, sprouting ability is highly variable and has been attributed to genetics, plant age, phenology, soil moisture and texture, and fire severity (Blaisdell and Mueggler 1956, Blaisdell et al. 1982, Clark et al. 1982, Cook et al. 1994). Bitterbrush sprouts from a region on the stem approximately 1.5 inches above and below the soil surface; the plant rarely sprouts if the root crown is killed by fire (Blaisdell and Mueggler 1956). Low intensity fires may allow for bitterbrush to sprout; however, community response also depends on soil moisture levels at time of fire (Murray 1983). Lower soil moisture allows more charring of the stem below ground level (Blaisdell and Mueggler 1956), thus sprouting will usually be more successful after a spring fire than after a fire in summer or fall (Murray 1983, Busse et al. 2000, Kerns et al. 2006).

Ephedra vigorously sprouts after fire from extensive woody crowns (Evans and Young 1978, Koniak 1985). Sprouting after fire may vary by season of burn and fire severity, however. Spiny hopsage is a sprouting shrub (Daubenmire 1970) that is fairly tolerant of fire due its dormancy during the summer months (Rickard and McShane 1984). After fire, these sprouting shrubs can produce significant new growth if there is enough moisture available (Shaw 1992). Other environmental conditions also determine the level of re-establishment that occurs, such as the salinity and temperature of soil. In order to germinate, seeds need moist conditions (Monsen et al. 2004). They do not compete well with annual invasive plants (Monsen et al. 2004).

Grasses on the site include desert needlegrass and bottlebrush squirreltail. The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses, the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983).

Desert needlegrass has persistent dead leaf bases making this species susceptible to burning. Fire removes this accumulation and a rapid, cool fire will not result in death of the plants (Humphrey 1984). Field observations indicate that desert needlegrass survives and increases after most wildfires. In a summation of 13 studies, Abella (2009) found that desert needlegrass increased in abundance (derived from cover, density, or frequency depending on the source of publication) on burned to unburned sites. Thatcher and Hart (1974) observed an increase in desert needlegrass in areas which appeared to have burned on a relict site, however they attributed this to soil type rather than species response. Webb and Wilshire (1980) found desert needlegrass exhibited 2 to 4 times more cover on streets of a Nevada ghost town which had been abandoned 51 years prior.

Invasive grasses, such as cheatgrass, displace desirable perennial grasses, reduce livestock forage, and accumulate large fuel loads that foster frequent fires (Davies and Svejcar 2008). While historical fire return intervals in ponderosa and sagebrush ecosystems exceed 15 to 100 years, areas dominated with cheatgrass are estimated to have a fire return interval of 3-5 years (Whisenant 1990, Fitzgerald 2005). Frequent fires threaten this plant community. On Peavine Mountain, frequent human-caused wildfires have become the norm, and areas of cheatgrass and medusahead (*Taeniatherum caput-medusae*) proliferate after fire.

Livestock/Wildlife Grazing Interpretations:

These sites are limited in extent, has low productivity, and occurs on steep sideslopes of hills and mountains, making them limited forage resources.

Antelope bitterbrush is an important shrub species to a variety of animals, such as domestic livestock, antelope, deer, and elk. Bitterbrush is critical browse for mule deer, as well as domestic livestock, antelope, and elk (Wood et al. 1995, Clements and Young 2002). Antelope bitterbrush is most commonly found on soils that provide minimal restriction to deep root penetration such as coarse textured soil, or finer textured soil with high stone content (Driscoll 1964). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison 1953).

Green ephedra is used as winter forage by wild ungulates and livestock (Jameson et al. 1962, Kufeld et al. 1973). Keeler 1989 found green ephedra to be toxic to cattle and sheep, but not to calves and lambs. Ephedra is an important component of bighorn sheep diets in the eastern Sierra Nevada (McCullough and Schneegas 1966).

Desert needlegrass (*Achnatherum speciosum*) is a compact bunchgrass with considerable basal leafage. Needlegrasses in general are valuable forage for both livestock and wildlife. Needlegrasses are grazed closely when the leaves are green in early spring, but are usually avoided once seed has matured (Sampson et al. 1951). Desert needlegrass is palatable to wildlife such as bighorn sheep and feral burros when young. Desert needlegrass tolerates light grazing but overgrazing may eliminate it from an ecological site. When mature, the fine basal leaves, intermingled with the coarse stems and flowering stalks, are grazed some by cattle and horses, but little by sheep (Sampson et al. 1951). It is best to graze it before seed develops because the seed has a sharp callus that can injure the eyes and mouths of grazing animals (Perkins and Ogle 2008).

Bottlebrush squirreltail generally increases in abundance when moderately grazed or protected (Hutchings and Stewart 1953). In addition, moderate trampling by livestock in big sagebrush rangelands of central Nevada enhanced bottlebrush squirreltail seedling emergence compared to untrampled conditions. Heavy trampling however was found to significantly reduce germination sites (Eckert and Spencer 1987).

Other Threats and Management Considerations:

Off-highway vehicle use, impacts from non-motorized recreation, and increased fire risk from recreational shooting are active threats to this ecological site (Morefield 2000, Nevada Division of Natural Heritage 2020). This sites limited extent ad proximity to population centers makes it vulnerable to the pressures of the urban interface. Off-road vehicles can destroy the fragile soil-vegetation complex and cause severe erosion. Wildfire has affected this site where it exists on Peavine mountain, however, its characteristic low fuel loads offer protection from this disturbance (Morefield 2000). Care should be made during fire suppression activity to limit impacts on these sites.

State and Transition Model Narrative for Group 24:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for MLRA 26 Disturbance Response Group 24.

Reference State 1.0:

The Reference State 1.0 is a representative of the natural range of variability under pristine conditions. The reference state has three general community phases. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought, and/or insect or disease attack.

Community Phase 1.1:
This community is dominated by ponderosa pine, altered andesite buckwheat (*Eriogonum robustum)* and desert needlegrass. Forbs and other grasses make up smaller components. Tree canopy cover is between 10 and 20 percent.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.3:
Time without disturbance allows ponderosa pine trees to mature.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.2:
A low-severity fire kills some ponderosa pine trees and/or reduces canopy via scorching.

Community Phase 1.2:
The predominant tree cover in this phase includes seedlings, saplings, and immature trees that will have cone-shaped crowns. This phase is the result of a fire that initially reduces ponderosa canopy but allows young trees to grow. Seedlings and saplings may increase in the understory of

mature trees in years with high precipitation as well. Understory vegetation may increase in this phase.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Time without disturbance allows ponderosa pine trees to mature.

Community Phase 1.3:
Without fire, ponderosa pine seedlings and saplings are able to reach maturity. Tree canopy cover increases to over 20 percent. Shrubs are a minor component of this site, but in this phase they may be decadent or dead due to shading and competition from trees. The herbaceous understory may be reduced.

Community Phase Pathway 1.3a, from Phase 1.2 to 1.1:
Low-severity or patchy fire reduces the canopy cover of ponderosa pine. Most mature trees will survive a low-severity fire, however there may be some crown scorching that reduces total cover.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire kills ponderosa pine trees and/or significantly reduces canopy via scorching.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0

Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, mustard (*Descurainia spp.),* and bur buttercup (*Ceratocephala testiculata*).

Slow variables: Over time the annual non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of non-native invasive weeds like cheatgrass. This state has the same three general community phases. These non-native species can be highly flammable, and promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. This community is dominated by ponderosa pine,

altered andesite buckwheat (*Eriogonum robustum)* and desert needlegrass. Forbs and other grasses make up smaller components. Tree canopy cover is between 10 and 20 percent.

PIPO/ERRO10/CAREX (F026XY065NV) Phase 2.1. D. Snyder, August 2016

PIPO/ERRO10/CAREX (F026XY065NV) Phase 2.1. D. Snyder, August 2016

Community Phase Pathway 2.1a, from Phase 2.1 to 2.3:
Time without disturbance allows ponderosa pine trees to mature.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.2:
A low-severity fire kills some ponderosa pine trees and/or reduces canopy via scorching.

Community Phase 2.2:
The predominant tree cover in this phase includes seedlings, saplings, and immature trees that will have cone-shaped crowns. This phase is the result of a fire that initially reduces ponderosa canopy but allows young trees to grow. Seedlings and saplings may increase in the understory of

mature trees in years with high precipitation as well. Understory vegetation may increase in this phase.

PIPO/ERRO10/CAREX (F026XY065NV) Phase 2.2 (foreground). D. Snyder, August 2016

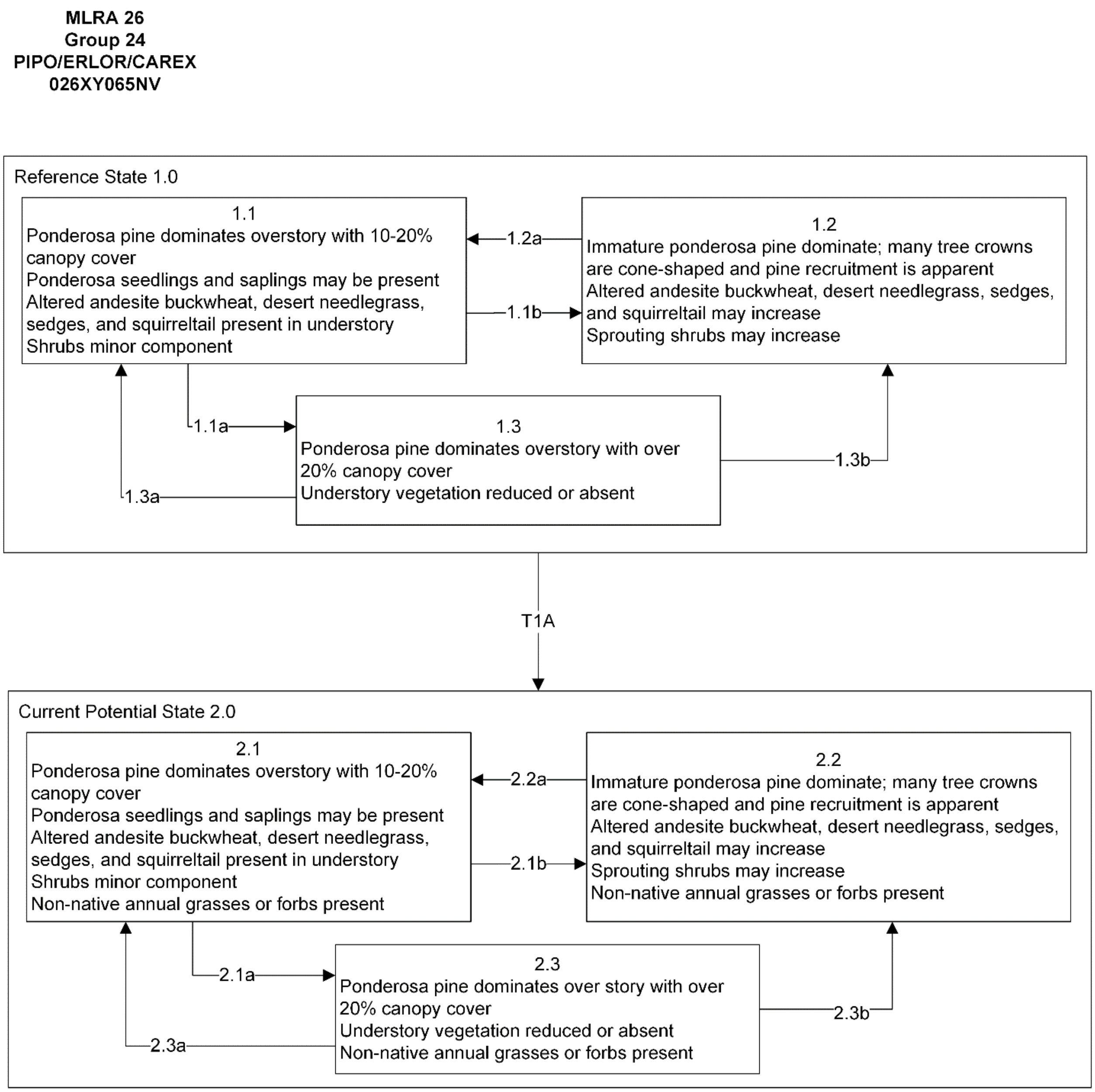
Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Time without disturbance allows ponderosa pine trees to mature.

Community Phase 2.3:
Without fire, ponderosa pine seedlings and saplings are able to reach maturity. Tree canopy cover increases to over 20 percent. Shrubs are a minor component of this site, but in this phase they may be decadent or dead due to shading and competition from trees. The herbaceous understory may be reduced.

Community Phase Pathway 2.3a, from Phase 2.2 to 2.1:
Low-severity or patchy fire reduces the canopy cover of ponderosa pine. Most mature trees will survive a low-severity fire, however there may be some crown scorching that reduces total cover.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire kills ponderosa pine trees and/or significantly reduces canopy via scorching.

Modal State and Transition Model for Group 1 in MRLA 26:



MLRA 26
Group 24
PIPO/ERLOR/CAREX
026XY065NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Time without disturbance.
1.1b: Low-severity fire and/or successive years with high precipitation that support pine recruitment.
1.2a: Time without disturbance.
1.3a: Low-severity or patchy fire reduces pine overstory.
1.3b: Low-severity fire, coupled with adequate moisture to support pine recruitment.

Transition T1A: Introduction of non-native annual species.

Current Potential 2.0 Community Phase Pathways
2.1a: Time without disturbance.
2.1b: Low-severity fire and/or successive years with high precipitation that support pine recruitment.
2.2a: Time without disturbance.
2.3a: Low-severity or patchy fire reduces pine overstory.
2.3b: Low-severity fire, coupled with adequate moisture to support pine recruitment.

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MLRA 26 Group 25: Grassy dry meadows

Description of MLRA 26 Disturbance Response Group 25

Disturbance Response Group (DRG) 25 consists of two ecological sites. These sites exist in areas with run-on moisture, such as inset fans, stream terraces, and small lake basins. These sites range in precipitation from 12 to over 16 inches. Sites within this DRG are characterized by a dominance of grasses and forbs, with minimal production of shrubs. Elevation ranges from 4,500 to 8,500 feet. Slopes range from 0 to 30 percent, but gradients of less than 15 percent are most typical. The soils of this group are typically very deep and poorly to moderately well-drained. Nevada bluegrass (*Poa nevadensis)*, Douglas sedge (*Carex douglasii)*, Lemmon's alkaligrass (*Puccinella lemmonii*), and various forbs are the dominant plants on these sites. Shrubs are typically only found in trace amounts, but may include Woods' rose (*Rosa woodsii*), rabbitbrush (*Ericameria* or *Chrysothamnus spp.*), big sagebrush (*Artemisia tridentata*), and/or silver sagebrush (*Artemisia cana*). Average normal-year annual production ranges from 400 to 1,700 lbs/ac. Production may vary significantly between wet and dry years.

Disturbance Response Group 25 Ecological Sites:

Dry Meadow	R026XF055NV
Ashy Sodic Basin	R026XF065CA

Modal Site:

The Dry Meadow ecological site (R025XY055NV) is the modal site that represents this DRG as it has the most acres mapped. This site occurs on inset fans. Slopes range from 0 to 30 percent, but slope gradients of 2 to 15percent are most typical. Elevation ranges from 6,500 to 8,000 feet. Soils of this site are very deep and somewhat poorly drained, typically having seasonally high water table in spring. The plant community is dominated by Nevada bluegrass. Sedges, primarily Douglas sedge, are an important part of this plant community. Forbs such as cinquefoil (*Potentilla* spp.), iris (*Iris missouriensis*), yarrow (*Achillea* spp.), and groundsel (*Senecio* spp.) are common. Woods' rose, rubber rabbitbrush (*Ericameria nauseosa*), big sagebrush, willows (*Salix* spp.), and mountain gooseberry (*Ribes montigenum*) may be present. Production ranges from 1,300 to 2,200 pounds per acre, with an average of 1,700 lbs/ac in normal years.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site's resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The ecological sites in this DRG are dominated by cool season perennial grasses and grass-likes such as Nevada bluegrass, mat muhly, sedges, rushes.

Nevada bluegrass and Sandberg bluegrass are no longer differentiated taxonomically; however, the two grasses typically grow in different ecological niches. What is colloquially known as Nevada bluegrass is a more robust growth form, typically found in locations with greater soil moisture during the growing season when compared to Sandberg bluegrass. This grass has root densities comparable to upland graminoid communities, and it primarily has fine fibrous roots (Manning et al. 1989).

Mountain rush is a cool season, sod-forming, rhizomatous, perennial graminoid – it is the most common rush found in the intermountain region. It has a low tolerance to drought, but can tolerate anoxic soil conditions during temporary flooding (Stevens et al. 2012). This species has been found with up to 1,800 grams of roots in just the top 10 cm of a single square meter of soil, which is second only to Nebraska sedge in terms of root mass (*Carex nebrascensis*) (Manning et al. 1989). Mountain rush primarily regenerates via rhizomes, but it can reproduce via seeds as well (Stubbendieck et al. 1992).

Mat muhly, a warm-season, strongly rhizomatous perennial grass that usually grows in loose clumps or mats (USDA 1988, Penskar and Higman 1999, Schultz 2002). Mat muhly reproduces by seed or rhizomes. Mat muhly can be found on dry to moist sites and often persists in an area for many years after hydrological modifications lower the water table (USDA 1988).

Beardless wildrye, also known as creeping wildrye, is a subdominant grass on this site. It is a cool-season perennial sod-forming grass that is strongly rhizomatous (Young-Mathews and Winslow 2010). In a study of native California grasses, beardless wildrye performed the best in terms of above-ground biomass and high resistance to invasion by non-native annuals (Lulow 2006).

Few shrubs can survive the extended inundation and high water tables that can occur on this site in wet years. Rubber rabbitbrush, wood's rose, and silver sagebrush may survive on the margins of this site. The natural multi-year drought cycles that occur in this region may allow one or all of these shrub species to increase, however one or more years with above-average winter precipitation will cause shrub mortality. Rubber rabbitbrush and Woods' rose are intolerant of high water tables, and will die out in wet years (Wasser 1982, Monsen et al. 2004). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992). Differences in root depth distribution between grasses and shrubs result in resource partitioning in this system.

The primary non-native weedy species found on this site is common dandelion (*Taraxacum officinale*). It is unlikely that dandelion will become a significant problem. Annual rabbitsfoot grass (*Polypogon monspeliensis*) is a non-native annual grass that may increase on this site with inappropriate grazing management. The native foxtail barley (*Hordeum jubatum)* may also increase with heavy grazing, as its coarse inflorescences are unpalatable when mature.

The ecological sites in this DRG have moderate to high resilience to disturbance and resistance to invasion. Ecological dynamics are driven by drought, flooding, and fire. The Great Basin sagebrush and grass communities have high spatial and temporal variability in precipitation, both among years and within growing seasons. The Dry Meadow ecological site is subject to both periodic drought and flooding, which influence the vegetative community from year to year. Grazing management has the potential to change this plant community, however its high elevation and location on the landscape makes it less susceptible than other meadow sites. Two possible alternative stable states have been identified for this DRG.

Fire Ecology:

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface, providing relative protection from disturbances that reduce above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). Season and severity of the fire will influence plant response as will post-fire soil moisture availability.

Nevada bluegrass (Sandberg bluegrass) is rarely damaged by wildfires unless there is heavy shrub cover that burns very hot. This grass produces very little litter, is short-statured, and is dormant for most of the summer, all of which are traits that reduce fire damage (Monsen et al. 2004).

Relatively frequent fires in and around this plant community in its natural state will generally preclude most shrub species from becoming dominant. Woods' rose sprouts following fire unless the shallow root crown is damaged (Wasser 1982, Miller et al. 2013), however this plant is unlikely to dominate the community because of the high water table. Rubber rabbitbrush is moderately tolerant to fire and can sprout (Miller et al. 2013). The majority of research concerning rabbitbrush has been conducted on green rabbitbrush. Green rabbitbrush has a large taproot and is known to be shorter-lived and less competitive than sagebrush. Seedling density, flower production, and shoot growth decline as competition from other species increases (McKell and Chilcote 1957, Miller et al. 2013). Depending on fire severity, rabbitbrush may increase after fire. Rubber rabbitbrush is top-killed by fire, but can sprout after fire and can also establish from seed (Young 1983).

Silver sagebrush is an evergreen shrub that often forms colonies from a system of extensive rhizomes (Stubbendieck et al. 1992). Silver sagebrush has been found to be less sensitive to fire than other sagebrush species due to its ability to sprout. The root system of silver sagebrush consists of a taproot with lateral roots and rhizomes, usually located within a few inches of the soil surface. Rhizome length of plains silver sagebrush in Montana averaged 1.1 m (3.4 ft). Silver sagebrush is a vigorous sprouter (Wright et al. 1979). It is able to sprout from roots, rhizomes, and the root crown after disturbance (Ellison and Woolfolk 1937, Whitson et al. 1991, Blaisdell et al. 1982). Silver sagebrush has spreading rhizomes underground and sprouts after fire (Cronquist et al. 1994, Blaisdell 1982). Silver sagebrush is also capable of reproducing by seed (Whitson et al. 1991). Seedling establishment can occur in the years after fire if the growing season is favorably wet (Wambolt et al. 1989). Survival and resprouting ability of silver sagebrush is considerably greater in the spring versus the fall (White and Currie 1983). As burn intensity increases, regrowth of silver sagebrush plants decreases (White and Currie 1983). Silver sagebrush may become dominant on this site between 3 to 10 years post-fire. It is more likely to increase after fire if the water table is lowered through drought or other disturbance, or with heavy grazing that reduces cover of herbaceous plants.

Fire likely was a relatively frequent occurrence on this site. The fine fuels and low moisture levels in late summer and fall make this site prone to fires ignited by lightning. Fire frequency in these sites will be tied to the upland ecosystems that surround them. In many Great Basin plant communities, changes in fire frequency occurred along with fire suppression, livestock grazing, and OHV use. Fire severity in sagebrush communities is described as "variable" depending on weather, fuels, and topography and is typically stand replacing (Sapsis and Kauffman 1991). The introduction and expansion of cheatgrass has dramatically altered the fire regime (Evans and Young 1978, Balch et al. 2013). Fire maintained the grass dominance of these ecosystems, therefore management changes that lengthen the fire return interval favors increases in the shrub component of the plant community. The reduction of grasses potentially facilitates increases in bare ground, inland salt grass, and invasive weeds. Lack of fire combined with drought and excessive herbivory allows shrubs to increase on the site.

Livestock/Wildlife Grazing Interpretations:

In wet areas on these ecological sites, bluegrasses, sedges, rushes, meadow barley, and creeping wildrye are dominant. Nevada bluegrass (Sandberg bluegrass) is very palatable and is preferred by both domestic livestock and wildlife during the spring and early summer, with reported crude protein levels of over 17% (Monsen et al. 2004). This bluegrass has been found to increase under grazing pressure in upland systems due to its early dormancy and short stature (Tisdale and Hironaka 1981).

Mountain rush is generally not eaten by cattle; it has low palatability due to a high lignin content (Stevens et al. 2012). Mat muhly withstands heavy grazing because of its sod-forming growth form (USDA 1988). It is a short-statured plant with stems typically 3 to 8 inches long and many basal and stem leaves between one-half and two or more inches long (USDA 1988).

Rocky mountain iris is unpalatable and is typically left ungrazed in wet meadows and dry meadows such as this (Pryor and Talbert 1958, Guillon 1964, Eckert 1981). Irises spread by tuberous roots; they will survive and spread with continuous overgrazing and will remain a significant part of the plant community even if management improves (Dayton 1960). Controlling iris in meadows has been the subject of much research. While preventing iris spread through proper grazing management is best, there has been success with the herbicide 2,4-D coupled with deferred grazing.

Overgrazing leads to a decline in understory plants like Nevada bluegrass (*Poa* sp.). Reduced bunchgrass vigor or density provides an opportunity for Rocky Mountain iris expansion. Creeping wildrye, so named due to its rhizomatous rooting characteristic, is tolerant of grazing and increases under grazing pressure (USDA 1988).

Woods' rose is readily browsed by mule deer and elk, with the heaviest used in spring and fall (Blauer at al. 1973, Wasser 1982, Monsen et al. 2004). Woods' rose is moderately grazing tolerant; dense prickles make the plant undesirable for most livestock (Monsen et al. 2004).

Silver sagebrush can provide an important source of browse and is used by livestock and big game when other food sources are scarce (Kufeld et al. 1973, Wasser 1982, Cronquist et al. 1994). In fall and winter feeding trials, silver sagebrush was among the most preferred sagebrush species for mule deer and sheep (Sheehy and Winward 1981). However, silver sagebrush is an aggressive colonizer and can occupy areas at high densities, due to its ability to sprout from the crown and to spread by rhizomes (Monsen et al. 2004). Silver sagebrush, as with other sagebrush species, has been known to increase with grazing

(Kachergis et al. 2014). A reduction of the herbaceous understory allows this shrub to increase and dominate these sites. Therefore, silver sagebrush can increase significantly under inappropriate grazing management on this site.

Changes in plant community composition caused by, human activity, invasive weeds, fire frequency associated with this ecological site could affect the distribution and presence of wildlife species.

Hydrologic Modification:

This site receives additional moisture from runoff from adjacent sites. Hydrologic alteration impacts can occur from off-site or on-site activities. Years of extreme drought can also result in a lowered water table. Excessive large animal use during wet periods can cause pugging, root shear, hummock formation, an increase in bare ground and modification to infiltration rates.

State and Transition Model Narrative for Group 25:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 disturbance response group 25.

Reference State 1.0:

The Reference State 1.0 is a representative of the natural range of variability under pristine conditions. The Reference State has three general community phases: a grass-dominant phase, a forb-dominant phase, and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire and precipitation patterns.

Community Phase 1.1:
This community is dominated by grasses and grass-likes. Nevada bluegrass, sedges, rushes, mat muhly, creeping wildrye are common.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
A wet winter and spring leads to flooded conditions in the spring and a high water table. These conditions favor various forb species and reduce productivity of Nevada bluegrass and other grasses.

Community Phase Pathway 1.1b, from Phase 1.1 to 1.3:
Continued drought conditions and lack of disturbance such as fire allows various shrubs to increase. Long term drought, herbivory, or combinations of these will cause a decline in perennial bunchgrasses and forbs.

Community Phase 1.2:

This community phase occurs during cycles of increased annual precipitation. A wide diversity of moisture-loving forbs dominate in this phase. Cinquefoil, groundsel, and/or fleabanes may be common. Carex, rushes, and bluegrasses are still present but their productivity is reduced.

Ashy Sodic Basin (R026XF065CA) Phase 1.2. T. Stringham, June 2016.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Drought conditions allow grasses and grass-likes to return to dominance.

Community Phase 1.3:
Basin big sagebrush increases in the absence of disturbance. Decadent big sagebrush and/or rubber rabbitbrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or from herbivory. Wyoming big sagebrush and black greasewood may also be present.

Dry Meadow (R026XY055NV), Phase 1.3. T. Stringham June 2016.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
A low severity fire, prolonged flooding, or combinations of these will reduce the shrub component and allow grass species to increase.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual plants, such as common dandelion and annual rabbitsfoot grass.

Slow variables: Over time the annual non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Annual non-native species cannot be easily removed from the system and have the potential to outcompete native vegetation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0 with three similar community phases. Ecological function has not changed; however, the resiliency of the state has been reduced by the presence of invasive weeds. Non-natives may increase in abundance but will not become dominant within this state. Negative feedbacks still enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1, but non-native species are present in trace amounts. This community is dominated by grasses and grass-likes. Nevada bluegrass, sedges, rushes, mat muhly, creeping wildrye are common.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
A wet winter and spring leads to flooded conditions in the spring and a high water table. These conditions favor various forb species and reduce productivity of Nevada bluegrass and other grasses.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Continued drought conditions and lack of disturbance such as fire allows various shrubs to increase. Long term drought, herbivory, or combinations of these will cause a decline in perennial bunchgrasses and forbs.

Community Phase 2.2:
This community phase occurs during cycles of increased annual precipitation. A wide diversity of moisture-loving forbs dominate in this phase. Cinquefoil, groundsel, and/or fleabanes may be common. Carex, rushes, and bluegrasses are still present but their productivity is reduced.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Drought conditions allow grasses and grass-likes to return to dominance.

Community Phase 2.3:
Basin big sagebrush increases in the absence of disturbance. Decadent big sagebrush and/or rubber rabbitbrush dominates the overstory and the deep-rooted perennial bunchgrasses in the

understory are reduced either from competition with shrubs and/or from herbivory. Wyoming big sagebrush and black greasewood may also be present. Additional weedy species like rabbitsfoot grass, foxtail barley, and Rocky Mountain iris may increase.

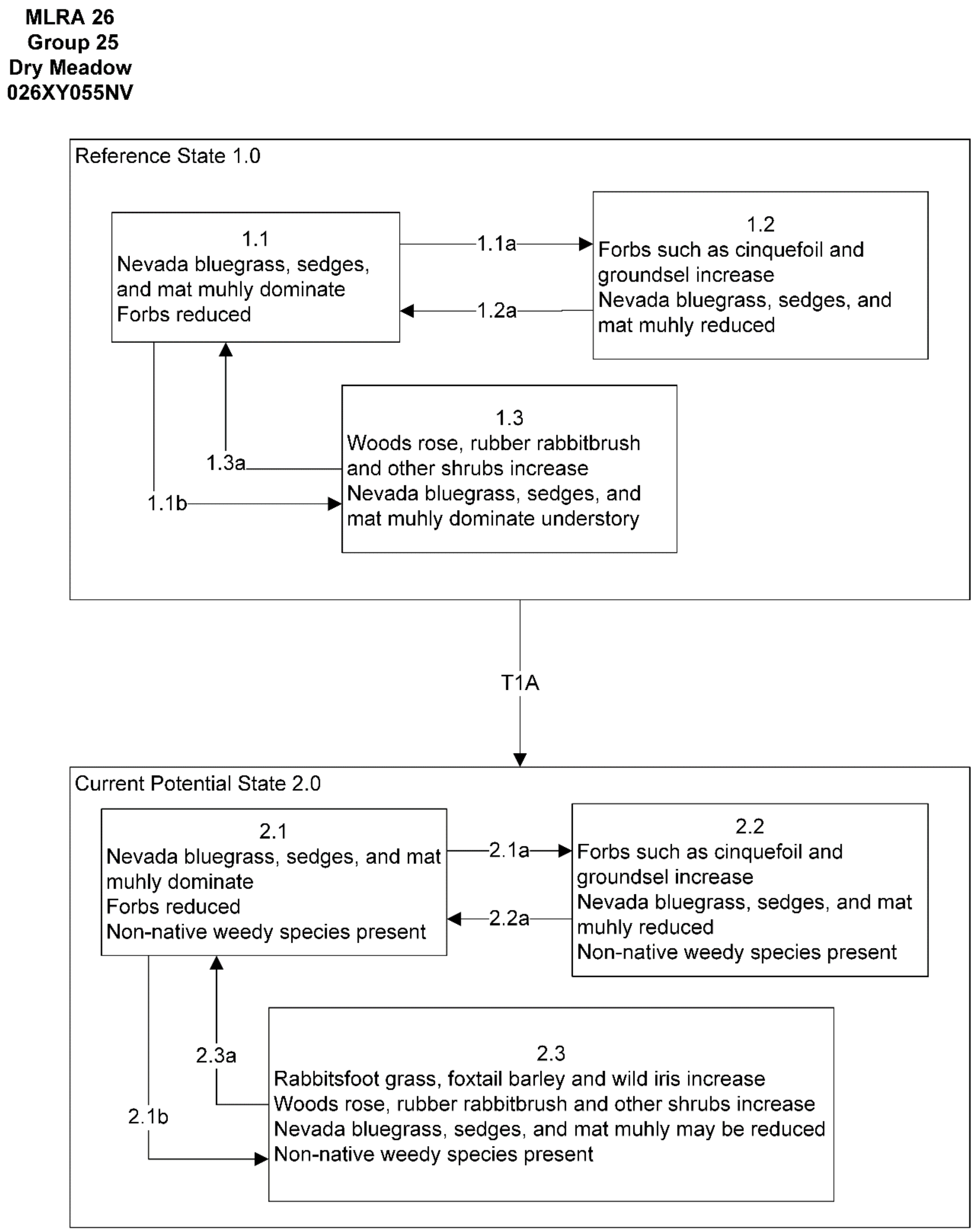
Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
A low severity fire, prolonged flooding, or combinations of these will reduce the shrub component and allow grass species to increase.

Possible Resilience Differences with other Ecological Sites:

Ashy Sodic Basin (R026XF065CA):

This site is associated with lacustrine sediments derived from volcanic rocks, with additions of volcanic ash. The dominant grass on this site is Lemmon's alkaligrass (*Puccinella lemmonii*). Douglas sedge (*Carex douglasii)*, California rayless fleabane (*Erigeron inomatus*) are other important herbaceous species. Shrubs are only found in trace amounts, but may include silver sagebrush (*Artemisia cana*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), and/or rubber rabbitbrush (*Ericameria nauseosa*).

Modal State and Transition Model for Group 25 MLRA 26:



MLRA 26
Group 25
Dry Meadow
026XY055NV
KEY

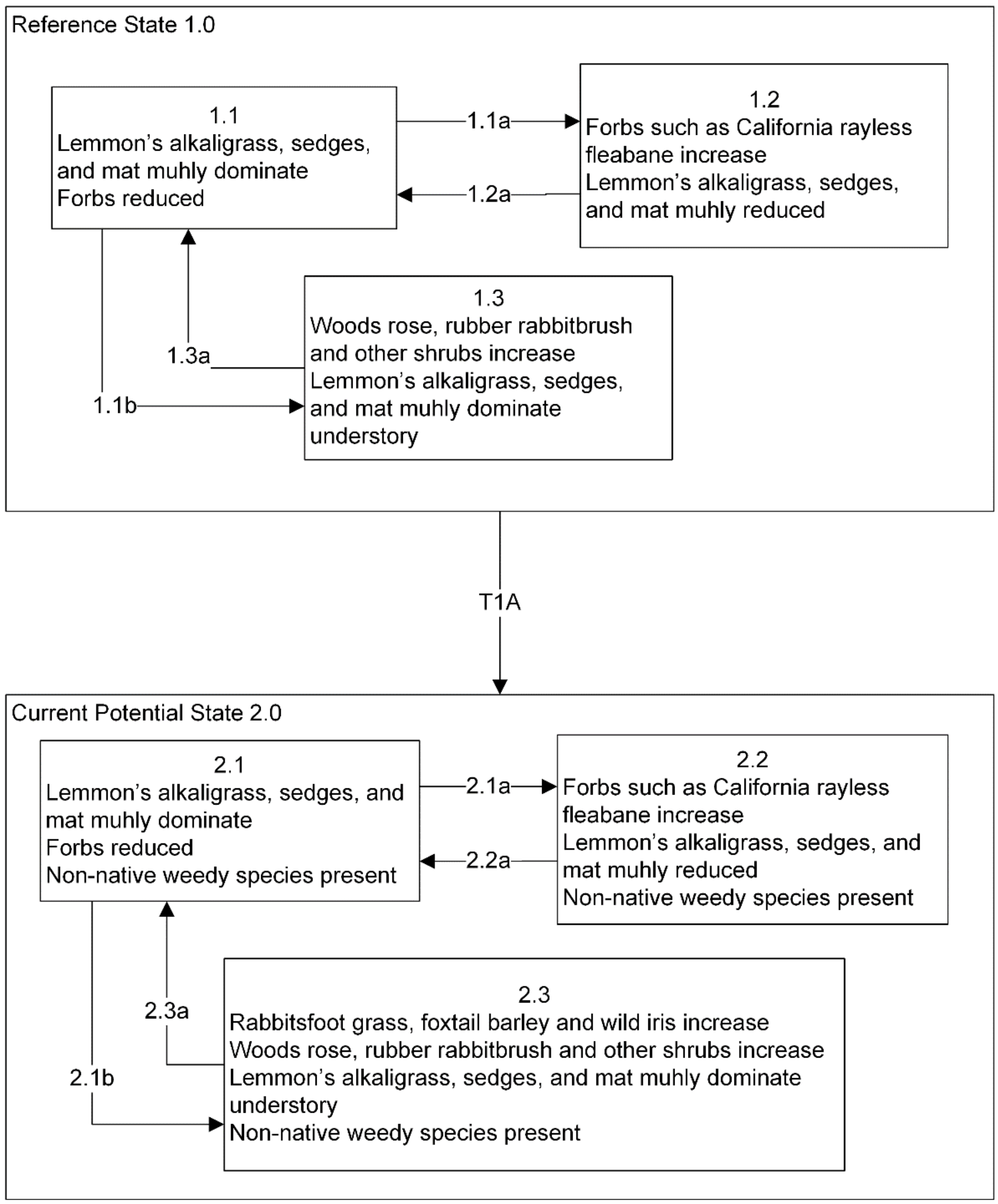
Reference State 1.0 Community Phase Pathways
1.1a: Release from drought.
1.1b: Time and lack of disturbance, coupled with continued dry conditions.
1.2a: Drought.
1.3a: Fire and/or release from drought.

Transition T1A: Introduction of non-native species like common dandelion.

Current Potential 2.0 Community Phase Pathways
2.1a: Release from drought.
2.1b: Time and lack of disturbance, coupled with continued dry conditions. Inappropriate grazing management may accelerate this transition.
2.2a: Drought.
2.3a: Fire and/or release from drought.

Additional State and Transition Models for Group 25 MLRA 26:

MLRA 26
Group 25
Ashy Sodic Basin
026XF065CA



MLRA 26
Group 25
Ashy Sodic Basin
026XF065CA
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Release from drought.
1.1b: Time and lack of disturbance, coupled with continued dry conditions.
1.2a: Drought.
1.3a: Fire and/or release from drought.

Transition T1A: Introduction of non-native species like common dandelion.

Current Potential 2.0 Community Phase Pathways
2.1a: Release from drought.
2.1b: Time and lack of disturbance, coupled with continued dry conditions. Inappropriate grazing management may accelerate this transition.
2.2a: Drought.
2.3a: Fire and/or release from drought.

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MLRA 26 Group 26: Inset fans and stream terraces with basin wildrye

Description of MLRA 26 Disturbance Response Group 26

Disturbance Response Group (DRG) 26 consists of two ecological sites. The precipitation of these sites ranges from 10 to over 16 inches. These sites occur on axial-stream floodplains, stream terraces, and inset fans typically next to perennial streams. In some areas this group is associated with degraded wet meadows, and is found on abandoned floodplain terraces. Slopes from 2 to 8 percent are typical, but may be as steep as 30 percent. Soils are deep to very deep and well drained. These sites typically have a seasonally high water table at depths of 30 to 60 inches, which facilitates significant fluctuations in herbage production. Sites in this DRG are characterized by a dominance of basin wildrye (*Leymus cinereus*). There is an overstory of either basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) or mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*). The elevation range for this group is 4,800 to over 8,000 feet. Annual production for a normal year ranges from 2,200 to 5,000 pounds per acre. The soils are very deep, well drained and are formed in mixed alluvium from mixed rock sources. The soils have a mollic epipedon. These sites were not seen during field work for this project, so this report is based off of one completed for a similar group in Major Land Resource Area 28A and 28B.

Disturbance Response Group 26 Ecological Sites:

Loamy Bottom 8-12" – Modal Site	R026XY030NV
Loamy Bottom 14+	R026XY057NV

Modal Site:

The Loamy Bottom 8-12” is the modal site that represents this DRG, as it has the most acres mapped. This site occurs on axial-stream floodplains and inset fans between 4,800 to 6,800 feet in elevation. Slopes range from 2 to 4 percent. The soils in this site are very deep and somewhat poorly drained. A seasonal water table can be as shallow as 20 inches in the spring, but can dip below 40 inches in wet periods. This site is subject to flooding at least one out of every three years. In many areas, this site occurs where a channel has become entrenched lowering the water table required to support a meadow plant community. These soils are susceptible to gullying which intercepts normal overflow patterns causing site degradation. The plant community is dominated by basin wildrye. Average production on a normal year is 5,000 lbs/ac.

Ecological Dynamics and Disturbance Response:

An ecological site is the product of all the environmental factors responsible for its development and it has a set of key characteristics that influence a site’s resilience to disturbance and resistance to invasive species. Key characteristics include 1) climate (precipitation, temperature), 2) topography (aspect, slope, elevation, and landform), 3) hydrology (infiltration, runoff), 4) soils (depth, texture, structure, organic matter), 5) plant communities (functional groups, productivity), and 6) natural disturbance regime (fire, herbivory, etc.) (Caudle et al. 2013). Biotic factors that influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al 2013).

The ecological sites in this DRG are dominated by deep-rooted cool season, perennial bunchgrasses and long-lived shrubs (50+ years) with high root to shoot ratios. The dominant shrubs usually root to the full depth of the winter-spring soil moisture recharge, which ranges from 1.0 to over 3.0 m. (Comstock and Ehleringer 1992). Root length of mature sagebrush plants was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987). These shrubs have a flexible generalized root system with development of both deep taproots and laterals near the surface (Comstock and Ehleringer 1992).

The perennial bunchgrasses generally have somewhat shallower root systems than the shrubs, but root densities are often as high as or higher than those of shrubs in the upper 0.5 m but taper off more rapidly than shrubs. However, basin wildrye is weakly rhizomatous and has been found to root to depths of 1 m or more and to exhibit greater lateral root spread than many other grass species (Abbott et al. 1991). General differences in root depth distributions between grasses and shrubs results in resource partitioning in these shrub/grass systems.

Basin wildrye is the dominant grass on this site. It is weakly rhizomatous and has been found to root to depths of up to 2 meters, and exhibits greater lateral root spread than many other grass species (Abbott et al. 1991, Reynolds and Fraley 1989). Basin wildrye is a large, cool-season perennial bunchgrass with an extensive deep coarse fibrous root system (Reynolds and Fraley 1989). Clumps may reach up to six feet in height (Ogle et al. 2012b). Basin wildrye does not tolerate long periods of inundation; it prefers cycles of wet winters and dry summers and is most commonly found in deep soils with high water holding capacities or seasonally high water tables (Ogle et al. 2012b, Perryman and Skinner 2007).

Seasonally high water tables have been found to be necessary for maintenance of site productivity and reestablishment of basin wildrye stands following disturbances such as fire, drought or excessive herbivory (Eckert et al. 1973). The sensitivity of basin wildrye seedling establishment to reduced soil water availability is increased as soil pH increases (Stuart et al. 1971). Lowering of the water table through extended drought, channel incision or groundwater pumping will decrease basin wildrye production and establishment, while sagebrush, rabbitbrush, and invasive weeds increase.

Nevada bluegrass and Sandberg bluegrass are no longer differentiated taxonomically; however, the two grasses typically grow in different ecological niches. What is colloquially known as Nevada bluegrass is a more robust growth forb, typically found in locations with greater soil moisture during the growing season when compared to Sandberg bluegrass. This grass has root densities comparable to upland graminoid communities, and it primarily has fine fibrous roots (Manning et al. 1989).

Basin big sagebrush tends to occupy areas with deeper soil that receive run-on moisture (Barker and McKell 1983, Winward 1980). Big sagebrush is generally long-lived; therefore, it is not necessary for new individuals to recruit every year for perpetuation of the stand. Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings of big sagebrush is dependent on adequate moisture conditions.

The Great Basin sagebrush communities have high spatial and temporal variability in precipitation both among years and within growing seasons. Nutrient availability is typically low but increases with elevation and closely follows moisture availability. The moisture resource supporting the greatest amount of plant growth is usually the water stored in the soil profile during the winter. The invasibility of plant communities is often linked to resource availability. Disturbance can decrease resource uptake due to damage or mortality of the native species and depressed competition or can increase resource pools by the decomposition of dead plant material following disturbance. The invasion of sagebrush communities by cheatgrass (*Bromus tectorum*) has been linked to disturbances (fire, abusive grazing) that have resulted in fluctuations in resources (Chambers et al. 2007). A primary disturbance on these ecological sites is channel incision leading to a lowered seasonal water table which facilitates an increase in shrubs and a decrease in perennial bunchgrasses (Chambers and Miller 2004). With continued site degradation, rubber rabbitbrush (*Ericameria nauseosa*) becomes the dominant plant.

Native insect outbreaks are also important drivers of ecosystem dynamics in sagebrush communities. Climate is generally believed to influence the timing of insect outbreaks especially sagebrush defoliator, Aroga moth (*Aroga websteri*). Aroga moth infestations have occurred in the Great Basin in the 1960s, early 1970s, and have been ongoing in Nevada since 2004 (Bentz et al. 2008). Thousands of acres of big sagebrush have been impacted, with partial to complete die-off observed. Aroga moth can partially or entirely kill individual plants or entire stands of big sagebrush (Furniss and Barr 1975).

The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency and eventually lead to an annual state or a state dominated by rabbitbrush. Other troublesome non-native weeds such as tall whitetop (broadleafed pepperweed) (*Lepidium latifolium*), scotch thistle (*Onopordum acanthium*) or bull thistle (*Cirsium vulgare*) are potential invaders on this site.

Millions of acres in the arid and semi-arid West were brush-beaten and planted with crested wheatgrass in the mid 1900's for the purpose of competing with weed species and increasing grass production on rangelands. Success and longevity of these seeding projects have been mixed (Williams et al. 2017). Crested wheatgrass is a cool-season, medium height, exotic perennial bunchgrass native to Asia. Sites within this DRG may exhibit an understory of crested wheatgrass in areas where historical seedings have been allowed to return to sagebrush.

There is some evidence that many Loamy Bottom ecological sites are degraded Wet Meadow ecological sites created through channel incision processes. Additionally, the encroachment of singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) into associated upland sites has the potential to modify the hydrology of this site through changes to the overall watershed water budget. Research indicates pinyon and juniper canopies intercept, on average, 44% of incoming rainfall (Stringham 2018) and a 10 to 12 inch dbh tree may transpire approximately 10 to 68 liters per day (Snyder et al. 2013). Further investigation and updating of ecological site concepts for this site is warranted.

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. A primary disturbance on these ecological sites is channel incision or other disturbance leading to a lowered seasonal water table. This facilitates an increase in shrubs and a decrease in basin wildrye. The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency and eventually lead to an annual state or a state dominated by rabbitbrush. Other troublesome non-native weeds such as whitetop (*Lepidium draba*), tall whitetop, scotch thistle or bull thistle are potential invaders on this site. Four possible alternative stable states have been identified for this DRG.

Hydrology:

The typical seasonally high water table occurs at depths of 30 to 60 inches which allows for significant production of basin wildrye. In many areas, this site occurs where a channel has become entrenched lowering the water table required to support a meadow plant community. However, with further channel incisement and associated water table lowering site degradation occurs. Most Great Basin streams have been prone to incision for the past two thousand years, thus separating changes attributable to ongoing stream incision from those caused by human impact can be difficult (Chambers et al. 2004). The most direct evidence that anthropogenic disturbance has attributed to stream incision in the central Great Basin is derived from research on the effects of roads on riparian areas (Forman and Deblinger 2000, Trombulak and Frissel 2000). Assigning cause and effect to more diffuse disturbances such as livestock grazing is more difficult. In general, overuse of the riparian area by livestock can negatively affect stream bank and channel stability, and localized changes in stream morphology have been associated with heavy livestock use in the western United States (see reviews in Trimble and Mendel 1995; Belsky et al. 1999). However, data that clearly demonstrate the relationship between regional stream incision and overuse by livestock have not been collected for the Great Basin (Chambers et al. 2004). The impact of feral horse use on riparian systems is also in need of documentation. In regards to restoration and management it is important to recognize that particular streams have a greater sensitivity to both natural and management disturbances. For further guidance see Chambers et al. (2004), Rosgen (2006), or the USDA, NRCS Stream Visual Assessment Protocol (1998).

Fire Ecology:

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. The initial condition of bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. For most forbs and grasses the growing points are located at or below the soil surface providing relative protection from disturbances which decrease above ground biomass, such as grazing or fire. Thus, fire mortality is more correlated to duration and intensity of heat which is related to culm density, culm-leaf morphology, size of plant and abundance of old growth (Wright 1971, Young 1983). In addition, season and severity of the fire will influence plant response as will post-fire soil moisture availability.

Basin wildrye is relatively resistant to fire, particularly dormant season fire, as plants sprout from surviving root crowns and rhizomes (Zschaechner 1985). Miller et al. (2013) reported increased total shoot and reproductive shoot densities in the first year following fire, although by year two there was little difference between burned and control treatments.

In many basin big sagebrush communities, changes in fire frequency occurred along with fire suppression, livestock grazing and OHV use. Few if any fire history studies have been conducted on basin big sagebrush; however, Sapsis and Kauffman (1991) suggest that fire return intervals in basin big sagebrush are intermediate between mountain big sagebrush (15 to 25 years) and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) (50 to 100 years). Fire severity in big sagebrush communities is described as "variable" depending on weather, fuels, and topography. However, fire in basin big sagebrush communities are typically stand replacing (Sapsis and Kauffman 1991). Basin big sagebrush does not sprout after fire. Because of the time needed to produce seed, it is eliminated by frequent fires (Bunting et al. 1987). Basin big sagebrush reinvades a site primarily by off-site seed or seed from plants that survive in unburned patches. Approximately 90% of big sagebrush seed is dispersed within 30 feet (9 m) of the parent shrub (Goodrich et al. 1985) with maximum seed dispersal at approximately 108 feet (33 m) from the parent shrub (Shumar and Anderson 1986). Therefore, regeneration of basin big sagebrush after stand replacing fires is difficult and dependent upon proximity of residual mature plants and favorable moisture conditions (Johnson and Payne 1968, Humphrey 1984).

The majority of research concerning rabbitbrush has been conducted on green rabbitbrush (*Chrysothamnus viscidiflorus*). Green rabbitbrush has a large taproot and is known to be shorter-lived and less competitive than sagebrush. Seedling density, flower production, and shoot growth decline as competition from other species increases (McKell and Chilcote 1957, Miller et al. 2013, Young and Evans 1974). Depending on fire severity, rabbitbrush may increase after fire. Rubber rabbitbrush is top-killed by fire, but can resprout after fire and can also establish from seed (Young 1983). Shortened fire intervals within this ecological site favor a creeping wildrye understory with varying amounts of rabbitbrush dominated overstory.

Hydrologic modification of this site may occur through channel incision or gully formation with post-fire rain events. Channel incision or gully formation has the potential to lower the site water table, drying out the site and favoring the dominance of sagebrush and rabbitbrush over the herbaceous component.

Livestock/Wildlife Grazing Interpretations:

Spring defoliation of basin wildrye and/or consistent, heavy grazing during the growing season has been found to significantly reduce basin wildrye production and density (Krall et al. 1971). Basin wildrye is valuable forage for livestock (Ganskopp et al. 2007) and wildlife, but is intolerant of heavy, repeated, or spring grazing (Krall et al. 1971). Basin wildrye is used often as a winter feed for livestock and wildlife; not only providing roughage above the snow but also cover in the early spring months (Majerus 1992).

Overgrazing leads to an increase in big sagebrush and a decline in understory plants like basin wildrye and Nevada bluegrass (*Poa* sp.). Reduced bunchgrass vigor or density provides an opportunity for creeping wildrye or mat muhly expansion and/or cheatgrass and other invasive species to occupy interspaces. Creeping wildrye, so named due to its rhizomatous rooting characteristic, is tolerant of grazing and increases under grazing pressure (USDA 1937).

If the site is dependent upon a water table supported by an associated stream channel, excessive livestock or wildlife trampling of the streamside vegetation could lead to channel morphology changes and eventual headcutting, incision or other channel instability processes. Any lowering of the water table associated with channel degradation has potential negative impacts on the associated loamy bottom plant community. The sagebrush / rabbitbrush component will expand with a lowering of the seasonal water table. The root length of mature sagebrush was measured to a depth of 2 meters in alluvial soils in Utah (Richards and Caldwell 1987).

State and Transition Model Narrative for Group 26:

This is a text description of the states, phases, transitions, and community pathways possible in the State and Transition model for the MLRA 26 disturbance response group 26.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. The Reference State has three general community phases; a shrub-grass dominant phase, a perennial grass dominant phase and a shrub dominant phase. State dynamics are maintained by interactions between climatic patterns and disturbance regimes. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Plant community phase changes are primarily driven by fire, periodic drought and/or insect or disease attack.

Community Phase 1.1:
This community is dominated by basin wildrye. Basin big sagebrush is a minor component. Other perennial grasses and forbs are present.

Loamy Bottom 10-14" (R028BY003NV) Phase 1.1 P. Novak-Echenique, June 2012. This is a similar site in MLRA 28B.

Community Phase Pathway 1.1a:
Fire will decrease or eliminate the sparse stand of sagebrush and perennial bunchgrasses and grass-likes remain dominant on the site. Fire will typically remove most of the sagebrush overstory and rabbitbrush will likely resprout.

Community Phase Pathway 1.1b:
Time and lack of disturbance such as fire allows for sagebrush to increase and eventually become decadent. Long term drought, herbivory, or combinations of these will cause a decline in perennial bunchgrasses and fine fuels, leading to a reduced fire frequency and allowing big sagebrush to dominate the site. Rabbitbrush may also increase.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early-seral community. Basin wildrye, Nevada bluegrass and other perennial grasses and grass-likes dominate. Rabbitbrush is present in minor amounts. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain.

Community Phase Pathway 1.2a:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush and rabbitbrush allows the shrub component to recover. The establishment of big sagebrush can take many years.

Community Phase 1.3:
Basin big sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs, herbivory, lowered water table from drought, or a combination of these three factors. Sagebrush may be decadent. Rabbitbrush may be a significant component. Beardless (creeping) wildrye, mat muhly or Sandberg or Nevada bluegrass may increase and become co-dominant with deep rooted bunchgrasses. Sagebrush may become decadent over time.

Community Phase Pathway 1.3a:
Fire will decrease or eliminate the overstory of sagebrush and allow for the perennial bunchgrasses to dominate the site. Fire will typically remove most of the sagebrush overstory. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs.

T1A: Transition from Reference State 1.0 to Current Potential State 2.0:

Trigger: This transition is caused by the introduction of non-native annual and perennial plants, such as cheatgrass, mustards, and whitetop (*Cardaria draba*).

Slow variables: Over time the non-native species will increase within the community.

Threshold: Any amount of introduced non-native species causes an immediate decrease in the resilience of the site. Non-native species cannot be easily removed from the system and have the potential to significantly alter disturbance regimes from their historic range of variation.

Current Potential State 2.0:

This state is similar to the Reference State 1.0 with three similar community phases. Ecological function has not changed; however, the resiliency of the state has been reduced by the presence of invasive weeds. Non-natives may increase in abundance but will not become dominant within this State. These non-natives can be highly flammable and can promote fire where historically fire had been infrequent. Negative feedbacks enhance ecosystem resilience and contribute to the stability of the state. These feedbacks include the presence of all structural and functional groups, low fine fuel loads, and retention of organic matter and nutrients. Positive feedbacks decrease ecosystem resilience and stability of the state. These include the non-natives' high seed output, persistent seed bank, rapid growth rate, ability to cross pollinate, and adaptations for seed dispersal.

Community Phase 2.1:
This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native species in trace amounts. This community is dominated by basin wildrye. Basin big sagebrush is a minor component. Other perennial grasses and forbs are present.

Community Phase Pathway 2.1a:
Fire will decrease or eliminate the sparse stand of sagebrush and perennial bunchgrasses and grass-likes remain dominant on the site. Fire will typically remove most of the sagebrush overstory and rabbitbrush will likely resprout. Non-native species are likely to increase after fire.

Community Phase Pathway 2.1b:
Time and lack of disturbance such as fire allows basin big sagebrush and rabbitbrush to increase. Eventually it may become decadent. Long term drought, herbivory, or combinations of these will cause a decline in perennial bunchgrasses and fine fuels leading to a reduced fire frequency and allowing basin big sagebrush to dominate the site. Rabbitbrush may also increase. Inappropriate grazing management reduces the perennial bunchgrass understory; conversely beardless (creeping) wildrye and/or mat muhly may increase in the understory depending on grazing management.

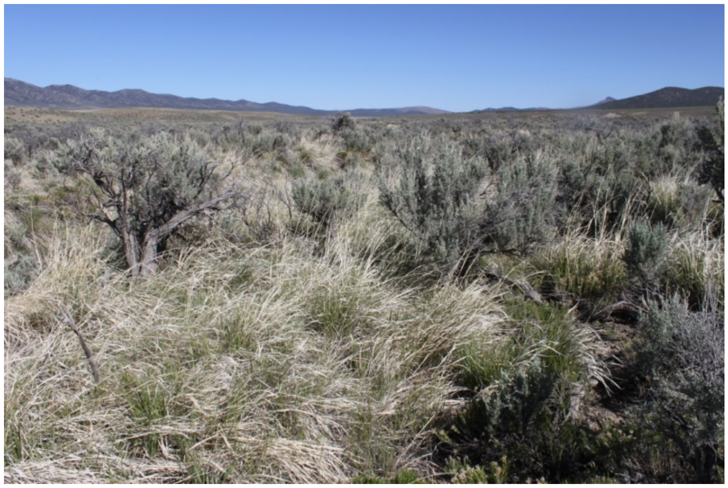
Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early seral community where annual non-native species are present. Sagebrush is present in trace amounts; perennial bunchgrasses and grass-likes dominate the site. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain. Rabbitbrush may be sprouting. Non-native species will increase after fire.

Loamy Bottom 10-14” (028BY003NV) Phase 2.2 T.K. Stringham, June 2012.
This is a similar site in MLRA 28B.

Community Phase Pathway 2.2a:
Time and lack of disturbance and/or grazing management that favors the establishment and growth of sagebrush and rabbitbrush allows the shrub component to recover. The establishment of big sagebrush can take many years.

Community Phase 2.3 (at-risk):
This community is at risk of crossing a threshold to another state. Sagebrush dominates the overstory and perennial bunchgrasses in the understory are reduced, either from competition with shrubs, inappropriate grazing, lowered water table or a combination of the three. Rabbitbrush may be a significant component. Beardless (creeping) wildrye, mat muhly or

Sandberg or Nevada bluegrass may increase and become co-dominant with deep rooted bunchgrasses. Non-native species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from grazing, drought, and fire.



Loamy Bottom 10-14” (028BY003NV) Phase 2.3 T.K. Stringham, June 2012. This is a similar site in MLRA 28B.

Community Phase Pathway 2.3a:
Fire will decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Fire will typically remove most of the sagebrush overstory. A severe infestation of Aroga moth could also cause a large decrease in sagebrush within the community, giving a competitive advantage to the perennial grasses and forbs. Non-native species respond well to fire and may increase post-burn.

T2A: Transition from Current Potential State 2.0 to Shrub State 3.0:

Trigger: To Community Phase 3.1: Repeated, heavy, growing season grazing will reduce and may eliminate basin wildrye, increase Sandberg bluegrass, and favor shrub growth and establishment. Alteration in the hydrology of the site may also cause an increase in sagebrush; with gullying of associated channel, the water table is dropped and may cause a decrease in perennial bunchgrasses. To Community Phase 3.2: Severe fire will remove sagebrush overstory, decrease perennial bunchgrasses and enhance Sandberg bluegrass.

Slow variables: Long term decrease in deep-rooted perennial grass density.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

Shrub State 3.0:

This state has two community phases: a decadent shrub phase and a sprouting shrub phase. This state is a product of many years of heavy grazing during time periods harmful to basin wildrye and/or hydrologic modification resulting in a lowered water table. Creeping wildrye, mat muhly and/or Sandberg's bluegrass may become the dominant grasses. Basin big sagebrush dominates the overstory and rabbitbrush may be a significant component. Sagebrush cover exceeds the site concept and may be decadent, reflecting stand maturity. Basin wildrye is significantly reduced or eliminated from the site. The shrub overstory as well as the Sandberg bluegrass, creeping wildrye, or mat muhly understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed.

Community Phase 3.1:
Decadent basin big sagebrush dominates the overstory. Rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Creeping wildrye, mat muhly, Sandberg bluegrass, and annual non-native species increase. Bare ground is higher than normal.

Loamy Bottom 10-14" (025XY003NV) Phase 3.1. T.K. Stringham, April 2013.
This is a similar site in MLRA 28B.

Loamy Bottom 10-14" (028BY003NV) Phase 3.1 T.K. Stringham, June 2012.
This is a similar site in MLRA 28B.

Loamy Bottom 10-14" (028BY003NV) Phase 3.1 T.K. Stringham, June 2012.
This is a similar site in MLRA 28B.

Community Phase Pathway 3.1a:
Fire, heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, will greatly reduce the overstory shrubs to trace amounts and allow for creeping wildrye, mat muhly or Sandberg bluegrass to dominate the site.

Community Phase 3.2:
Creeping wildrye, mat muhly, Sandberg bluegrass, and/or rabbitbrush dominates the site. Annual non-native species may be present but are not dominant. Trace amounts of sagebrush may be present.

Loamy Bottom (028XY003NV) Phase 3.2 T.K. Stringham, April 2013.
This is a similar site in MLRA 28B.

Loamy Bottom 10-14" (028BY003NV) Phase 3.2. T.K. Stringham, June 2012.
This is a similar site in MLRA 28B.

Community Phase Pathway 3.2a:
Time and lack of disturbance may allow sagebrush to recover.

R3A: Restoration from Shrub State 3.0 to Current Potential State 2.0:

Brush management such as mowing, coupled with seeding of basin wildrye. May be coupled with restoration of the water table where channel incision has occurred. Engineered structures are recommended. See USDA, NRCS National Engineering Handbook (2008).

R3B: Restoration from Shrub State 3.0 to Seeded State 4.0:

Brush management such as mowing, coupled with seeding of deep rooted non-native bunchgrasses.

T3A: Transition from Shrub State 3.0 to Annual State 5.0:

Trigger: To Community Phase 5.1: Repeated, heavy, growing season grazing will decrease or eliminate deep rooted perennial bunchgrasses, increase cheatgrass and non-native forbs, and favor shrub growth and recruitment. Alteration in the hydrology of the site may also cause an increase in sagebrush; with gullying of associated channel the water table is dropped and may cause a decrease in perennial bunchgrasses. To Community Phase 5.2: Severe fire will remove sagebrush overstory and cheatgrass will be the dominate plant species. Rabbitbrush may be present. Failed brush management and seeding will also result in Community Phase 5.2.

Slow variables: Long term decrease in deep-rooted perennial grass density and increase in shrub overstory. Channel incisement may be occurring.

Threshold: Loss of deep-rooted perennial bunchgrasses changes nutrient cycling, nutrient redistribution, and reduces soil organic matter.

Seeded State 4.0:

This state has two community phases one that is characterized by the dominance of seeded introduced species and the other with shrubs dominating the overstory. Crested wheatgrass and other desired seeded species, including basin big sagebrush and native and non-native forbs, may be present. Seeded species may be chosen based on current hydrologic conditions; crested wheatgrass tolerates a drier environment than basin wildrye.

Community Phase 4.1:
Introduced bunchgrass species and other non-native species such as crested wheatgrass dominate the community. Native and non-native seeded forbs may be present. Trace amounts of big sagebrush may be present, especially if seeded. Annual non-native species may be present.

Community Phase Pathway 4.1a:
Inappropriate grazing management particularly during the growing season reduces perennial bunchgrass vigor and density and facilitates shrub recruitment and growth**.**

Community Phase 4.2:
Basin big sagebrush and seeded wheatgrass species co-dominate. Annual non-native species may be present.

Community Phase Pathway 4.2a:
Low severity fire, brush management, and/or Aroga moth infestation will reduce the sagebrush overstory and allow seeded wheatgrass species to become dominant.

Annual State 5.0:

The Annual State is likely possible within this group of ecological sites, however it was not observed during field work. Johanson (2011) documented the presence of an Annual State within the Utah portion of MLRA 28A for the Loamy Bottom ecological site (R028AY006UT). Cheatgrass was found to be the dominant species along with a diverse selection of invasive forbs including Russian thistle, knapweed and various non-native thistles. State resiliency is maintained through increased fire frequency and efficient utilization of soil nitrogen (Johanson 2011). This state has two plant community phases one that is characterized by an overstory of big sagebrush and an understory dominated by cheatgrass and the other a post-fire community dominated by cheatgrass with a trace amount of shrubs.

Community Phase 5.1:
Basin big sagebrush dominates the overstory and cheatgrass dominates the understory. Various non-native, invasive forbs may be sub-dominate.

Community Phase Pathway 5.1a:
Severe fire or failed brush treatment and seeding will greatly reduce the overstory of sagebrush to trace amounts and facilitate the dominance of cheatgrass and non-native forbs.

Community Phase 5.2:

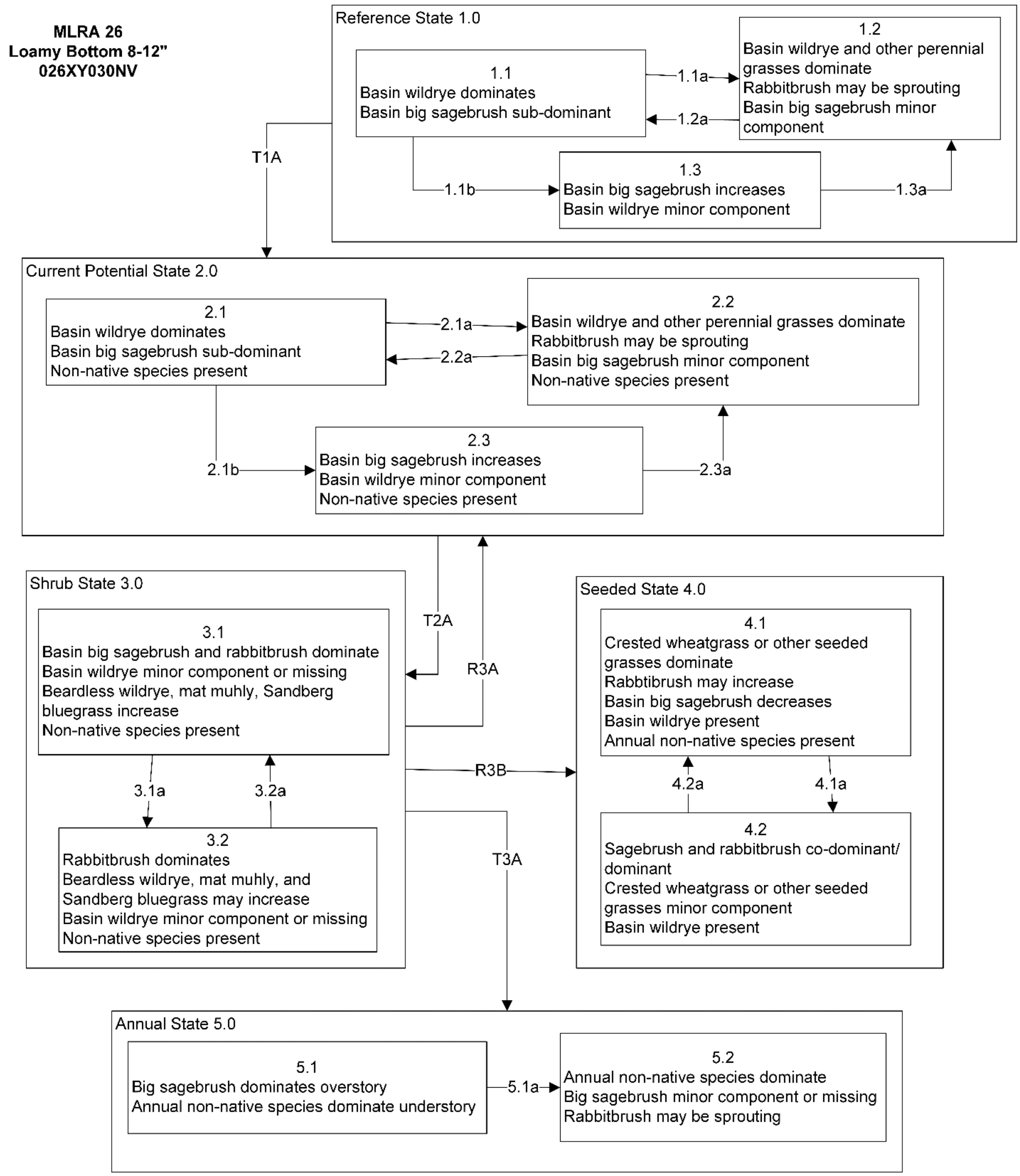
Cheatgrass dominates and various non-native, invasive forbs may be co-dominant. Rabbitbrush may be sprouting. Creeping wildrye, mat muhly, Sandberg bluegrass, and/or rabbitbrush are minor components if present. Trace amounts of sagebrush may be present.

Potential Resilience Differences with Other Ecological Sites:

Loamy Bottom 14+" P.Z. (R026XY057NV):

This site occurs at higher elevations (6,200 to over 8,000 feet) and receives more annual precipitation than the modal site. Mountain big sagebrush is the dominant shrub. In addition to rabbitbrush, willow, wood’s rose, currant, buffaloberry, chokecherry, snowberry, and elderberry may be present. Production is lower than the modal site at 2,200 lbs/ac in normal years.

Modal State and Transition Model for Group 26 MLRA 26:



MLRA 26
Loamy Bottom 8-12"
026XY030NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory, chronic drought or combinations may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.

Transition T1A: Introduction of non-native species such as cheatgrass.

Current Potential State 2.0 Community Phase Pathways
2.1a: Fire creates grass/sagebrush mosaic. Aroga moth may also cause a large die-off in sagebrush; non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing management, chronic drought or combinations may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Fire reduces sagebrush. Aroga moth infestation may create a sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

Transition T2A: Hydrologic alteration (lowering of water table i.e. gullying of associated channel), inappropriate grazing management, or combinations of these (to 3.1). Fire (to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire and/or brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (not likely to occur).

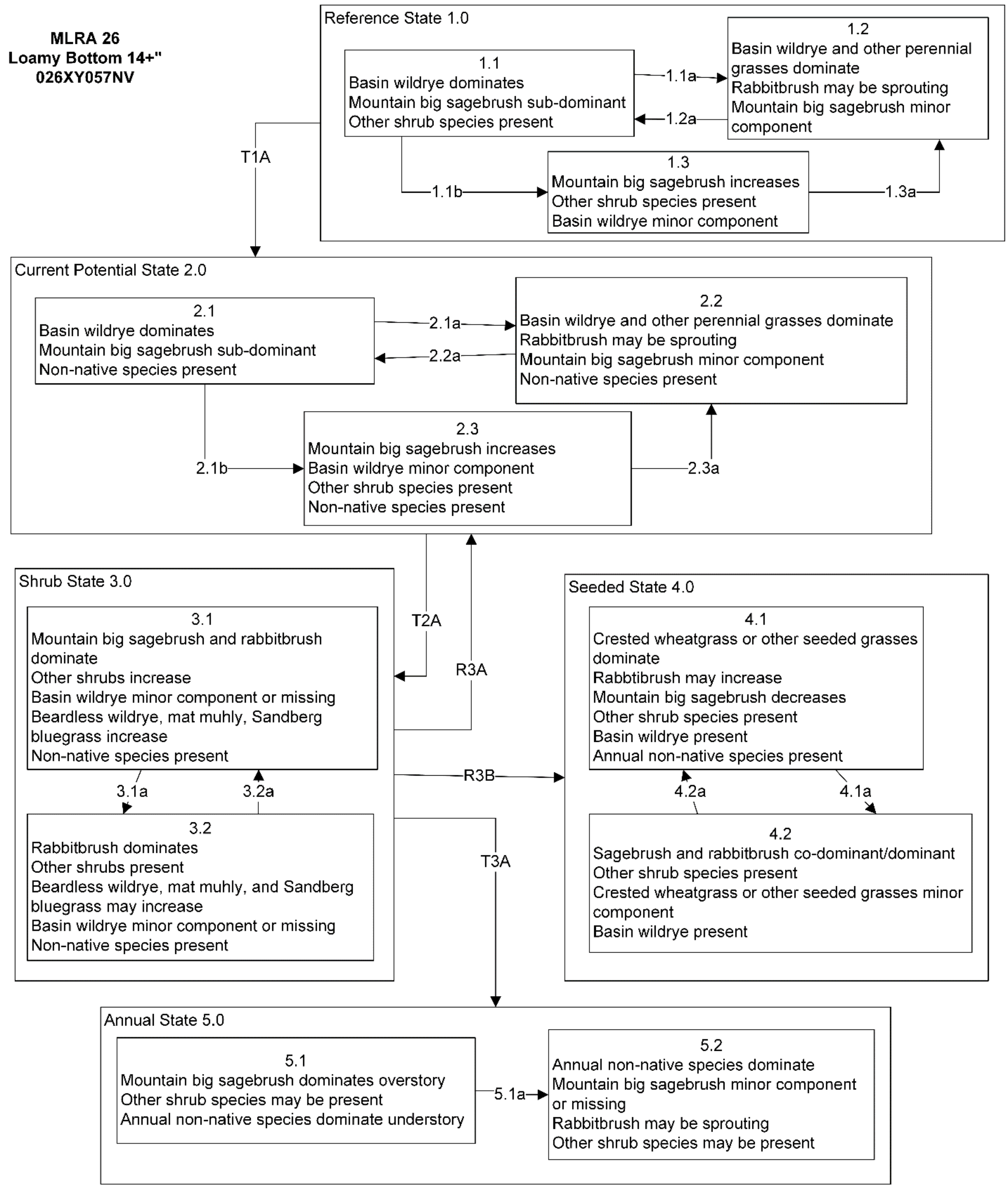
Transition T3A: Continual inappropriate grazing management and/or hydrologic alteration (i.e. gullying of associated channel) (to 5.1). Severe fire, and/or failed brush management and seeding (to 5.2).

Restoration R3A: Brush management and seeding of basin wildrye; may be coupled with restoration of channel (to 2.2).
Restoration R3B: Brush management with minimal soil disturbance coupled with seeding of desired species (to 4.1).

Seeded State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance; inappropriate grazing management may also reduce perennial understory.
4.2a: Fire, brush management, and/or Aroga moth infestation.

Annual State 5.0 Community Phase Pathways
5.1a: Severe fire or failed brush treatment/seeding.

Additional State and Transition Models for Group 26 MLRA 26:



MLRA 26
Loamy Bottom 14+"
026XY057NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Fire significantly reduces sagebrush and other shrub cover and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory, chronic drought or combinations may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Fire significantly reduces cover of sagebrush and other shrubs and leads to early/mid-seral community, dominated by grasses and forbs. Aroga moth may cause a large die-off in sagebrush resulting in a mosaic of grass and sagebrush.

Transition T1A: Introduction of non-native species such as cheatgrass.

Current Potential State 2.0 Community Phase Pathways
2.1a: Fire creates grass/sagebrush mosaic. Aroga moth may also cause a large die-off in sagebrush; non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing management, chronic drought or combinations may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush and other shrubs.
2.3a: Fire reduces sagebrush. Aroga moth infestation may create a sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

Transition T2A: Hydrologic alteration (lowering of water table i.e. gullying of associated channel), inappropriate grazing management, or combinations of these (to 3.1). Fire (to 3.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire and/or brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (not likely to occur).

Transition T3A: Continual inappropriate grazing management and/or hydrologic alteration (i.e. gullying of associated channel) (to 5.1). Severe fire, and/or failed brush management and seeding (to 5.2).

Restoration R3A: Brush management and seeding of basin wildrye; may be coupled with restoration of channel (to 2.2).
Restoration R3B: Brush management with minimal soil disturbance coupled with seeding of desired species (to 4.1).

Seeded State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance; inappropriate grazing management may also reduce perennial understory.
4.2a: Fire, brush management, and/or Aroga moth infestation.

Annual State 5.0 Community Phase Pathways
5.1a: Severe fire or failed brush treatment/seeding.

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Supplemental Information

Supplemental information will be available in separate documents and will be posted at the Major Land Resources (MLRA) Reports page on the Nevada Agricultural Experiment Station site or on the UNR Rangeland Ecology Lab page. These documents will also be available by request from Tamzen Stringham.

1. Disturbance Response Group List

Provided as a separate file for convenient use.

2. Field notes completed for the MLRA 26 STM Project

Field notes and landscape photographs collected between 2015 and 2017.

3. List of all site visits for the MLRA 26 STM project – chronological

This is an abbreviated version of the site visit list. The full spreadsheet of site visit data is available electronically by request.

4. Site visit counts by Disturbance Response Group and by STM State

Summarized site visit data.

5. Geospatial data

These data will include DRG maps and site visit locations.