Great Basin Ecological Site Development Project: State and Transition Models for Major Land Resource Area 23, Nevada and portions of California

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Executive Summary

This report was completed in February 2019 in fulfillment of Agreement L16AC00135 with the Bureau of Land Management. It contains state-and-transition models (STMs) for 99 ecological sites within Major Land Resource Area 23 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 and Patti Novak-Echenique, developed these products. The team examined local knowledge, soil mapping data, and published literature on 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 23 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 and were utilized during the STM-building process. DRGs can also be used to map ecological sites. This report is organized by DRG, with one generalized STM narrative for the group, followed by individualized STMs for each ecological site within the group. Fieldwork reports including site visit locations and field note reports are included as appendices.

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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:

1. Dr. Tamzen Stringham: Rangeland Ecologist and State-and-Transition Model expert
2. Devon Snyder: UNR Rangeland Ecologist
3. Patti Novak-Echenique: NRCS Nevada, State Rangeland Management Specialist
4. Amanda Wartgow: UNR Rangeland Ecologist
5. Alyssa Badertscher: UNR technician
6. Kelsey O'Neill: UNR technician

Soil support was provided by:

- Edward Blake: NRCS Nevada, Soil Scientist, Retired
- Joseph Chiaretti: NRCS Nevada, Soil Scientist, Retired
- Chris Savastio, NRCS Soil Scientist and MLRA Soil Survey Leader
- Matt Cole, NRCS Soil Scientist

Additional support members of the team:

- Steven Ponte
- Steve Surian (BLM)
- Rebecca Carter (BLM)
- Andrew Mueller

- Robin Tausch
- Keith Barker
- Mike Dolan
- Steve Matthews
- Andrew Johnson (BLM)
- Amanda Gearhart (BLM)
- Valda Lockie (BLM)
- Clifton Motheral (BLM)
- Juliet Wallis (BLM)
- Ryan Desliu (BLM)

Initial office meetings were conducted with all Core Team members present to group sites into preliminary Disturbance Response Groups (DRGs). 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 restrictive horizon
- If possible, soil series is recorded
- Fire history if relevant
- Other known disturbances
- 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 190 field notes over the course of five field seasons and ten weeks of field work. The Final Report contains the Disturbance Response Group list for MLRA 23, 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 appendices 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 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.

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, Phase 1.1 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).

Phase 2.4 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 exist. 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 23

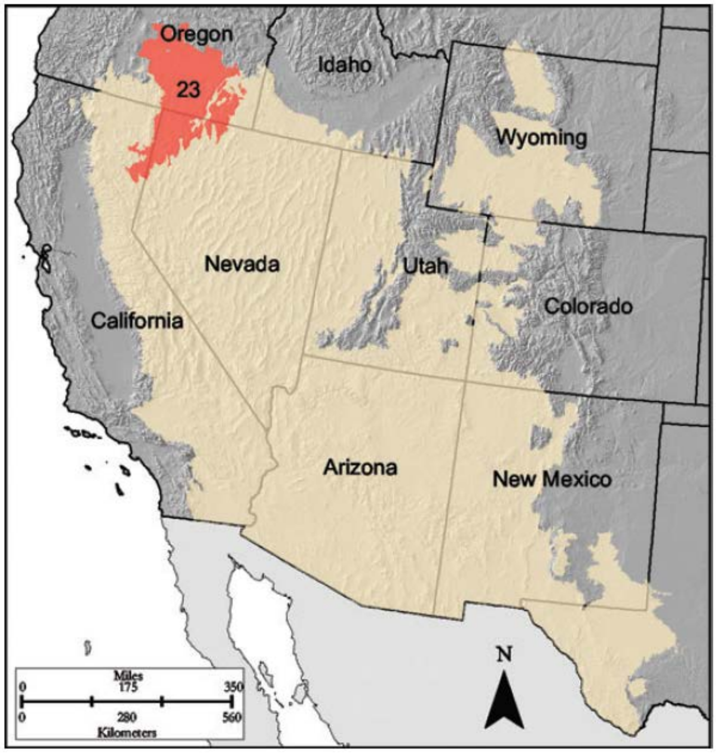

Figure 1. MLRA 23 (USDA 2006).

Major Land Resource Area 23, known as the Malheur High Plateau, is 22,895 square miles (14.6 million acres) in size. Most of MLRA 23 is located in southeastern Oregon, with the remainder in northwestern Nevada and along the Nevada border in northeastern California. Elevation ranges from 3,900 – 6,900 feet in most of the area, but it exceeds 9,000 feet on some mountains. This MLRA consists of nearly level to moderately steep plateaus, basins, and valleys bordered by long, gently sloping alluvial vans. Occasional north-south fault-block mountain ranges separate the basins. Volcanic plateaus with basalt rock rims are common. Most of this are consists of young andesite and basalt layers. Basins between mountains are filled with alluvium, continental sediments, and volcanic ash. Playas or shallow seasonal lakes are common in the lowest areas within the closed basins. The dominant soil orders in MLRA 23 are Aridisols and Mollisols. Soils primarily have a mesic or frigid temperature regime, and aridic or xeric moisture regime. Soils tend to be loamy or clayey.

The average annual precipitation is 6 – 12 inches, but can be as high as 57 inches in certain mountain ranges. 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 39-52°F, decreasing with elevation. The freeze-free period averages 105 days, but ranges from 35 to 175 days along an elevation gradient.

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<u>Disturbance Response Groups – MLRA 23</u>

DRG Ecological Site Name		Dominant Vegetation	ESD ID
<u>1: Low and Lahontan sagebrush and bluebunch wheatgrass/Thurber's needlegrass</u>			
Claypan 10-14"	***Modal Site***	**ARAR8/PSSPS-ACTH7**	**R023XY031NV**
Clay Slope 8-12"		ARARL3/PSSPS	R023XY037NV
Gravelly Claypan 10-12"		ARAR8/ACTH7	R023XY059NV
Gravelly Clay 10-12"		ARARL3/ACTH7	R023XY093NV
Scabland 10-14"		ARAR8/POSE	R023XY021NV
Cobbly Claypan 8-12"		ARAR8/PSSPS-ACTH7	R023XY060NV
Shallow Stony Loam 9-12"	*Correlated CA Site*	ARAR8/PSSPS-ACTH7	R023XF081CA
Shallow Stony Clay Loam 9-12"	*Correlated CA Site*	ARARL3/PSSPS	R023XF083CA
<u>2: Low and Lahontan sagebrush and Idaho fescue; no annual state</u>			
Claypan 14-16"	***Modal Site***	**ARAR8/FEID-PSSPS**	**R023XY017NV**
Mountain Ridge 14+		ARAR8/FEID-POSE	R023XY008NV
Shallow Loam 14+"		ARAR8/FEID	R023XY014NV
Clay Plain		ARARL/ACTH7-POFEF	R023XY090NV
<u>3: Lahontan sagebrush on ashy soils</u>			
Ashy Claypan (cool) 10-14"	***Modal Site***	**ARARL3/FEID-ACTH7**	**R023XY079NV**
Ashy Claypan 10-14"		ARARL3/PSSPS-ACTH7	R023XY078NV
<u>4: Low or Lahontan sagebrush and Sandberg bluegrass</u>			
Very Cobbly Claypan	***Modal Site***	**ARAR8/POSE**	**R023XY044NV**
Churning Clay		ERNAW/ELEL5-POSE	R023XY001NV
Shallow Clay 9-16"	*Correlated CA Site*	ARAR8/ELEL5-ACTH7	R023XF093CA
<u>5: Mountain big sagebrush and bluebunch wheatgrass</u>			
South Slope 12-16"	***Modal Site***	**ARTRV/PSSPS**	**R023XY016NV**
Ashy Slope 12-14"		ARTRV/FEID-ACOCO	R023XY094NV
Loamy 12-14"		ARTRV/PSSPS-LECI4	R023XY041NV
Loamy 14-16"		ARTRV/FEID-PSSPS	R023XY007NV
Stony Loam 12-14"		PUTR2-ARTRV/PSSPS	R023XY015NV
Well Drained Fan		PUTR2-ARTRV/PSSPS	R023XY022NV
Stony South Slope 12-16"		ARTRV/PSSPS-LECI4	R023XY018NV
Granitic South Slope 12-14"		ARTRV/PSSPS	R023XY042NV
Deep Loamy 10-12"		ARTR2-PERA4/ACTH7-PSSPS	R023XY098NV
Granitic Slope 14-16"		ARTRV/FEID-PSSPS	R023XY043NV
<u>6: High resilience mountain big sagebrush and Idaho fescue</u>			
Ashy Loam 14-16"	***Modal Site***	**ARTRV-PUTR2/FEID-ACHNA**	**R023XY066NV**
Mountain Shoulders 14-18"		ARTRV/FEID-ACHNA	R023XY061NV
Ashy Sandy Loam 10-12"		ARTR2/ACTH7-PSSPS-FEID	R023XY096NV
Steep North Slope		ARTRV/FEID	R023XY054NV

Granitic Loam 14-16"		ARTRV/ACHNA	R023XY058NV
Stony Granitic Slope 14+"		ARTRV-AMUT/PSSPS	R023XY050NV
Gravelly North Slope		ARTR4/FEID	R023XY053NV
South Slope 16+"		ARTRV-PUTR2/PSSPS-BRMA4	R023XY064NV
Ashy Loam 10-12"		ARTR2/FEID-ACTH7	R023XY071NV
Deep Loamy 14-16"		ARTRV/FEID-ACHNA	R023XY084NV

8: Mountain big sagebrush and mountain brome

Loamy 16+"	***Modal Site***	**ARTRV/BRMA4-ACHNA**	**R023XY019NV**
Loamy Slope 16+"		ARTRV/BRMA4-ACHNA-FEID	R023XY065NV
Granitic Slope 16+"		ARTRV/BRMA4	R023XY048NV

9: Wyoming big sagebrush and Thurber's needlegrass

Loamy 8-10"	***Modal Site***	**ARTRW8/ACTH7**	**R023XY006NV**
Loamy Slope 10-14"		ARTRW8/PSSPS	R023XY039NV
Loamy 10-12"		ARTR2/PSSPS-ACTH7	R023XY020NV
Loamy Fan 8-10"		ARTR2/LECI4-ELLAL	R023XY097NV
Granitic Loam 10-12"		ARTRW8/ACTH7-PSSPS	R023XY057NV
Granitic Loam 8-10"		ARTRW8/ACTH7	R023XY068NV
Droughty Loam 8-10"		ARTRW8-GRSP/ACHY-ACSP12	R023XY038NV
Granitic South Slope 8-12"		ARTRW8/PSSPS	R023XY049NV
Loamy Fan 10-12"		ARTR2/POA-ACHNA	R023XY082NV
Granitic Fan 8-10"		ARTR2/LECI4-ACTH7	R023XY040NV
Sandy 8-12"		ARTR2/ACHY-HECO26	R023XY051NV
Channery Hill 8-10"		ARTRW8-PERA4/ACHY	R023XY099NV
Stony Slope 8-10"		ARTRW8/ACSP12	R023XY101NV
Gravelly Clay Slope 10-12"		ARTRW8-GLSPA/PSSPS-ACTH7	R023XY102NV
Stony Loam 9-12"	*Correlated CA Site*	ARTRW8/PSSPS	R023XF082CA
Loamy Upland 9-12"	*Correlated CA Site*	ARTRT/LECI4-ACTH7	R023XF091CA

10: Low production Wyoming and Lahontan sagebrush sites with sparse Juniper

Gravelly Clay 8-10"	***Modal Site***	**ARARL3/ACTH7**	**R023XY047NV**
Loamy Hill 10-14"		JUOS/ARTRW8/LESAS2	R023XY076NV
Chalky Knoll		ARTRW8/ACHY	R023XY088NV
South Slope 8-12"		ARTRW8/ACSP12-PSSPS	R023XY030NV
Shallow Granitic Hill 10-14"		JUOS/ARARL3/ACTH7	R023XY063NV
Shallow Loam 10-14"		JUOS/ARTRW/LESAS2	R023XY077NV
Shallow Hill 10-14"		JUOS/ARARL3/LESAS2	R023XY075NV

12: Seasonally flooded closed clayey basins

Wet Clay Basin	***Modal Site***	**IVAX-AAFF/MURI**	**R023XY023NV**
Clay Basin		ARCA13/PONE3-LETR5	R023XY003NV
Clay Floodplain	*Correlated CA Site*	ARCA13/PONE3	R023XF092CA

13: Black sagebrush

Shallow Calcareous Loam 8-12"	***Modal Site***	**ARNO4/PSSPS-ACTH7**	**R023XY052NV**
Very Shallow Stony Loam 9-12"	*Correlated CA Site*	ARNO4/PSSPS-ACTH7	R023XF087CA

14: Stabilized sand dunes with sagebrush and saltbrush

Dunes 8-10"	***Modal Site***	**ARTR-GRSP-ATCA2/ACHY**	**R023XY011NV**

15: Big sagebrush with rhizomatous grasses

Clayey 10-14"	***Modal Site***	**ARTRT/ELLAL-LETR5**	**R023XY033NV**
Clay Upland 9-16"	*Correlated CA Site*	ARTRT/ELEL5-PASM	R023XF084CA

16: Seasonally flooded areas with basin wildrye

Dry Floodplain	***Modal Site***	**ARTRT/LECI4**	**R023XY005NV**
Saline Bottom		SAVE4/LECI4	R023XY010NV
Loamy Bottom 8-12"		ARTRT/LECI4	R023XY009NV
Dry Meadow		PONE3	R023XY013NV
Loamy Bottom 12-16"		ARTRV/LECI4	R023XY056NV
Loamy Bottom 9-16"	*Correlated CA Site*	ARTRT/LECI4	R023XF088CA

17: Mountain mahogany and mountain big sagebrush

Mahogany Savanna R023XY026NV	***Modal Site***	**CELE3/ARTRV/FEID-PSSPS-ACHNA**	
Granitic Mahogany Savanna		CELE3/ARTRV/PONE-ACLE9	R023XY069NV

18: Utah juniper with Thurber's needlegrass and various sagebrush species

JUOS WSG: 0X0403	***Modal Site***	**JUOS/ARAR8/ACTH7**	**F023XY035NV**
JUOS WSG: 0R0409		JUOS/ARARL3/ACTH7-ACSP12	F023XY045NV
JUOS WSG: 0R0402		JUOS/ARTRW8/ACTH7-ACSP12	F023XY046NV

19: Western juniper and low sagebrush with bluebunch wheatgrass and Idaho fescue

JUOC WSG: 0R2003	***Modal Site***	**JUOC/ARAR8/FEID-PSSPS**	**F023XY095NV**
JUOC WSG: 0R2003		JUOC/ARAR8/PSSPS-ACTH7	F023XY091NV

20: Juniper and mountain big sagebrush

JUOS WSG:0R0401	***Modal Site***	**JUOS/ARTRV/PSSPS-ACTH7**	**F023XY036NV**
JUOC WSG: 1R2001		JUOC/ARTRV/PSSPS	F023XY024NV

23: Quaking aspen

POTR5 WSG: 1R1701	***Modal Site***	**POTR5/SYMPH/BRMA4-ELTRT**	**F023XY028NV**
Aspen Thicket		POTR5/ACHNA-BRMA4-ELTRT	R023XY027NV

The following list of ecological sites were omitted from 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 assigned to them in SSURGO. Other sites are minor inclusions in the MLRA and may only occur on a few hundred acres. For our purposes, we focused on providing ecological information for DRGs that were extensive enough to be meaningful for management.

MLRA 23 ecological sites not modeled for this project:

Site Name	**Reason**	**Site Vegetation**	**Site ID**
ABCO/WSG: 5R7	*Small acreage*	ABCO/CEVE	F023XY092NV
Loamy Slope 14-16"	*Zero acres mapped*	ARTRV-PUTR2/FEID-ACHNA	R023XY100NV
Ashy Slope 10-12"	*Zero acres mapped*	ARTRW8/FEID-ACTH7	R023XY072NV
Granitic Mahogany Thicket	*Zero acres mapped*	CELE3/ARTRV/ACHNA	R023XY073NV
Mahogany Thicket	*Zero acres mapped*	CELE3/ARTRV/ACNEN2-PONE3	R023XY074NV
Snowpocket	*Zero acres mapped*	LUCA/ACLE9	R023XY062NV
PIAL WSG 0R0701	*Small acreage*	PIAL/ARTRV/BRMA4	F023XY070NV
Wet Meadow	*Riparian*	PONE3-LETR5-CAREX	R023XY089NV
Stony Claypan 10-14"	*Zero acres mapped*	PUTR2-ARAR8/PSSPS-ACTH7	R023XY080NV
Stony Granitic Slope 12-14"	*Zero acres mapped*	PUTR2-ARTRV/PSSPS-ACTH7	R023XY067NV

Group 1: Low and Lahontan sagebrush and bluebunch wheatgrass/Thurber's needlegrass

Description of MLRA 23 DRG 1:

Disturbance Response Group (DRG) 1 consists of eight ecological sites. The California sites, Shallow Stony Loam 9-12” (023XF081CA) and Shallow Stony Clay Loam 9-12” (023XF083CA), correlate with the Nevada ecological sites Cobbly Claypan 8-12” (023XY060NV) and Clay Slope 8-12” (023XY037NV), respectively. The precipitation zone for these sites ranges from 8 to over 20 inches. The elevation range for this group is 4500 to 7000 feet. Slopes range from 2 to 50 percent but slopes of 2 to 30 percent are most typical. Annual production in a normal year ranges from 200 to 1200 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 Lahontan sagebrush (*Artemisia arbuscula* ssp. *longicaulis)*, low sagebrush (*Artemisia arbuscula)*, or early or alkali sagebrush (*Artemisia arbuscula* ssp. *longiloba*). The understory is dominated by deep rooted cool season perennial bunchgrasses; primarily bluebunch wheatgrass (*Pseudoroegneria spicata)* and Thurber’s needlegrass (*Achnatherum thurberianum)*. Bluegrasses (*Poa* sp.), Webber’s needlegrass and other bunchgrasses are also common on these sites. Forbs make up a small component of the annual production. Soils in this group have a moderate to strong-structured clayey subsoil that exhibits shrink-swell behavior and become saturated during the springtime.

Many of the ecological sites in this group are described as having low sagebrush as the dominant shrub. During our visits to these sites for this project, 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 23.

Disturbance Response Group 1 Ecological Sites:

Claypan 10-14" – Modal	023XY031NV
Clay Slope 8-12"	023XY037NV
Gravelly Claypan 10-12"	023XY059NV
Gravelly Clay 10-12"	023XY093NV
Scabland 10-14”	023XY021NV
Cobbly Claypan 8-12"	023XY060NV
Shallow Stony Loam 9-12”	023XF081CA
Shallow Stony Clay Loam 9-12”	023XF083CA

Modal Site:

The Claypan 10-14” (023XY031NV) ecological is the modal site for this group as it has the most acres mapped. This site occurs on summits and moderate slopes of hills and plateaus on all aspects. Slopes range from 2 to 30 percent, but slope gradients of 2 to 15 percent are typical. Elevations are 5500 to

7000 feet. The soils in this site have thin surface layers and are typically underlain by heavy clay subsoils that exhibit moderate to strong structure. These fine textured subsoils will swell on wetting then shrink and crack upon drying. Swelling of the subsoil with wetting in the early spring results in poor soil aeration, forming a perched water table near the surface. Infiltration of water is restricted once these soils are saturated and the site is subject to loss of water by runoff. The thin surface layer has a low available water capacity due to its limited thickness and reduction in surface layer depth results in decreased productivity of the plant community. These soils normally have a high percentage of gravels and cobbles on the surface which occupy plant growing space yet help to reduce evaporation and conserve soil moisture. Plant growth is initiated with the spring warming of these soils. Pedestalling of some grass plants is common during the winter due to frost heaving. Low sagebrush and Lahontan sagebrush are the dominant shrubs. Bluebunch wheatgrass and Thurber's needlegrass are dominant grasses. Squawapple (*Pheraphyllum ramosissimum)* and antelope bitterbrush are also found on this site. Production is about 700 lbs/acre for a normal year.

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). 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).

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).

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).

Early sagebrush (also known as alkali sagebrush) is a unique subspecies of *Artemisia arbuscula* 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).

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. 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 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. To date, we have not been able to find specific research on the fire response of Lahontan sagebrush.

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. The two dominant grasses on this site, bluebunch wheatgrass and Thurber's needlegrass, have different responses to fire. Bluebunch wheatgrass has coarse stems with little leafy material, therefore the plant's aboveground biomass burns rapidly and little heat is transferred downward into the crowns (Young 1983). Bluebunch wheatgrass was described as fairly tolerant of burning, other than in May in eastern Oregon (Britton et al. 1990). Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Bluebunch wheatgrass is considered to experience slight damage to fire but is more susceptible in drought years (Young 1983).

Conversely, 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 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). 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 this ecological site and others in this DRG. This recently differentiated subspecies of low sagebrush (Winward and McArthur 1995) is moderately to highly palatable to browse species (McArthur 2005, Rosentreter 2005). Dwarf sagebrush species such as Lahontan sagebrush, low sagebrush, and black sagebrush are preferred by mule deer for browse among the sagebrush species.

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.

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975, Britton et al. 1990). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949). Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.

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).

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).

State and Transition Model Narrative 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 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:
This community is dominated by Lahontan/low sagebrush, bluebunch wheatgrass and Thurber's needlegrass. Forbs and other grasses make up smaller components. Antelope bitterbrush 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. Bluebunch wheatgrass, Thurber's needlegrass 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. Mature and/or 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. Sandberg bluegrass may increase and become co-dominant with deep rooted bunchgrasses.

Gravelly Clay 10-12” (023XY093NV) Phase 1.3 T. K. Stringham, July 2015

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:

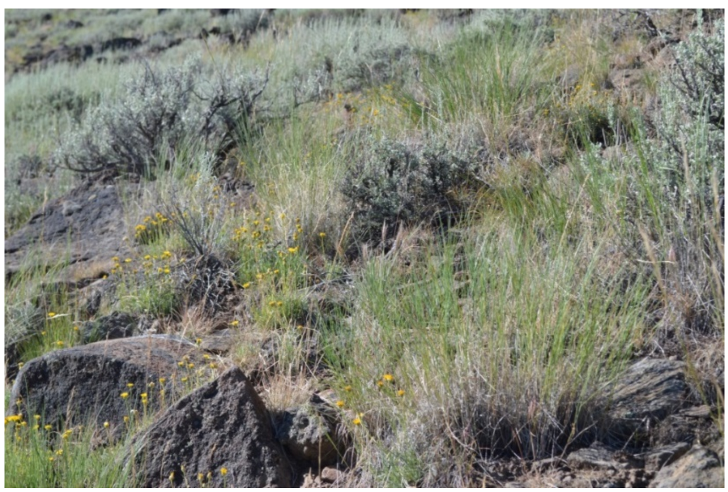
Trigger: This transition is caused by the introduction of non-native annual plants, such as cheatgrass, medusahead, mustards, and bur buttercup.
Slow variables: Over time, the annual non-native plants will increase within the community. The change in dominance from perennial grasses to annual grasses 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.

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, bluebunch wheatgrass and Thurber's needlegrass dominate the site. Forbs and other shrubs and grasses make up smaller components of this site.

Gravelly Claypan 10-12" (023XY059NV) Phase 2.1 T. K. Stringham, August 2014



Clay Slope 8-12" (023XY037NV) Phase 2.1 T. K. Stringham, June 2015

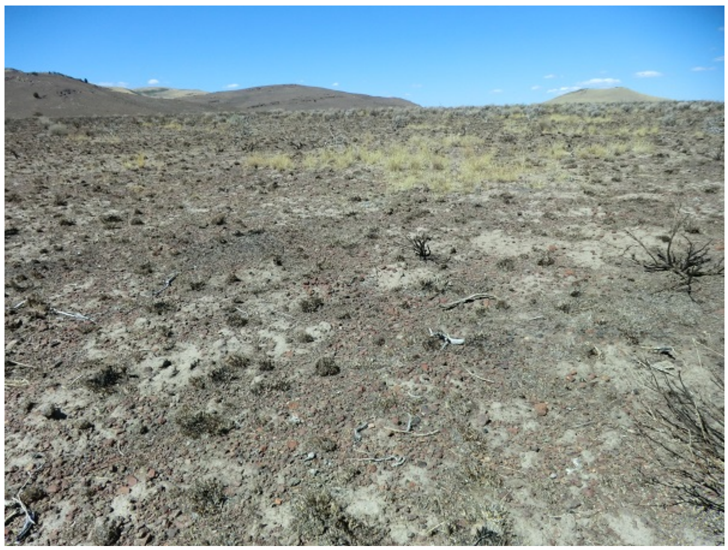
Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Fire reduces the shrub overstory and allows for perennial bunchgrasses to dominate the site. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring or a change in management favoring 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 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.



Claypan 10-14" (023XY031NV) Phase 2.2 P. Novak-Echenique, August 2014

Claypan 10-14" (023XY031NV) Phase 2.2 T. K. Stringham, June 2015

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 Pathway 2.2b, from Phase 2.2 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 2.3 (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. Sandberg bluegrass may increase and 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.

Claypan 10-14” (023XY031NV) Phase 2.3 T. K. Stringham, August 2014

Scabland 10-14" (023XY021NV) Phase 2.3 T. K. Stringham, July 2015

Clay Slope 8-12" (023XY037NV) Phase 2.3 T.K. Stringham, May 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 increase. 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 increase. 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 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 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.

Community Phase Pathway 2.4a, from Phase 2.4 to 2.3:
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 2.2:
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: 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.

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

Trigger: Time and lack of disturbance or management action allows for Utah juniper and/or western 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 number of live shrubs. Minimal recruitment of new shrub cohorts.

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

Trigger: Fire or soil disturbing treatment would transition to Community Phase 5.1.
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. Sandberg bluegrass 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. 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.

Gravelly Claypan 10-12" (023XY059NV) Phase 3.1 P. Novak-Echenique, May 2015

Very Cobbly Claypan (023XY044NV) Phase 3.1 T.K. Stringham, July 2015

Shallow Stony Loam 9-12" (023XF081CA) Phase 3.1 T.K. Stringham, October 2018

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. 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 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 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.

T3B: Transition from Shrub State 3.0 to Annual State 5.0

Trigger: Fire and/or treatments that disturb the soil and existing grass community. Further inappropriate grazing management transitions the site to phase 5.2.
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.

Tree State 4.0:

This state is characterized by a dominance of Utah and/or western 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:
Utah juniper and/or western juniper dominates 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.

Claypan 10-14” (023XY031NV) Phase 4.1 T. K. Stringham, August 2014

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:
Utah juniper /western juniper dominate overstory. Lahontan sagebrush is decadent and dying with numerous skeletons present or sagebrush may be missing from the system. 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 movement may be apparent.

T4A: Transition from Tree State 4.0 to Annual State 5.0:

Trigger: Catastrophic crown fire would reduce or eliminate trees to transition the site to 5.1. Tree removal when annual non-natives such as cheatgrass are present would also transition the site to state 5.0.
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 nutrient cycling and distribution.

R4A: Restoration from Tree State 4.0 to Current Potential State 2.0:

Tree removal with minimum soil disturbance such as hand felling or mastication within community phase 4.1. This treatment may be combined with seeding for increased success when there is little understory.

Annual State 5.0:

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, medusahead, and mustards. Resiliency has declined and further degradation from fire facilitates a cheatgrass and sprouting shrub plant community. The fire return interval is shortened due to the dominance of cheatgrass in the understory and frequent fire drives site dynamics.

Community Phase 5.1:
Annuals such as cheatgrass, medusahead, or tumblemustard dominate; Sandberg bluegrass and perennial forbs may still be present in trace amounts. Surface erosion may increase with summer convection storms and could be identified by increased pedestalling of plants, rill formation, or extensive water flow paths.

Clay Slope 8-12" (023XY037NV) Phase 5.1 T. K. Stringham, June 2014

Gravelly Claypan 10-12" (023XY059NV) Phase 5.1 T. K. Stringham, July 2015

Shallow Stony Loam 9-12” (023XF081CA) Phase 5.1 T.K. Stringham, October 2018

Community Phase Pathway 5.1a, from Phase 5.1 to 5.2:

Time and lack of disturbance allows sprouting shrubs and some sagebrush to recover after fire.

Community Phase 5.2:

Medusahead or cheatgrass dominate the understory. Lahontan or low sagebrush dominates the overstory and sprouting shrubs may be present.

Shallow Stony Clay Loam 9-12” (023XF083CA) Phase 5.2 T.K. Stringham, October 2018

Potential Resilience Differences with other Ecological Sites:

Clay Slope 8-12" (023XY037NV):

This site has a Lahontan sagebrush, bluebunch wheatgrass, and Thurber's needlegrass community that is very similar to the modal site, however with less precipitation and less production. Elevations range from 4500 to 6000 feet and production varies from 400 lbs/ac to 700 lbs/ac. This site is similar to the modal site, with five stable states. Upon further inspection the Claypan 10-14" site, written in 1963, may be more similar to this site concept with Lahontan sagebrush.

Gravelly Claypan 10-12" (023XY059NV):

The dominant grasses on this site are Thurber's and Webber's needlegrass. Like the modal site, Low sagebrush is the dominant shrub and spiny hopsage (*Grayia spinosa*) is a subdominant shrub. It is less productive than the modal site with 450 lbs/ac in a normal year. This site is found on convex summits and backslopes of low hills and erosional fan remnants, from 5000 to 6000 feet. The soils on this site have formed in alluvium or residuum derived from volcanic rock sources. These soils are generally shallow or moderately deep. There is a moderate to strong-structured, clay subsoil ranging from 8 to 12 inches in the soil profile. The soils have high amounts of gravel and/or small cobbles (over 65 percent ground cover) on the surface which provide a stabilizing effect on surface erosion conditions. This site has a four state model; it is unlikely to get a tree state or an eroded state. This site has been seen in a shrub state with no non-native annuals, indicating that it can transition from Reference to the Shrub State, Transition T1B: Long-term inappropriate grazing management favors shrubs and the shallow-rooted Sandberg bluegrass.

Gravelly Clay 10-12" (023XY093NV):

The soils in this site are typically moderately deep with depth to a moderate to strong-structure, clayey, subsoil ranging from 10 to 12 inches. Permeability is moderate and the soils are well drained. Available water capacity is low. Infiltration is restricted once these soils are wetted and they are subject to water loss by runoff. The soils have high amounts of gravels and/or cobbles on the surface which provide a stabilizing effect on surface erosion conditions. The plant community is dominated by Lahontan sagebrush and Thurber's needlegrass. It is less productive than the modal with 500 lbs/ac in a normal year. This site has a four state model without a tree state.

Scabland 10-14" (023XY021NV):

This site is dominated by Sandberg bluegrass, and is much less productive than the modal site with 200 lbs/ac in a normal year. It may have scattered juniper trees. The soils of this site have a very shallow effective rooting depth and are well drained. The soils are typically modified with over 50 percent gravels and other coarse fragments throughout the profile. These soils also have high amounts of gravels, cobbles, or stones on the surface which occupy plant growing space yet provide a stabilizing effect on surface erosion conditions. The available water capacity of these soils is very low. A surface cover of rock fragments helps to reduce evaporation and conserve the limited soil moisture. The harsh environment for plant growth presented by these soil properties restricts site productivity.

Characteristic herbaceous plants have shallow root systems and the ability to make rapid early growth before evaporation depletes the limited supply of soil moisture. This site has a four state model without a tree state.

Cobbly Claypan 8-12" (023XY060NV):

This site has many cobbles on the soil surface, and is less productive than the modal site with 375 lbs/ac. The soils on this site have formed in alluvium or residuum derived from volcanic rock sources. These soils have a shallow effective rooting zone with depth to bedrock ranging from 10 to 20 inches. Depth to a dense, strong-structured, clay subsoil is less than 10 inches. Available water holding capacity is low. The soils have high amounts of cobbles and/or small stones (over 65 percent ground cover) on the surface which provides a stabilizing effect on surface erosion conditions. Pedestalling of some grass plants is common during the winter due to frost heave. The plant community is dominated by low sagebrush, bluebunch wheatgrass, and Thurber's needlegrass. This site is similar to the modal site; the model has five stable states.

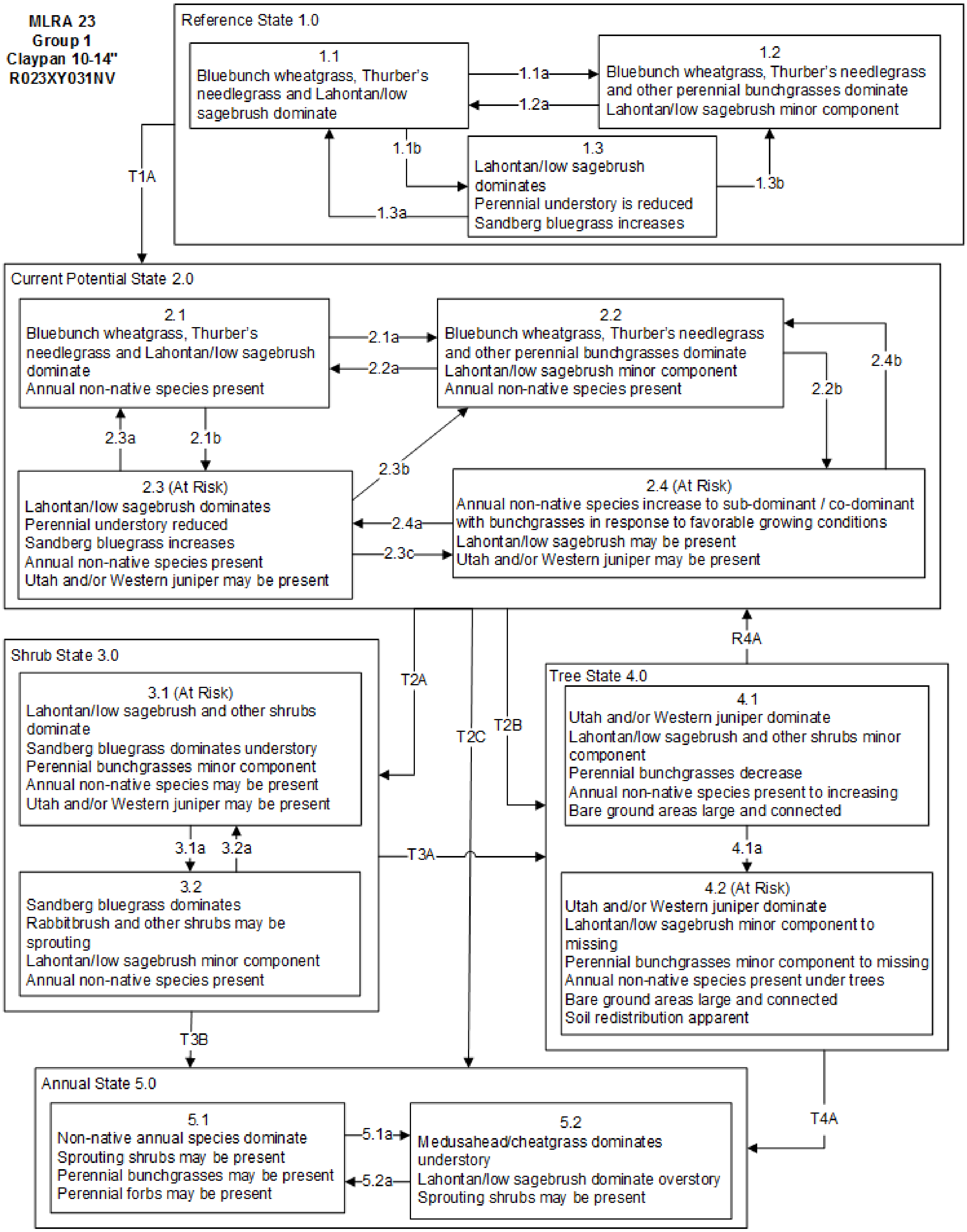
Shallow Stony Clay Loam 9-12" (023XF083CA):

This site has a similar plant community to the modal site, dominated by bluebunch wheatgrass, Lahontan sagebrush and Thurber's needlegrass. Spiny hopsage (*Grayia spinosa*) may also be present. The soils have a shallow effective rooting depth and low soil moisture capacity. Production is lower than the modal site at 600 lbs/ac in a normal year. The soils in this site and Shallow Stony Loam (023XF081CA) are very similar, but are believed to have a higher amount or distribution of clay. This site is similar to the modal site; the model has five stable states.

Shallow Stony Loam 9-12" (023XF081CA):

This site is characterized by shallow effective rooting depth and low soil moisture capacity. The plant community is similar to the modal site with a Western juniper component. Production is also similar to the modal site at 700 lbs/ac in a normal year, but in favorable years can produce as much as 1000 lbs/ac. This site is similar to the modal site; the model has five stable states.

Modal State and Transition Model for Group 1 in MLRA 23:



MLRA 23
Group 1
Claypan 10-14"
R023XY031NV
KEY

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

Transition T1A: Introduction of non-native annual species.

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: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combination or brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community or 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). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2B: Time and lack of fire allows Utah/Western juniper to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.
Transition T2C: Severe fire and/or multiple fires.

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 (unlikely/may take many years).

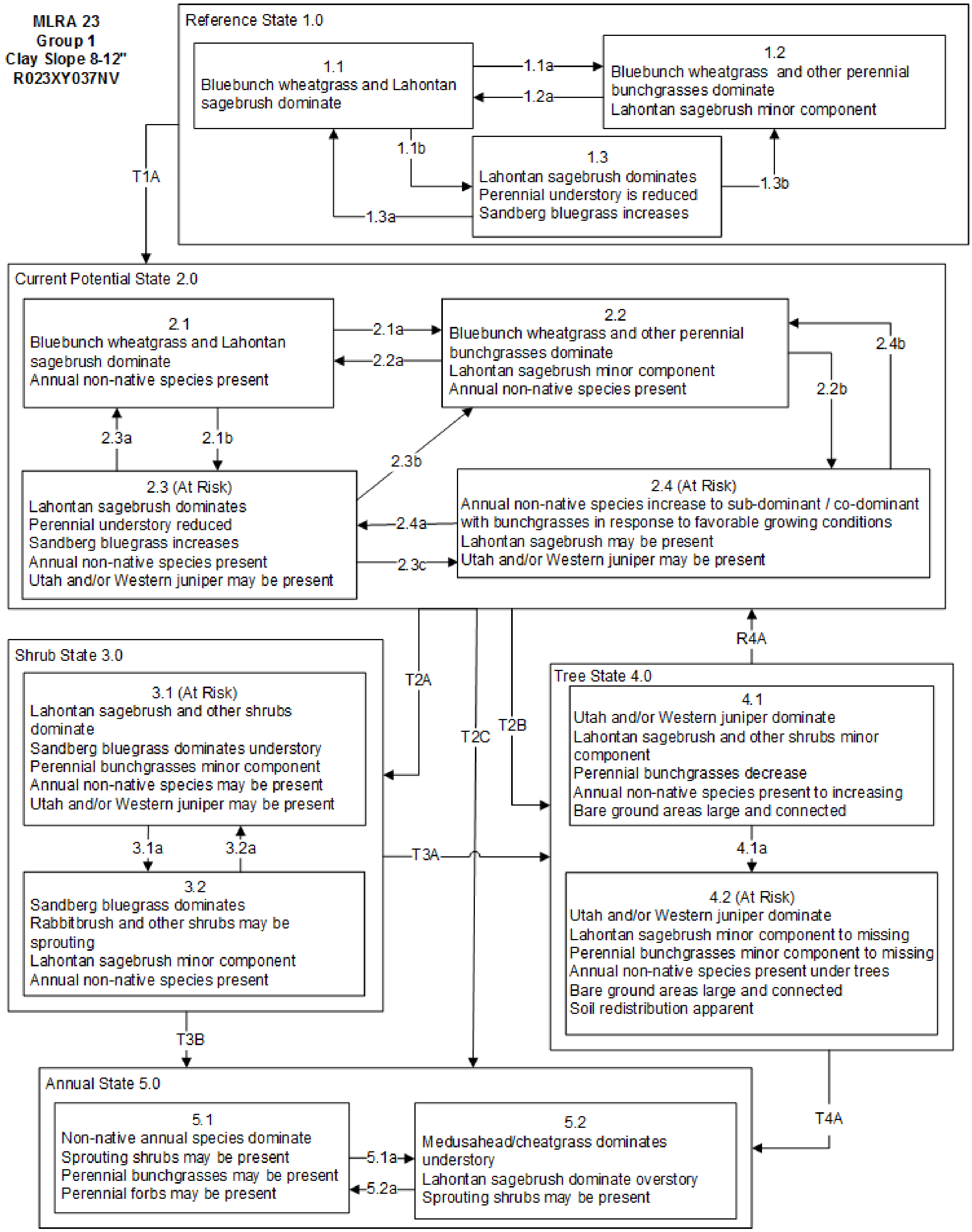
Transition T3A: Time and lack of fire allows Utah/Western juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.
Transition T3B: Invasive annual grasses increase under shrubs, or, high-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (to 5.1).

Tree State 4.0 Community Phase Pathways
4.1a: Time without disturbance allows maturation of the tree community.

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (to 4.1).
Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (to 5.1).

Annual State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance.
5.2a: Fire.

Additional State and Transition Models for Group 1 in MLRA 23:



MLRA 23
Group 1
Clay Slope 8-12"
R023XY037NV
KEY

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

Transition T1A: Introduction of non-native annual species.

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: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combination or brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community or 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). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2B: Time and lack of fire allows Utah/Western juniper to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.
Transition T2C: Severe fire and/or multiple fires.

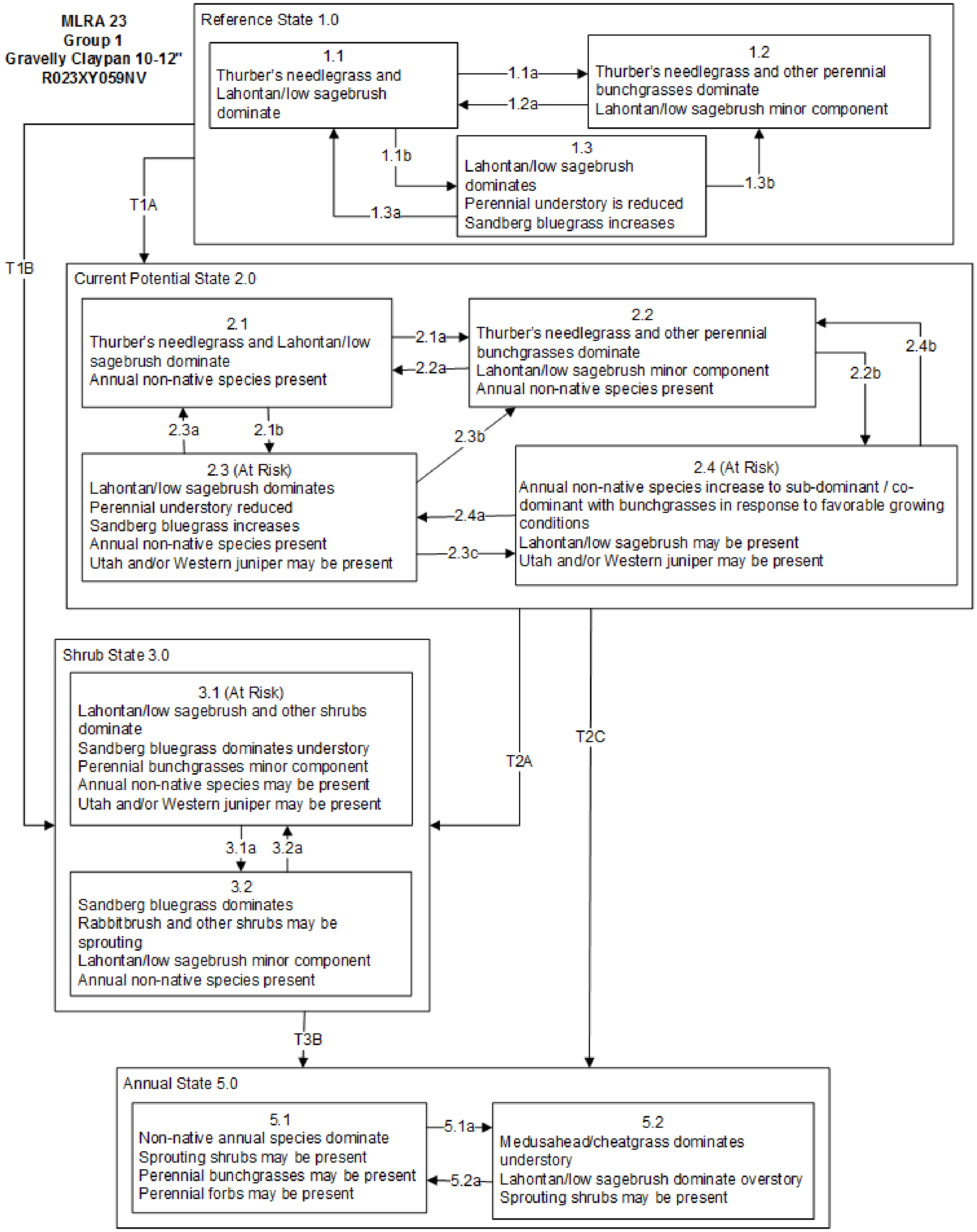
Shrub State 3.0 Community Phase Pathways
3.1a: High severity fire; brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Time and lack of fire allows Utah/Western juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.
Transition T3B: Invasive annual grasses increase under shrubs, or, high-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (to 5.1).

Tree State 4.0 Community Phase Pathways
4.1a: Time without disturbance allows maturation of the tree community.

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (to 4.1).
Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (to 5.1).

Annual State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance.
5.2a: Fire.


MLRA 23
Group 1
Gravelly Claypan 10-12"
R023XY059NV
Reference State 1.0
1.1
Thurber's needlegrass and Lahontan/low sagebrush dominate
1.1a
1.2a
1.2
Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
1.1b
1.3
Lahontan/low sagebrush dominates
Perennial understory is reduced
Sandberg bluegrass increases
1.3a
1.3b
T1A
T1B
Current Potential State 2.0
2.1
Thurber's needlegrass and Lahontan/low sagebrush dominate
Annual non-native species present
2.1a
2.2a
2.2
Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
Annual non-native species present
2.4b
2.2b
2.3a
2.1b
2.3b
2.3 (At Risk)
Lahontan/low sagebrush dominates
Perennial understory reduced
Sandberg bluegrass increases
Annual non-native species present
Utah and/or Western juniper may be present
2.4a
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/low sagebrush may be present
Utah and/or Western juniper may be present
Shrub State 3.0
3.1 (At Risk)
Lahontan/low sagebrush and other shrubs dominate
Sandberg bluegrass dominates understory
Perennial bunchgrasses minor component
Annual non-native species may be present
Utah and/or Western juniper may be present
T2A
T2C
3.1a
3.2a
3.2
Sandberg bluegrass dominates
Rabbitbrush and other shrubs may be sprouting
Lahontan/low sagebrush minor component
Annual non-native species present
T3B
Annual State 5.0
5.1
Non-native annual species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
Perennial forbs may be present
5.1a
5.2a
5.2
Medusahead/cheatgrass dominates understory
Lahontan/low sagebrush dominate overstory
Sprouting shrubs may be present

MLRA 23
Group 1
Gravelly Claypan 10-12"
R023XY059NV
KEY

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

Transition T1A: Introduction of non-native annual species.
Transition T1B: Long-term inappropriate grazing management favors shrubs and Sandberg bluegrass.

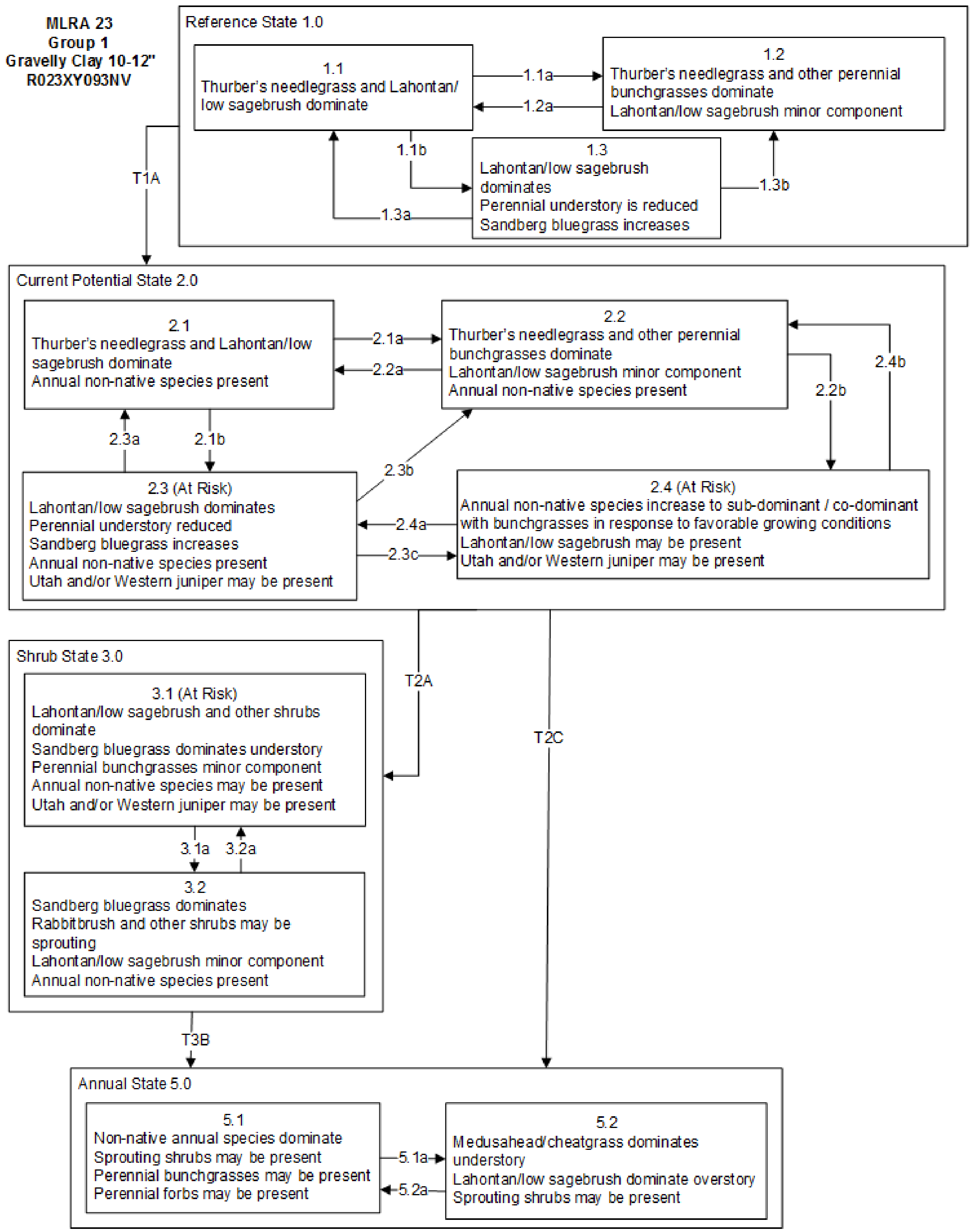
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs: non-native annual species present.
2.1b: Time and lack of disturbance 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: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combination or brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community or 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). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2C: Severe fire and/or multiple fires.

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 (unlikely/may take many years).

Transition T3B: Invasive annual grasses increase under shrubs, or, high-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (to 5.1).

Annual State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance.
5.2a: Fire.



MLRA 23
Group 1
Gravelly Clay 10-12"
R023XY093NV
Reference State 1.0
1.1
Thurber's needlegrass and Lahontan/low sagebrush dominate
1.1a
1.2a
1.2
Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
1.1b
1.3
Lahontan/low sagebrush dominates
Perennial understory is reduced
Sandberg bluegrass increases
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Thurber's needlegrass and Lahontan/low sagebrush dominate
Annual non-native species present
2.1a
2.2a
2.2
Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
Annual non-native species present
2.4b
2.2b
2.3a
2.1b
2.3b
2.3 (At Risk)
Lahontan/low sagebrush dominates
Perennial understory reduced
Sandberg bluegrass increases
Annual non-native species present
Utah and/or Western juniper may be present
2.4a
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/low sagebrush may be present
Utah and/or Western juniper may be present
T2A
T2C
Shrub State 3.0
3.1 (At Risk)
Lahontan/low sagebrush and other shrubs dominate
Sandberg bluegrass dominates understory
Perennial bunchgrasses minor component
Annual non-native species may be present
Utah and/or Western juniper may be present
3.1a
3.2a
3.2
Sandberg bluegrass dominates
Rabbitbrush and other shrubs may be sprouting
Lahontan/low sagebrush minor component
Annual non-native species present
T3B
Annual State 5.0
5.1
Non-native annual species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
Perennial forbs may be present
5.1a
5.2a
5.2
Medusahead/cheatgrass dominates understory
Lahontan/low sagebrush dominate overstory
Sprouting shrubs may be present

MLRA 23
Group 1
Gravelly Clay 10-12"
R023XY093NV
KEY

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

Transition T1A: Introduction of non-native annual species.

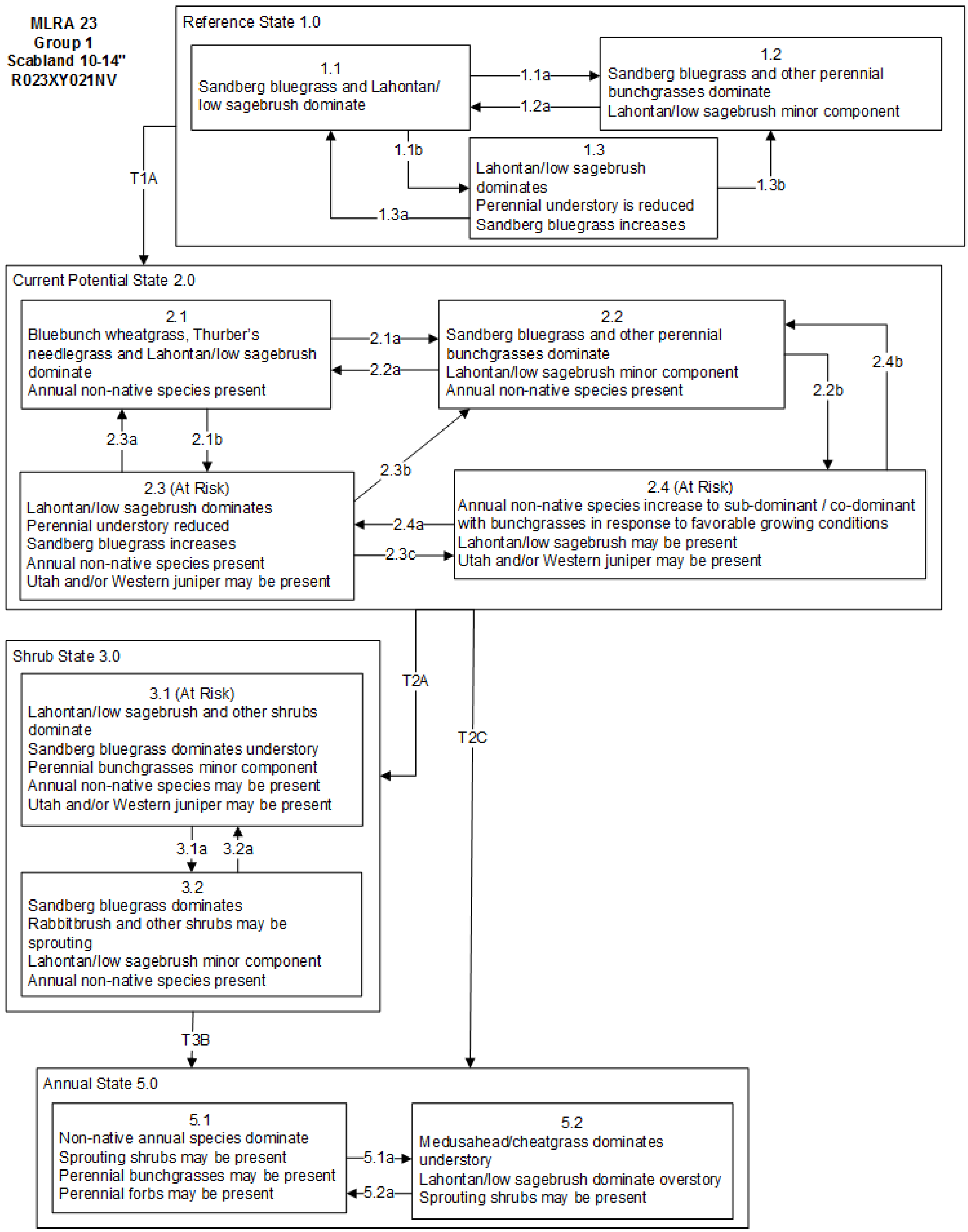
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs: non-native annual species present.
2.1b: Time and lack of disturbance 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: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combination or brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community or 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). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2C: Severe fire and/or multiple fires.

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 (unlikely/may take many years).

Transition T3B: Invasive annual grasses increase under shrubs, or, high-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (to 5.1).

Annual State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance.
5.2a: Fire.



MLRA 23
Group 1
Scabland 10-14"
R023XY021NV
Reference State 1.0
1.1
Sandberg bluegrass and Lahontan/ low sagebrush dominate
1.1a
1.2a
1.2
Sandberg bluegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
1.1b
1.3
Lahontan/low sagebrush dominates
Perennial understory is reduced
Sandberg bluegrass increases
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass, Thurber's needlegrass and Lahontan/low sagebrush dominate
Annual non-native species present
2.1a
2.2a
2.2
Sandberg bluegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
Annual non-native species present
2.4b
2.2b
2.3a
2.1b
2.3b
2.3 (At Risk)
Lahontan/low sagebrush dominates
Perennial understory reduced
Sandberg bluegrass increases
Annual non-native species present
Utah and/or Western juniper may be present
2.4a
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/low sagebrush may be present
Utah and/or Western juniper may be present
T2A
T2C
Shrub State 3.0
3.1 (At Risk)
Lahontan/low sagebrush and other shrubs dominate
Sandberg bluegrass dominates understory
Perennial bunchgrasses minor component
Annual non-native species may be present
Utah and/or Western juniper may be present
3.1a
3.2a
3.2
Sandberg bluegrass dominates
Rabbitbrush and other shrubs may be sprouting
Lahontan/low sagebrush minor component
Annual non-native species present
T3B
Annual State 5.0
5.1
Non-native annual species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
Perennial forbs may be present
5.1a
5.2a
5.2
Medusahead/cheatgrass dominates understory
Lahontan/low sagebrush dominate overstory
Sprouting shrubs may be present

MLRA 23
Group 1
Scabland 10-14"
R023XY021NV
KEY

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

Transition T1A: Introduction of non-native annual species.

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: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combination or brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community or 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.

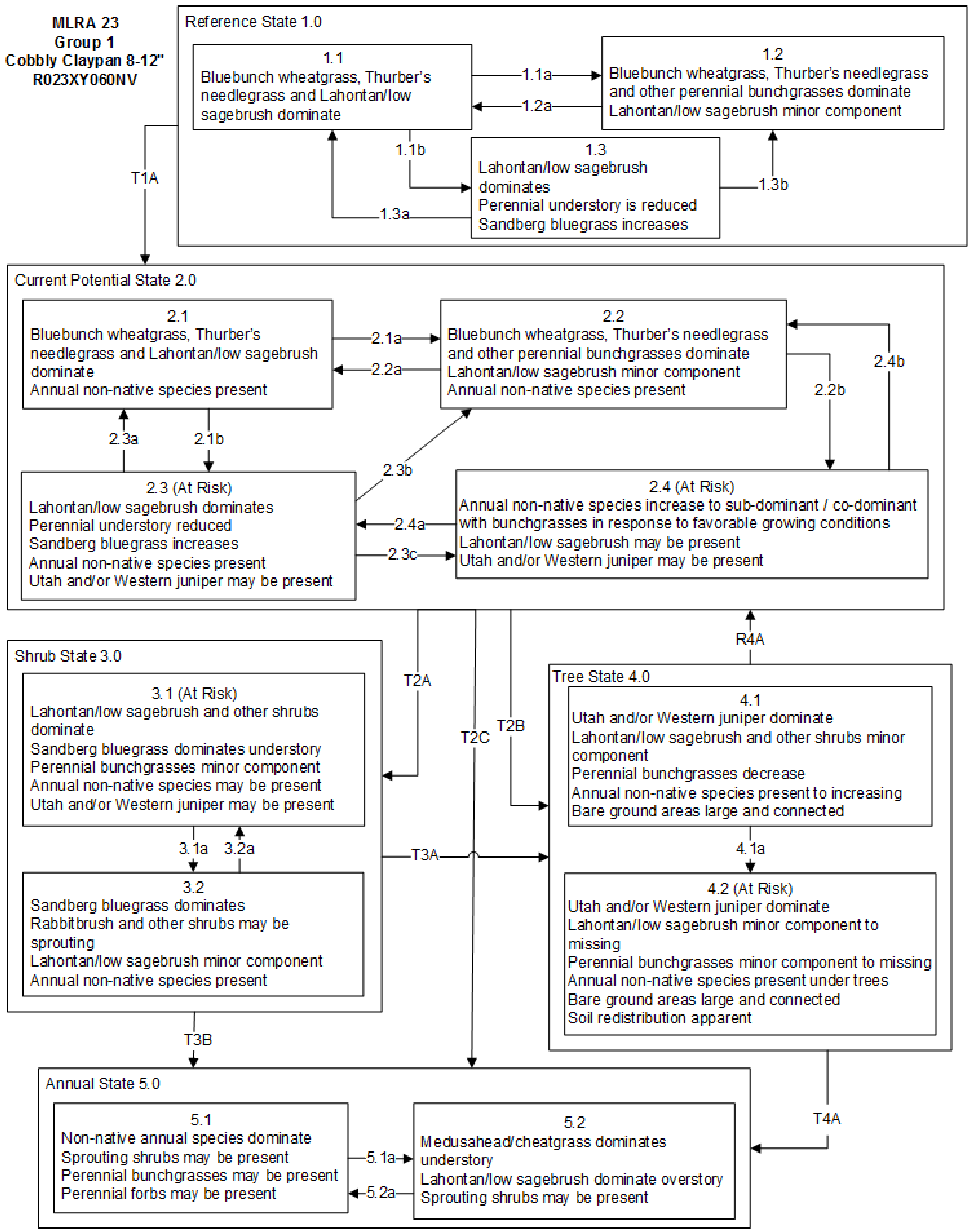
Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (to 3.1). Brush management of Community Phase 2.3 may result in Community Phase 3.2.

Transition T2C: Severe fire and/or multiple fires.

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 (unlikely/may take many years).

Transition T3B: Invasive annual grasses increase under shrubs, or, high-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (to 5.1).

Annual State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance.
5.2a: Fire.


MLRA 23
Group 1
Cobbly Claypan 8-12"
R023XY060NV
Reference State 1.0
1.1
Bluebunch wheatgrass, Thurber's needlegrass and Lahontan/low sagebrush dominate
1.2
Bluebunch wheatgrass, Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
1.3
Lahontan/low sagebrush dominates
Perennial understory is reduced
Sandberg bluegrass increases
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass, Thurber's needlegrass and Lahontan/low sagebrush dominate
Annual non-native species present
2.2
Bluebunch wheatgrass, Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
Annual non-native species present
2.3 (At Risk)
Lahontan/low sagebrush dominates
Perennial understory reduced
Sandberg bluegrass increases
Annual non-native species present
Utah and/or Western juniper 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
Lahontan/low sagebrush may be present
Utah and/or Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.2b
2.4b
2.4a
2.3c
Shrub State 3.0
3.1 (At Risk)
Lahontan/low sagebrush and other shrubs dominate
Sandberg bluegrass dominates understory
Perennial bunchgrasses minor component
Annual non-native species may be present
Utah and/or Western juniper may be present
3.2
Sandberg bluegrass dominates
Rabbitbrush and other shrubs may be sprouting
Lahontan/low sagebrush minor component
Annual non-native species present
3.1a
3.2a
T2A
T2C
T2B
R4A
T3A
T3B
Tree State 4.0
4.1
Utah and/or Western juniper dominate
Lahontan/low 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)
Utah and/or Western juniper dominate
Lahontan/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
T4A
Annual State 5.0
5.1
Non-native annual species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
Perennial forbs may be present
5.2
Medusahead/cheatgrass dominates understory
Lahontan/low sagebrush dominate overstory
Sprouting shrubs may be present
5.1a
5.2a

MLRA 23
Group 1
Cobbly Claypan 8-12"
R023XY060NV
KEY

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

Transition T1A: Introduction of non-native annual species.

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: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combination or brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community or 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). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2B: Time and lack of fire allows Utah/Western juniper to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.
Transition T2C: Severe fire and/or multiple fires.

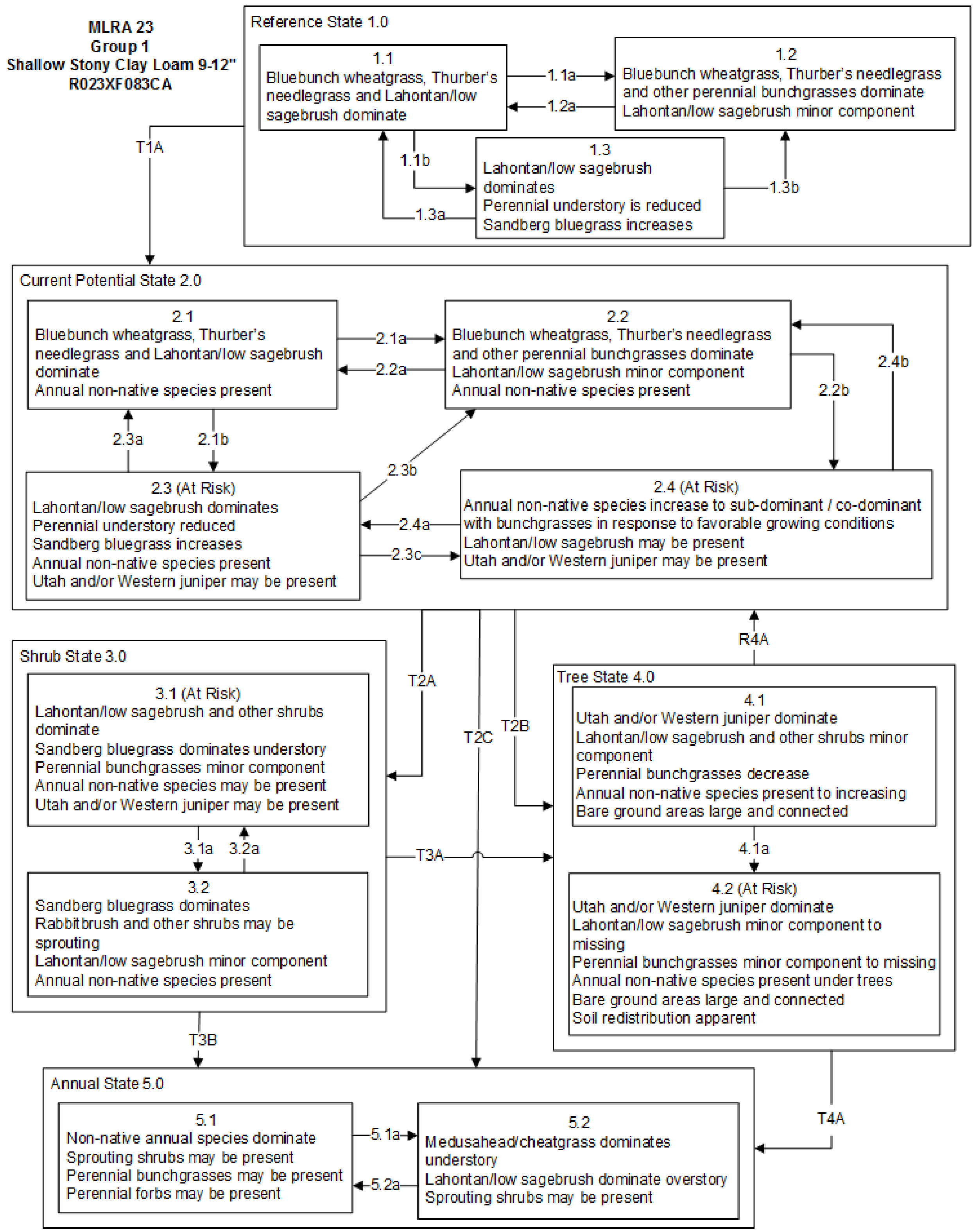
Shrub State 3.0 Community Phase Pathways
3.1a: High severity fire; brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Time and lack of fire allows Utah/Western juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.
Transition T3B: Invasive annual grasses increase under shrubs, or, high-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (to 5.1).

Tree State 4.0 Community Phase Pathways
4.1a: Time without disturbance allows maturation of the tree community.

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (to 4.1).
Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (to 5.1).

Annual State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance.
5.2a: Fire.



MLRA 23
Group 1
Shallow Stony Clay Loam 9-12"
R023XF083CA
Reference State 1.0
1.1
Bluebunch wheatgrass, Thurber's needlegrass and Lahontan/low sagebrush dominate
1.1a
1.2a
1.2
Bluebunch wheatgrass, Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
1.1b
1.3
Lahontan/low sagebrush dominates
Perennial understory is reduced
Sandberg bluegrass increases
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass, Thurber's needlegrass and Lahontan/low sagebrush dominate
Annual non-native species present
2.1a
2.2a
2.2
Bluebunch wheatgrass, Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
Annual non-native species present
2.4b
2.2b
2.3a
2.1b
2.3b
2.3 (At Risk)
Lahontan/low sagebrush dominates
Perennial understory reduced
Sandberg bluegrass increases
Annual non-native species present
Utah and/or Western juniper may be present
2.4a
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/low sagebrush may be present
Utah and/or Western juniper may be present
T2A
T2C
T2B
R4A
Shrub State 3.0
3.1 (At Risk)
Lahontan/low sagebrush and other shrubs dominate
Sandberg bluegrass dominates understory
Perennial bunchgrasses minor component
Annual non-native species may be present
Utah and/or Western juniper may be present
3.1a
3.2a
3.2
Sandberg bluegrass dominates
Rabbitbrush and other shrubs may be sprouting
Lahontan/low sagebrush minor component
Annual non-native species present
T3A
Tree State 4.0
4.1
Utah and/or Western juniper dominate
Lahontan/low 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)
Utah and/or Western juniper dominate
Lahontan/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
T3B
T4A
Annual State 5.0
5.1
Non-native annual species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
Perennial forbs may be present
5.1a
5.2a
5.2
Medusahead/cheatgrass dominates understory
Lahontan/low sagebrush dominate overstory
Sprouting shrubs may be present

MLRA 23
Group 1
Shallow Stony Clay Loam 9-12"
R023XF083CA
KEY

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

Transition T1A: Introduction of non-native annual species.

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: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combination or brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community or 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). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2B: Time and lack of fire allows Utah/Western juniper to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.
Transition T2C: Severe fire and/or multiple fires.

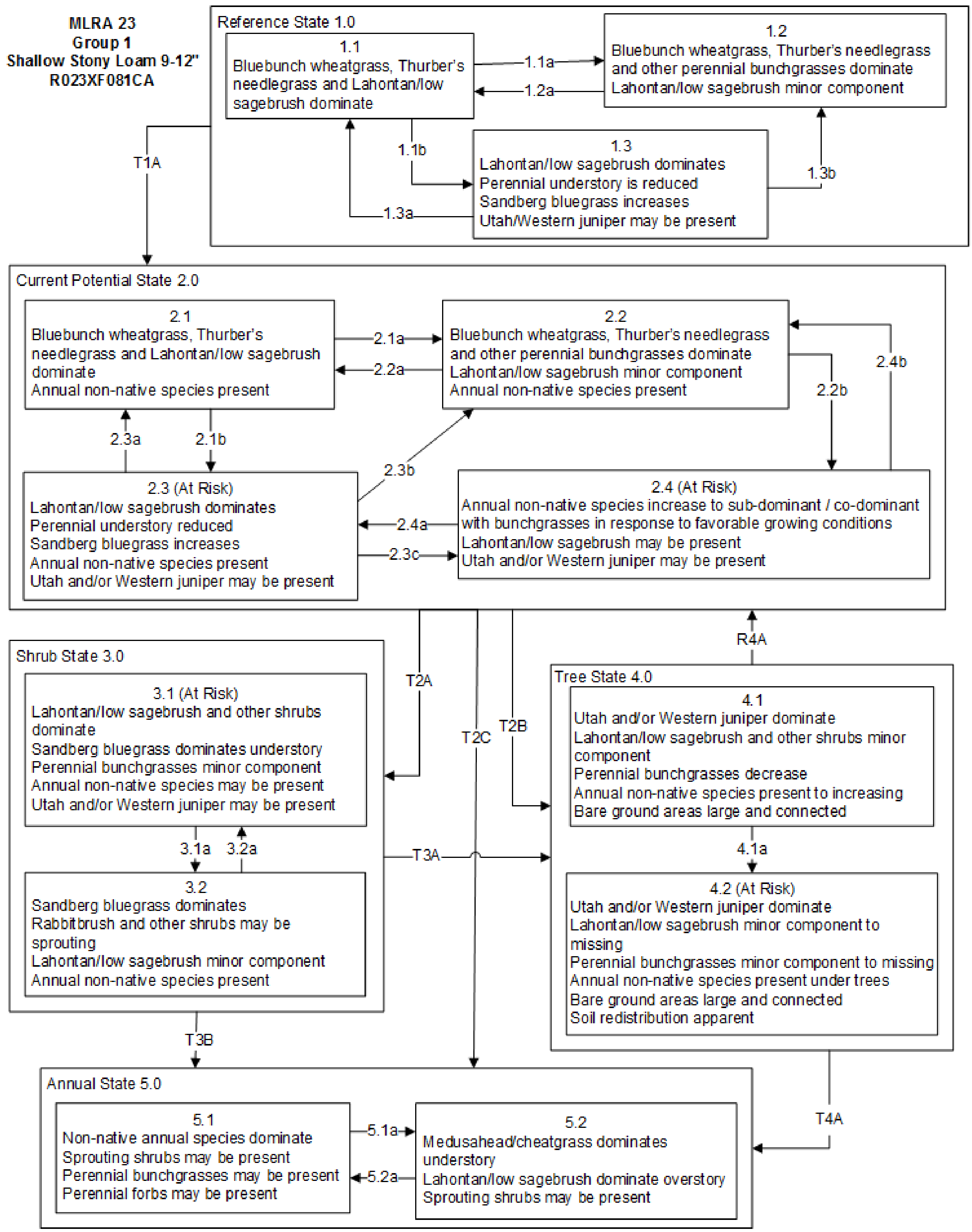
Shrub State 3.0 Community Phase Pathways
3.1a: High severity fire; brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Time and lack of fire allows Utah/Western juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.
Transition T3B: Invasive annual grasses increase under shrubs, or, high-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (to 5.1).

Tree State 4.0 Community Phase Pathways
4.1a: Time without disturbance allows maturation of the tree community.

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (to 4.1).
Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (to 5.1).

Annual State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance.
5.2a: Fire.


MLRA 23
Group 1
Shallow Stony Loam 9-12"
R023XF081CA
Reference State 1.0
1.1
Bluebunch wheatgrass, Thurber's needlegrass and Lahontan/low sagebrush dominate
1.1a
1.2a
1.2
Bluebunch wheatgrass, Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
1.1b
1.3a
1.3
Lahontan/low sagebrush dominates
Perennial understory is reduced
Sandberg bluegrass increases
Utah/Western juniper may be present
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass, Thurber's needlegrass and Lahontan/low sagebrush dominate
Annual non-native species present
2.1a
2.2a
2.2
Bluebunch wheatgrass, Thurber's needlegrass and other perennial bunchgrasses dominate
Lahontan/low sagebrush minor component
Annual non-native species present
2.4b
2.2b
2.3a
2.1b
2.3b
2.3 (At Risk)
Lahontan/low sagebrush dominates
Perennial understory reduced
Sandberg bluegrass increases
Annual non-native species present
Utah and/or Western juniper may be present
2.4a
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/low sagebrush may be present
Utah and/or Western juniper may be present
T2A
T2C
T2B
R4A
Shrub State 3.0
3.1 (At Risk)
Lahontan/low sagebrush and other shrubs dominate
Sandberg bluegrass dominates understory
Perennial bunchgrasses minor component
Annual non-native species may be present
Utah and/or Western juniper may be present
3.1a
3.2a
3.2
Sandberg bluegrass dominates
Rabbitbrush and other shrubs may be sprouting
Lahontan/low sagebrush minor component
Annual non-native species present
T3A
Tree State 4.0
4.1
Utah and/or Western juniper dominate
Lahontan/low 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)
Utah and/or Western juniper dominate
Lahontan/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
T3B
T4A
Annual State 5.0
5.1
Non-native annual species dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
Perennial forbs may be present
5.1a
5.2a
5.2
Medusahead/cheatgrass dominates understory
Lahontan/low sagebrush dominate overstory
Sprouting shrubs may be present

MLRA 23
Group 1
Shallow Stony Loam 9-12"
R023XF081CA
KEY

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

Transition T1A: Introduction of non-native annual species.

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: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combination or brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community or 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). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2B: Time and lack of fire allows Utah/Western juniper to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.
Transition T2C: Severe fire and/or multiple fires.

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 (unlikely/may take many years).

Transition T3A: Time and lack of fire allows Utah/Western juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.
Transition T3B: Invasive annual grasses increase under shrubs, or, high-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (to 5.1).

Tree State 4.0 Community Phase Pathways
4.1a: Time without disturbance allows maturation of the tree community.

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (to 4.1).
Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (to 5.1).

Annual State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance.
5.2a: Fire.

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Group 2: Low and Lahontan sagebrush and Idaho fescue; no annual state

Description of MLRA 23 DRG 2:

Disturbance Response Group (DRG) 2 consists of four ecological sites. The precipitation zone ranges from 8 to greater than 20 inches. The elevation ranges from 5500 to 9500 feet. Slopes range from 2 to 75 percent but slopes of 2 to 15 percent are most typical. Soils in this group are fine-textured and may have large amounts of rock fragments. All soils have a heavy clay or bedrock layer that restricts rooting depth and water percolation. Sites within this disturbance response group are characterized by a dominance of low sagebrush (*Artemisia arbuscula*). The understory is dominated by deep-rooted cool season perennial bunchgrasses, primarily Idaho fescue (*Festuca idahoensis*). Bluebunch wheatgrass (*Pseudoroegneria spicata*), needlegrasses (*Achnatherum* sp.), and bluegrasses (*Poa* sp.) are also common on these sites. Forbs such as asters (*Aster* sp.), lupine (*Lupinus spp.)* and balsamroots (*Balsamorhiza* sp.) make up a minor component of the total production. Annual production in a normal year ranges from 250 lbs/acre to 700 lbs/acre for this group.

Many of the ecological sites in this group are described as having low sagebrush as the dominant shrub. During our visits to these sites for this project, 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 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 23.

Disturbance Response Group 2 – Ecological Sites:

Claypan 14-16" – Modal	023XY017NV
Mountain Ridge 14+	023XY008NV
Shallow Loam 14+"	023XY014NV
Clay Plain	023XY090NV

Modal Site:

The Claypan 14-16” (023XY017NV) ecological site is the modal site for this group as it has the most acres mapped. This site occurs on summits and sideslopes of mountains and higher elevation plateaus on all aspects. Slopes range from 2 to 30 percent, but slope gradients of 2 to 8 percent are most typical. Elevations are 6500 to 8000 feet. Average annual precipitation is 14 to over 16 inches. These soils normally have a high percentage of gravels and cobbles on the surface which occupy plant growing space yet help to reduce evaporation and conserve soil moisture. Depth to a fine textured subsoil ranges from 5 to 10 inches. The subsoils swell on wetting, and shrink and crack upon drying. Swelling of the subsoil with wetting in the early spring results in poor soil aeration, forming a perched water table near the surface. Infiltration of water is restricted once these soils are saturated and the site is subject to loss of water by runoff. Loss of the surface layer results in decreased productivity of the plant community. The surface layer has a low available water capacity due to its limited thickness. Because of the higher elevations where this site occurs, the soils are cool and plant growth is not initiated until mid- to late spring. Pedestalling of some grass plants is common during the winter due to frost heaving. The dominant plants on this site are low sagebrush, Idaho fescue, and bluebunch wheatgrass. Thurber's needlegrass may be a significant component along with several perennial forbs. This site's annual production is 700 lbs/ac in normal years but can range from 500 to 900 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 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). 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).

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).

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).

In the Clay Plain ecological site, early sagebrush (*Artemisia arbuscula ssp. longiloba)* is the dominant shrub. Early sagebrush (also known as alkali sagebrush) is a unique subspecies of *Artemisia arbuscula* 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).

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 moderate to high resilience to disturbance and resistance to invasion. 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 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. To date, we have not been able to find specific research on the fire response of Lahontan sagebrush.

The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant. Idaho fescue is the dominant grass within this community. Idaho fescue's response to fire varies with condition and size of the plant, season and severity of fire, and ecological conditions. Mature Idaho fescue plants are commonly reported to be severely damaged by fire in all seasons (Wright et al. 1979). Initial mortality may be high (in excess of 75%) on severe burns, but usually varies from 20 to 50% (Barrington et al. 1988). Rapid burns have been found to leave little damage to root crowns, and new tillers are produced with onset of fall moisture (Johnson et al. 1994). However, Wright and others (1979) found the dense, fine leaves of Idaho fescue provided enough fuel to burn for hours after a fire had passed, thereby killing or seriously injuring the plant regardless of the intensity of the fire (Wright et al. 1979). Idaho fescue is commonly reported to be more sensitive to fire than the other prominent grass on this site, bluebunch wheatgrass (Conrad and Poulton 1966). However, Robberecht and Defosse (1995) suggested the latter was more sensitive. They observed culm and biomass reduction with moderate fire severity in bluebunch wheatgrass, whereas a high fire severity was required for this reduction in Idaho fescue. Also, given the same fire severity treatment, post-fire culm production was initiated earlier and more rapidly in Idaho fescue (Robberecht and Defosse 1995).

Bluebunch wheatgrass has coarse stems with little leafy material, therefore the plant's aboveground biomass burns rapidly and little heat is transferred downward into the crowns (Young 1983). Bluebunch wheatgrass was described as fairly tolerant of burning, other than in May in eastern Oregon (Britton et al. 1990). Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Bluebunch wheatgrass is considered to experience slight damage from fire but is more susceptible in drought years (Young 1983). Most authors classify the plant as undamaged by fire (Kuntz 1982).

Thurber's needlegrass, a minor component on these sites, 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.

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). 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 this ecological site and others in this DRG. This recently differentiated subspecies of low sagebrush (Winward and McArthur 1995) is moderately to highly palatable to browse species (McArthur 2005, Rosentreter 2005). Dwarf sagebrush species such as Lahontan sagebrush, low sagebrush, and black sagebrush are preferred by mule deer for browse among the sagebrush species.

Idaho fescue tolerates light to moderate grazing (Ganskopp and Bedell 1981) and is moderately resistant to trampling (Cole 1987). Heavy grazing may lead to replacement of Idaho fescue with non-native species such as cheatgrass (Mueggler 1975).

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975, Britton et al. 1990). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949). Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover.

The Thurber’s needlegrass component of this plant community is an important forage source for livestock and wildlife in the arid regions of the West (Ganskopp 1988). Although the seeds, with their hard callus, 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). 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).

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.

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 23 Disturbance Response Group 2.

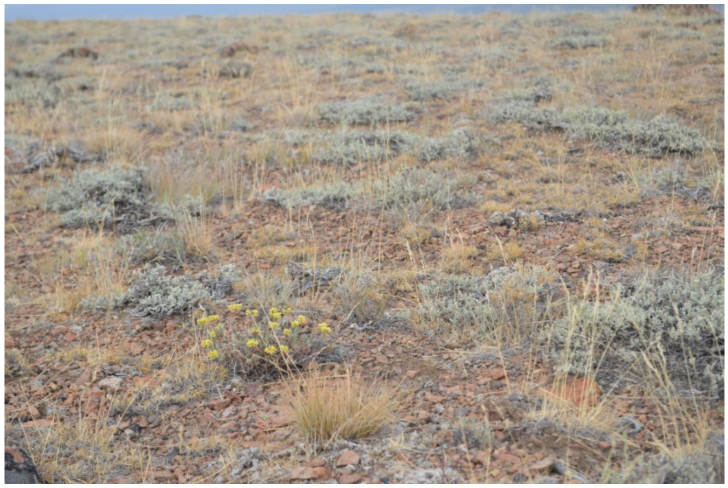
Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. The reference state has three 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 Idaho fescue with a large component of low sagebrush and bluebunch wheatgrass. Bluegrass and antelope bitterbrush are common within the community. An assortment of forbs is present and may comprise a significant portion of total annual production.

Claypan 14-16" (023XY017NV) Phase 1.1 T. K. Stringham, August 2014

Shallow Loam 14+ (023XY014NV) Phase 1.1 T. K. Stringham, August 2014



Mountain Ridge 14+ (023XY008NV) Phase 1.1 T. K. Stringham, August 2014

Mountain Ridge 14+ (023XY008NV) Phase 1.1 T. K. Stringham, June 2015

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 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. Idaho fescue, bluebunch wheatgrass, Thurber's needlegrass and other perennial bunchgrasses dominate. Patches of intact sagebrush may remain depending on fire severity. 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 reestablish.

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 are reduced, either from competition with shrubs and/or from herbivory.

Mountain Ridge 14+ (023XY008NV) Phase 1.3 T. K. Stringham, June 2015

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 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 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 1.3 will remove sagebrush overstory, decrease perennial bunchgrasses and allow Sandberg bluegrass to become dominant. Annual non-native species are not present in the community.

Slow variables: Long-term decline 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 and has three similar community phases. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. 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 compositionally similar to the Reference State Community Phase 1.1 with the presence of non-native species in trace amounts. This community is dominated by Idaho fescue with a large component of low sagebrush and bluebunch wheatgrass. Bluegrass and antelope bitterbrush are common within the community. An assortment of forbs is present and may comprise a significant portion of total production.

Claypan 14-16" (023XY017NV) Phase 2.1 T. K. Stringham, August 2014

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 sagebrush to increase and become decadent. Long-term drought reduces fine fuels and leads to a reduced fire frequency, allowing big sagebrush to dominate the site. Inappropriate grazing management reduces the deep-rooted perennial bunchgrass understory, however the shallow-rooted 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.

Claypan 14-16” (023XY017NV) Phase 2.2 or 3.2 T. K. Stringham, August 2014

Claypan 14-16" (023XY017NV) Phase 2.2 P. Novak-Echenique, May 2015

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Time and/or grazing management that favors the establishment and growth of sagebrush allow the shrub component to recover. The establishment of sagebrush can take a very long time: years to decades depending on management and the patchiness of existing sagebrush plants

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. Sandberg bluegrass may increase and 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.

Claypan 14-16" (023XY017NV) Phase 2.3 T. K. Stringham, August 2014

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 increase. 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 and low 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 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, decrease perennial bunchgrasses and enhance Sandberg bluegrass. Annual non-native species will increase.
Slow variables: Long term reduction 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 Tree State 4.0

Trigger: Time and lack of disturbance or management action allows Utah juniper and/or western 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 number of live shrubs. Minimal recruitment of new shrub cohorts.

Shrub State 3.0:

This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Sandberg bluegrass will increase with a reduction in deep rooted perennial bunchgrass competition and become the dominant grasses. 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:

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. Bluegrasses and annual non-native species increase. Bare ground is significant. Mule’s ear, balsamroot and other perennial forbs may make up a significant component of the understory. Some excessive pedestalling of grasses may be seen. Bare ground may be increasing.

Claypan 14-16” (023XY017NV) Phase 3.1 T. K. Stringham, July 2015

Mountain Ridge 14+ (023XY008NV) Phase 3.1. T.K. Stringham, October 2018.

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 bluegrasses to dominate the site. After fire on these sites soil stability can decrease due to wind erosion. Seeding of plants to reduce erosion may be necessary.

Community Phase 3.2 (At-Risk):
Bluegrass dominates the site; annual non-native species may be present but are not dominant. Rabbitbrush may be sprouting. Mule's ear, balsamroot and other perennial forbs may make up a significant component of the understory. Trace amounts of sagebrush may be present. Seeded species may be present.

Clay Plain (023XY090NV) T. K. Stringham, August 2014

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 Tree State 4.0

Trigger: Time and lack of disturbance or management action allows Utah juniper and/or western 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.

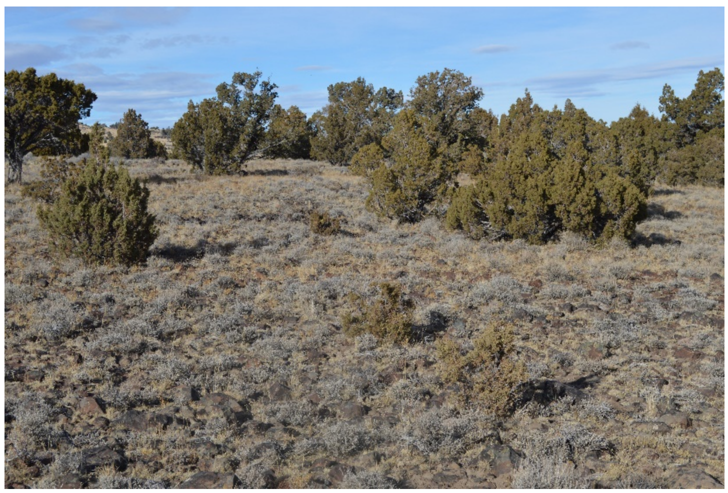
Slow variables: Over time the abundance and size of trees will increase.

Threshold: Trees dominate ecological processes and number of shrub skeletons exceed number of live shrubs. Minimal recruitment of new shrub cohorts.

Tree State 4.0:

This state is characterized by a dominance of Utah juniper and/or western juniper in the overstory. Low 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:
Utah juniper and/or western juniper dominates 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.



Claypan 14-16" (023XY017NV) Phase 4.1, Phase II Trees. T.K. Stringham, October 2018.

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

Community Phase 4.2:
Utah juniper and/or western juniper dominate the overstory. Low sagebrush is decadent and dying with numerous skeletons present or sagebrush may be missing from the system. 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 movement may be apparent.

Potential Resilience Differences with other Ecological Sites:

Mountain Ridge 14+" (023XY008NV):

This site is significantly less productive than the modal with an average of 250 lb/ac in normal years. The dominant plants are the same however there may be a component of black sagebrush. This site occurs on windswept mountain ridges. The soils in this site are shallow to very shallow and well drained. The soil surface has high amounts of gravels or cobbles. Many soils have a thin clayey horizon just above bedrock. Shallow soil depth and high volumes of coarse fragments in the soil profile result in a very low available water capacity. This site is similar to the modal site and has 4 states.

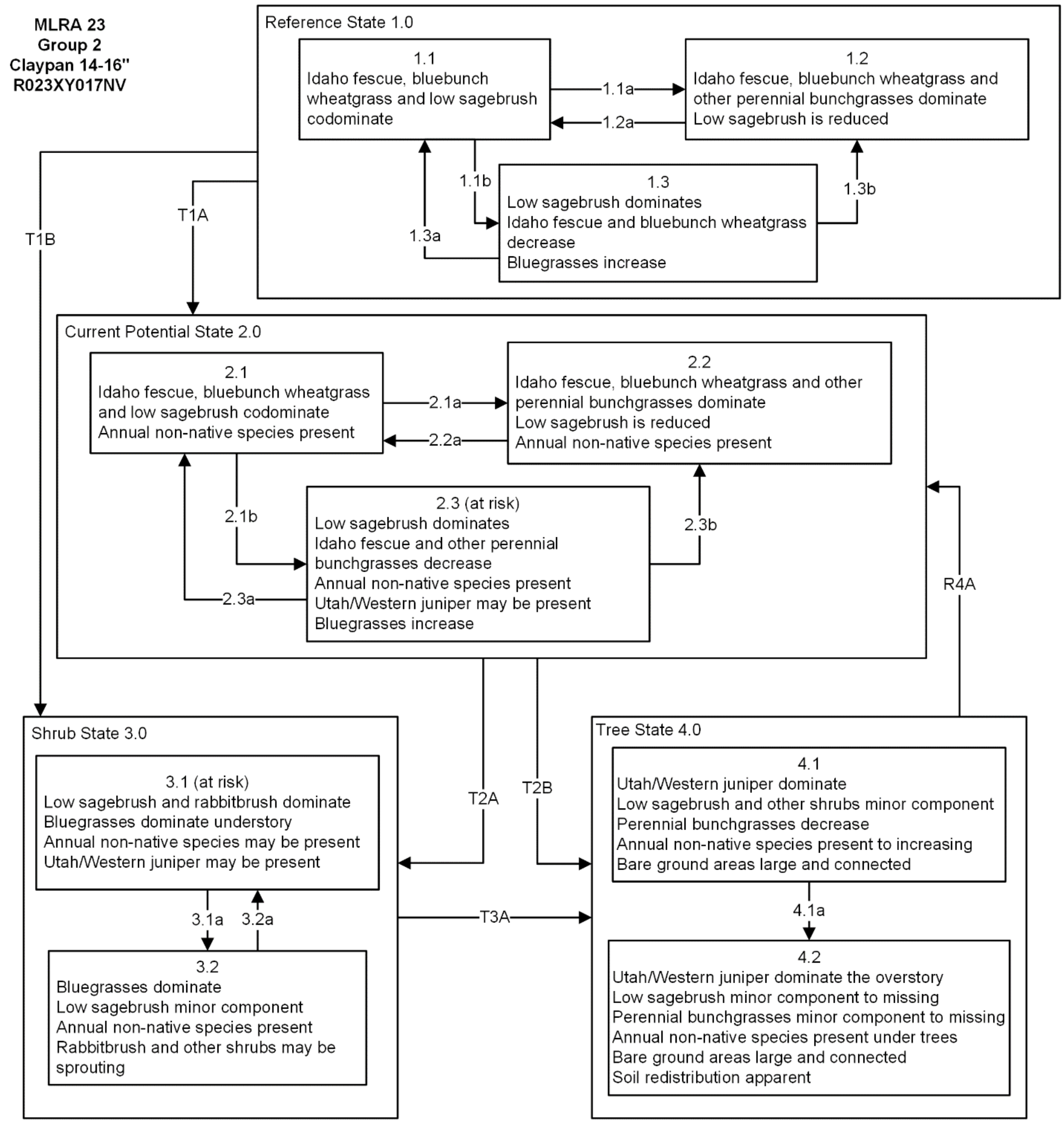
Shallow Loam 14+" (023XY014NV):

This site is slightly less productive than the modal site with 600 lb/ac in normal years but may be more resilient because it tends to occur on north aspects. The dominant plants are the same however there may be a diversity of larger forbs like arrowleaf balsamrot (*Balsamhoriza sagitatta)*, cutleaf balamroot (*Balsamhoriza macrophylla)*, and mulesear (*Wyethia amplexicaulis).* The soils in this site are shallow to bedrock or a heavy textured subsoil. The soils are well drained, permeability is moderately slow to slow, and runoff is moderately rapid to rapid. Some soils contain heavy clay seams intermingled within a fractured bedrock matrix. This site is similar to the modal site and has 4 states.

Clay Plain (023XY090NV):

This site occurs on the outer margins of lake plains and basin floors. Slope gradients of 0 to 2 percent are typical. The soils of this site have formed in lacustrine sediments as well as alluvium from mixed rock sources. These soils have a layer restrictive to root development at a very shallow depth. This site is found on low-lying positions that receive run-in moisture from higher landscapes. The soils are thus subject to ponding (saturated soil conditions) for brief periods in the spring. Early sagebrush *(Artemisia arbuscula ssp. longicaulis)* is the dominant shrub. Dominant grasses include western needlegrass, bottlebrush squirreltail, bluegrass. Basin wildrye is also an important grass on this site. Following disturbance such as fire and/or hoof action from grazing this site is susceptible to wind erosion. Management after disturbance may require seeding of species to reduce erosion. This site does not have a tree state, however it has an eroded state and is a 4-state model.

Modal State and Transition Model for Group 2 in MRLA 23:



MLRA 23
Group 2
Claypan 14-16"
R023XY017NV
KEY

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 and/or herbivory
1.3b: High severity fire significantly reduces sagebrush.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.
Transition T1B: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).

Current Potential State 2.0 Community Phase Pathways
2.1a: 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; non-native annual species present.
2.1b: Time and lack of disturbance such fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub regeneration
2.3a: Low severity fire and/or late-fall/winter grazing management causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).
Transition T2B: Time and lack of fire allows Utah juniper and pinyon pine to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.

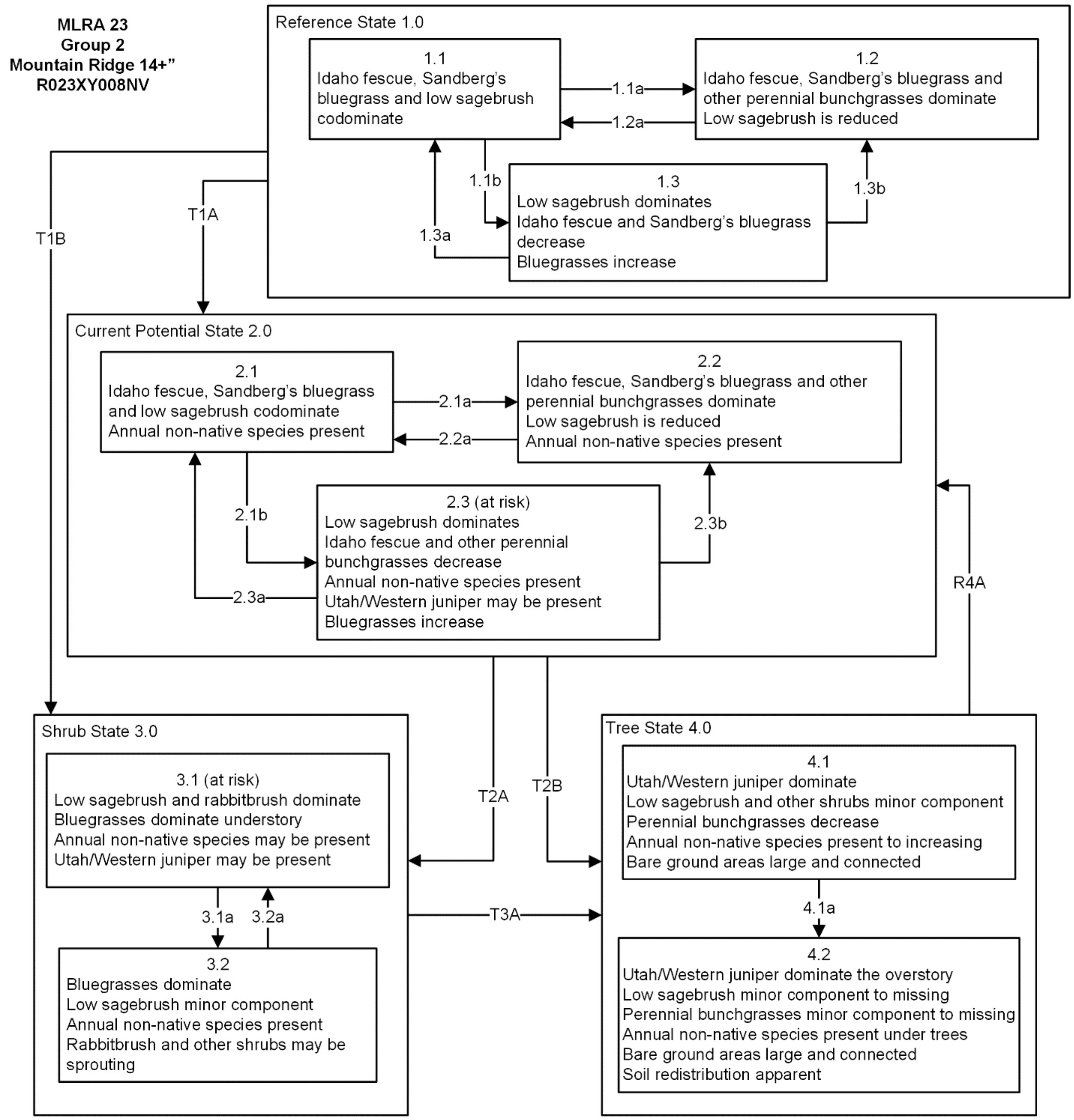
Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely to occur)

Transition T3A: Time and lack of fire allows Utah/Western juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Tree State 4.0
4.1a: Time without disturbance allows maturation of the tree community

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (4.1)

Additional State and Transition Models for Group 2 in MLRA 23:



MLRA 23
Group 2
Mountain Ridge 14+"
R023XY008NV
KEY

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 and/or herbivory
1.3b: High severity fire significantly reduces sagebrush.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.
Transition T1B: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).

Current Potential State 2.0 Community Phase Pathways
2.1a: 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; non-native annual species present.
2.1b: Time and lack of disturbance such fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub regeneration
2.3a: Low severity fire and/or late-fall/winter grazing management causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

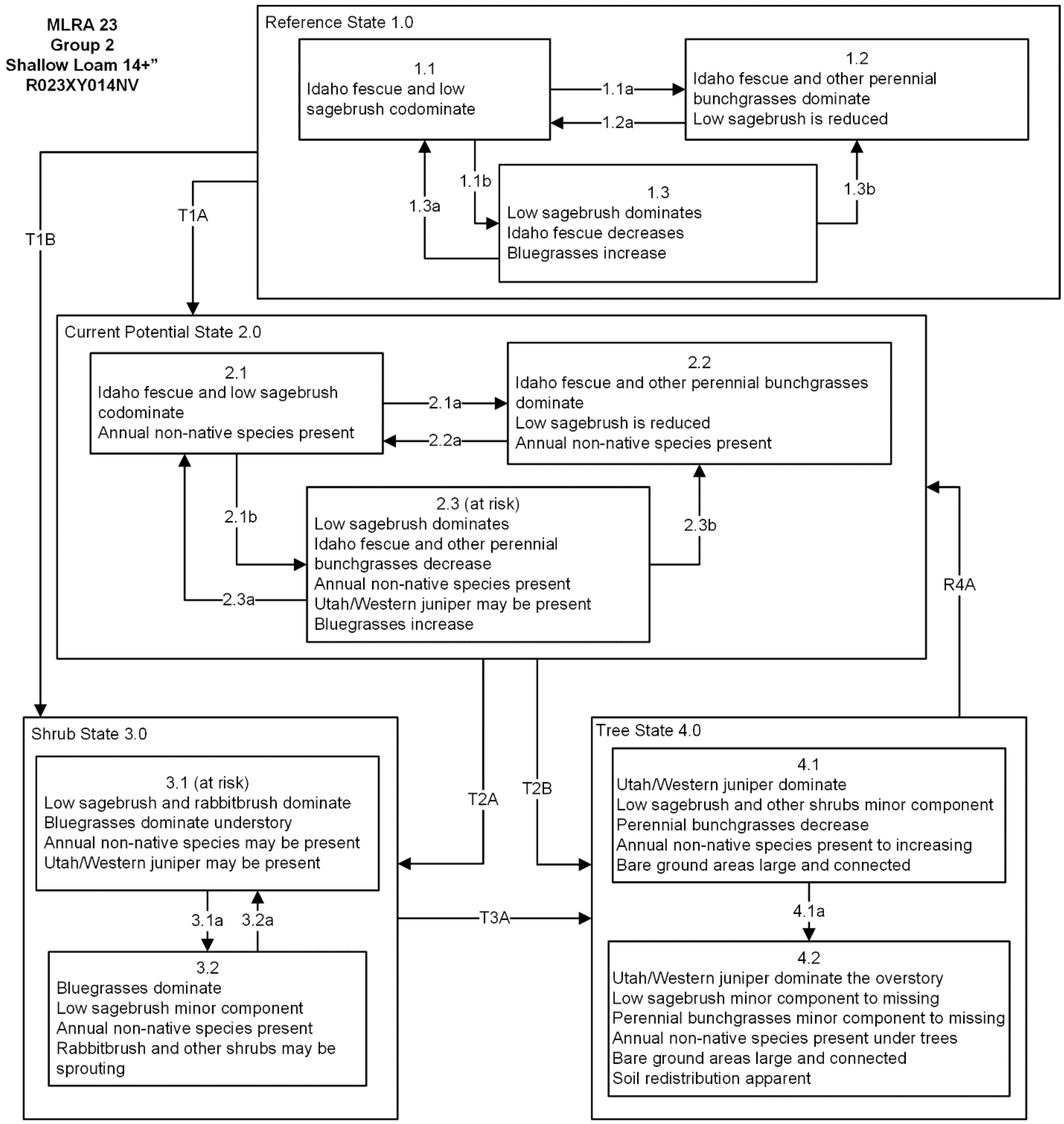
Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).
Transition T2B: Time and lack of fire allows Utah juniper and pinyon pine to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely to occur)

Transition T3A: Time and lack of fire allows Utah/Western juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Tree State 4.0
4.1a: Time without disturbance allows maturation of the tree community

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (4.1)


MLRA 23
Group 2
Shallow Loam 14+"
R023XY014NV
Reference State 1.0
1.1
Idaho fescue and low sagebrush codominate
1.1a
1.2a
1.2
Idaho fescue and other perennial bunchgrasses dominate
Low sagebrush is reduced
1.1b
1.3a
1.3b
1.3
Low sagebrush dominates
Idaho fescue decreases
Bluegrasses increase
T1A
T1B
Current Potential State 2.0
2.1
Idaho fescue and low sagebrush codominate
Annual non-native species present
2.1a
2.2a
2.2
Idaho fescue and other perennial bunchgrasses dominate
Low sagebrush is reduced
Annual non-native species present
2.1b
2.3a
2.3b
2.3 (at risk)
Low sagebrush dominates
Idaho fescue and other perennial bunchgrasses decrease
Annual non-native species present
Utah/Western juniper may be present
Bluegrasses increase
R4A
T2A
T2B
Shrub State 3.0
3.1 (at risk)
Low sagebrush and rabbitbrush dominate
Bluegrasses dominate understory
Annual non-native species may be present
Utah/Western juniper may be present
3.1a
3.2a
3.2
Bluegrasses dominate
Low sagebrush minor component
Annual non-native species present
Rabbitbrush and other shrubs may be sprouting
T3A
Tree State 4.0
4.1
Utah/Western juniper dominate
Low 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
Utah/Western juniper dominate the overstory
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

MLRA 23
Group 2
Shallow Loam 14+"
R023XY014NV
KEY

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 and/or herbivory
1.3b: High severity fire significantly reduces sagebrush.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.
Transition T1B: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).

Current Potential State 2.0 Community Phase Pathways
2.1a: 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; non-native annual species present.
2.1b: Time and lack of disturbance such fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub regeneration
2.3a: Low severity fire and/or late-fall/winter grazing management causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

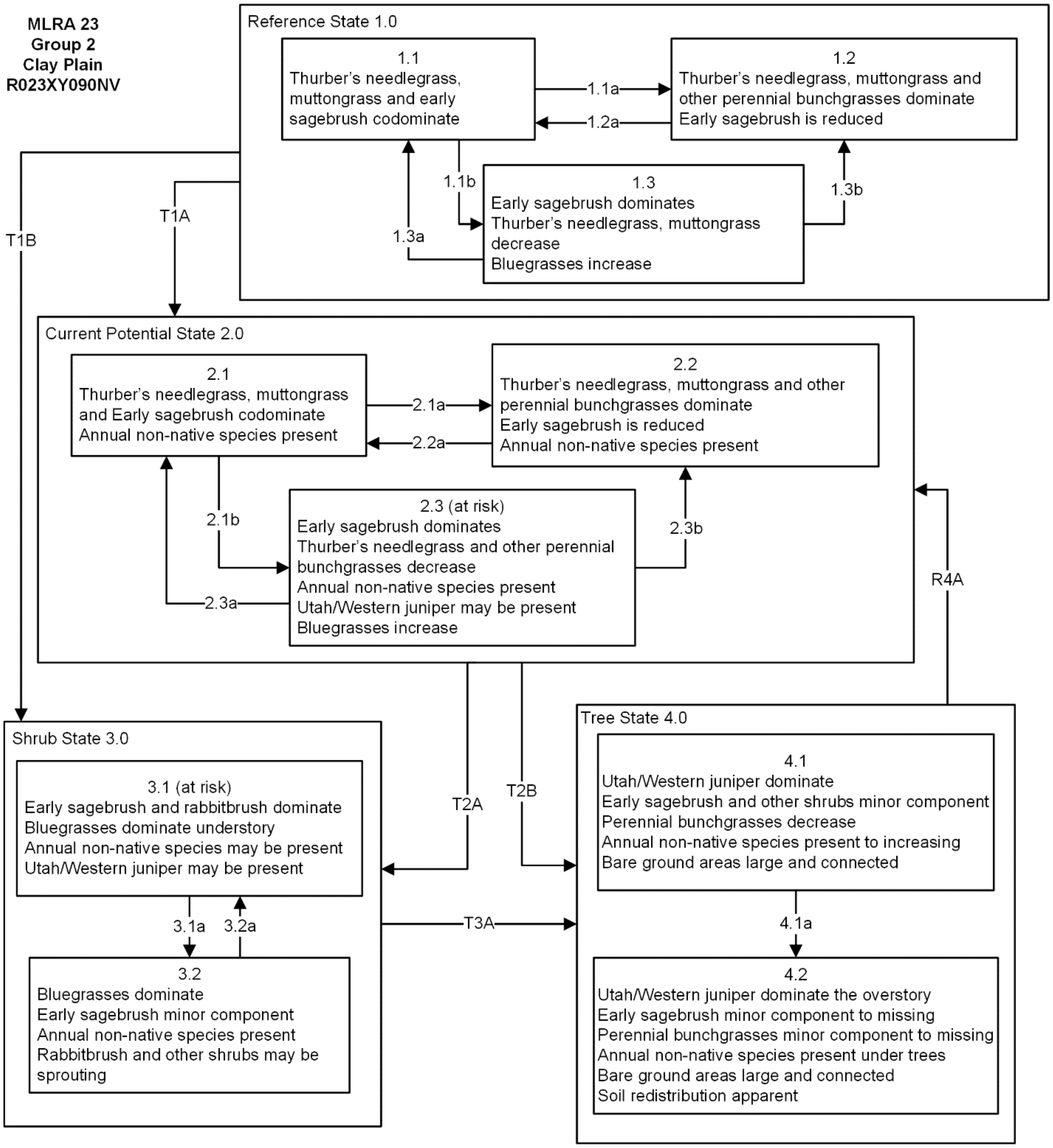
Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).
Transition T2B: Time and lack of fire allows Utah juniper and pinyon pine to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely to occur)

Transition T3A: Time and lack of fire allows Utah/Western juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Tree State 4.0
4.1a: Time without disturbance allows maturation of the tree community

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (4.1)


MLRA 23
Group 2
Clay Plain
R023XY090NV
Reference State 1.0
1.1
Thurber's needlegrass, muttongrass and early sagebrush codominate
1.2
Thurber's needlegrass, muttongrass and other perennial bunchgrasses dominate
Early sagebrush is reduced
1.3
Early sagebrush dominates
Thurber's needlegrass, muttongrass decrease
Bluegrasses increase
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
T1B
Current Potential State 2.0
2.1
Thurber's needlegrass, muttongrass and Early sagebrush codominate
Annual non-native species present
2.2
Thurber's needlegrass, muttongrass and other perennial bunchgrasses dominate
Early sagebrush is reduced
Annual non-native species present
2.3 (at risk)
Early sagebrush dominates
Thurber's needlegrass and other perennial bunchgrasses decrease
Annual non-native species present
Utah/Western juniper may be present
Bluegrasses increase
2.1a
2.2a
2.1b
2.3a
2.3b
R4A
T2A
T2B
Shrub State 3.0
3.1 (at risk)
Early sagebrush and rabbitbrush dominate
Bluegrasses dominate understory
Annual non-native species may be present
Utah/Western juniper may be present
3.1a
3.2a
3.2
Bluegrasses dominate
Early sagebrush minor component
Annual non-native species present
Rabbitbrush and other shrubs may be sprouting
T3A
Tree State 4.0
4.1
Utah/Western juniper dominate
Early 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
Utah/Western juniper dominate the overstory
Early 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

MLRA 23
Group 2
Clay Plain
R023XY090NV
KEY

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 and/or herbivory
1.3b: High severity fire significantly reduces sagebrush.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.
Transition T1B: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).

Current Potential State 2.0 Community Phase Pathways
2.1a: 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; non-native annual species present.
2.1b: Time and lack of disturbance such fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub regeneration
2.3a: Low severity fire and/or late-fall/winter grazing management causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).
Transition T2B: Time and lack of fire allows Utah juniper and pinyon pine to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely to occur)

Transition T3A: Time and lack of fire allows Utah/Western juniper to establish and dominate site resources; may be coupled with inappropriate grazing management that reduces perennial grass density and increases tree establishment.

Tree State 4.0
4.1a: Time without disturbance allows maturation of the tree community

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (4.1)

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<u>Group 3: Lahontan sagebrush on ashy soils</u>

Description of MLRA 23 DRG 3:

Disturbance Response Group (DRG) 3 consists of two ecological sites. There are very high amounts of vitric volcanic ash and glass throughout the soil profile, which enhances the water holding capacity of these soils. Infiltration is rapid and permeability is moderate. These sites occur on summits and north-facing aspects of shoulders and moderate sideslopes of plateaus, hills, and lower mountains. Slopes range from 2 to 50 percent, but slope gradients of 2 to 8 percent are most typical. Elevations are from 5800 to 7300 feet. Average annual precipitation is 10 to 14 inches. The soils in this site are shallow to moderately deep and well drained. Surface soils are medium to moderately coarse textured and are underlain by medium textured subsoils. Available water capacity is moderate. Runoff is medium and the potential for sheet and rill erosion is moderate to high depending on slope. The plant community on these sites is typically dominated by Lahontan sagebrush (*Artemisia arbuscula ssp. longicaulis*) and/or low sagebrush (*Artemisia arbuscula)*. These sites are also dominated by Idaho fescue (*Festuca idahoensis*), Thurber's needlegrass (*Achnatherum thurberianum*), bluebunch wheatgrass, and a variety of forbs. Juniper (*Juniperus spp.)* may also be present on the site. Normal year annual production for these sites ranges from 900 to 1000 lbs/acre.

Ecological sites in this group are described as having low sagebrush as the dominant shrub. During our visits to these and other sites for this project, 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 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 23.

Disturbance Response Group 3 – Ecological Sites:

Ashy Claypan (cool) 10-14" Modal	023XY079NV
Ashy Claypan 10-14"	023XY078NV

Modal Site:

The modal site for this group is Ashy Claypan (cool) 10-14" (R023XY079NV). This site occurs on north-facing aspects of shoulders and sideslopes of plateaus and lower mountains. Slopes range from 2 to 50 percent, but slope gradients of 2 to 8 percent are most typical. Elevations are 5800 to 7300 feet. Average annual precipitation is 10 to 14 inches. The soils in this site are shallow to moderately deep and well drained. Surface soils are medium to moderately coarse textured and are underlain by medium textured subsoils. Available water capacity is moderate. There are very high amounts of vitric volcanic ash and glass throughout the soil profile which enhances the water holding capacity of these soils. Infiltration is rapid and permeability is moderate. Runoff is medium and the potential for sheet and rill erosion is moderate to high depending on slope. The plant community is dominated by Lahontan/low sagebrush, Idaho fescue, needlegrasses, and other perennial forbs. Normal year annual production is 900 lb/ac, but ranges from 600 – 1200 lb/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). 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).

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 some portion of the growing season (Fosberg and Hironaka 1964, Blackburn et al. 1968a and b, 1969a and b). 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).

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 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).

Infilling by younger trees increases canopy cover causing a decrease in understory perennial vegetation and an increase in bare ground. As juniper trees increase in density so does their litter. Phenolic compounds of juniper scales can have an inhibitory effect on grass growth (Jameson 1970). Furthermore, infilling shifts stand level biomass from ground fuels to canopy fuels which has the potential to significantly impact fire behavior. The more tree-dominated the site becomes, the less likely they are to burn under moderate conditions, resulting in infrequent high intensity fires (Gruell 1999, Miller et al. 2008). Additionally, as the understory vegetation declines in vigor and density with increased canopy, the seed and propagules of the understory plant community also decrease significantly. The increase in bare ground allows for the invasion of non-native annual species such as cheatgrass. With intensive wildfire, the potential for conversion to annual exotics is a serious threat (Tausch 1999, Miller et al. 2008).

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. Tap roots of juniper have a relatively rapid rate of root elongation and are thus able to persist until precipitation conditions are more favorable (Emerson 1932). At the southern end of this site's extent, Utah Juniper may be the dominant species or may coexist and/or hybridize with Western Juniper.

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. 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:

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 the bunchgrasses within the site along with seasonality and intensity of the fire all factor into the individual species response. Sandberg bluegrass, the dominant grass on 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.

Idaho fescue, the dominant grass within this community, response to fire varies with condition and size of the plant, season and severity of fire, and ecological conditions. Mature Idaho fescue plants are commonly reported to be severely damaged by fire in all seasons (Wright et al. 1979). Initial mortality may be high (in excess of 75%) on severe burns, but usually varies from 20 to 50% (Barrington et al. 1989). Rapid burns have been found to leave little damage to root crowns, and new tillers are produced with onset of fall moisture (Johnson et al. 1994). However, Wright and others (1979) found the dense, fine leaves of Idaho fescue provided enough fuel to burn for hours after a fire had passed, thereby killing or seriously injuring the plant regardless of the intensity of the fire (Wright et al. 1979). Idaho fescue is commonly reported to be more sensitive to fire than the other prominent grass on this site, bluebunch wheatgrass (Conrad and Poulton 1966). However Robberecht and Defosse (1995) suggested the latter was more sensitive. They observed culm and biomass reduction with moderate fire severity in bluebunch wheatgrass, whereas a high fire severity was required for this reduction in Idaho fescue. Also, given the same fire severity treatment, post-fire culm production was initiated earlier and more rapidly in Idaho fescue (Robberecht and Defosse 1995). The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant.

Thurber's needlegrass, a minor component on these sites, 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 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). 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 this ecological site and others in this DRG. This recently differentiated subspecies of low sagebrush (Winward and McArthur 1995) is moderately to highly palatable to browse species (McArthur 2005, Rosentreter 2005). Dwarf sagebrush species such as Lahontan sagebrush, low sagebrush, and black sagebrush are preferred by mule deer for browse among the sagebrush species.

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 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.

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).

Idaho fescue tolerates light to moderate grazing (Ganskopp and Bedell 1981) and is moderately resistant to trampling (Cole 1989). However, Idaho fescue decreases under heavy grazing by livestock (Eckert and Spencer 1986, Eckert and Spencer 1987) and wildlife (Gaffney 1941). Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton and others (1979) observed the effects of harvest date on basal area of 5 bunchgrasses in eastern Oregon, including Idaho fescue, and found grazing from August to October (after seed set) has the least impact on these bunchgrasses. Therefore, abusive grazing during the growing season will reduce perennial bunchgrasses, with the exception of Sandberg bluegrass (Tisdale and Hironaka 1981). Abusive grazing by cattle or horses will likely increase low sagebrush, rabbitbrush and some forbs such as arrowleaf balsamroot. Annual non-native weedy species may invade, such as cheatgrass and mustards, and potentially medusahead.

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).

Western wheatgrass (*Pascopyrum smithii*) and thickspike wheatgrass (*Elymus lanceolatus)* are two rhizomatous grasses that are often found on this site. Their rhizomatous growth habit makes these grasses tolerant to grazing and more likely to survive fire. These grasses may become more dominant under heavy grazing conditions.

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 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.

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.

State and Transition Model Narrative 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 23 disturbance response group 3.

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 Idaho fescue, needlegrasses and Lahontan/low sagebrush. Forbs and other grasses make up smaller components of the community.

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 or drought allows 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. Idaho fescue, needlegrasses and other perennial bunchgrasses dominate. Lahontan/low sagebrush is significantly reduced or absent. 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. Mature and/or decadent sagebrush dominates the overstory. Idaho fescue and other deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs and/or from herbivory. Sandberg bluegrass may increase and become co-dominant with deep rooted bunchgrasses.

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, mustards, and bur buttercup.

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. Idaho fescue, needlegrasses and Lahontan/low sagebrush dominate. Forbs and other shrubs and grasses make up smaller components of this site.

Ashy Claypan 10-14" (023XY079NV) Phase 2.1 T. K. Stringham, August 2014

Ashy Claypan 10-14" (R023XY079NV) Phase 2.1 T. K. Stringham, July 2015

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 present and likely to increase after fire.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Time and lack of disturbance allows sagebrush to increase and become decadent. Inappropriate grazing management may also reduce perennial 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. Lahontan/low sagebrush is reduced and Idaho fescue, needlegrasses and other perennial bunchgrasses dominate the site. Rabbitbrush and other sprouting shrubs may be sprouting within 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.

Community Phase Pathway 2.2b, from Phase 2.2 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 2.3:
Lahontan/low sagebrush dominates. Idaho fescue and other perennial bunchgrasses decrease. Annual non-native species present. Utah Juniper and/or pinyon may be present.

Ashy Claypan (cool) 10-14” (023XY079), Phase 2 (At Risk) P. Novak-Echenique, May 2015

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
Low severity fire creates sagebrush/grass mosaic, herbivory, or combinations. Brush management with minimal soil disturbance.

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 increase. Brush management with minimal soil disturbance reduces 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). 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 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.

Community Phase Pathway 2.4a, from Phase 2.4 to 2.3:
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 2.2:
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: 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.

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

Trigger: Time and lack of disturbance or management action allows Utah juniper and/or western 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 number of live shrubs. Minimal recruitment of new shrub cohorts.

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

Trigger: Fire or soil disturbing treatment would transition to Community Phase 5.1.

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. Sandberg bluegrass will increase with a reduction in deep rooted perennial bunchgrass competition and become the dominant grasses. 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:
Decadent Lahontan/low sagebrush and rabbitbrush dominate the overstory. Bluegrasses dominate understory. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Annual non-native species may be present. Utah juniper and/or pinyon may be present.

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 (At-Risk):
Bluegrass dominates the site; annual non-native species may be present but are not dominant. Lahontan/low sagebrush minor component. Rabbitbrush and other shrubs may be sprouting.

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 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 juniper and/or western 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.

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

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.

T3C: Transition from Shrub State 3.0 to Eroded State 6.0

Trigger: Inappropriate grazing management causing a removal of perennial bunchgrasses and a disruption of the soil surface would increase soil erosion. Soil disturbing treatments such as a brush beating and failed seeding.

Slow variable: Bare ground interspaces large and connected; water flow paths long and continuous, understory is sparse, pedestalling of plants significant.

Threshold: Soil redistribution and erosion is significant and linked to vegetation mortality evidenced by pedestalling and burying of herbaceous species and / or lack of recruitment in the interspaces.

Tree State 4.0:

This state is characterized by a dominance of Utah and/or western 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:
Utah and/or western juniper dominate. Lahontan/low sagebrush and other shrubs minor component. Perennial bunchgrasses decrease. Annual non-native species present to increasing. Bare ground areas large and connected.

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Time without disturbance allows maturation of the tree community.

Community Phase 4.2:
Utah and/or western juniper dominate the overstory. Lahontan/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.

T4A: Transition from Tree State 4.0 to Annual State 5.0:

Trigger: Catastrophic crown fire would reduce or eliminate trees to transition the site to 5.1. Tree removal when annual non-natives such as cheatgrass are present would also transition the site to State 5.0.

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.

T4B: Transition from Tree State 4.0 to Eroded State 6.0:

Trigger: Time and lack of disturbance allows tree competition to eliminate herbaceous understory. Catastrophic fire would eliminate the tree canopy and increase production of annual species in the understory, allowing a dominance of non-native annual species and Sandberg bluegrass and/or muttongrass.

Slow variables: Bare ground interspaces large and connected; water flow paths long and continuous; understory sparse

Threshold: Soil redistribution and erosion is significant and linked to vegetation mortality evidenced by pedestalling and burying of herbaceous species and / or lack of recruitment in the interspaces

Annual State 5.0:

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, medusahead, 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 5.1:
Annual non-native species such as cheatgrass, medusahead, or mustards dominate; perennial bunchgrasses and forbs may still be present in trace amounts. Lahontan/low sagebrush minor component or missing.

Eroded State 6.0:

This state has one community phase. Loss of the A horizon and extreme pedestalling are identifiable features. 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. Regeneration of shrubs is not evident.

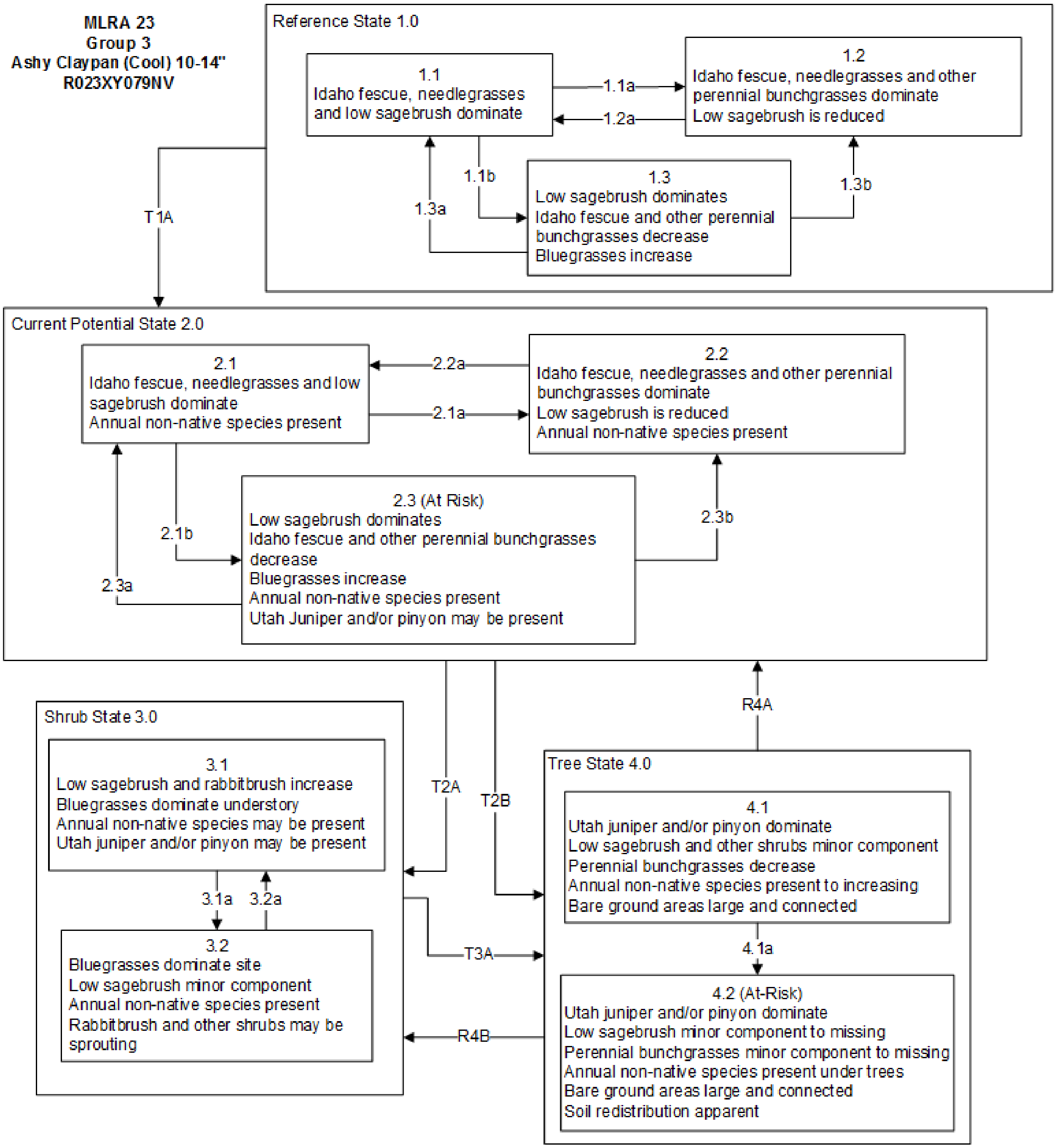
Community Phase 6.1:
Lahontan/low sagebrush and/or rabbitbrush may dominate overstory. Sandberg bluegrass and/or annual non-native species may dominate understory. Soils actively eroding; bare ground significantly increased; excessive frost-heaving/pedestalling.

Potential Resilience Differences with other Ecological Sites:

Ashy Claypan 10-14" (023XY078NV):

This site is slightly more productive than the modal site, with production ranging from 700 to 1300 lb/ac, 1000 lb/ac in normal years. The dominant grasses are Thurber's needlegrass and bluebunch wheatgrass. The dominant shrub is still Lahontan and/or low sagebrush, and may have a component of antelope bitterbrush. This site is found at the lower elevation of the group's range, from 5800-7000 feet. This site has the same model as the modal site with 6 states.

Modal State and Transition Model for Group 3 in MLRA 23



MLRA 23
Group 3
Ashy Claypan (Cool) 10-14"
R023XY079NV

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 and/or herbivory.
1.3b: High severity fire significantly reduces sagebrush and leads to early/mid seral community, dominated by grasses and forbs.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.

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.
2.3a: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combinations. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2B: Time and lack of fire allows Utah juniper and pinyon pine to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.

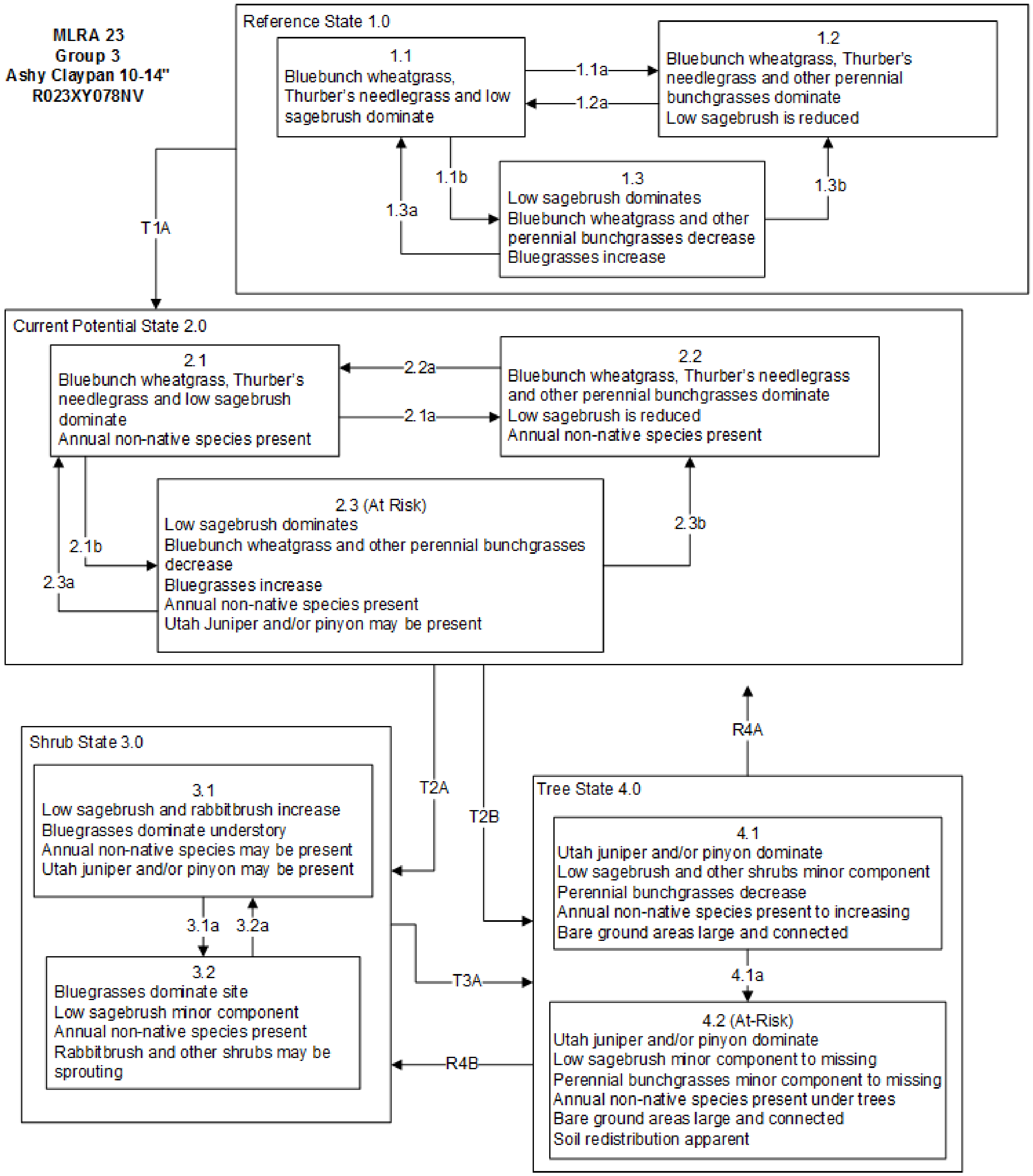
Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance. (unlikely to occur)

Transition T3A: Inappropriate grazing management, soil disturbing treatments and/or high severity fire, significantly reduces perennial cover and increases soil erosion/movement.

Tree State 4.0 Community Phase Pathways
4.1a: Time without disturbance allows maturation of the tree community.

Restoration Pathway R4A: Tree removal and seeding of desired species.
Restoration Pathway R4B: Tree removal without seeding.

Additional State and Transition Models for Group 3 in MLRA 23:



MLRA 23
Group 3
Ashy Claypan 10-14"
R023XY078NV
KEY

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 and/or herbivory.
1.3b: High severity fire significantly reduces sagebrush and leads to early/mid seral community, dominated by grasses and forbs.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.

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.
2.3a: Low severity fire creates sagebrush/ grass mosaic, herbivory, or combinations. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community. Brush management with minimal soil disturbance reduces sagebrush.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1). Brush management of Community Phase 2.3 may result in Community Phase 3.2.
Transition T2B: Time and lack of fire allows Utah juniper and pinyon pine to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance. (unlikely to occur)

Transition T3A: Inappropriate grazing management, soil disturbing treatments and/or high severity fire, significantly reduces perennial cover and increases soil erosion/movement.

Tree State 4.0 Community Phase Pathways
4.1a: Time without disturbance allows maturation of the tree community.

Restoration Pathway R4A: Tree removal and seeding of desired species.
Restoration Pathway R4B: Tree removal without seeding.

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Group 4: Low or Lahontan sagebrush and Sandberg bluegrass

Description of MLRA 23 DRG 4:

Disturbance Response Group (DRG) 4 consists of three ecological sites, Very Cobbly Claypan (023XY044NV), Churning Clay (023XY001NV), and Shallow Clay 9-16" (023XF093CA). The California ecological site, Shallow Clay 9-16" (023XF093CA) encompasses a wide precipitation range, suggesting the site concept is too broad. The Shallow Clay 9-16" ecological site correlates to the Nevada ecological site Very Cobbly Claypan. The precipitation zone for these sites ranges from 9 to 16 inches. The elevations range from 5000 to 6500 feet. Slopes range from 0 to 15 percent, but are typically from 0 to 4 percent. These sites occur on plateau summits, piedmont slopes and on interplateau basins. The soils are characterized by dark, reddish brown, clay surface soils that are subject to mild to extreme swelling and shrinking. This continual active soil movement can damage the root system of many plants. The plant community is dominated by Sandberg bluegrass (*Poa secunda*), low sagebrush (*Artemisia arbuscula*) or Lahontan sagebrush (*Artemisia arbuscula* ssp. *longicaulis)*. Thurber's needlegrass (*Achnatherum therberianum),* bottlebrush squirreltail *(Elymus elymoides)* and rabbitbrush (*Chrysothamnus and Ericameria spp.)* are also important components. Juniper (*Juniperus spp.*) may also be present on the site. The Nevada site production ranges from 225-275 lbs/acre in a normal year whereas California site production is 450 lbs/acre in a normal year.

The ecological sites in this group are described as having low sagebrush as the dominant shrub. During our visits to these sites for this project, 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 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 23.

Disturbance Response Group 4 Ecological Sites

Very Cobbly Claypan – Modal	023XY044NV
Churning Clay	023XY001NV
Shallow Clay 9-16 "	023XF093CA

Modal Site:

The Very Cobbly Claypan (023XY031NV) ecological site is the modal site for this group. This site occurs on plateau summits, on the summit and shoulders of rock pediments and upper piedmont slopes, and on interplateau basins. Slopes range from 0 to 15 percent, but slope gradients of 2 to 4 percent are most typical. Elevations are 5000 to 6500 feet. The soils from this site have formed from residuum or colluvium derived from volcanic parent materials. These soils are characterized by dark, reddish-brown, clay textured surface soils that are underlain by clayey subsoils. In many areas the soil surface is covered with a thin, light colored, layer of silt. The soil surface has very high amounts (>75% surface cover) of cobbles and/or stones that are usually tightly interlocked. The soils are subject to swelling when saturated and shrinking with drying. The plant community is dominated by low sagebrush or Lahontan sagebrush and Sandberg bluegrass. Production is about 275 lbs/acre for a normal year.

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 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). 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).

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).

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).

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, 1969a and b). 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).

The perennial bunchgrasses that are dominant on this site include Thurber's needlegrass and bottlebrush squirreltail. 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 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 low to moderate resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and increased nutrient availability. 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 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. To date, we have not been able to find specific research on the fire response of Lahontan sagebrush.

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.

Squirreltail is considered fire tolerant due to its small size, coarse stems, broad leaves and generally sparse leafy material (Wright 1971, 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 bottle brush squirreltail among cheatgrass dominated ranges (Hironaka and Tisdale 1973).

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). 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.

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.

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).

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). Bottlebrush squirreltail is more tolerant of grazing than Indian ricegrass but all bunchgrasses are sensitive to over utilization within the growing season.

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 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 23 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 and Sandberg bluegrass. Forbs and other grasses make up smaller components. Western juniper 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 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. Sandberg bluegrass and other perennial bunchgrasses dominate. Depending on fire severity patches of intact 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 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.

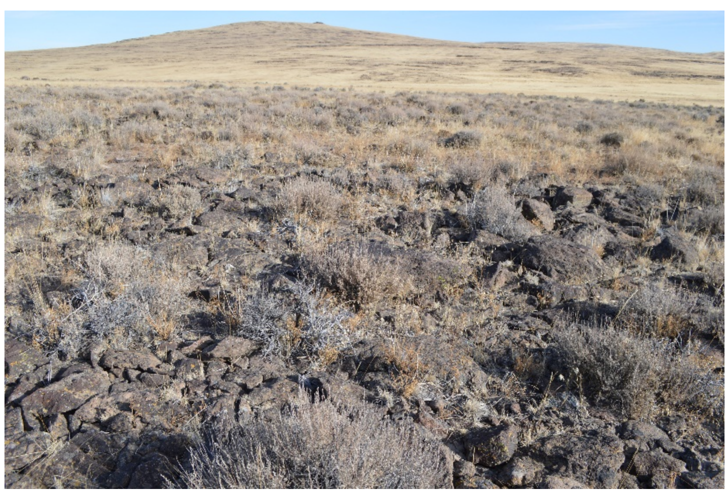
Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire will decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Fires may be high severity in this community phase due to the dominance of sagebrush resulting in removal of overstory shrub community.

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.

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.



Very Cobbly Claypan (R023XYNV044) Phase 2.3 T.K. Stringham, October, 2018

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 and bluegrasses 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 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 sagebrush to increase and become decadent. Long-term drought reduces fine fuels and leads to a reduced fire frequency, allowing big sagebrush to dominate the site.

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; Sandberg bluegrass and Thurber's needlegrass 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. 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.

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 increase. 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 and low 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 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, 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.

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.

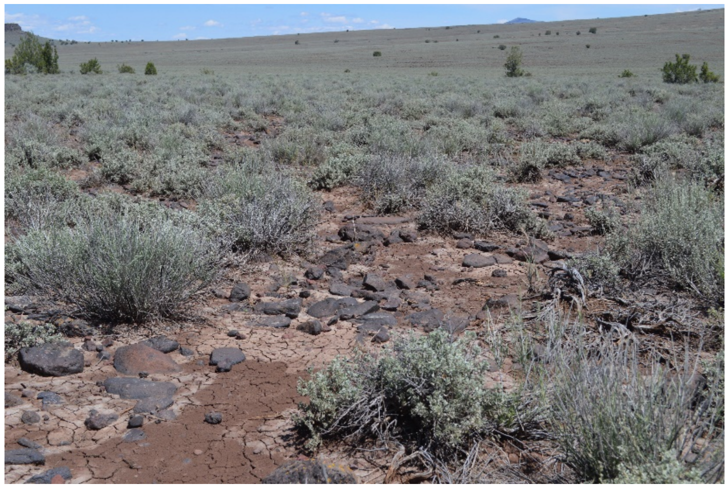
Slow variables: Increased production and cover of non-native annual species.

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. Sandberg bluegrass will increase with a reduction in deep rooted perennial bunchgrass competition and become the dominant grasses. 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:
Low sagebrush and rabbitbrush dominate. Bluegrasses dominate understory. Annual non-native species may be increasing to co-dominant. Juniper may be present.



Very Cobbly Claypan (R023XYNV044) Phase 3.1 T.K. Stringham, July 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 Sandberg bluegrass to dominate the site.

Community Phase 3.2 (At-Risk):
Bluegrass dominates the site; annual non-native species may be present but are not dominant. Low sagebrush minor component. Rabbitbrush and other shrubs may be sprouting.

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.

T3B: Transition from Shrub State 3.0 to Eroded State 5.0

Trigger: Inappropriate grazing management causing a removal of perennial bunchgrasses and a disruption of the soil surface would increase soil erosion. Soil disturbing treatments such as a brush beating and failed seeding.

Slow variable: Bare ground interspaces large and connected; water flow paths long and continuous, understory is sparse, pedestalling of plants significant.

Threshold: Soil redistribution and erosion is significant and linked to vegetation mortality evidenced by pedestalling and burying of herbaceous species and / or lack of recruitment in the interspaces.

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, medusahead, 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:
Annual non-native species such as cheatgrass, medusahead, and mustards dominate. Perennial bunchgrasses reduced. Low sagebrush minor component or missing.

Very Cobbly Claypan (R023XYNV044) Phase 4.1 T.K. Stringham, June 2014

Eroded State 5.0:

This state has one community phase. Loss of the silty A horizon in the soil and vertic cracks on the soil surface are identifiable features. Abiotic factors including soil redistribution and erosion, soil temperature, soil cracking and heaving 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. Regeneration of shrubs other than rabbitbrush and horsebrush is not evident.

Community Phase 5.1:
Rabbitbrush may dominate the overstory. Squirreltail, Sandberg bluegrass and/or annual non-native species may dominate understory. Squirreltail and annual grasses are able to seed themselves into the soil that is otherwise inhospitable to tiller development by most other perennial plants. Soils actively churning, bare ground is significantly increased, and excessive frost-heaving/pedestalling may be present.

Churning Clay (R023XY001NV) Eroded State 5.1 T.K. Stringham, June 2017

Potential Resilience Differences with other Ecological Sites

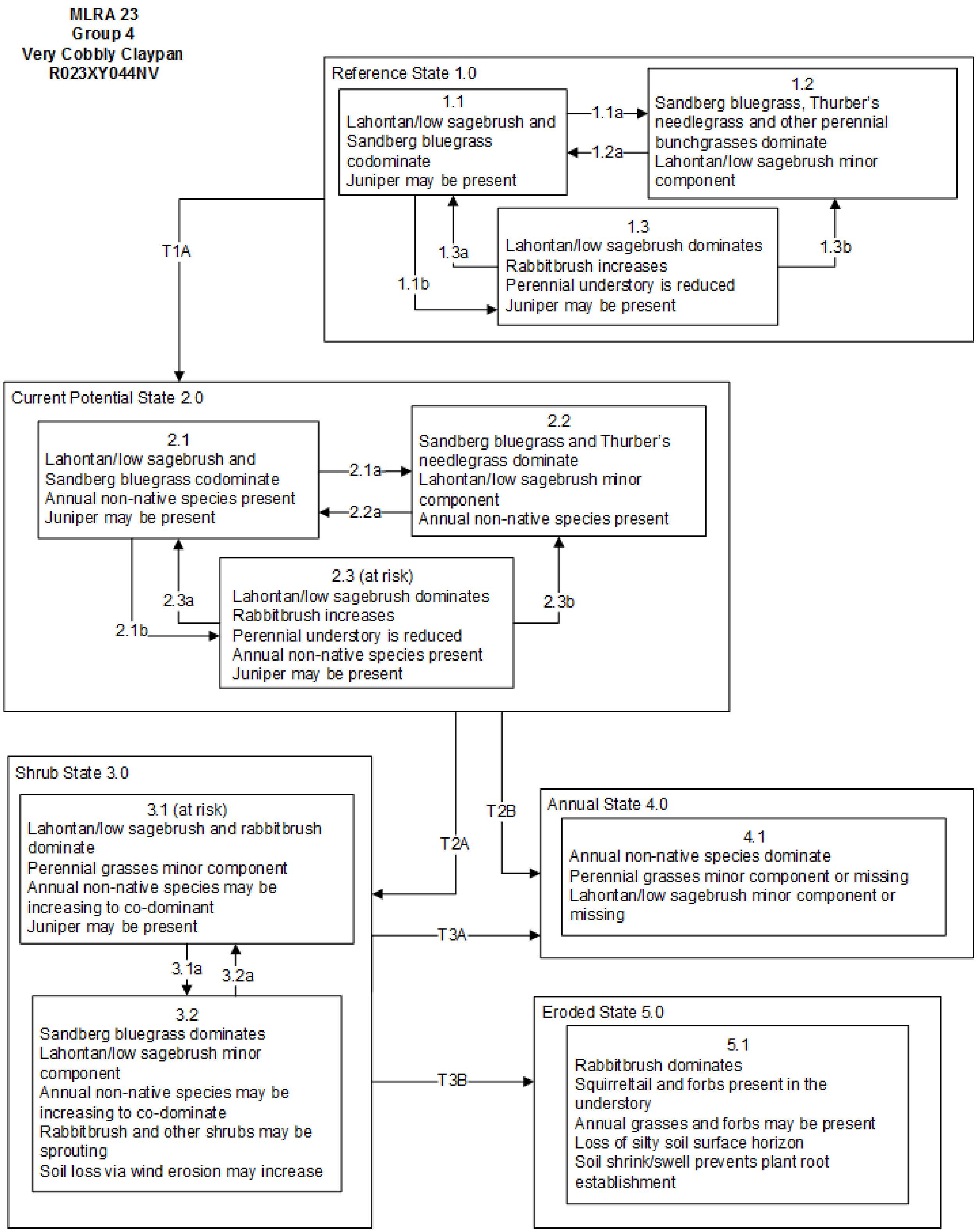
Churning Clay (023XY001NV):

This site is slightly less productive at 225 lbs/ac in normal years. Similar to the modal site, the soils are characterized by dark, reddish-brown, clay surface soils but are without large stones and cobbles. They are subject to extreme swelling and shrinking. This continuous active soil movement damages the root system of many plants. Annual plants as well as rabbitbrush and squirreltail are the primary species capable of surviving these soil conditions. Pedestalling of plants is common due to the high shrink-swell characteristics of the clay soils. The plant community is dominated by Washoe rubber rabbitbrush (*Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & Baird ssp. nauseosa var. washoensis*), bottlebrush squirreltail, Sandberg bluegrass and low sagebrush.
During our site visits for this project we were unable to determine of Churning Clay is a unique ecological site or if it is a Very Cobbly Claypan site with highly disturbed vegetation and soil structure. The Eroded State of the Very Cobbly Claypan site is close in characteristics to this ecological site: it lacks a silty surface soil and is dominated by rubber rabbitbrush. Churning Clay currently is a stand-alone ecological site, so we have created a separate STM for it. This site has four stable states.

Shallow Clay 9-16“ (023XF093CA):

This site has a similar plant community to the modal site, but is more productive at 450 lbs/ac in a normal year. Western juniper may be present on this site. The clay soils are also subject to shrink-swell fracturing, with a silty surface texture and stones or cobbles on the surface. This site’s STM is similar to the modal site, with 5 stable states.

Modal State and Transition Model for Group 4 in MLRA 23:



MLRA 23
Group 4
Very Cobbly Claypan
R023XY044NV
KEY

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 or late fall/winter herbivory causing mechanical damage to sagebrush would reduce sagebrush overstory.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass.

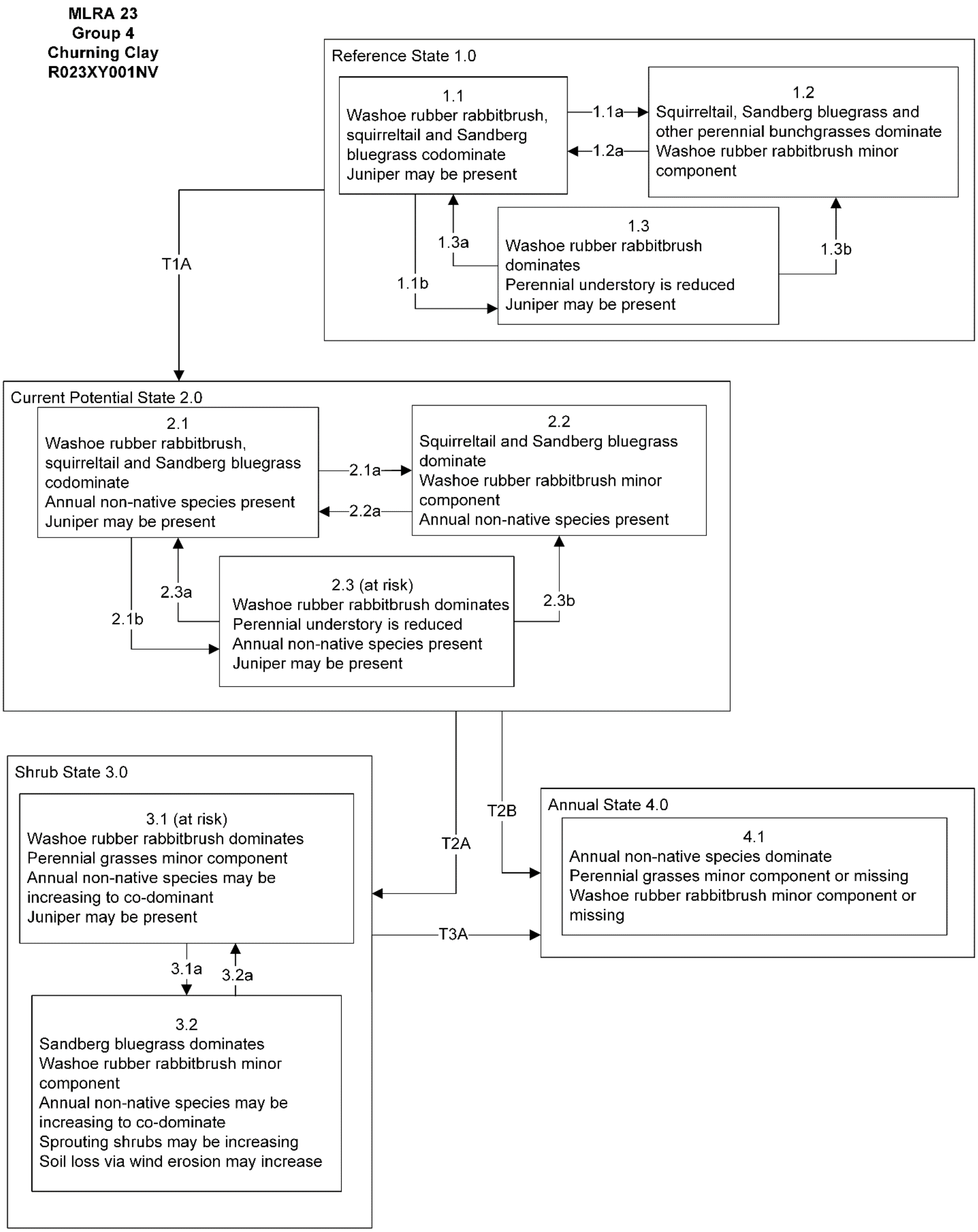
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance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

Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).
Transition T2B: Inappropriate grazing management, soil disturbing treatments, fire or multiple fires.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely to occur).

Transition T3A: Catastrophic fire.
Transition T3B: Inappropriate grazing management.

Additional State and Transition Models for Group 4 in MLRA 23:



MLRA 23
Group 4
Churning Clay
R023XY001NV
KEY

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 or late fall/winter herbivory causing mechanical damage to sagebrush would reduce sagebrush overstory.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass.

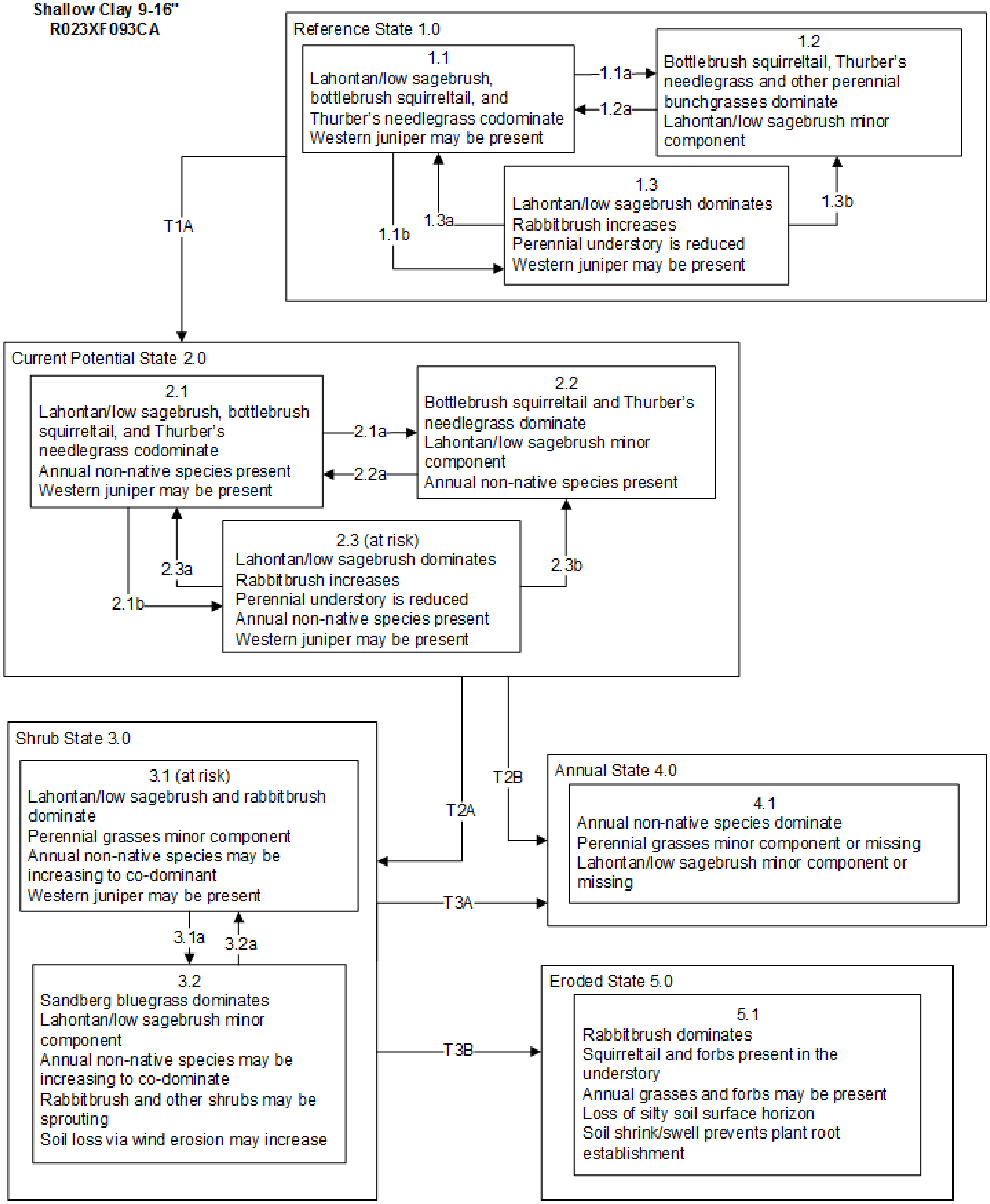
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: Time and lack of disturbance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

Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).
Transition T2B: Inappropriate grazing management, soil disturbing treatments, fire or multiple fires.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely to occur).

Transition T3A: Catastrophic fire.

MLRA 23
Group 4
Shallow Clay 9-16"
R023XF093CA



MLRA 23
Group 4
Shallow Clay 9-16"
R023XF093CA
KEY

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 or late fall/winter herbivory causing mechanical damage to sagebrush would reduce sagebrush overstory.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

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 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 such fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub regeneration.
2.3a: Low severity fire resulting in a mosaic pattern. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).
Transition T2B: Inappropriate grazing management, soil disturbing treatments, fire or multiple fires.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely to occur).

Transition T3A: Catastrophic fire.
Transition T3B: Inappropriate grazing management.

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<u>Group 5: Mountain big sagebrush and bluebunch wheatgrass</u>

Description of MLRA 23 DRG 5:

Disturbance Response Group (DRG) 5 consists of ten ecological sites. These sites range in precipitation from 10 to over 22 inches. The elevation range of this group is 5,000 to 9,000 feet. Slopes range widely from 2 to 75 percent. The soils on these sites are shallow to very deep, well to moderately well drained and have low to high available water holding capacity. Soil textures are variable and may be modified by high volumes of rock fragments. Annual production on these sites ranges from 450 to 1,600 lbs/acre in a normal year. The potential native plant community for these sites varies depending on precipitation, elevation and landform. These sites are characterized by a dominance of mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana*) and bluebunch wheatgrass (*Pseudoroegnaria spicata)* in the understory. Other common shrubs include antelope bitterbrush (*Purshia tridentata*) and Utah serviceberry (*Amelanchier utahensis*). Thurber's needlegrass (*Achnatherum thurberianum*), basin wildrye (*Leymus cinereus*), and mountain brome (*Bromus marginatus*) are also important grass species on these sites. Forbs make up a minor component of the production and include balsamroot (*Balsamhoriza* sp.), hawksbeard (*Crepis* sp.) and buckwheats (*Eriogonum* sp.).

Disturbance Response Group 5 – Ecological Sites:

South Slope 12-16" – Modal	023XY016NV
Ashy Slope 12-14"	023XY094NV
Loamy 14-16"	023XY007NV
Stony Loam 12-14"	023XY015NV
Loamy 12-14"	023XY041NV
Well Drained Fan	023XY022NV
Stony South Slope 12-16"	023XY018NV
Granitic South Slope 12-14"	023XY042NV
Deep Loamy 10-12"	023XY098NV
Granitic Slope 14-16"	023XY043NV

Modal Site:

The South Slope 12-16" (023XY016NV) ecological site is the modal site for this group as it has the most acres mapped. This site occurs on moderately steep to steep mountain slopes having a southerly exposure. Slopes range from 15 to 75 percent, but slope gradients of 30 to 50 percent are most typical. Elevations are 6500 to 8000 feet. The soils in this site are normally deep to bedrock and well drained. Surface soils are medium to moderately coarse textured, have dark colored surface layers, and are typically more than 12 inches thick. The soils are usually gravelly throughout the profile. Water intake rates are high, but the capacity to store moisture for plant growth is reduced by the volume of gravels and cobbles within the soil profile. Because of the steep southerly exposures of this site, soils receive more sunlight and warm sooner. Thus, plant growth is initiated earlier than on adjacent landscapes, and high evapotranspiration potentials result in depletion of the available soil moisture supply sooner than on surrounding areas. The plant community is dominated by bluebunch wheatgrass and mountain big sagebrush. Annual production for a normal year is 1,200 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 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 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). 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 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).

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).

The perennial bunchgrasses that are dominant include bluebunch wheatgrass, Thurber'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.

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).

Where sites in this group are found adjacent to juniper stands, there is potential for infilling by Utah juniper (*Juniperus osteosperma*) or western juniper (*J. occidentalis)*. Without disturbance in these areas, 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).

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. Five possible states have been identified for the South Slope 12-16" ecological site. Differences in resilience to disturbance for the remaining ecological sites contained within this DRG are described at the end of this document.

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:

Pre-settlement fire return intervals in mountain big sagebrush communities varied from 15 to 25 years (Burkhardt and Tisdale 1969, Houston 1973, Miller et al. 2000). 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 2009).

The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequency and eventually lead to an annual dominated community. Conversely, without fire, sagebrush will increase and the potential for encroachment by juniper also increases. Without fire or changes in management, juniper will dominate the site and mountain big sagebrush will be severely reduced. The herbaceous understory will also be reduced; however Idaho fescue may remain underneath trees on north facing slopes. 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.

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). 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 and snowberry 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). Snowberry is also 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). If balsamroot or mules ear is common before fire, it will increase after fire or with heavy grazing (Wright 1985). 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).

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)

Bluebunch wheatgrass, the dominant grass on this site, has coarse stems with little leafy material, therefore the tops aboveground biomass burns rapidly and little heat is transferred downward into the crowns (Young 1983). Bluebunch wheatgrass was described as fairly tolerant of burning, other than in May in eastern Oregon (Britton et al. 1990). Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage from fire but is more susceptible in drought years (Young 1983). Most authors classify the plant as undamaged by fire (Kuntz 1982).

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).

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 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).

Livestock/Wildlife Grazing Interpretations:

Sheehy and Winward (1981) studied preferences of mule deer and sheep in a controlled experiment: deer showed the most preference for low sagebrush, mountain and foothill sagebrush, and Bolander silver sagebrush and least preference for black sagebrush. In a study by Personius et al (1987), mountain big sagebrush was the most preferred taxon by mule deer. 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 (Kasworm et al. 1984).

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).

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975, Britton et al. 1990). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949). Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.

The Thurber's needlegrass component of this plant community 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).

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).

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.

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.

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 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 23 Disturbance Response Group 5.

Reference State 1.0:

The Reference State 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 long term drought and/or insect or disease attack.

Community Phase 1.1:
Mountain big sagebrush is the major overstory shrub in this plant community. Bluebunch wheatgrass is the dominant understory species. Antelope bitterbrush is also common on this site.

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 may be of low severity, resulting in a mosaic pattern.. 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:
Time and lack of disturbance such as fire allows 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 allowing big sagebrush to dominate the site.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early seral community phase. Bluebunch wheatgrass and other perennial grasses dominate. Douglas rabbitbrush and Utah serviceberry may be sprouting. Big sagebrush is killed by fire and may be reduced or eliminated within the burned community. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain. Perennial forbs may increase post-fire but will likely return to pre-burn levels within a few years.

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

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

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
Low severity fire and/or Aroga moth infestation would reduce the mountain big sagebrush overstory and allow the perennial bunchgrasses to recover.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire will reduce or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. A fire following an unusually wet spring or a change in management may be 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: Introduction of annual non-native species.

Slow variable: 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 similar community phases. 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-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 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:
The plant community consists of mountain big sagebrush as the major overstory shrub, with snowberry also common on this site. Bluebunch wheatgrass is the dominant understory species. Annual non-native species are now present in this community. Cheatgrass is the species most likely to invade.

Loamy 14-16 (R023XY007NV) Phase 2.1 T. K. Stringham, July 2015

South Slope 12-16" (023XY016) Phase 2.1 P. Novak-Echenique, May 2015

Stony South Slope (R023XY018NV) Phase 2.1 D. Snyder, July 2016

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Fire will decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Fires will 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 2.1b, from Phase 2.1 to 2.3:
Time and lack of disturbance allows sagebrush to increase and become decadent. Chronic drought will reduce fine fuels and lead to a reduced fire frequency allowing big sagebrush to dominate the site. Inappropriate grazing management will reduce the perennial bunchgrass understory; conversely Sandberg bluegrass may increase in the understory depending on grazing management. Excessive sheep grazing favors Sandberg bluegrass; however, where cattle are the dominant grazers, cheatgrass often increases.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early seral community phase where non-native species are present. Bluebunch wheatgrass and other perennial grasses dominate. Douglas rabbitbrush and Utah serviceberry may be sprouting. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain. Perennial forbs may increase post-fire but will likely return to pre-burn levels within a few years. 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 big sagebrush may take many years.

Community Phase Pathway 2.2b, from Phase 2.2 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 2.3:
Mountain 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 grazing management. Perennial forbs such as balsamroot may increase with inappropriate herbivory. Annual non-natives are present.

Loamy 14-16” (R023XY007NV) Phase 2.3 T. K. Stringham, August 2016

Loamy 12-14 (023XY041NV) Phase 2.3 T. K. Stringham, August 2014

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
An Aroga moth infestation that reduces shrub cover or a change in management that encourages growth of bunchgrasses allows perennial bunchgrasses to increase. Release from long term drought conditions may also cause an increase in the amount of grasses.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
Fire reduces mountain big sagebrush overstory and allows perennial bunchgrasses and sprouting shrubs to increase.

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 and/or sagebrush dominate; however, annual non-native species such as cheatgrass may be sub-dominant in the understory. Annual production and abundance of these annuals may increase drastically in years with heavy spring precipitation. If this site originated from phase 2.3 there may be significant shrub cover as well. This site is susceptible to further degradation from grazing, drought, and fire.

Stony Loam 12-14” (R023XY015NV) Phase 2.4 T.K. Stringham, June 2014

Loamy 12-14” (023XY041NV) Phase 2.4 T. K. Stringham, August 2014

Stony South Slope (R023XY018NV) Phase 2.4 D. Snyder, July 2016

Granitic Slope 14-16” (R023XY043NV) Phase 2.4 T.K. Stringham, August 2016

Community Phase Pathway 2.4a, from Phase 2.4 to 2.2:
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 2.3:
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: Inappropriate, long-term grazing of perennial bunchgrasses during growing season would favor shrubs and initiate transition to Community Phase 3.1. Inappropriate grazing management in the presence of non-native annual gasses will transition to 3.2.

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.

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 State 2.0 to Tree State 5.0

Trigger: Time and lack of disturbance or management action allows Utah 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 number of live shrubs.

Shrub State 3.0:

This state has two community phases and is the product of many years of heavy grazing during time periods harmful to deep-rooted perennial bunchgrasses. With a reduction in deep-rooted perennial bunchgrass competition, bluegrasses and squirreltail will increase and become the dominant grass. Sagebrush dominates the overstory. Bitterbrush and/or rabbitbrush may be significant components. Sagebrush cover exceeds site concept and may be decadent, reflecting stand maturity and lack of seedling establishment due to competition with mature plants. Bare ground is also increasing. 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 overstory and rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Juniper may be present or increasing. Annual non-native species are present to increasing. Understory may be sparse, with bare ground increasing. Utah juniper or western juniper may be present as a result of encroachment from neighboring sites and lack of disturbance.

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire reduces the shrub component, allows bluegrasses to dominate with sprouting shrubs. Mechanical brush removal without seeding may also achieve this pathway.

Community Phase 3.2:
This site is at risk of crossing to an annual state. Mountain big sagebrush dominates the overstory while annual non-native species dominate the understory.

Well Drained Fan (R023XY022NV) Phase 3.2 T. K. Stringham, June 2015

Community Phase Pathway 3.2a, from Phase 3.2 to 3.1:
Time without disturbance such as fire allows sagebrush to return to dominance.

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

Trigger: To Community Phase 4.1: Severe fire. To Community Phase 4.2: Inappropriate grazing management in the presence of annual non-native species.

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 Tree State 5.0:

Trigger: Time and a lack of disturbance or management action allows for Utah Juniper and singleleaf pinyon to dominate site. 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 overtop mountain sagebrush and out-compete shrubs for water and sunlight. Shrub skeletons exceed live shrubs with minimal recruitment of new cohorts.

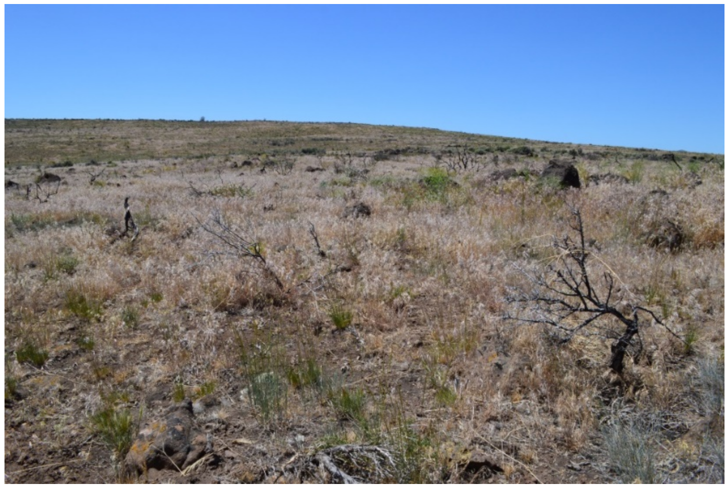
R3A: Restoration from Shrub State 3.0 to Current Potential State 2.0:

Sagebrush removal by mechanical or chemical treatments such as brush beating and/or herbicide usually coupled with seeding of perennial bunchgrass species. This restoration leads to Community Phase 2.2.

Annual State 4.0:

This state has two community phases. One phase is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard. The second phase has either mountain big sagebrush and/or rabbitbrush dominating the overstory with an understory of annual non-natives. Because this is a productive site, some deeprooted 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 tansy mustard and cheatgrass dominate this phase. Perennial grasses may be present but are subdominant to annual grasses. Sprouting shrubs may be present.



Stony Loam 12-14" (R023XY015NV) Phase Annual T. K. Stringham, June 2014

South Slope 12-16" (023XY016NV) Phase Annual T. K. Stringham, August 2014

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Time and lack of disturbance allows sprouting shrubs and some sagebrush to recover after fire.

Community Phase 4.2
Sprouting shrubs dominate aspect/overstory. Big sagebrush may show some recruitment, however annual non-native species are highly competitive with big sagebrush seedlings and recovery of sagebrush may take many years. Perennial grasses may be present but are subdominant to annual grasses. Annual non-native species dominate understory. Forbs can make up a minor component, especially after fire.

South Slope 12-16” (R023XY016NV) Phase 4.2 T. K. Stringham, August 2016

Granitic South Slope 12-14” (R023XY042NV) Phase 4.2, P. Novak-E, August 2016

Loamy 12-14” (R023XY007NV) Phase 4.2. T.K. Stringham, October 2018

Community Phase Pathway 4.2a, from Phase 4.2 to 4.1:
Fire kills big sagebrush and temporarily removes the shrub component. Annual grasses tolerate fire and proliferate.

Tree State 5.0:

This state has two community phases that are characterized by the dominance of Western and/or Utah juniper 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:
Western and/or Utah juniper 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.

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

Community Phase 5.2 (At Risk):
Western and/or 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. 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.

Loamy 14-16” (R023XY007NV) Phase 5.2. T.K. Stringham, October 2018

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 5.1. Tree removal when annual non-natives such as cheatgrass are present would also transition the site to state 5.0.

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 nutrient cycling and distribution.

R5B: Restoration from Tree State 5.0 to Current Potential State 2.0:

Tree removal with minimum soil disturbance such as hand felling or mastication within community phase 5.1. This treatment may be combined with seeding for increased success when there is little understory.

Potential Resilience Differences with other Ecological Sites:

Loamy 14-16" (023XY007NV):

This site's production range is higher than the modal site, however the average production for a normal year is still 1200 lbs/ac. Slopes on this site typically range from 4 to 30 percent. The soils are formed from volcanic rocks and are well drained with thick, dark loamy surface layers. The understory of this site is codominated by Idaho fescue and bluebunch wheatgrass. This site is similar to the modal with a five state model.

Stony Loam 12-14" (023XY015NV):

This site is less productive than the modal site with only 900 lbs/ac in normal years. Slopes on this site typically range from 4 to 15 percent. Soils in this site have a loam surface layer modified with high volumes of stones and cobbles. Unlike the modal site, the dominant shrub on this site is antelope bitterbrush with mountain big sagebrush making up only a small component of the plant community. This site is similar to the modal with a five state model.
This site is similar to the modal site and has a five state model.

Loamy 12-14" (023XY041NV):

This site is slightly more productive than the modal site with 1300 lbs/ac in normal years. Slopes typically range from 8 to 30 percent. Unlike the modal site, this site has a moderate to high available water capacity. Because of the concave or depressional relief of this site, additional moisture is received as run-in from surrounding landscapes and blowing snow tends to accumulate on this site. Basin wildrye is a dominant grass in this site, along with bluebunch wheatgrass and needlegrasses. This site is similar to the modal with a five state model.

Ashy Slope 12-14" (023XY094NV):

This site is less productive than the modal site with only 1000 lbs/ac in normal years. Slopes typically range from 4 to 15 percent. Soils in this site have high amounts of vitric volcanic ash and glass throughout the soil profile, allowing for high available water capacity. Unlike the modal site, Idaho fescue is the dominant grass on this site. This site is similar to the modal with a five state model.

Well Drained Fan (023XY022NV):

This site is slightly less productive with 1100 lbs/ac in normal years. Slopes typically range from 2 to 15 percent. Soils are medium textured with moderate to high available water holding capacity. Potential for sheet and rill erosion is moderate. Unlike the modal site, antelope bitterbrush codominates with basin big sagebrush and/or mountain big sagebrush. This site has four states (no tree state).

Stony South Slope 12-16" (023XY018NV):

This site is slightly less productive with 1000 lbs/ac in normal years. Slopes typically range from 50 to 75 percent. Unlike the modal site, the soils of this site are shallow to moderately deep to bedrock and have have very stony or cobbly to extremely stony or cobbly surfaces. Due to the stones and cobbles this site may be more resilient and less susceptible to fire. Basin wildrye is a subdominant grass in this site, below bluebunch wheatgrass. Bush oceanspray (*Holodiscus dumosus*) can also be found on this site and is a small component of the shrub community. This site has four states (no tree state).

Deep Loamy 10-12" (023XY098NV):

The site is less productive than the modal site with only 1000 lbs/ac in normal years. Slopes range from 2 to 15 percent and elevations range from 5000 to 6000 feet. The soils of this site have formed in mixed alluvium and are moderately deep to deep with a moderate available water capacity. A mollic epipedon is typically present. Unlike the modal site, Thurber's needlegrass is the dominant grass with bluebunch wheatgrass and basin wildrye as subdominates. A mix of Wyoming big sagebrush and mountain big sagebrush can seen in this site. This site has four states (no tree state).

Granitic Slope 14-16" (023XY043NV):

This site is significantly less productive than the modal site with 700 lbs/ac in normal years. The soils in this site are formed in colluvium or residuum from granitic rock sources. They are moderately deep and coarse-textured with low available water capacity and moderately rapid permeability. Unlike the modal site, the dominant grass in this site is Idaho fescue with bluebunch wheatgrass, bluegrasses and needlegrass as subdominants. This site has four states (no tree state).

Granitic South Slope 12-14" (023XY042NV):

This site has a similar plant community to the modal site but is significantly less productive with only 800 lbs/ac in normal years. The soils of this site have formed in residuum and colluvium derived from granitic rock sources. The soils are well drained, runoff is medium to very rapid, and permeability is moderately slow. This site does not have a tree state but can have an eroded state that might occur if thunderstorms occur after a fire (T3C). Bare ground will be significant with flow paths and soil redistribution visible on the landscape. This site has five stable states, however it has an eroded state but does not have a tree state. For simplicity in interpreting this narrative, we've labeled the Eroded state as 6.0 to avoid confusion with the Tree State 5.0, even though it is missing in this state and transition model diagram.

Eroded State 6.0 Narrative, Transitions to and from:

This section is separated from the primary Group narrative because it has only been found to occur in one site: Granitic South Slope 12-14".

T3C: Transition from Shrub State 3.0 to Eroded State 6.0:

Trigger: Catastrophic fire followed by significant rain events. Likely exacerbated by previous inappropriate grazing management causing a removal of perennial bunchgrasses and a disruption of the soil surface.

Slow variable: Bare ground interspaces large and connected; water flow paths long and continuous, understory is sparse, pedestalling of plants significant.

Threshold: Soil redistribution and erosion is significant, which prevents plants from reestablishing from seed. Plants are pedestaled and may be buried by moving soil.

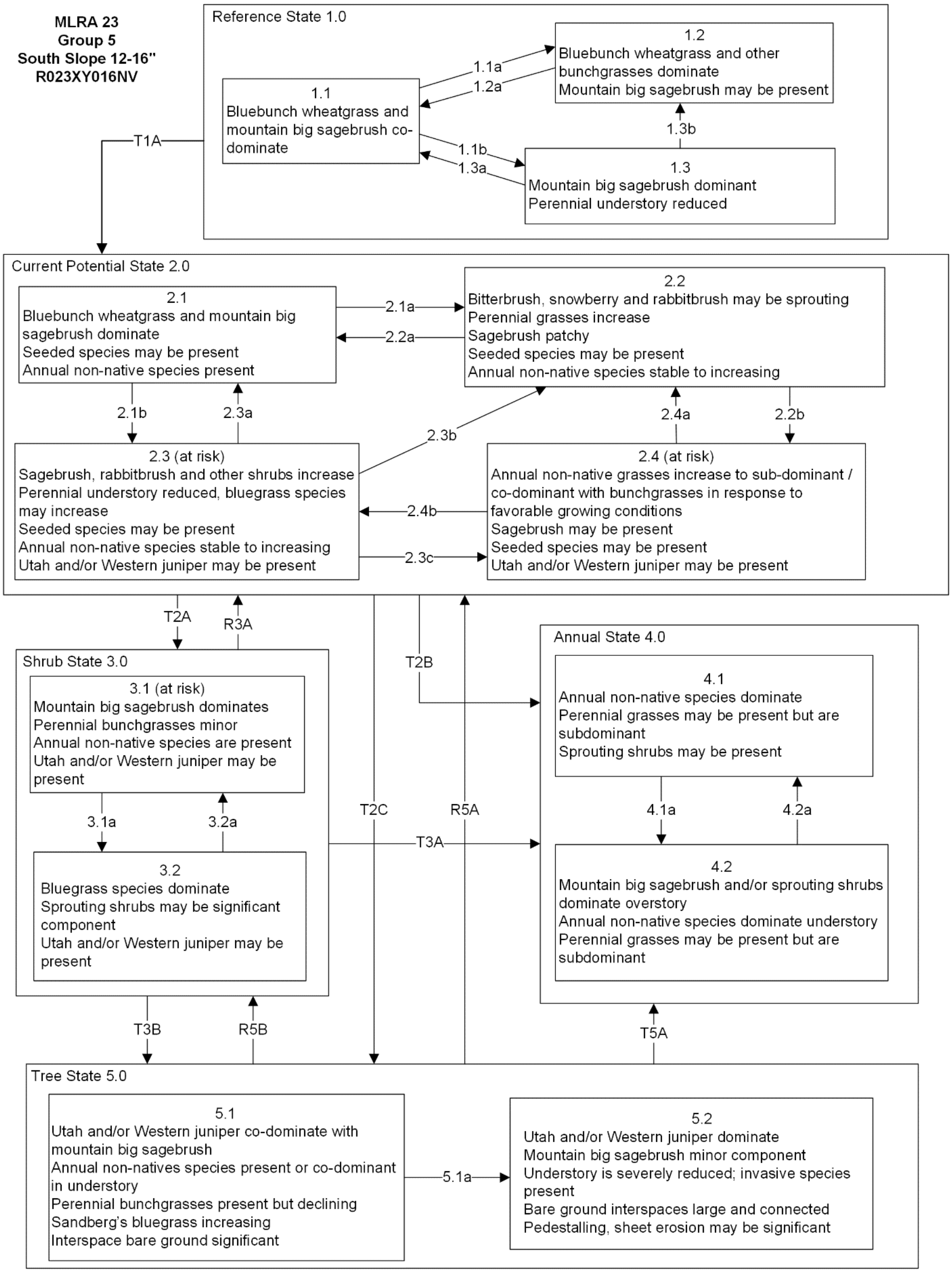
Eroded State 6.0:

Abiotic factors including soil redistribution and erosion, soil temperature, soil crusting and sealing, and plant pedestalling are primary drivers of ecological function within this state. Soil movement creates a positive feedback that maintains bare soil and erosion. Soil moisture, soil nutrients and soil organic matter distribution and cycling are severely altered due to degraded soil surface conditions. Rabbitbrush may be a significant component. Regeneration of shrubs or herbaceous species is not evident. This state occurs more readily on steep slopes (>50%).

Community Phase 6.1:
Site has significant bare ground and evidence of soil erosion, including rills. Rabbitbrush, bottlebrush squirreltail, shrubby buckwheat (*Eriogonum microthecum)* are dominant plants. Perennial and annual forbs are present. Non-native annual plants are present.

Granitic South Slope 12-14" (R023XY042NV) Rill Erosion, Phase 6.1. 80% bare ground. T.K. Stringham, August 2016.

Modal State and Transition Model for Group 5 in MLRA 23:


MLRA 23
Group 5
South Slope 12-16"
R023XY016NV
Reference State 1.0
1.1
Bluebunch wheatgrass and mountain big sagebrush co-dominate
1.2
Bluebunch wheatgrass and other bunchgrasses dominate
Mountain big sagebrush may be present
1.3
Mountain big sagebrush dominant
Perennial understory reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass and mountain big sagebrush dominate
Seeded species may be present
Annual non-native species present
2.2
Bitterbrush, snowberry and rabbitbrush may be sprouting
Perennial grasses increase
Sagebrush patchy
Seeded species may be present
Annual non-native species stable to increasing
2.3 (at risk)
Sagebrush, rabbitbrush and other shrubs increase
Perennial understory reduced, bluegrass species may increase
Seeded species may be present
Annual non-native species stable to increasing
Utah and/or Western juniper may be present
2.4 (at risk)
Annual non-native grasses increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Seeded species may be present
Utah and/or Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
R3A
T2B
T2C
R5A
Shrub State 3.0
3.1 (at risk)
Mountain big sagebrush dominates
Perennial bunchgrasses minor
Annual non-native species are present
Utah and/or Western juniper may be present
3.2
Bluegrass species dominate
Sprouting shrubs may be significant component
Utah and/or Western juniper may be present
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Perennial grasses may be present but are subdominant
Sprouting shrubs may be present
4.2
Mountain big sagebrush and/or sprouting shrubs dominate overstory
Annual non-native species dominate understory
Perennial grasses may be present but are subdominant
4.1a
4.2a
T3B
R5B
T5A
Tree State 5.0
5.1
Utah and/or Western juniper co-dominate with mountain big sagebrush
Annual non-natives species present or co-dominant in understory
Perennial bunchgrasses present but declining
Sandberg's bluegrass increasing
Interspace bare ground significant
5.2
Utah and/or Western juniper dominate
Mountain big sagebrush minor component
Understory is severely reduced; invasive species present
Bare ground interspaces large and connected
Pedestalling, sheet erosion may be significant
5.1a

MLRA 23
Group 5
South Slope 12-16"
R023XY016NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T2C: Time and lack of disturbance allows for an increase in tree cover; inappropriate grazing management and/or chronic drought can reduce fine fuels and lead to increased tree establishment and dominance (5.1).

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: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T3B: Time and a lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management (5.1).

Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species.

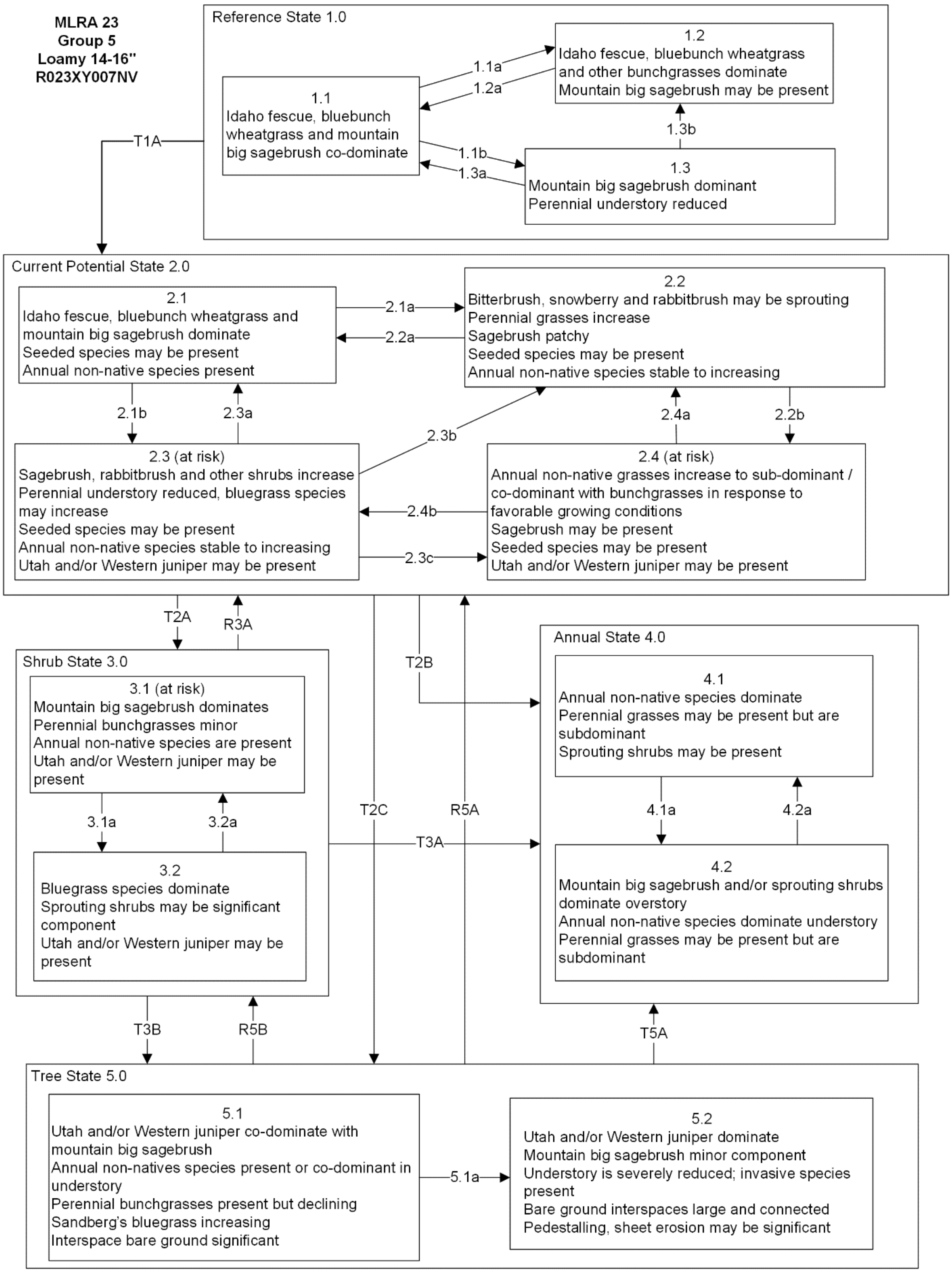
Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.

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

Restoration R5A: Tree removal and seeding of desired species or recovery of herbaceous understory.
Restoration R5B: Tree removal when Sandberg bluegrass is dominant and remains in understory.

Transition T5A: Catastrophic fire, inappropriate tree removal practices (4.1).

Additional State and Transition Models for Group 5 in MRLA 23:


MLRA 23
Group 5
Loamy 14-16"
R023XY007NV
Reference State 1.0
1.1
Idaho fescue, bluebunch wheatgrass and mountain big sagebrush co-dominate
1.2
Idaho fescue, bluebunch wheatgrass and other bunchgrasses dominate
Mountain big sagebrush may be present
1.3
Mountain big sagebrush dominant
Perennial understory reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Idaho fescue, bluebunch wheatgrass and mountain big sagebrush dominate
Seeded species may be present
Annual non-native species present
2.2
Bitterbrush, snowberry and rabbitbrush may be sprouting
Perennial grasses increase
Sagebrush patchy
Seeded species may be present
Annual non-native species stable to increasing
2.3 (at risk)
Sagebrush, rabbitbrush and other shrubs increase
Perennial understory reduced, bluegrass species may increase
Seeded species may be present
Annual non-native species stable to increasing
Utah and/or Western juniper may be present
2.4 (at risk)
Annual non-native grasses increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Seeded species may be present
Utah and/or Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
R3A
T2B
T2C
R5A
Shrub State 3.0
3.1 (at risk)
Mountain big sagebrush dominates
Perennial bunchgrasses minor
Annual non-native species are present
Utah and/or Western juniper may be present
3.2
Bluegrass species dominate
Sprouting shrubs may be significant component
Utah and/or Western juniper may be present
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Perennial grasses may be present but are subdominant
Sprouting shrubs may be present
4.2
Mountain big sagebrush and/or sprouting shrubs dominate overstory
Annual non-native species dominate understory
Perennial grasses may be present but are subdominant
4.1a
4.2a
T3B
R5B
T5A
Tree State 5.0
5.1
Utah and/or Western juniper co-dominate with mountain big sagebrush
Annual non-natives species present or co-dominant in understory
Perennial bunchgrasses present but declining
Sandberg's bluegrass increasing
Interspace bare ground significant
5.2
Utah and/or Western juniper dominate
Mountain big sagebrush minor component
Understory is severely reduced; invasive species present
Bare ground interspaces large and connected
Pedestalling, sheet erosion may be significant
5.1a

MLRA 23
Group 5
Loamy 14-16"
R023XY007NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T2C: Time and lack of disturbance allows for an increase in tree cover; inappropriate grazing management and/or chronic drought can reduce fine fuels and lead to increased tree establishment and dominance (5.1).

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: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T3B: Time and a lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management (5.1).

Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species.

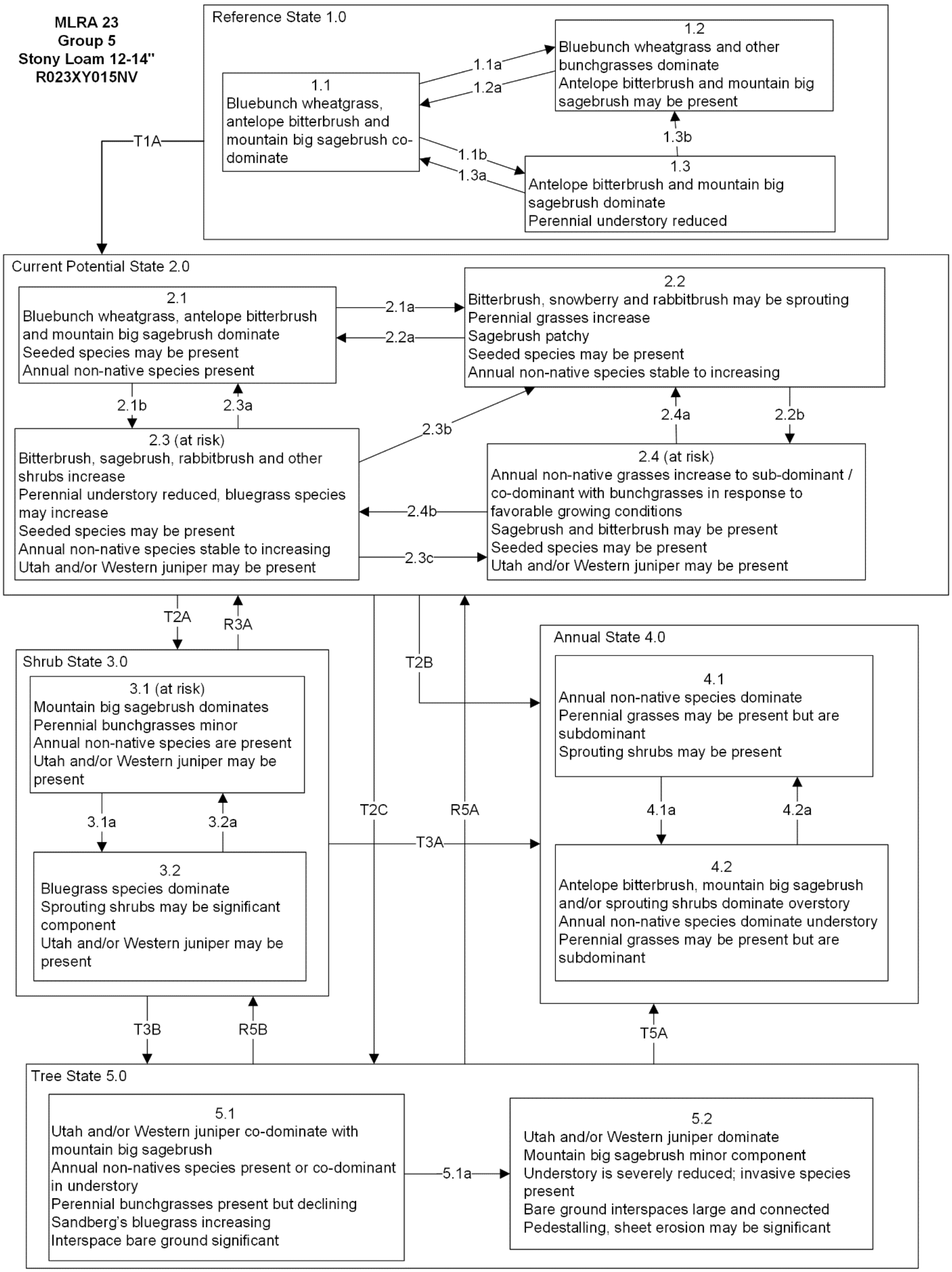
Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.

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

Restoration R5A: Tree removal and seeding of desired species or recovery of herbaceous understory.
Restoration R5B: Tree removal when Sandberg bluegrass is dominant and remains in understory.

Transition T5A: Catastrophic fire, inappropriate tree removal practices (4.1).

MLRA 23
Group 5
Stony Loam 12-14"
R023XY015NV



MLRA 23
Group 5
Stony Loam 12-14"
R023XY015NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T2C: Time and lack of disturbance allows for an increase in tree cover; inappropriate grazing management and/or chronic drought can reduce fine fuels and lead to increased tree establishment and dominance (5.1).

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: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T3B: Time and a lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management (5.1).

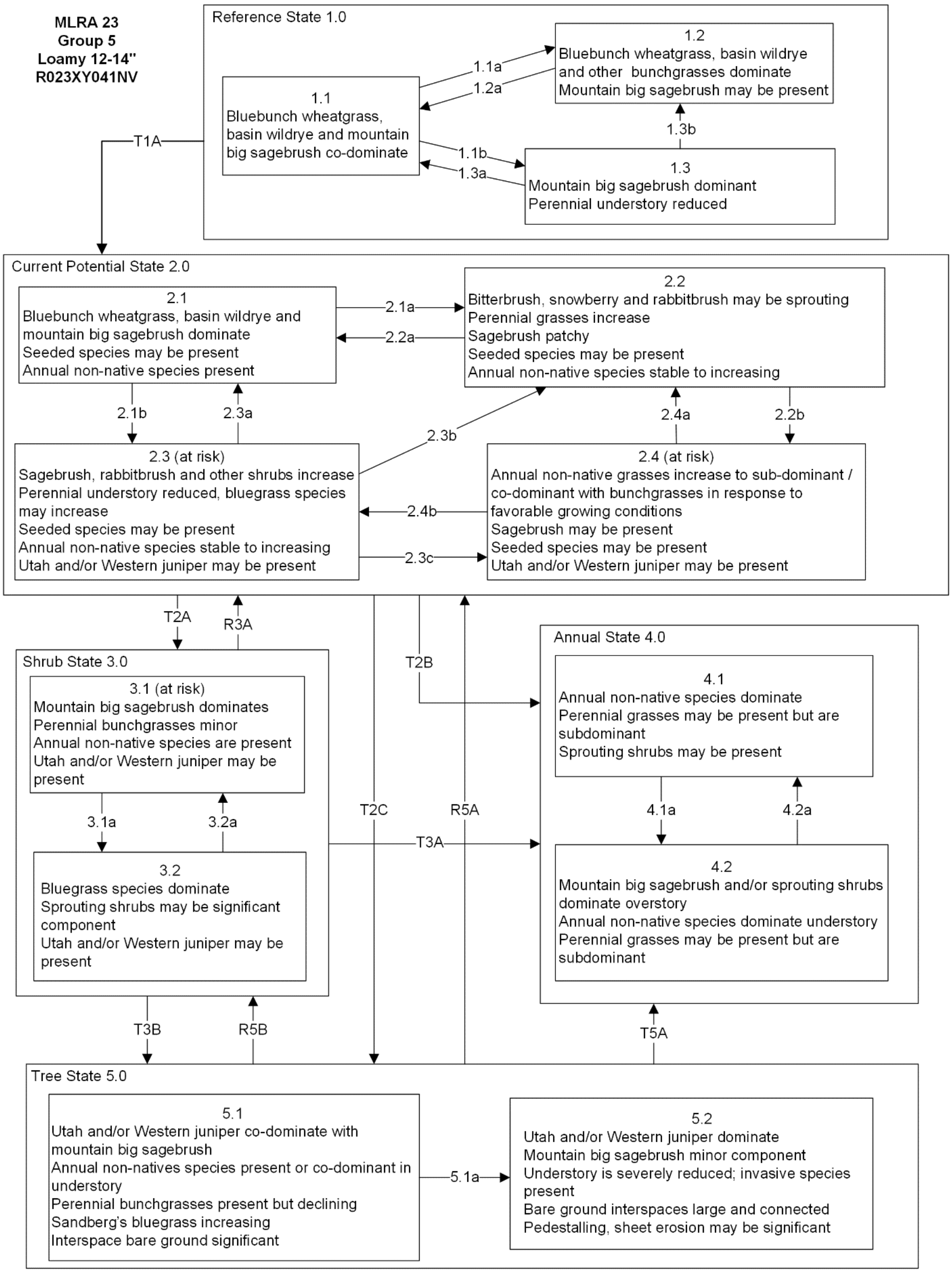
Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.

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

Restoration R5A: Tree removal and seeding of desired species or recovery of herbaceous understory.
Restoration R5B: Tree removal when Sandberg bluegrass is dominant and remains in understory.

Transition T5A: Catastrophic fire, inappropriate tree removal practices (4.1).



MLRA 23
Group 5
Loamy 12-14"
R023XY041NV
Reference State 1.0
1.1
Bluebunch wheatgrass, basin wildrye and mountain big sagebrush co-dominate
1.2
Bluebunch wheatgrass, basin wildrye and other bunchgrasses dominate
Mountain big sagebrush may be present
1.3
Mountain big sagebrush dominant
Perennial understory reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass, basin wildrye and mountain big sagebrush dominate
Seeded species may be present
Annual non-native species present
2.2
Bitterbrush, snowberry and rabbitbrush may be sprouting
Perennial grasses increase
Sagebrush patchy
Seeded species may be present
Annual non-native species stable to increasing
2.3 (at risk)
Sagebrush, rabbitbrush and other shrubs increase
Perennial understory reduced, bluegrass species may increase
Seeded species may be present
Annual non-native species stable to increasing
Utah and/or Western juniper may be present
2.4 (at risk)
Annual non-native grasses increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Seeded species may be present
Utah and/or Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
R3A
T2B
T2C
R5A
Shrub State 3.0
3.1 (at risk)
Mountain big sagebrush dominates
Perennial bunchgrasses minor
Annual non-native species are present
Utah and/or Western juniper may be present
3.2
Bluegrass species dominate
Sprouting shrubs may be significant component
Utah and/or Western juniper may be present
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Perennial grasses may be present but are subdominant
Sprouting shrubs may be present
4.2
Mountain big sagebrush and/or sprouting shrubs dominate overstory
Annual non-native species dominate understory
Perennial grasses may be present but are subdominant
4.1a
4.2a
T3B
R5B
T5A
Tree State 5.0
5.1
Utah and/or Western juniper co-dominate with mountain big sagebrush
Annual non-natives species present or co-dominant in understory
Perennial bunchgrasses present but declining
Sandberg's bluegrass increasing
Interspace bare ground significant
5.2
Utah and/or Western juniper dominate
Mountain big sagebrush minor component
Understory is severely reduced; invasive species present
Bare ground interspaces large and connected
Pedestalling, sheet erosion may be significant
5.1a

MLRA 23
Group 5
Loamy 12-14"
R023XY041NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T2C: Time and lack of disturbance allows for an increase in tree cover; inappropriate grazing management and/or chronic drought can reduce fine fuels and lead to increased tree establishment and dominance (5.1).

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: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T3B: Time and a lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management (5.1).

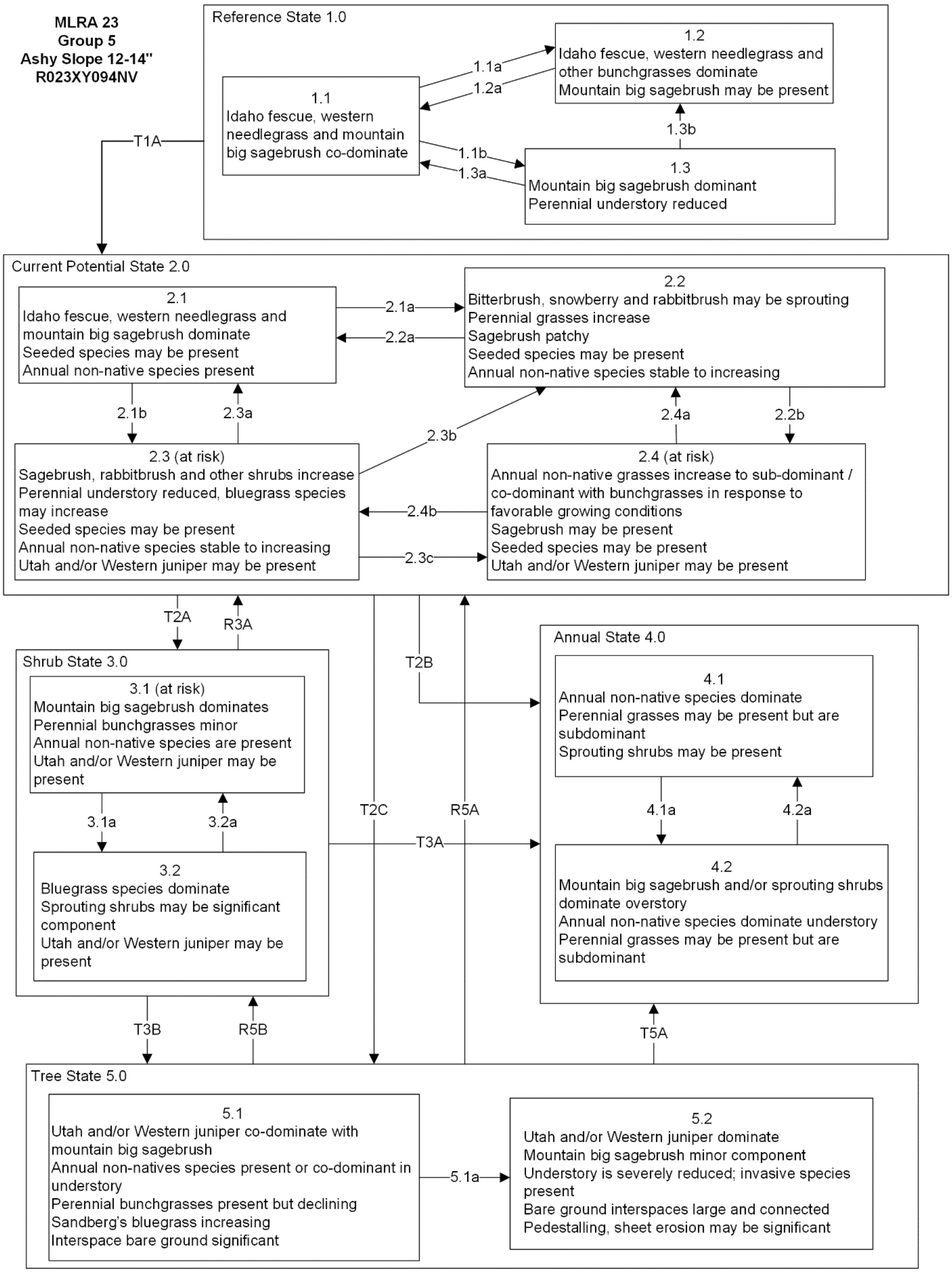
Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.

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

Restoration R5A: Tree removal and seeding of desired species or recovery of herbaceous understory.
Restoration R5B: Tree removal when Sandberg bluegrass is dominant and remains in understory.

Transition T5A: Catastrophic fire, inappropriate tree removal practices (4.1).


MLRA 23
Group 5
Ashy Slope 12-14"
R023XY094NV
Reference State 1.0
1.1
Idaho fescue, western needlegrass and mountain big sagebrush co-dominate
1.2
Idaho fescue, western needlegrass and other bunchgrasses dominate
Mountain big sagebrush may be present
1.3
Mountain big sagebrush dominant
Perennial understory reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Idaho fescue, western needlegrass and mountain big sagebrush dominate
Seeded species may be present
Annual non-native species present
2.2
Bitterbrush, snowberry and rabbitbrush may be sprouting
Perennial grasses increase
Sagebrush patchy
Seeded species may be present
Annual non-native species stable to increasing
2.3 (at risk)
Sagebrush, rabbitbrush and other shrubs increase
Perennial understory reduced, bluegrass species may increase
Seeded species may be present
Annual non-native species stable to increasing
Utah and/or Western juniper may be present
2.4 (at risk)
Annual non-native grasses increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Seeded species may be present
Utah and/or Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
R3A
T2B
T2C
R5A
Shrub State 3.0
3.1 (at risk)
Mountain big sagebrush dominates
Perennial bunchgrasses minor
Annual non-native species are present
Utah and/or Western juniper may be present
3.2
Bluegrass species dominate
Sprouting shrubs may be significant component
Utah and/or Western juniper may be present
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Perennial grasses may be present but are subdominant
Sprouting shrubs may be present
4.2
Mountain big sagebrush and/or sprouting shrubs dominate overstory
Annual non-native species dominate understory
Perennial grasses may be present but are subdominant
4.1a
4.2a
T3B
R5B
T5A
Tree State 5.0
5.1
Utah and/or Western juniper co-dominate with mountain big sagebrush
Annual non-natives species present or co-dominant in understory
Perennial bunchgrasses present but declining
Sandberg's bluegrass increasing
Interspace bare ground significant
5.2
Utah and/or Western juniper dominate
Mountain big sagebrush minor component
Understory is severely reduced; invasive species present
Bare ground interspaces large and connected
Pedestalling, sheet erosion may be significant
5.1a

MLRA 23
Group 5
Ashy Slope 12-14"
R023XY094NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T2C: Time and lack of disturbance allows for an increase in tree cover; inappropriate grazing management and/or chronic drought can reduce fine fuels and lead to increased tree establishment and dominance (5.1).

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: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T3B: Time and a lack of fire allows for trees to dominate site; may be coupled with inappropriate grazing management (5.1).

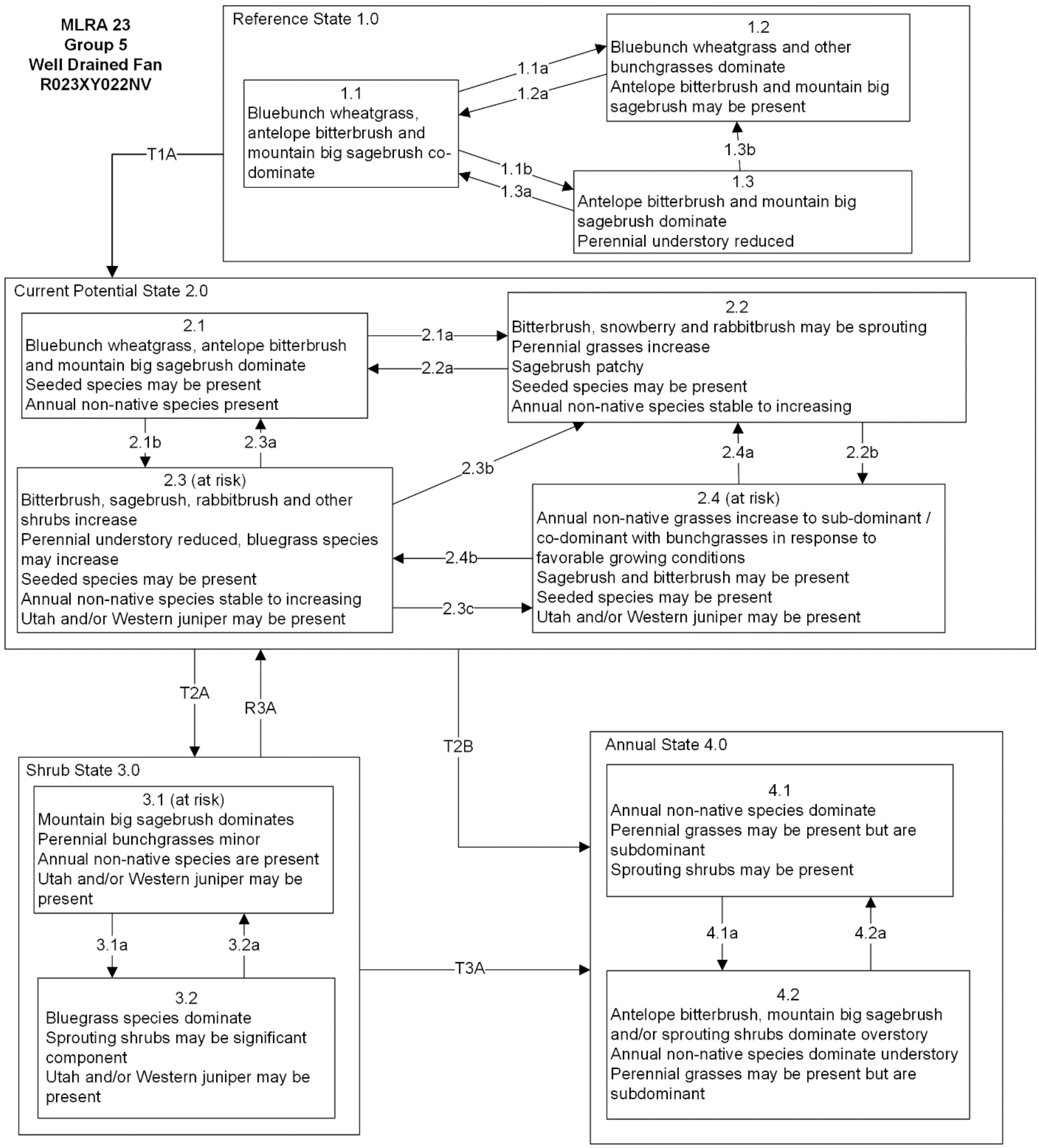
Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.

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

Restoration R5A: Tree removal and seeding of desired species or recovery of herbaceous understory.
Restoration R5B: Tree removal when Sandberg bluegrass is dominant and remains in understory.

Transition T5A: Catastrophic fire, inappropriate tree removal practices (4.1).


MLRA 23
Group 5
Well Drained Fan
R023XY022NV
Reference State 1.0
1.1
Bluebunch wheatgrass, antelope bitterbrush and mountain big sagebrush co-dominate
1.2
Bluebunch wheatgrass and other bunchgrasses dominate
Antelope bitterbrush and mountain big sagebrush may be present
1.3
Antelope bitterbrush and mountain big sagebrush dominate
Perennial understory reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass, antelope bitterbrush and mountain big sagebrush dominate
Seeded species may be present
Annual non-native species present
2.2
Bitterbrush, snowberry and rabbitbrush may be sprouting
Perennial grasses increase
Sagebrush patchy
Seeded species may be present
Annual non-native species stable to increasing
2.3 (at risk)
Bitterbrush, sagebrush, rabbitbrush and other shrubs increase
Perennial understory reduced, bluegrass species may increase
Seeded species may be present
Annual non-native species stable to increasing
Utah and/or Western juniper may be present
2.4 (at risk)
Annual non-native grasses increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush and bitterbrush may be present
Seeded species may be present
Utah and/or Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
R3A
T2B
Shrub State 3.0
3.1 (at risk)
Mountain big sagebrush dominates
Perennial bunchgrasses minor
Annual non-native species are present
Utah and/or Western juniper may be present
3.2
Bluegrass species dominate
Sprouting shrubs may be significant component
Utah and/or Western juniper may be present
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Perennial grasses may be present but are subdominant
Sprouting shrubs may be present
4.2
Antelope bitterbrush, mountain big sagebrush and/or sprouting shrubs dominate overstory
Annual non-native species dominate understory
Perennial grasses may be present but are subdominant
4.1a
4.2a

MLRA 23
Group 5
Well Drained Fan
R023XY022NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

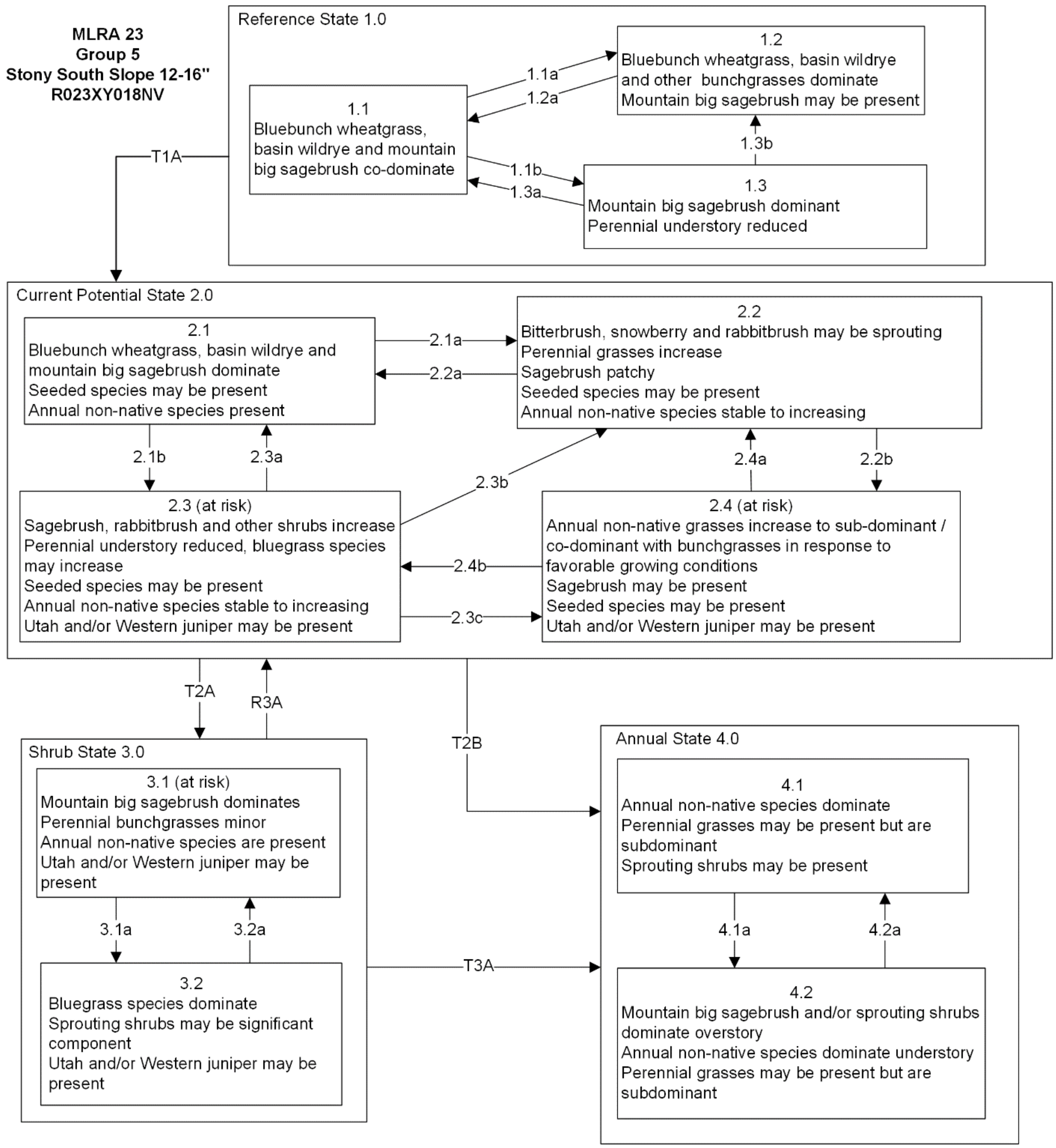
Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).

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: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).

Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.


MLRA 23
Group 5
Stony South Slope 12-16"
R023XY018NV
Reference State 1.0
1.1
Bluebunch wheatgrass, basin wildrye and mountain big sagebrush co-dominate
1.2
Bluebunch wheatgrass, basin wildrye and other bunchgrasses dominate
Mountain big sagebrush may be present
1.3
Mountain big sagebrush dominant
Perennial understory reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass, basin wildrye and mountain big sagebrush dominate
Seeded species may be present
Annual non-native species present
2.2
Bitterbrush, snowberry and rabbitbrush may be sprouting
Perennial grasses increase
Sagebrush patchy
Seeded species may be present
Annual non-native species stable to increasing
2.3 (at risk)
Sagebrush, rabbitbrush and other shrubs increase
Perennial understory reduced, bluegrass species may increase
Seeded species may be present
Annual non-native species stable to increasing
Utah and/or Western juniper may be present
2.4 (at risk)
Annual non-native grasses increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush may be present
Seeded species may be present
Utah and/or Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
R3A
T2B
Shrub State 3.0
3.1 (at risk)
Mountain big sagebrush dominates
Perennial bunchgrasses minor
Annual non-native species are present
Utah and/or Western juniper may be present
3.2
Bluegrass species dominate
Sprouting shrubs may be significant component
Utah and/or Western juniper may be present
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Perennial grasses may be present but are subdominant
Sprouting shrubs may be present
4.2
Mountain big sagebrush and/or sprouting shrubs dominate overstory
Annual non-native species dominate understory
Perennial grasses may be present but are subdominant
4.1a
4.2a

MLRA 23
Group 5
Stony South Slope 12-16"
R023XY018NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

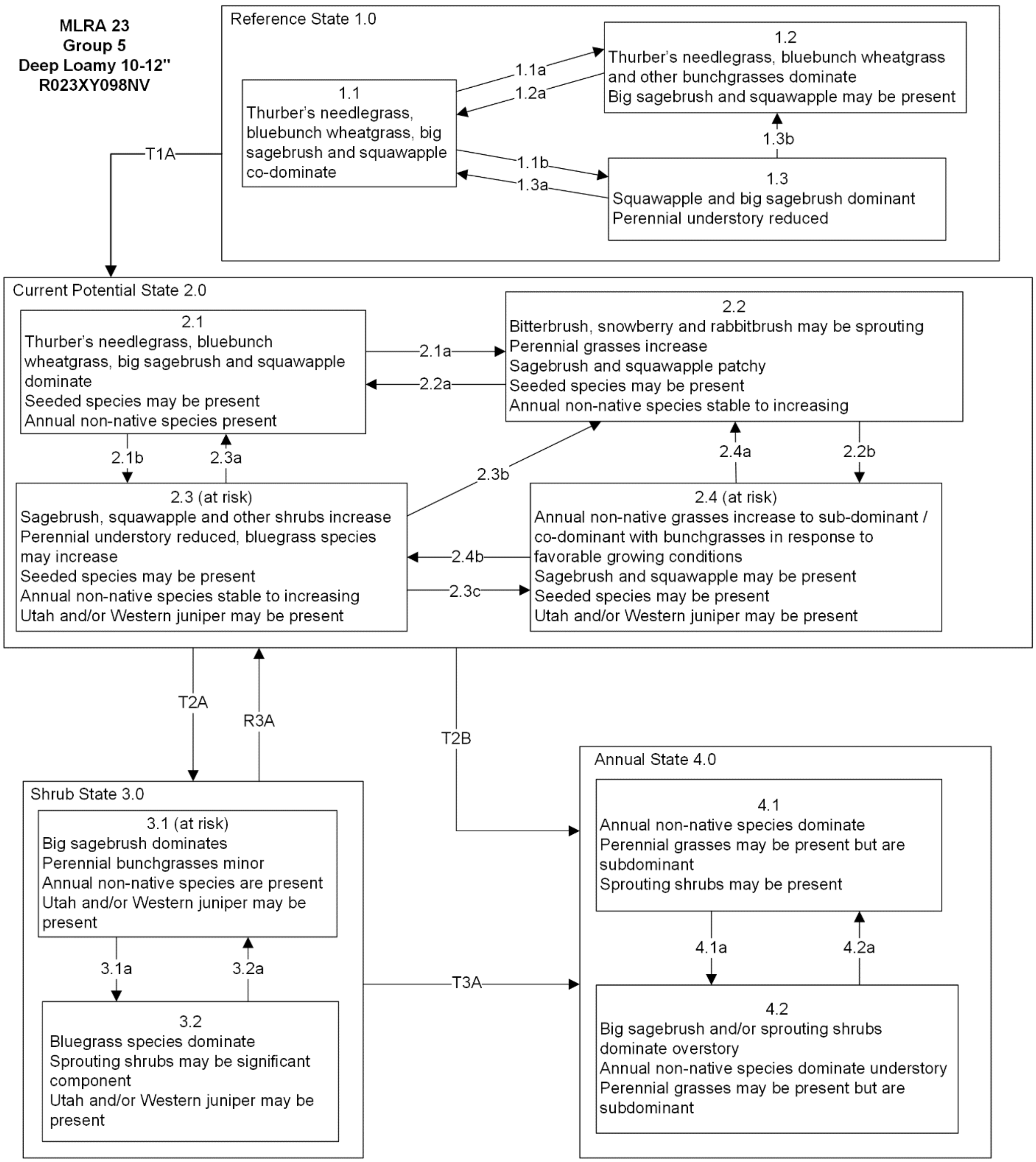
Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).

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: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).

Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.


MLRA 23
Group 5
Deep Loamy 10-12"
R023XY098NV
Reference State 1.0
1.1
Thurber's needlegrass, bluebunch wheatgrass, big sagebrush and squawapple co-dominate
1.2
Thurber's needlegrass, bluebunch wheatgrass and other bunchgrasses dominate
Big sagebrush and squawapple may be present
1.3
Squawapple and big sagebrush dominant
Perennial understory reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Thurber's needlegrass, bluebunch wheatgrass, big sagebrush and squawapple dominate
Seeded species may be present
Annual non-native species present
2.2
Bitterbrush, snowberry and rabbitbrush may be sprouting
Perennial grasses increase
Sagebrush and squawapple patchy
Seeded species may be present
Annual non-native species stable to increasing
2.3 (at risk)
Sagebrush, squawapple and other shrubs increase
Perennial understory reduced, bluegrass species may increase
Seeded species may be present
Annual non-native species stable to increasing
Utah and/or Western juniper may be present
2.4 (at risk)
Annual non-native grasses increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Sagebrush and squawapple may be present
Seeded species may be present
Utah and/or Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.4a
2.2b
2.4b
2.3c
T2A
R3A
T2B
Shrub State 3.0
3.1 (at risk)
Big sagebrush dominates
Perennial bunchgrasses minor
Annual non-native species are present
Utah and/or Western juniper may be present
3.2
Bluegrass species dominate
Sprouting shrubs may be significant component
Utah and/or Western juniper may be present
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Perennial grasses may be present but are subdominant
Sprouting shrubs may be present
4.2
Big sagebrush and/or sprouting shrubs dominate overstory
Annual non-native species dominate understory
Perennial grasses may be present but are subdominant
4.1a
4.2a

MLRA 23
Group 5
Deep Loamy 10-12"
R023XY098NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).

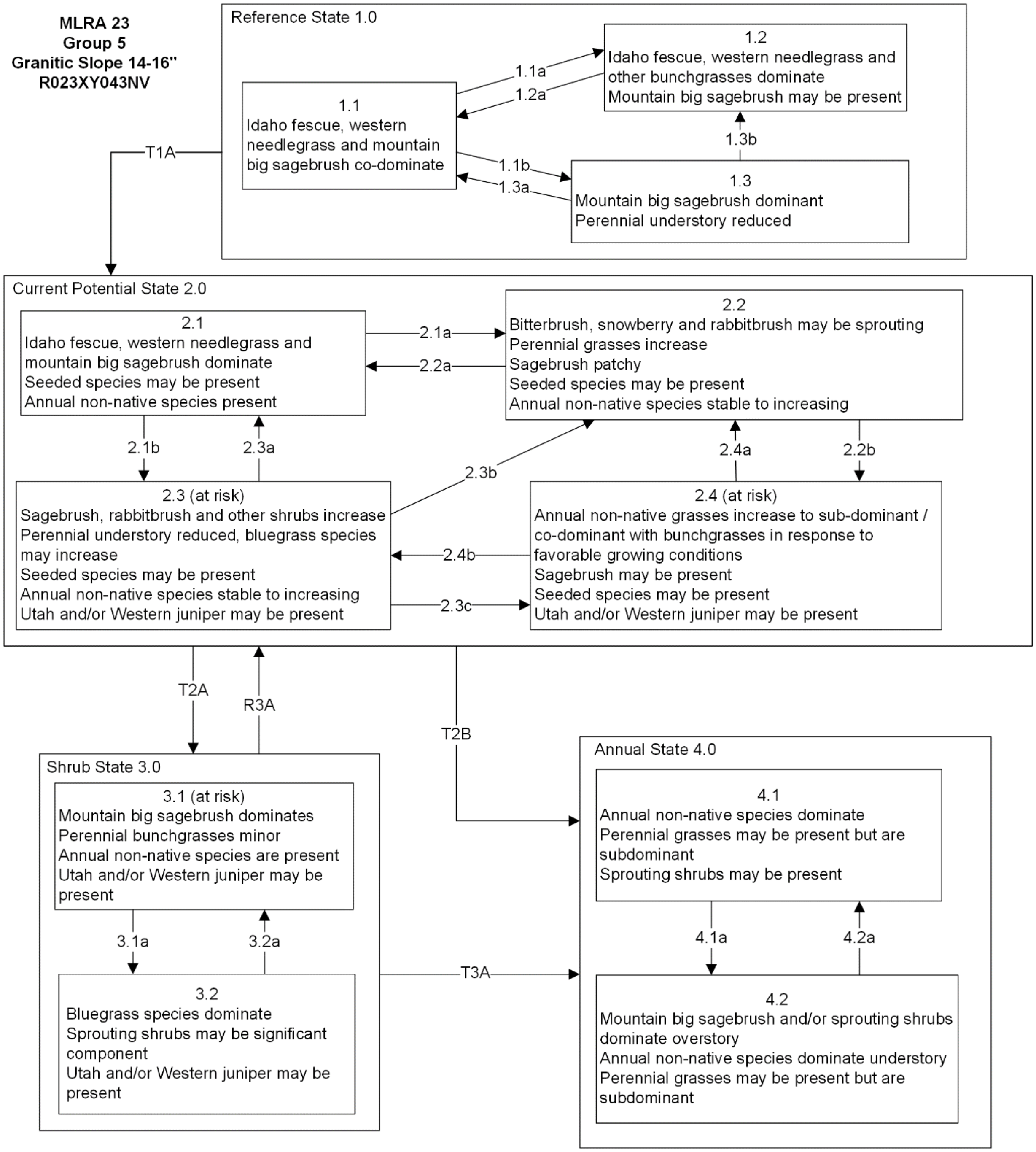
Shrub State 3.0 Community Phase Pathways
3.1a: Fire and/or brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (not likely to occur).

Transition T3A: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).

Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.

MLRA 23
Group 5
Granitic Slope 14-16"
R023XY043NV



MLRA 23
Group 5
Granitic Slope 14-16"
R023XY043NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (4.2).

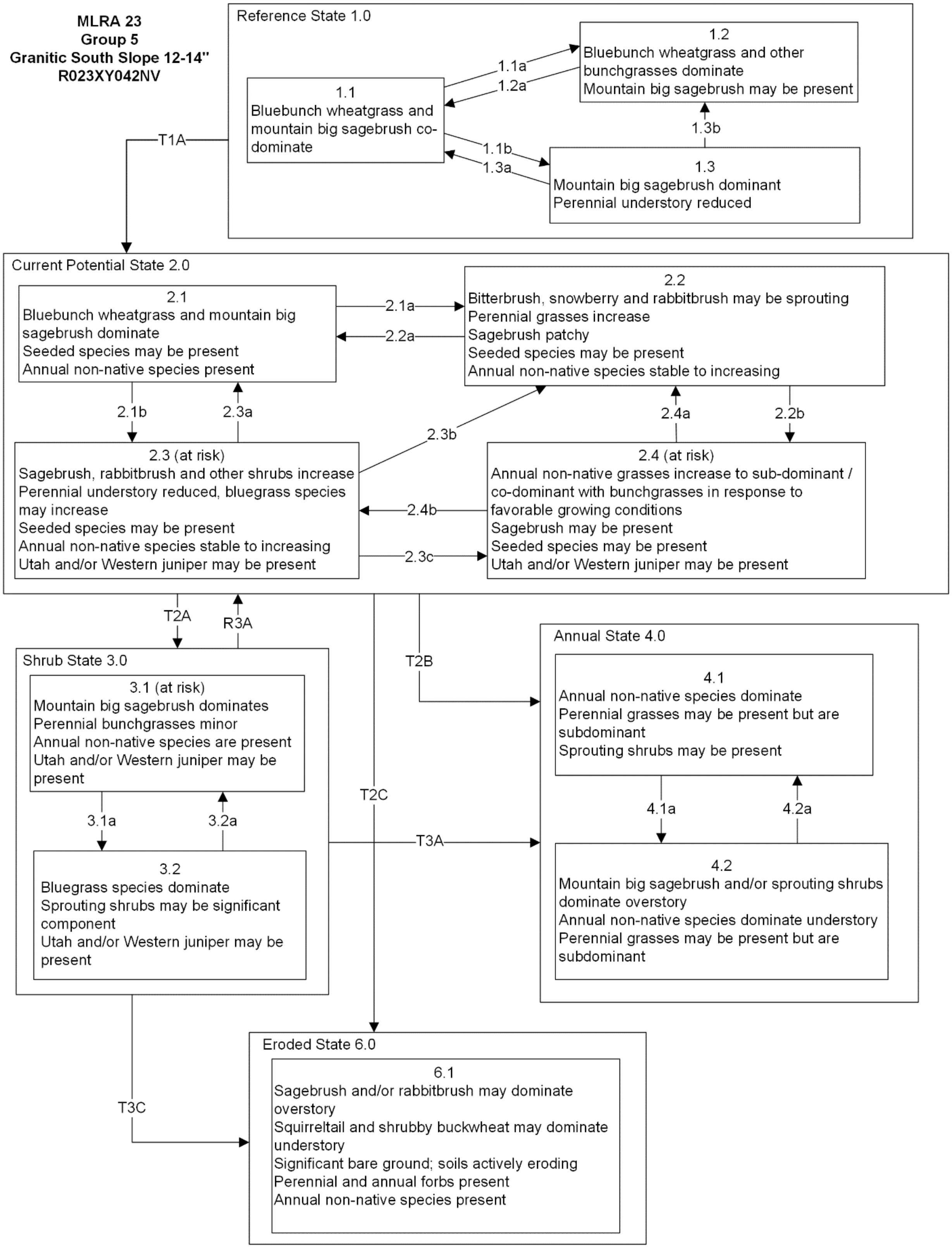
Shrub State 3.0 Community Phase Pathways
3.1a: Fire and/or brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (not likely to occur).

Transition T3A: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).

Restoration R3A: Shrub removal/management with minimal soil disturbance coupled with seeding of desired species.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.

MLRA 23
Group 5
Granitic South Slope 12-14"
R023XY042NV



MLRA 23
Group 5
Granitic South Slope 12-14"
R023XY042NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 and/or excessive herbivory and/or chronic drought may also decrease perennial understory.
1.2a: Time and lack of disturbance such as fire allows for regeneration of sagebrush.
1.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic.
1.3b: High severity fire 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 or Aroga moth infestation 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 and/or inappropriate grazing management and/or chronic drought facilitate an increased shrub overstory and decreased bunchgrass understory.
2.2a: Time and lack of disturbance allows for sagebrush 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: Low severity fire and/or Aroga moth infestation creates sagebrush/ bunchgrass mosaic. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads 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: Fall and spring growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Fall and spring growing season conditions unfavorable to cheatgrass production.

Transition T2A: Time and lack of disturbance such as fire combined with inappropriate grazing management (3.1).
Transition T2B: Multiple fires (4.1), inappropriate grazing management in the presence of annual non-native species (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: Catastrophic fire and/or soil disturbing vegetation and seeding treatments that fail (4.1). Inappropriate grazing management in the presence of annual non-native species (4.2).
Transition T3C: Inappropriate grazing management and/or soil disturbing treatments significantly reduces perennial cover and increases soil erosion.

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (unlikely to occur).
4.2a: Fire.

Eroded State 6.0 Community Phase Pathways
None.

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Group 6: High-resilience mountain big sagebrush and Idaho fescue

Description of MRLA 23 DRG 6:

Disturbance Response Group (DRG) 6 consists of ten ecological sites ranging in precipitation from 10 to over 20 inches per year. The elevation of this group ranges from 5,700 to 9,000 feet. Slopes range widely from 2 to 50 percent. Soils on these sites are typically moderately deep to deep and well drained. The soils are moderately fine to coarse textured and vary in their depths. The available water holding capacity ranges from low to high. Sites in this group with ashy soils tend to have a high water holding capacity even at lower precipitation ranges. The potential native plant community of these sites is dominated by mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) and Idaho fescue (*Festuca idahoensis).* Needlegrasses (*Achnatherum spp*.). Bluebunch wheatgrass (*Pseudoroegnaria spicata*), and antelope bitterbrush (*Purshia tridentata*) are also common throughout these sites. Forbs such as balsamroot (*Balsamorhiza sagittata*), hawksbeard (*Crepis spp.),* and lupines (*Lupinu*s spp.) are common on these sites and make up a minor component of total annual production. The annual production of this group has a wide range from 700 to 1500 pounds per acre for a normal year.

Disturbance Response Group 6 Ecological Sites:

Ashy Loam 14-16" – Modal	023XY066NV
Mountain Shoulders 14-18"	023XY061NV
Ashy Sandy Loam 10-12"	023XY096NV
Steep North Slope 14+"	023XY054NV
Granitic Loam 14-16"	023XY058NV
Stony Granitic Slope 14+”	023XY050NV
Gravelly North Slope	023XY053NV
South Slope 16+”	023XY064NV
Ashy Loam 10-12"	023XY071NV
Deep Loamy 14-16"	023XY084NV

Modal Site:

The Ashy Loam 14-16” (023XY066NV) modal site occurs on mountain sideslopes and mountain valley fans on all aspects. Slope gradients of 2 to 15 percent are typical for this site. Elevations in this site range from 6,000 to 8,000 feet. Soils on this site are derived from colluvium and residuum of volcanic rocks. The soils in this site are moderately deep to deep and well drained and have high amounts of vitric volcanic ash throughout the soil profile, resulting in high water holding capacity. These soils are moderately coarse to medium textured and more than ten inches thick to the subsoil or underlying material. Soils are neutral to slightly acid. The plant community is dominated by Idaho fescue, needlegrasses, mountain big sagebrush and antelope bitterbrush. Bluebunch wheatgrass is also common throughout this site. Mountain big sagebrush is usually prevalent enough to dominate the visual aspect. Normal year production is 1,300 lb/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 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).

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).

Although these sites were not seen with significant cover of non-native species, it is important to recognize the potential impact of invasion. 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 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).

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).

The perennial bunchgrasses that are dominant on this site include Idaho fescue and bluebunch 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 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.

South slopes will generally express a higher abundance of bluebunch wheatgrass, while north slopes will have more Idaho fescue. Production will be higher on sites with deeper soils. Overgrazing by livestock and horses will cause a decrease in deep-rooted perennial bunchgrasses, mainly Idaho fescue and bluebunch wheatgrass. Continued inappropriate grazing may result in an increase in bluegrasses, balsamroot, lupine, sagebrush, and Rabbitbrush (*Chrysothamnus visidiflorus)*.

The ecological sites in this DRG have high resilience to disturbance and resistance to invasion. Resilience increases with elevation, aspect, increased precipitation and nutrient availability. Two possible stable states have been identified for this group. Minor differences in resilience to disturbance for the remaining ecological sites contained within this DRG are described at the end of this document.

Fire Ecology:

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 2001). 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 2009). The introduction of annual weedy species, like cheatgrass, may cause an increase in fire frequenc and put the site at risk for further invasion. Fire is a natural disturbance in this ecosystem; without fire, juniper may increase, however it was never seen in large quanitities during site visits.

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). 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 and snowberry 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). Snowberry is also 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). If balsamroot or mules ear is common before fire, they will increase after fire or with heavy grazing (Wright 1985).

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).

Idaho fescue, the dominant grass within this community, response to fire varies with condition and size of the plant, season and severity of fire, and ecological conditions. The bunchgrass can survive light-severity fires, but can be severely damaged by fire in all seasons (Wright et al. 1979, Wright 1985). Idaho fescue is a dense, fine-leaved bunchgrass, which allows fires to burn and smolder in the accumulated leaves at the base of the plant. Rapid tillering can occur after fire when root crowns are not killed and soil moisture is favorable (Johnson et al. 1994, Robberecht and Defossé 1995).

Bluebunch wheatgrass has coarse stems with little leafy material, therefore the tops aboveground biomass burns rapidly and little heat is transferred downward into the crowns (Young 1983). Bluebunch wheatgrass was described as fairly tolerant of burning, other than in May in eastern Oregon (Britton et al. 1990). Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage from fire but is more susceptible in drought years (Young 1983). Most authors classify the plant as undamaged by fire (Kuntz 1982).

The grasses likely to invade this site are cheatgrass and medusahead. These invasive grasses can 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).

Livestock/Wildlife Grazing Interpretations:

Sheehy and 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. 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 (Kasworm et al. 1984).

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). 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). Grazing tolerance of antelope bitterbrush is dependent on site conditions (Garrison 1953).

Idaho fescue is valuable forage for livestock and wildlife. However, Idaho fescue decreases under heavy grazing by livestock (Eckert and Spencer 1986, Eckert and Spencer 1987) and wildlife (Gaffney 1941).

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975, Britton et al. 1990). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949). Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.

Reduced bunchgrass vigor or density provides an opportunity for bluegrass expansion and/or cheatgrass and other invasive species to occupy interspaces, leading to increased fire frequency and potentially an annual plant community. Bluegrasses increase under grazing pressure (Tisdale and Hironaka 1981) and is capable of co-existing with cheatgrass. Excessive sheep grazing favors 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 bluegrass or cheatgrass may become the dominant understory with inappropriate grazing management.

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

State and Transition Model Narrative Group 6:

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 6.

Reference State 1.0:

The Reference State 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:
The plant community is dominated by Idaho fescue with smaller components of bluebunch wheatgrass and basin wildrye. Mountain big sagebrush is the dominant shrub, with antelope bitterbrush subdominant. An assortment of forbs is present and may comprise a significant portion of total production.

Ashy Loam 14-16 (R023XY066NV) Phase 1.1 T. K. Stringham, July 2015

Ashy Sandy Loam 10-12" (023XY096NV) Phase 1.1. T. Stringham, August 2014

Steep North Slope (R023XY054NV) Phase 1.1 T. K. Stringham, July 2015

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 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 decrease significant reduction in sagebrush within the community, giving 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 allows 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 allowing big sagebrush to dominate the site.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early seral community phase. Idaho fescue, bluebunch wheatgrass and other perennial grasses dominate. Big sagebrush is

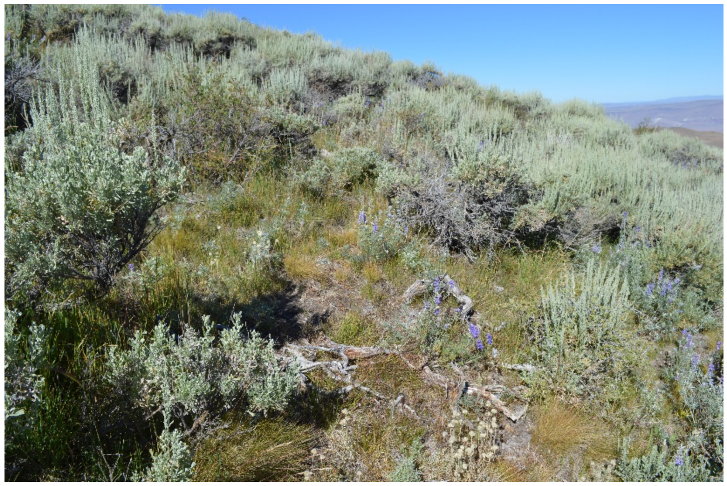
killed by fire and will be reduced or eliminated from the burned community. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain. Forbs may increase post-fire but will likely return to pre-burn levels within a few years.

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

Community Phase 1.3:
Mountain 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 and/or from herbivory. Bluegrasses and/or squirreltail will likely increase in the understory.

Mountain Shoulder 14-18" (023XY061NV) Phase 1.3. T. Stringham, August 2014

Ashy Loam 14-16 (R023XY066NV) Phase 1.3 T. K. Stringham, July 2015



Loamy Slope 16+ (R023XY065NV) Phase 1.3 D. Snyder, July 2016

Community Phase Pathway 1.3a, from phase 1.3 to 1.1:
A low severity fire, Aroga moth or combinations of these disturbances will reduce the sagebrush overstory and create a sagebrush/grass mosaic with sagebrush and perennial bunchgrasses codominant.

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 will typically be low severity due to low fine 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: Introduction of annual non-native species.

Slow variable: 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 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 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. The plant community is dominated by Idaho fescue with smaller components of bluebunch wheatgrass and basin wildrye. Mountain big sagebrush is the dominant shrub with antelope bitterbrush also common on this site. Smooth brome or other perennial non-native bunchgrasses may be present. Cheatgrass is the most likely species to invade.

Ashy Sandy Loam 10-12" (023XY096NV) Phase 2.1. T. Stringham, August 2014
This site showed evidence of shrub decadence on the Wyoming and basin big sagebrush from an Aroga moth outbreak.

Mountain Shoulder 14-18 (R023XY061NV) Phase 2.1 T. K. Stringham, June 2015

Community Phase Pathway 2.1a, from phase 2.1 to 2.2:
Fire will decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Fires will 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 2.1b, from phase 2.1 to 2.3:
Time and lack of disturbance allows sagebrush to increase and become decadent. Chronic drought will reduce fine fuels and lead to a reduced fire frequency allowing big sagebrush to dominate the site. Inappropriate grazing management will reduce the perennial bunchgrass understory; conversely bluegrasses may increase in the understory depending on grazing management. Excessive sheep grazing favors short-statured bluegrasses; however, where cattle are the dominant grazers, cheatgrass often increases.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early seral community phase where non-native species are present. Idaho fescue, bluebunch wheatgrass and other perennial grasses dominate. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain. Rabbitbrush may be sprouting. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Annual non-native species are stable or increasing within the community, still only present in low numbers.

Ashy Sandy Loam 10-12” (023XY096NV). Phase 2.2. T. Stringham, August 2014

Ashy Sandy Loam 10-12" (023XY096NV). Phase 2.2. T. Stringham, August 2014

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 big sagebrush can take many years.

Community Phase 2.3:
Mountain big sagebrush, rabbitbrush and bitterbrush increase, Idaho fescue and bluebunch wheatgrass decrease. Bluegrasses may be increasing. Smooth brome and other non-native species are stable to increasing. Juniper and pinyon may be present as a result of encroachment from neighboring sites, and lack of disturbance.

Community Phase Pathway 2.3a, from phase 2.3 to 2.1:
A low severity fire, Aroga moth or combinations will reduce the sagebrush overstory and create a sagebrush/grass mosaic.

Community Phase Pathway 2.3b, 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. 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 are likely to increase after fire.

Potential Resilience Differences with other Ecological Sites:

Mountain Shoulders 14-18" (023XY061NV):

This site is significantly less productive than the modal site with only 700 lbs/ac in normal years. Soils on this site are shallow and have high amounts of coarse fragments in the soil profile. This community occurs on wind-swept mountain summits and shoulders and tends to have heavy snowpack until late spring. Mountain big sagebrush on this site tends to be low in stature due to these severe environmental conditions. Needlegrasses such as Columbia, western, and Letterman's are common grasses along with Idaho fescue and bluebunch wheatgrass. Forbs are common. Slopes typically range from 2 to 15 percent, elevations range from 6700 to 8500 feet, and precipitation ranges from 14 to over 18 inches. This site is similar to the modal site with 2 stable states.

Ashy Sandy Loam 10-12" (023XY096NV):

This site is less productive than the modal site with only 900 lbs/ac in normal years. Soils on this site have high amounts of vitric volcanic ash and glass throughout the soil profile which enhances water holding capacity. Soils are moderately coarse to medium textured allowing for rapid infiltration of water. This site can have a mix of Wyoming, basin, and mountain big sagebrush. Thurber's needlegrass is more dominant than Idaho fescue or bluebunch wheatgrass. This site is similar to the modal site with 2 stable states.

Steep North Slope 14+"(023XY054NV):

This site has similar productivity and soils to the modal site but occurs on northern-aspect slopes that typically range from 30 to 50 percent with precipitation up to 18 inches annually. Idaho fescue and Cusick's bluegrass occur more frequently on the site than bluebunch wheatgrass. This site is similar to the modal site with 2 stable states.

Granitic Loam 14-16" (023XY058NV):

This site is slightly less productive than the modal site with only 1300 lbs/ac in favorable years. Soils on this site are well-drained, formed from granitic rock sources, and have a shallow rooting depth to soft bedrock. Water holding capacity is low. Needlegrasses (i.e. Letterman's, Columbia, and western) dominate the grass community rather than Idaho fescue and bluebunch wheatgrass. This site is similar to the modal site with 2 stable states.

Stony Granitic Slope 14+" (023XY050NV)

This site is less productive than the modal site with only 900 lbs/ac in normal years. Slopes typically range from 30 to 50 percent with elevations from 7000 – 9000 ft. Soils are doughtier than others at this elevation due to low available water capacity and the wind-prone physiographic setting these sites occur within. The dominant grasses that grow in this site are bluebunch wheatgrass and basin wildrye. This site is likely similar to the modal site with 2 stable states, however this site was not seen during site visits for this report.

Gravelly North Slope (023XY053NV):

This site is slightly less productive than the modal site with 1000 lbs/ac in normal years. Soils are similar to those of the modal site, however this site is restricted to smooth to convex north-facing backslopes of mountains. Threetip sagebrush (*Artemisia tripartita*) is the dominant shrub. Research reports threetip sagebrush to have variable sprouting-behavior after fire (Akinsoji 1988, Bunting et al. 1987) and is unpalatable to livestock (Rosentreter 2005). Idaho fescue and Cusick's bluegrass occur more frequently on the site than bluebunch wheatgrass. This site is similar to the modal site with 2 stable states.

South Slope 16+" (023XY064NV)

This site is more productive than the modal site with 1400 lbs/ac in normal years. Surface soils are medium to moderately coarse textured and generally more than 20 inches thick. Available water capacity is low to moderate. Because of the southerly exposures of this site, more sunlight is received and the soils tend to warm and plant growth is initiated earlier than on adjacent sites. High evapotranspiration potentials result in depletion of the available soil moisture supply sooner than on surrounding areas at the high elevations where this site occurs. Runoff is medium to rapid and the potential for sheet and rill erosion is moderate to high depending upon slope. This site is likely similar to the modal site with 2 stable states, however this site was not seen during site visits for this report.

Ashy Loam 10-12" (023XY071NV):

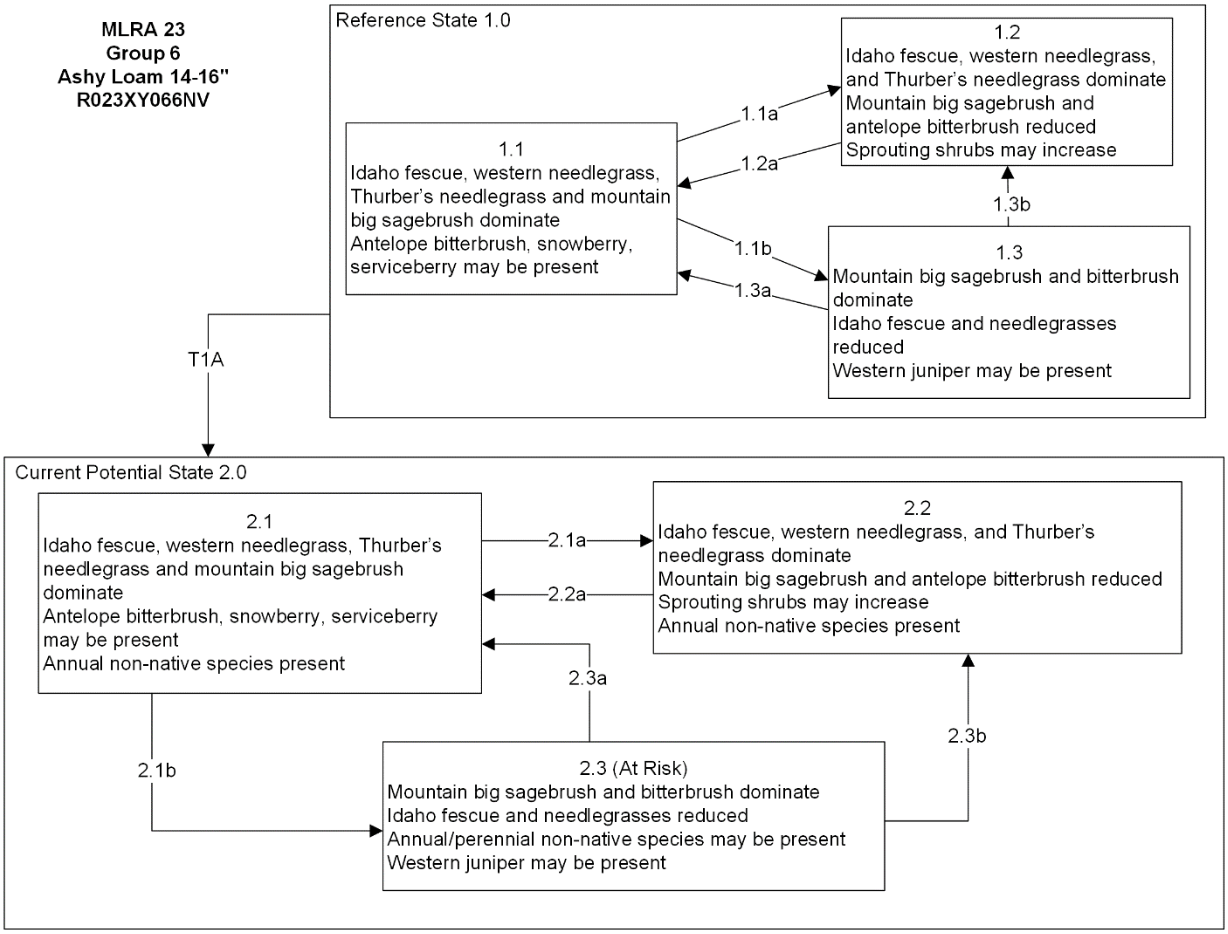
The site is slightly less productive than the modal site with 1100 lbs/ac in normal years. This site is found on concave positions of upper fan piedmonts and inset fans with slope typically ranging from 2 to 4 percent. Soils on this site are moderately deep to deep and available water capacity is high in part due to the high amounts of volcanic ash and glass throughout the soil profile. This site is dominated by basin big sagebrush rather than mountain big sagebrush. Unlike the modal site, the grass community is dominated by Idaho fescue and Thurber's needlegrass with bluebunch wheatgrass representing only a small component. This site is likely similar to the modal site with 2 stable states, however this site was not seen during site visits for this report.

Deep Loamy 14-16" (023XY084NV):

This site is more productive than the modal site with 1500 lbs/ac in normal years. Soils on this site are deep, fertile, and well-drained. These soils have high amounts of vitric volcanic ash and glass throughout the soil profile which enhances water holding capacity. Unlike the modal site, the grass community is dominated by Idaho fescue and needlegrasses (i.e. Letterman's, Columbia, and western) with bluebunch wheatgrass representing only a small component. This site is likely similar to the modal site with 2 stable states, however this site was not seen during site visits for this report.

Modal State and Transition Model for Group 6 in MRLA 23:

MLRA 23
Group 6
Ashy Loam 14-16"
R023XY066NV



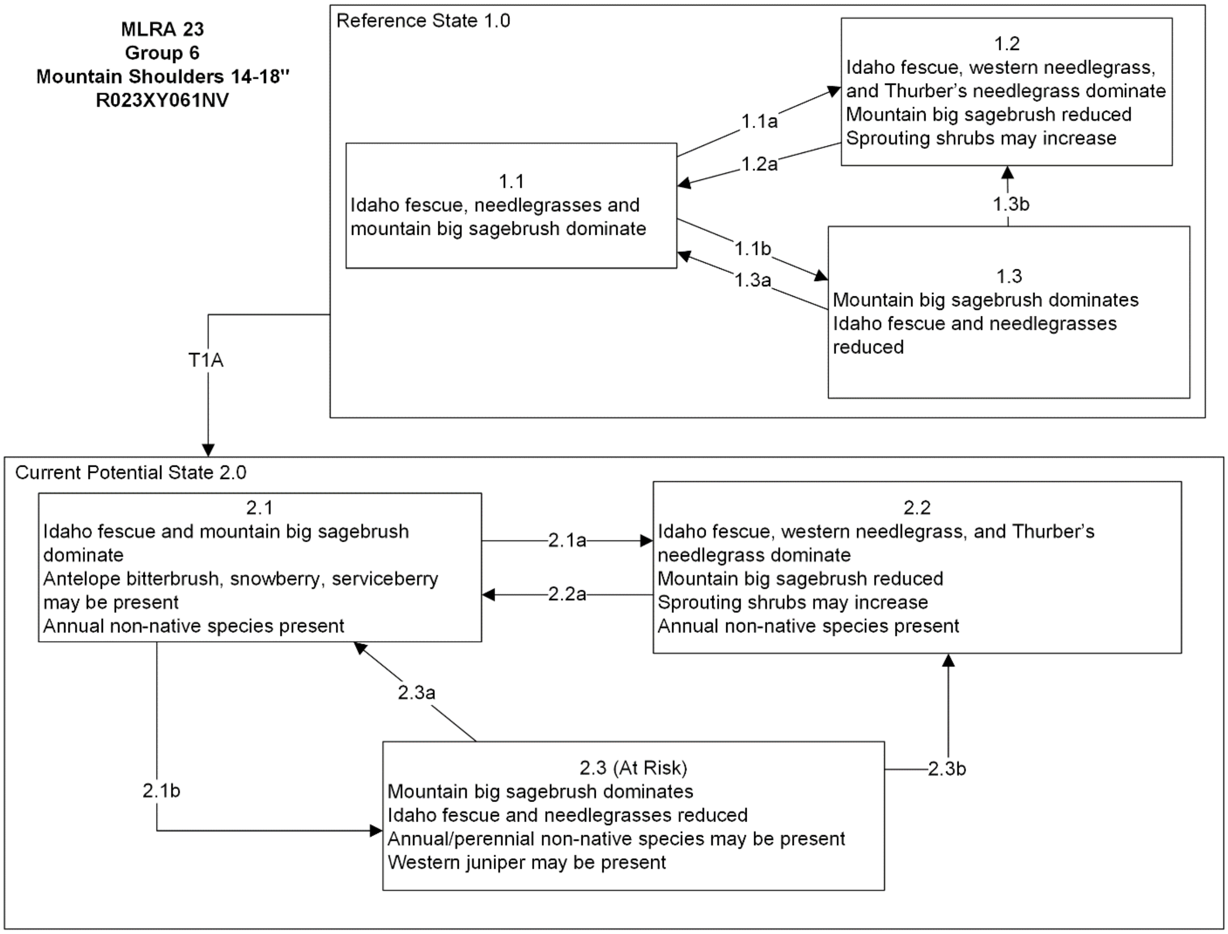
MLRA 23
Group 6
Ashy Loam 14-16"
R023XY066NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.

Additional State and Transition Models for Group 6 in MRLA 23:

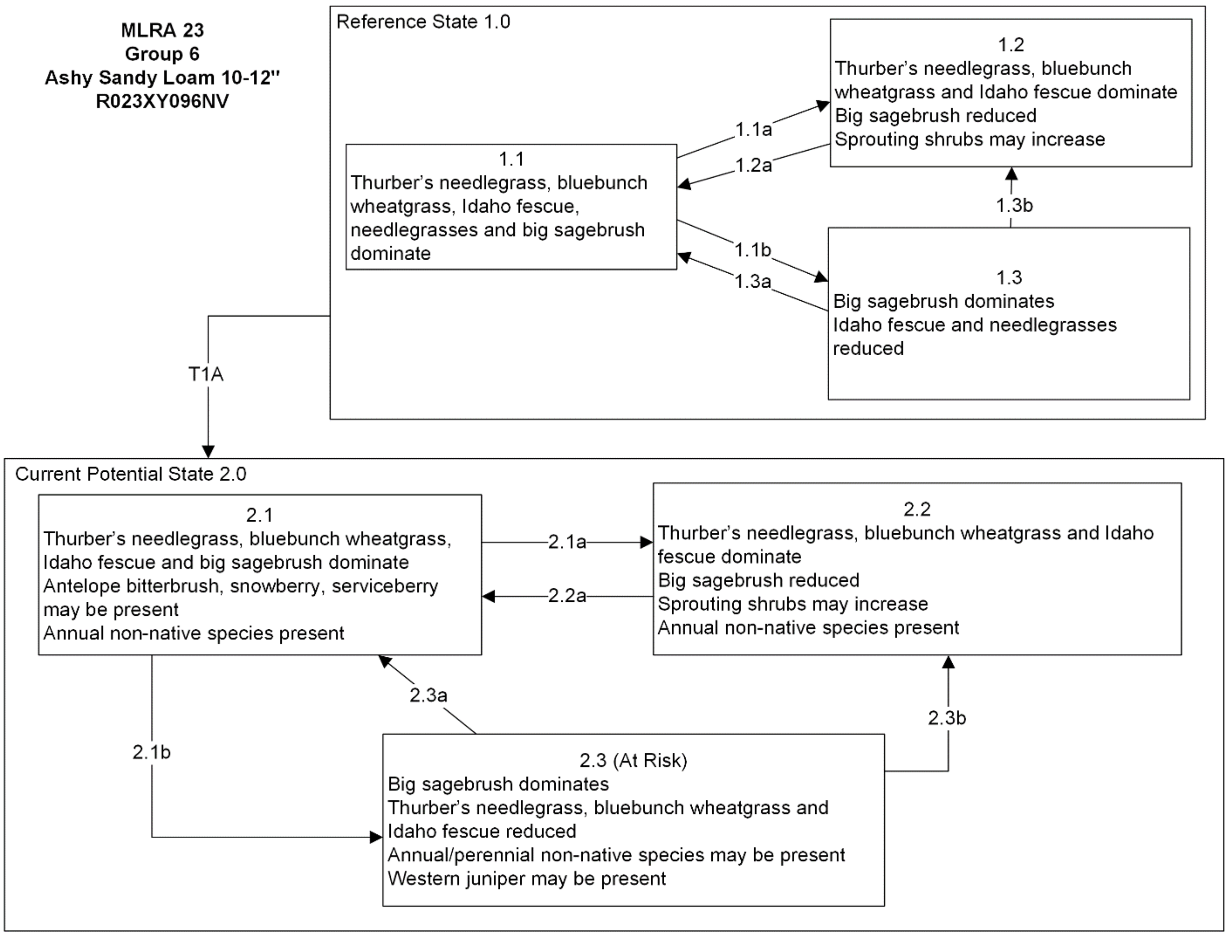


MLRA 23
Group 6
Mountain Shoulders 14-18"
R023XY061NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.



MLRA 23
Group 6
Ashy Sandy Loam 10-12"
R023XY096NV
Reference State 1.0
1.1
Thurber's needlegrass, bluebunch wheatgrass, Idaho fescue, needlegrasses and big sagebrush dominate
1.2
Thurber's needlegrass, bluebunch wheatgrass and Idaho fescue dominate
Big sagebrush reduced
Sprouting shrubs may increase
1.3
Big sagebrush dominates
Idaho fescue and needlegrasses reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Thurber's needlegrass, bluebunch wheatgrass, Idaho fescue and big sagebrush dominate
Antelope bitterbrush, snowberry, serviceberry may be present
Annual non-native species present
2.2
Thurber's needlegrass, bluebunch wheatgrass and Idaho fescue dominate
Big sagebrush reduced
Sprouting shrubs may increase
Annual non-native species present
2.3 (At Risk)
Big sagebrush dominates
Thurber's needlegrass, bluebunch wheatgrass and Idaho fescue reduced
Annual/perennial non-native species may be present
Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b

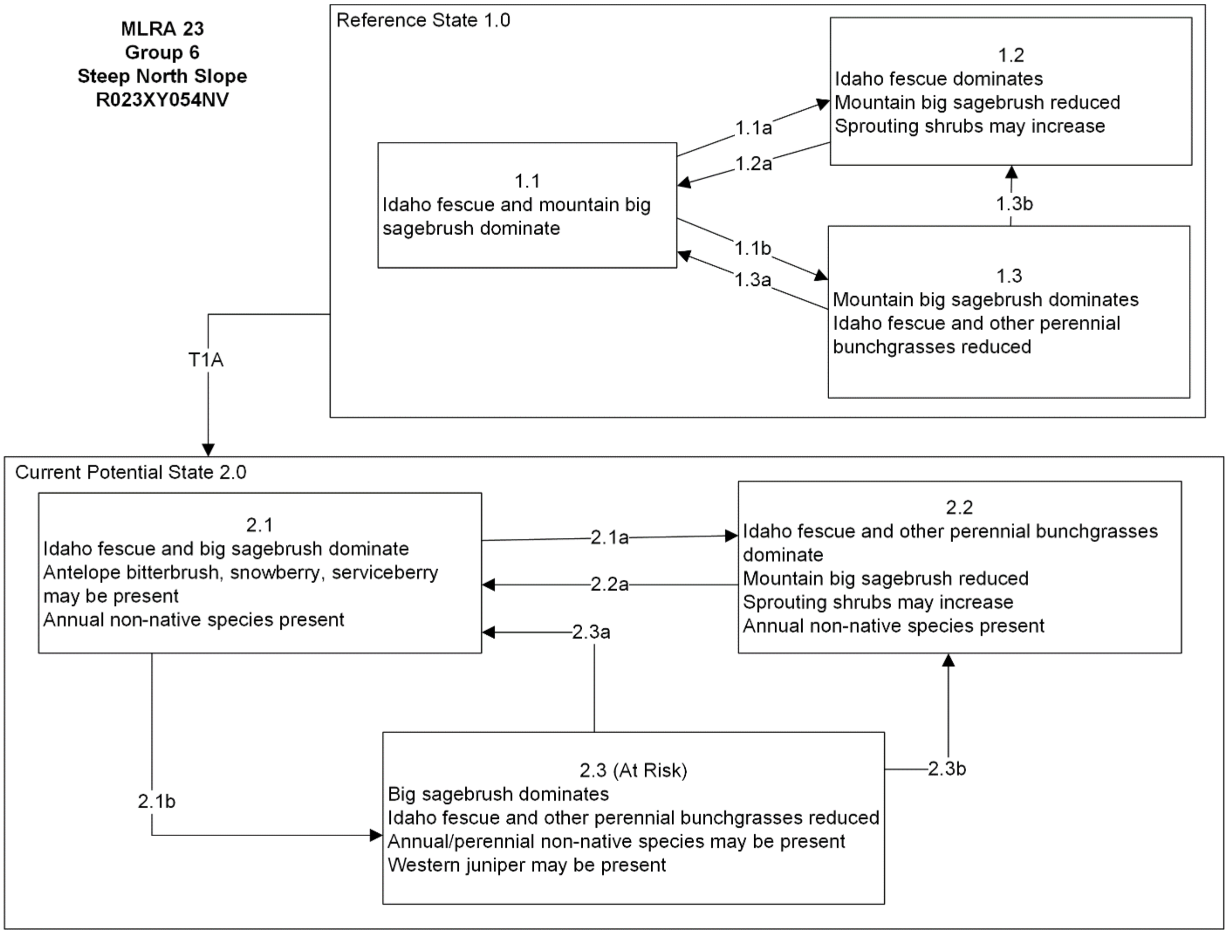
MLRA 23
Group 6
Ashy Sandy Loam 10-12"
R023XY096NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.

MLRA 23
Group 6
Steep North Slope
R023XY054NV

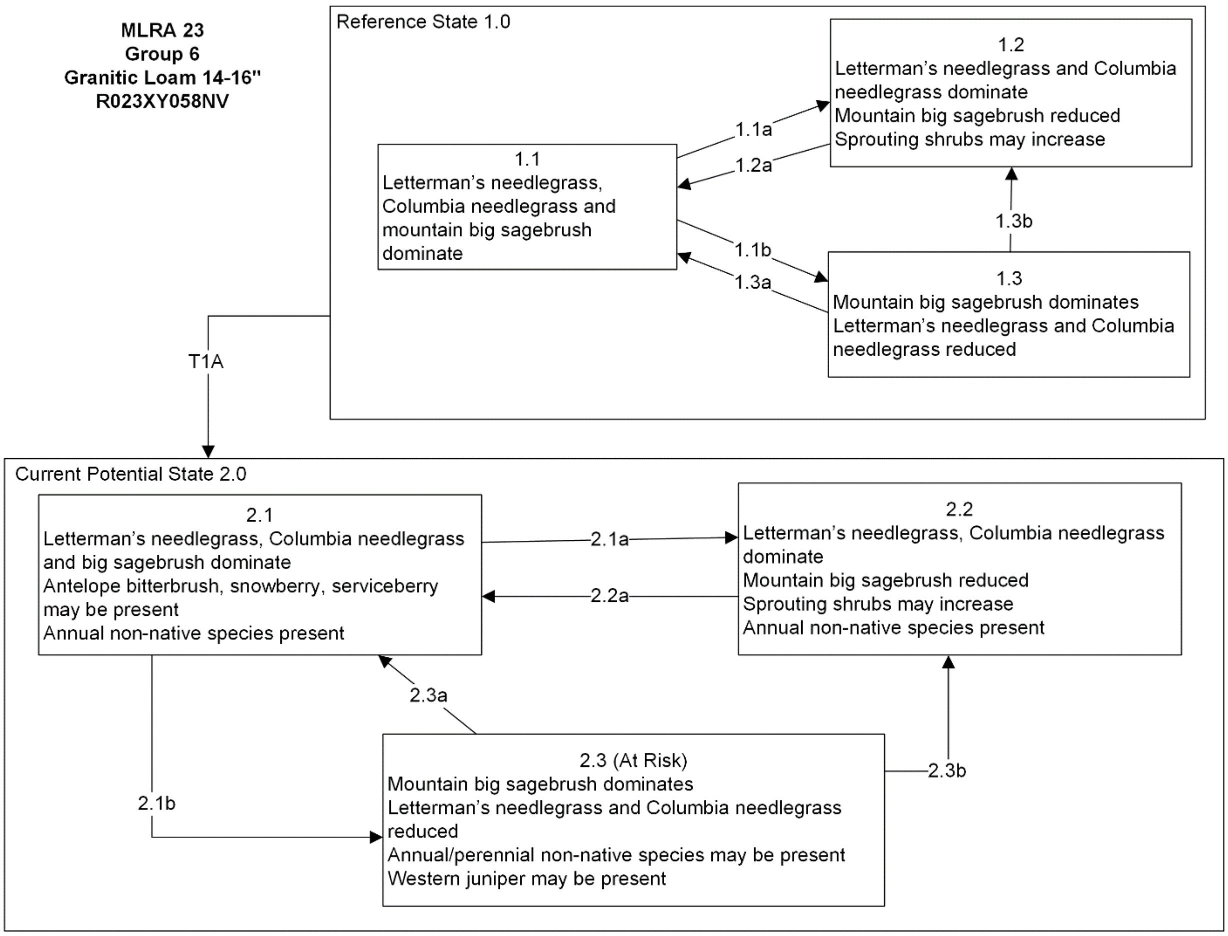


MLRA 23
Group 6
Steep North Slope
R023XY054NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.

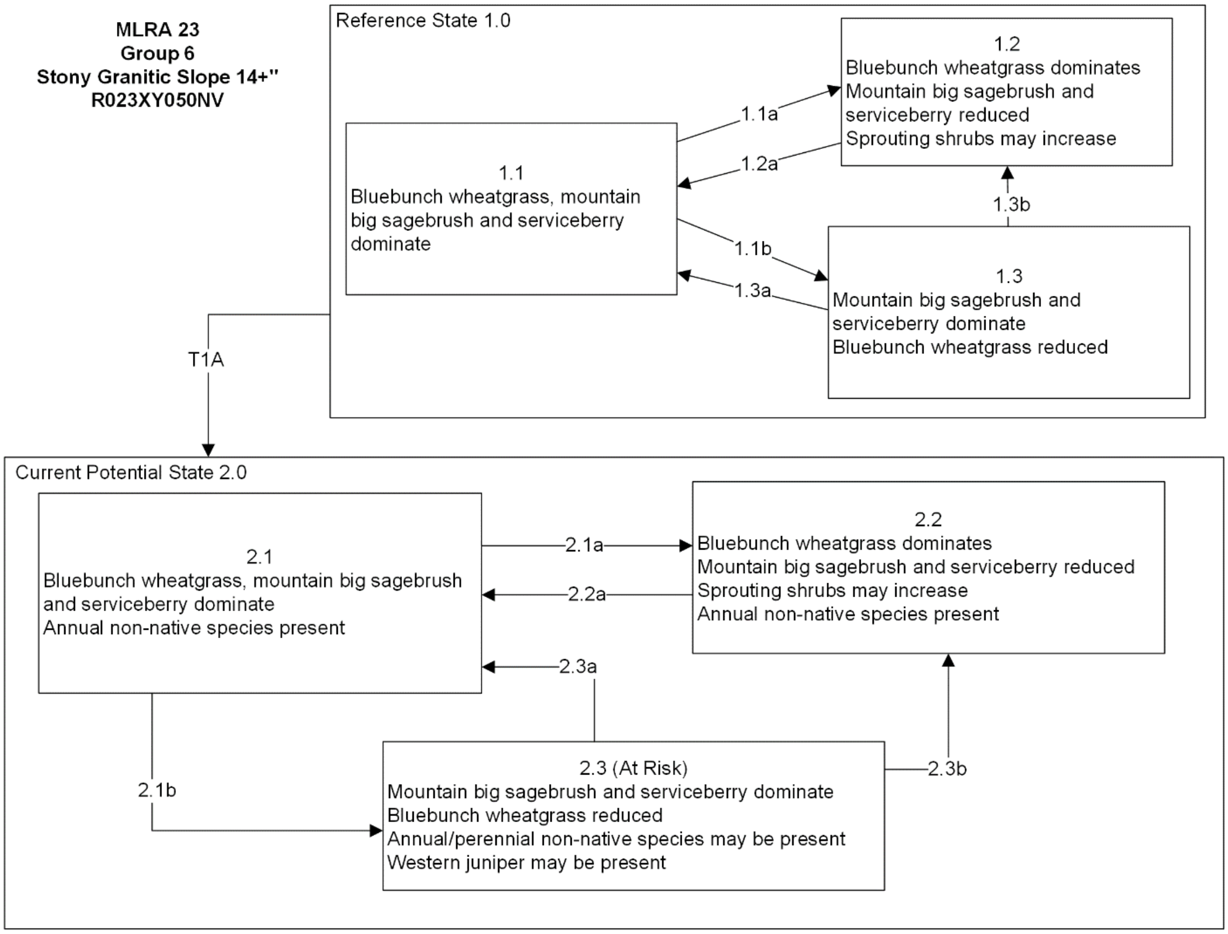

MLRA 23
Group 6
Granitic Loam 14-16"
R023XY058NV
Reference State 1.0
1.1
Letterman's needlegrass, Columbia needlegrass and mountain big sagebrush dominate
1.2
Letterman's needlegrass and Columbia needlegrass dominate
Mountain big sagebrush reduced
Sprouting shrubs may increase
1.3
Mountain big sagebrush dominates
Letterman's needlegrass and Columbia needlegrass reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Letterman's needlegrass, Columbia needlegrass and big sagebrush dominate
Antelope bitterbrush, snowberry, serviceberry may be present
Annual non-native species present
2.2
Letterman's needlegrass, Columbia needlegrass dominate
Mountain big sagebrush reduced
Sprouting shrubs may increase
Annual non-native species present
2.3 (At Risk)
Mountain big sagebrush dominates
Letterman's needlegrass and Columbia needlegrass reduced
Annual/perennial non-native species may be present
Western juniper may be present
2.1a
2.2a
2.3a
2.1b
2.3b

MLRA 23
Group 6
Granitic Loam 14-16"
R023XY058NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.

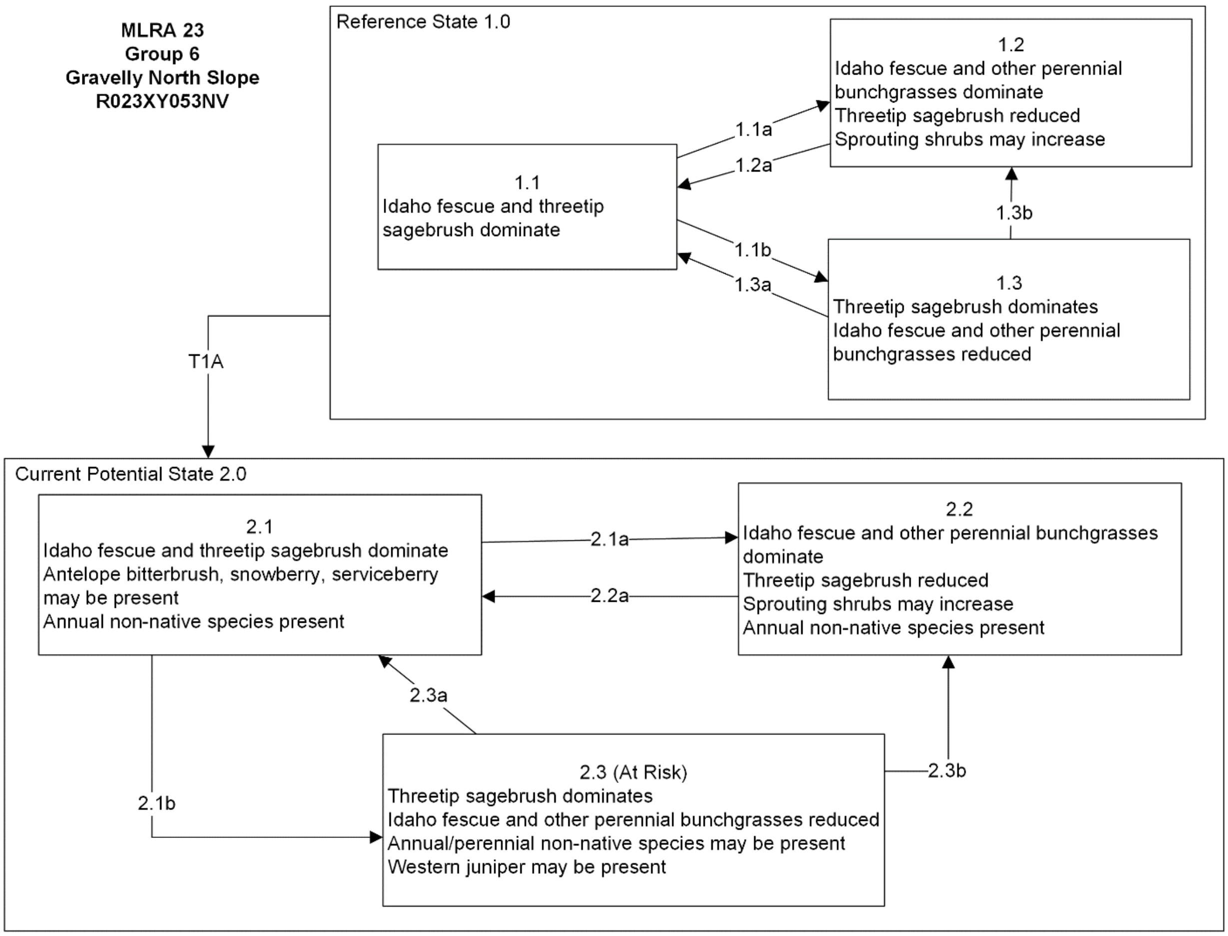

MLRA 23
Group 6
Stony Granitic Slope 14+"
R023XY050NV
Reference State 1.0
1.1
Bluebunch wheatgrass, mountain big sagebrush and serviceberry dominate
1.2
Bluebunch wheatgrass dominates
Mountain big sagebrush and serviceberry reduced
Sprouting shrubs may increase
1.3
Mountain big sagebrush and serviceberry dominate
Bluebunch wheatgrass reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass, mountain big sagebrush and serviceberry dominate
Annual non-native species present
2.2
Bluebunch wheatgrass dominates
Mountain big sagebrush and serviceberry reduced
Sprouting shrubs may increase
Annual non-native species present
2.3 (At Risk)
Mountain big sagebrush and serviceberry dominate
Bluebunch wheatgrass reduced
Annual/perennial non-native species may be present
Western juniper may be present
2.1a
2.2a
2.3a
2.1b
2.3b

MLRA 23
Group 6
Stony Granitic Slope 14+"
R023XY050NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.

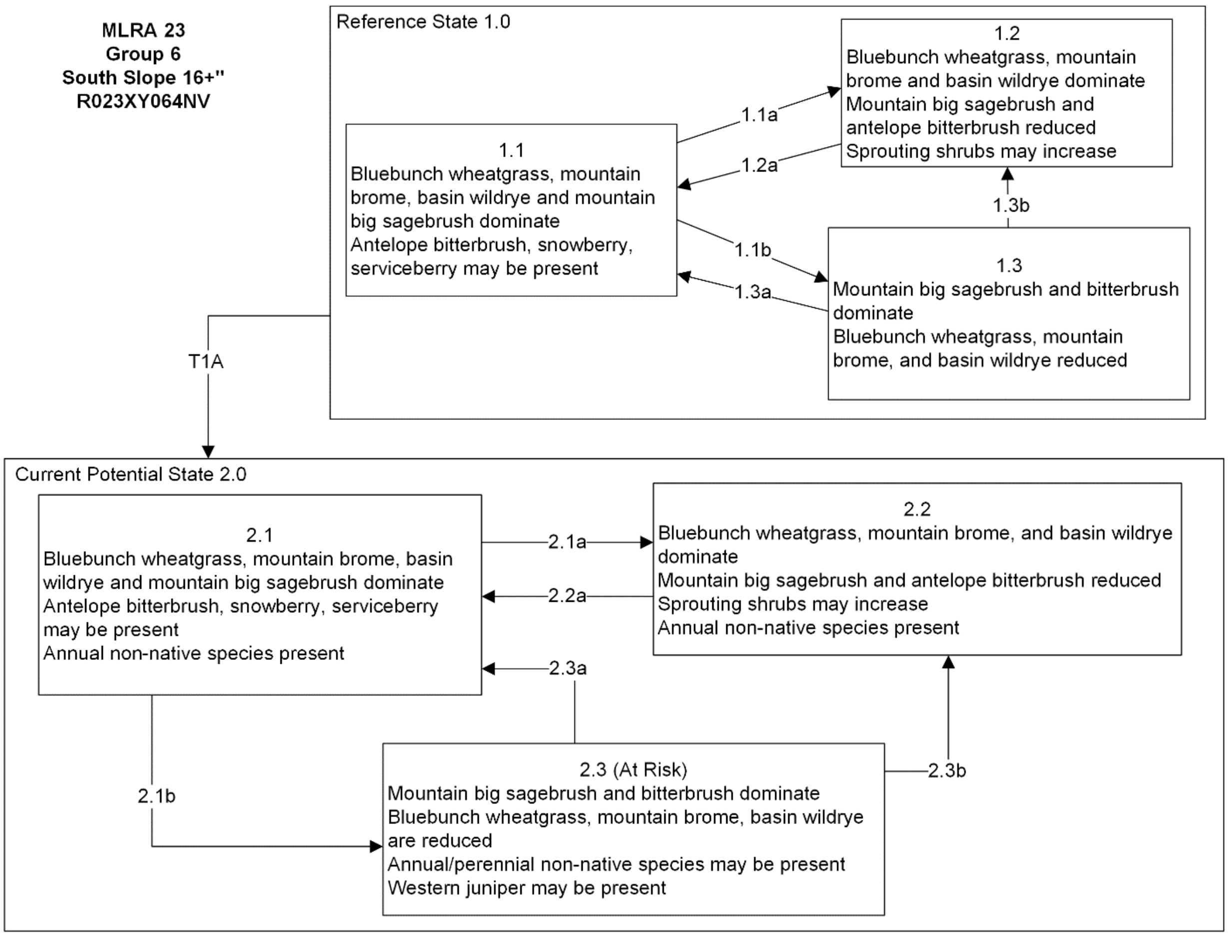

MLRA 23
Group 6
Gravelly North Slope
R023XY053NV
Reference State 1.0
1.1
Idaho fescue and threetip sagebrush dominate
1.2
Idaho fescue and other perennial bunchgrasses dominate
Threetip sagebrush reduced
Sprouting shrubs may increase
1.3
Threetip sagebrush dominates
Idaho fescue and other perennial bunchgrasses reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Idaho fescue and threetip sagebrush dominate
Antelope bitterbrush, snowberry, serviceberry may be present
Annual non-native species present
2.2
Idaho fescue and other perennial bunchgrasses dominate
Threetip sagebrush reduced
Sprouting shrubs may increase
Annual non-native species present
2.3 (At Risk)
Threetip sagebrush dominates
Idaho fescue and other perennial bunchgrasses reduced
Annual/perennial non-native species may be present
Western juniper may be present
2.1a
2.2a
2.3a
2.1b
2.3b

MLRA 23
Group 6
Gravelly North Slope
R023XY053NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.

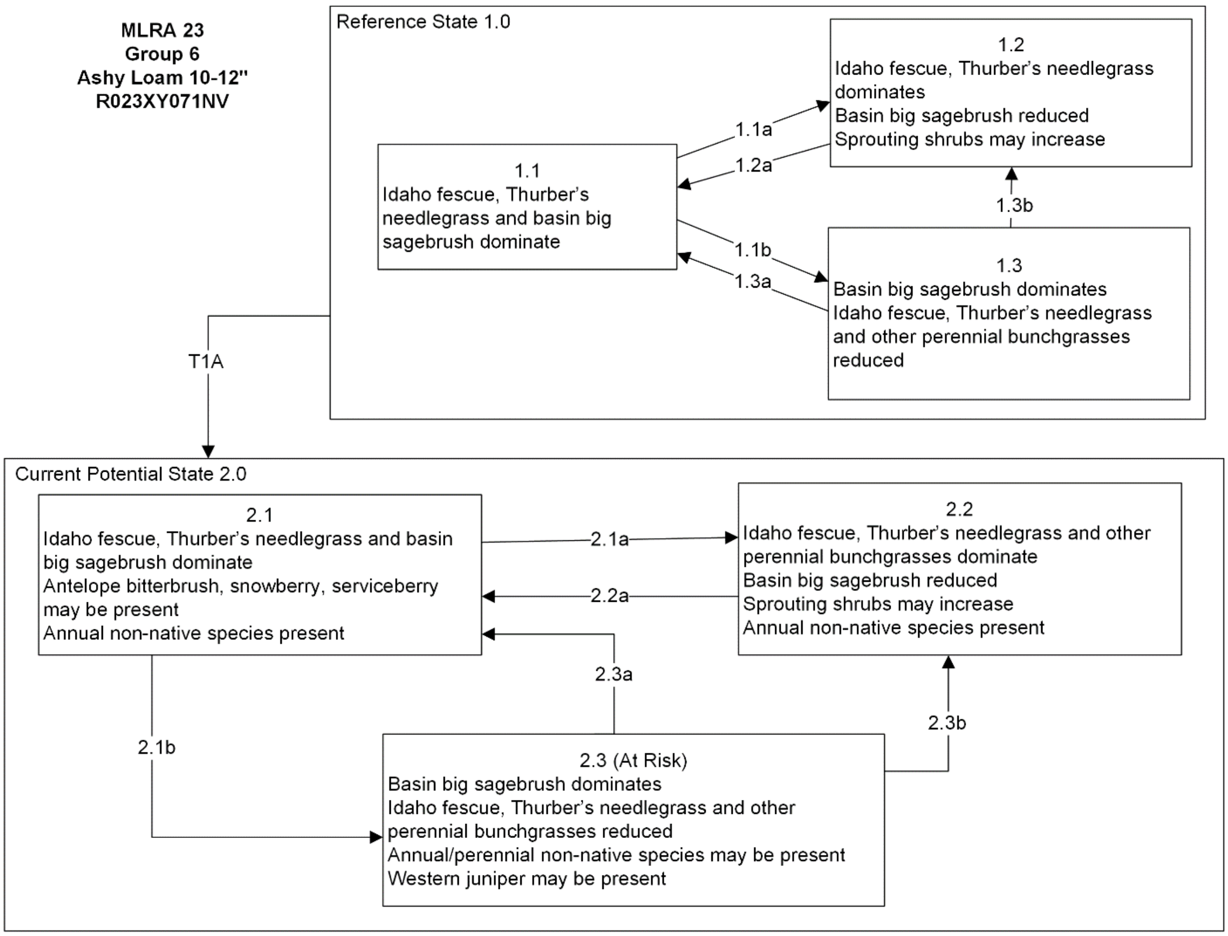

MLRA 23
Group 6
South Slope 16+"
R023XY064NV
Reference State 1.0
1.1
Bluebunch wheatgrass, mountain brome, basin wildrye and mountain big sagebrush dominate
Antelope bitterbrush, snowberry, serviceberry may be present
1.2
Bluebunch wheatgrass, mountain brome and basin wildrye dominate
Mountain big sagebrush and antelope bitterbrush reduced
Sprouting shrubs may increase
1.3
Mountain big sagebrush and bitterbrush dominate
Bluebunch wheatgrass, mountain brome, and basin wildrye reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Bluebunch wheatgrass, mountain brome, basin wildrye and mountain big sagebrush dominate
Antelope bitterbrush, snowberry, serviceberry may be present
Annual non-native species present
2.2
Bluebunch wheatgrass, mountain brome, and basin wildrye dominate
Mountain big sagebrush and antelope bitterbrush reduced
Sprouting shrubs may increase
Annual non-native species present
2.3 (At Risk)
Mountain big sagebrush and bitterbrush dominate
Bluebunch wheatgrass, mountain brome, basin wildrye are reduced
Annual/perennial non-native species may be present
Western juniper may be present
2.1a
2.2a
2.3a
2.1b
2.3b

MLRA 23
Group 6
South Slope 16+"
R023XY064NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.


MLRA 23
Group 6
Ashy Loam 10-12"
R023XY071NV
Reference State 1.0
1.1
Idaho fescue, Thurber's needlegrass and basin big sagebrush dominate
1.2
Idaho fescue, Thurber's needlegrass dominates
Basin big sagebrush reduced
Sprouting shrubs may increase
1.3
Basin big sagebrush dominates
Idaho fescue, Thurber's needlegrass and other perennial bunchgrasses reduced
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Idaho fescue, Thurber's needlegrass and basin big sagebrush dominate
Antelope bitterbrush, snowberry, serviceberry may be present
Annual non-native species present
2.2
Idaho fescue, Thurber's needlegrass and other perennial bunchgrasses dominate
Basin big sagebrush reduced
Sprouting shrubs may increase
Annual non-native species present
2.3 (At Risk)
Basin big sagebrush dominates
Idaho fescue, Thurber's needlegrass and other perennial bunchgrasses reduced
Annual/perennial non-native species may be present
Western juniper may be present
2.1a
2.2a
2.3a
2.1b
2.3b

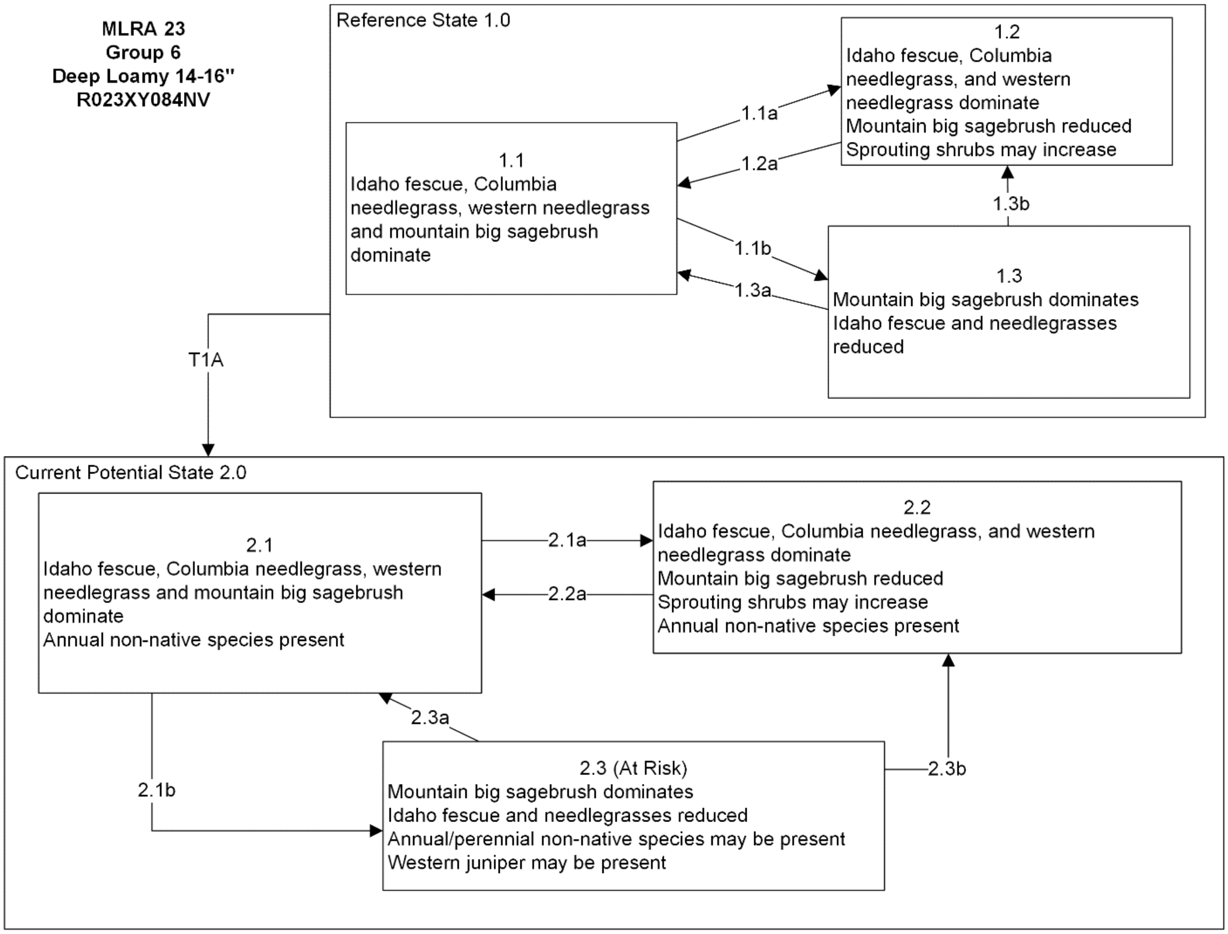
MLRA 23
Group 6
Ashy Loam 10-12"
R023XY071NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.

MLRA 23
Group 6
Deep Loamy 14-16"
R023XY084NV



MLRA 23
Group 6
Deep Loamy 14-16"
R023XY084NV
KEY

Reference State 1.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover.
1.1b: Time and lack of disturbance allows for sagebrush to increase and become decadent; herbivory and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire, Aroga moth and/or herbivory, would create sagebrush/grass mosaic.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community. A high severity Aroga moth infestation may also reduce sagebrush cover.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community 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. A high severity Aroga moth infestation could also reduce sagebrush cover; non-native annual species present.
2.1b: Time and lack of disturbance allows for shrubs to increase and become decadent; inappropriate grazing management and/or chronic drought may also reduce fine fuels and lead to reduced fire frequency and increased shrub cover.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire, Aroga moth and/or grazing management creates sagebrush/grass mosaic.
2.3b: High severity fire significantly reduces sagebrush cover, leading to early mid-seral community.

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Group 8: Mountain big sagebrush and mountain brome

Description of MLRA 23 DRG 8:

Disturbance Response Group (DRG) 8 consists of three ecological sites. These sites range in precipitation from 16 to over 20 inches annually. The slopes on these sites range widely from 2 to 75 percent but slopes of 15 to 30 are most typical. Elevations range from 6500 to 9000 feet. Soils on these sites are derived from volcanic rock, mixed rock or granitic parent material. These soils can be coarse to moderately fine textured. Available water capacity ranges from very low to high. Some soils exhibit gravels on the surface and throughout the soil profile. These sites are dominated by mountain brome (*Bromus marginatus)*, needlegrasses (*Achnatherum* spp.), and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*). Mountain snowberry (*Symphoricarpos oreophilus*), Idaho fescue (*Festuca idahoensis*), basin wildrye (*Leymus cinereus*) and bluegrasses (*Poa* sp.) are also commonly found on these sites. Forbs such as yarrow (*Achillea* sp.), balsamroot (*Balsamorhiza* sp.), and hawksbeard (*Crepis* sp.) make up a minor component of the total production. Total production on these sites ranges from 1100 to 1800 lbs/acre in normal years.

Disturbance Response Group 8 Ecological Sites:

Loamy 16+" – Modal	023XY019NV
Loamy Slope 16+"	023XY065NV
Granitic Slope 16+"	023XY048NV

Modal Site:

The Loamy 16+” (023XY019NV) ecological site is the modal site for this group as it has the most acres mapped. This site occurs on mostly concave mountain and plateau sideslopes on all aspects. At lower elevations this site is restricted to cool, moist, northerly exposures. Slopes range from 2 to 50 percent, but slope gradients of 2 to less than 30 percent are most typical. Elevations are 6500 to 9000 feet. Average annual precipitation is 16 to over 20 inches. The soils of this site have formed in colluvium derived from volcanic rock or mixed parent materials. The soils are deep, fertile, and well drained. These soils have thick, dark-colored, medium-textured surface layers. Subsoils are friable loams, clay loams, or clays. Soil temperature regime is cryic and soils are neutral to slightly acidic and non-calcareous. Sheet and rill erosion potential is slight to moderate depending on the slope. Few overland flow patterns are discernible. Wind erosion potential is slight. These soils present very few limitations to the growth of native vegetation. The plant community is dominated by mountain brome, Columbia needlegrass (*Achnatherum nelsonii*), western needlegrass (*Achnatherum occidentale*), and mountain big sagebrush. Snowberry *(Symphoricarpos oreophilus)* is often present. Annual production is 1800 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 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 influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

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 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). Mountain big sagebrush and antelope bitterbrush (*Purshia tridentata)* 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 factor that most limits establishment of bitterbrush seedlings is competition for water resources with the invasive species cheatgrass (Clements and Young 2002).

The perennial bunchgrasses that are co-dominant with the shrubs include mountain brome, needlegrasses, Idaho fescue, bluegrasses and grass-like plants such as sedges. 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. The root systems of short-lived perennial grasses such as bluegrasses and mountain brome penetrate only the upper 40cm of the soil, whereas longer lived perennial bunchgrasses can reach depths up to 160 cm (Spence 1937). 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).

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).

Juniper may occur where these sites are adjacent to woodlands. An extended fire return interval and/or inappropriate grazing can facilitate juniper invasion. Eventually, juniper will dominate the site and out-compete sagebrush for water and sunlight severely reducing both the shrub and herbaceous understory (Lett and Knapp 2005, Miller and Tausch 2001). Fescue and bluegrasses may remain underneath trees on north-facing slopes.

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. Five possible stable states have been identified for the Loamy Slope 16+" ecological site. Differences in resilience to disturbance for the remaining ecological sites contained within this DRG are described at the end of this document.

Annual Invasive Grasses:

This group is highly resilient, however both the Loamy 16+ and Loamy Slope 16+ sites were seen in annual states, with cheatgrass as the dominant plant (by weight). This group's elevation range is 6000 – 9000 feet. While the group is highly resilient because if its elevation and deep, productive soils, over time it may become more vulnerable to invasion by cheatgrass at lower elevations. High elevations in the Great Basin remain relatively uninvaded by cheatgrass (Bradley and Mustard 2006) and exhibit low risk of invasion (Suring et al. 2005). However, changing climate along with local adaptations of cheatgrass at the "invasion edge" are creating more opportunities for invasion in areas previously undisturbed by these plants (Leger et al. 2009, Bradley 2009). Cheatgrass invasions are being recorded at higher elevations (Mealor et al. 2012, Bradley 2009) and risk of invasion should be considered in post-fire rehabilitation planning. Across a variety of elevations, a healthy native perennial herbaceous community, coupled with management that reduces litter and seed banks, are the most effective tool to reduce cheatgrass invasions (Chambers et al. 2007, Jones et al. 2015).

Cheatgrass is a cool-season annual grass that maintains an advantage over native plants, in part because it is a 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). Cheatgrass originated from Eurasia and both were first reported in North America in the late 1800s (Mack and Pyke 1983, Furbush 1953).

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.

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 (*Agropyron cristatum*) and Sandberg bluegrass (*Poa secunda*) 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 (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 (*Pseudoroegneria spicata*) 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). Both mature medusahead and cheatgrass are 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:

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 2001). 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 2009).

Mountain 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 fire (Merrill et al. 1982). Currant (*Ribes*), 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). If balsamroot (*Balsamorhiza* sp.) or mule-ears (*Wyethia* sp.) is common before fire, these plants will increase after fire or with heavy grazing (Wright 1985).

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). It is commonly seeded after wildfires due to its ability to establish quickly and reduce erosion (Tilley et al. 2004). Mountain brome significantly decreases after burning (Nimir and Payne 1978).

Idaho fescue's response to fire varies with condition and size of the plant, season and severity of fire, and ecological conditions. Mature Idaho fescue plants are commonly reported to be severely damaged by fire in all seasons (Wright et al. 1979). Initial mortality may be high (in excess of 75%) on severe burns, but usually varies from 20 to 50% (Barrington et al 1988). Rapid burns have been found to leave little damage to root crowns, and new tillers are produced with onset of fall moisture (Johnson et al. 1994). However, Wright and others (1979) found the dense, fine leaves of Idaho fescue provided enough fuel to burn for hours after a fire had passed, thereby killing or seriously injuring the plant regardless of the intensity of the fire (Wright et al. 1979). Idaho fescue is commonly reported to be more sensitive to fire than another prominent grass on this site, bluebunch wheatgrass (Conrad and Poulton 1966). However Robberecht and Defossé (1995) suggested the latter was more sensitive. They observed culm and biomass reduction with moderate fire severity in bluebunch wheatgrass, whereas a high fire severity was required for this reduction in Idaho fescue. Also, given the same fire severity treatment, post-fire culm production was initiated earlier and more rapidly in Idaho fescue (Robberecht and Defossé 1995). The effect of fire on bunchgrasses relates to culm density, culm-leaf morphology, and the size of the plant.

Cheatgrass is likely to invade this group where vectors are present. Invasion is more likely in areas with abnormal disturbance (livestock gathering areas, areas with heavy recreation use) or after fire. Invasive annual 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 for sagebrush systems, 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:

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. This same study found that juniper (mostly *Juniperus horizontalis*) constituted half of the diet of mule deer and approximately 1/6 of the late winter diets of elk and bighorn sheep (Kasworm et al. 1984). Sheehy and 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.

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 for elk winter forage (Kufeld 1973).

Idaho fescue tolerates light to moderate grazing (Ganskopp and Bedell 1981) and is moderately resistant to trampling (Cole 1987). However, Idaho fescue decreases under heavy grazing by livestock (Eckert & Spencer, 1986; Eckert & Spencer, 1987) and wildlife (Gaffney, 1941). Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton and others (1979) observed the effects of harvest date on basal area of 5 bunchgrasses in eastern Oregon, including Idaho fescue, and found grazing from August to October (after seed set) has the least impact on these bunchgrasses. Heavy grazing during the growing season will reduce perennial bunchgrasses and increase sagebrush (Laycock 1967). Abusive grazing by cattle or horses will likely increase sagebrush, rabbitbrush, and some forbs such as arrowleaf balsamroot and mule-ears. Annual non-native weedy species such as cheatgrass and mustards may invade.

State and Transition Model Narrative 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 23 Disturbance Response Group 8.

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 mountain brome and needlegrasses, in association with a variety of mountain brush species such as mountain big sagebrush, and mountain snowberry. Perennial forbs are a small component of this plant community and include balsamroot, hawksbeard (*Crepis* sp.), lupine (*Lupinus* sp.) and others.

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 to dominate the site. Fires would 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. 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 allows sagebrush to increase and become decadent. Long-term drought, herbivory, or combinations of these would cause a decline in perennial bunchgrasses and fine fuels leading to a reduced fire frequency allowing mountain big sagebrush to dominate the site.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community phase. Perennial bunchgrasses, such as mountain brome, needlegrasses and Idaho fescue dominate. Sagebrush is killed by fire and may be a minor component and present in unburned patches. Mountain snowberry and rabbitbrush may be sprouting. Forbs may increase post-fire but will likely return to pre-burn levels within a few years.

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Time and lack of disturbance over time allows the sagebrush and other woody shrubs to recover and increase in size and density.

Community Phase 1.3:
Mountain big sagebrush and other woody shrubs increase in the absence of disturbance. Western and/or Utah juniper may be present. Decadent sagebrush dominates the overstory and the deep-rooted perennial bunchgrasses in the understory are reduced either from competition with shrubs or from grazing management. Balsamroot and other perennial forbs may also increase on the site.

Loamy Slope 16+ (023XY065NV) Phase 1.3 T. K. Stringham, August 2014

Loamy Slope 16+ (R023XY065NV) Phase 1.3 D. Snyder, July 2016

Community Phase Pathway 1.3a, from phase 1.3 to 1.1:
Fire would decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Fires would typically be small and patchy due to low fine 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 1.2:
High severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by 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 plants, such as cheatgrass, and mustards.

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 four 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. The presence of invasive weeds alters the fuel type in this state, making it less resistant to disturbance. Non-native annual grasses and forbs tend to senesce and dry out early in the season, making them highly flammable during the dry part of summer. This increases the likelihood of fire, leading to positive feedbacks: flammable plants lead to fire, which allows more annual flammable plants to grow.

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. The plant community is dominated by mountain brome, and needlegrasses, in association with a variety of mountain brush species such as mountain big sagebrush, and mountain snowberry. The overall aspect is dominated by perennial grasses with sparse shrubs. Perennial forbs are a small component of this plant community.

Community Phase Pathway 2.1a, from phase 2.1 to 2.2:
Fire would reduce the shrub overstory and allow perennial bunchgrasses to dominate the site. Fires would typically be low severity resulting in a mosaic pattern 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 are likely to increase after fire.

Community Phase Pathway 2.1b, from phase 2.1 to 2.3:
Time and lack of disturbance allows sagebrush to increase and become decadent. Long-term drought would reduce fine fuels and lead to a reduced fire frequency allowing big sagebrush to dominate the site. Inappropriate grazing management would reduce the perennial bunchgrass understory; conversely perennial forbs such as balsamroot 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. Perennial bunchgrasses dominate sagebrush and other shrubs are present in trace amounts. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain. Mountain snowberry and rabbitbrush may be sprouting. Forbs may increase post-fire but will likely return to pre-burn levels within a few years.

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 big sagebrush can take many years.

Community Phase 2.3:
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. Western and/or Utah juniper may be present and without management will likely increase. Annual non-natives species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is at risk and is susceptible to further degradation from grazing, drought, and fire.

Loamy Slope 16+ (R023XY065NV) Phase 2.3 T. K. Stringham, June 2015

Community Phase Pathway 2.3a, from phase 2.3 to 2.1:
A change in grazing management that decreases shrubs would allow the perennial bunchgrasses in the understory to increase. Heavy fall grazing may cause mechanical damage and subsequent death to sagebrush, facilitating an increase in 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 would 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 2.2:
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. An Aroga moth infestation could cause a large decrease in sagebrush, giving a competitive advantage to perennial bunchgrasses 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). 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. This pathway is more likely in areas that have experienced high usage, such as livestock gathering areas, sheep bedding grounds, or areas near roads.

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. Seeded species may be present. Western and/or Utah juniper may be invading. This site is susceptible to further degradation from grazing, drought, and fire.

Loamy 16+ (R023XY065NV) Phase 2.4 T. K. Stringham, June 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:
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: To Community Phase 3.1: Inappropriate grazing will decrease or eliminate deep-rooted perennial bunchgrasses, increase Sandberg bluegrass and favor shrub growth and establishment.

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 Tree State 4.0:

Trigger: Time and lack of disturbance or management action allows for Utah and/or Western 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. Over time, 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.

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

Trigger: Severe fire or multiple fires, coupled with soil disturbance would transition to Community Phase 5.1.

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. Sagebrush and/or snowberry dominate the overstory. Sagebrush cover exceeds the 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. Forbs will increase with a reduction in deep rooted perennial bunchgrass competition and become the dominant herbaceous layer on this site. The site is at risk of severe fire due to high levels of woody fuels.

Community Phase 3.1:
Decadent sagebrush and other shrubs dominate the overstory. Snowberry may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Mule-ears, balsamroot and other perennial forbs may make up a significant component of the understory. Annual invasive grasses, if present, may increase.

Loamy 16 + (R023XY019NV) Phase 3.1 T. K. Stringham, June 2015

Community Phase Pathway 3.1a, from phase 3.1 to 3.2:
Fire or 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 perennial forbs to dominate the site.

Community Phase 3.2:
Perennial forbs such as lupine, mule-ears, or arrowleaf balsamroot dominate the site. Annual non-native species may be present but are not dominant. Sagebrush is a minor component of the community and may be present in trace amounts. Over time, sprouting shrubs like snowberry will increase.

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.

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

Trigger: Absence of disturbance over time allows for Utah and/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. Over time, 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 and/or Western juniper density.

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

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

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.

Tree State 4.0:

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

Community Phase 4.1:
Utah and/or Western juniper dominates 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 bluegrasses and forbs in the interspaces. Sagebrush is stressed and dying. This is the equivalent of Phase II tree encroachment (Miller et al. 2000). Annual non-native species are present under tree canopies. Bare ground interspaces are large and connected.

Loamy Slope 16+ (023XY065NV) Phase 4.1 T. K. Stringham, August 2014

Community Phase Pathway 4.1a, from phase 4.1 to 4.2:
Time and lack of disturbance or management allows the maturation of the juniper community. Trees out-compete the herbaceous understory species for sunlight and water.

Community Phase 4.2 (At Risk):
Western and/or Utah juniper dominates overstory 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. Mountain big sagebrush may be present in trace amounts, however dead skeletons will be more numerous than living sagebrush. Perennial bunchgrasses may or may not be present. Bare ground interspaces are large and connected. Soil redistribution is evident. This is the equivalent of Phase III tree encroachment (Miller et al. 2000). This Phase is at risk of transitioning to the Annual State.

R4A: Restoration from Tree State 4.0 to Current Potential State 2.0:

Tree removal with minimum soil disturbance such as hand felling or mastication within community phase 4.1. This treatment may be combined with seeding for increased success when there is little understory.

T4A: Transition from Tree State 4.0 to Annual State 5.0:

Trigger: Catastrophic crown fire would reduce or eliminate trees and/or tree removal when annual non-natives are present would also transition the site.

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 nutrient cycling and distribution.

Annual State 5.0:

An abiotic threshold has been crossed and state dynamics are driven by fire and time. The understory of this community 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 5.1:
Non-native annual species dominate the community. Perennial grasses and forbs may be present, but are subdominant to annual grasses (by weight). Surface erosion may increase with summer convection storms and would be apparent through increased pedestalling of plants, rill formation, or extensive water flow paths.

Community Phase Pathway 5.1a, from phase 5.1 to 5.2:
Time without disturbance allows the sagebrush to establish.

Community Phase 5.2:
Mountain big sagebrush dominates the overstory. Annual non-native species such as cheatgrass dominate the understory. Perennial bunchgrasses may be present in trace amounts.

Community Phase Pathway 5.2a, from phase 5.2 to 5.1:
Fire reduces or eliminates the shrub overstory and allows annual non-native species to dominate the site.

Loamy 16+ (R023XY019NV) Phase Annual T. K. Stringham, July 2015

Potential Resilience Differences with other Ecological Sites:

Loamy Slope 16+" (023XY065NV):

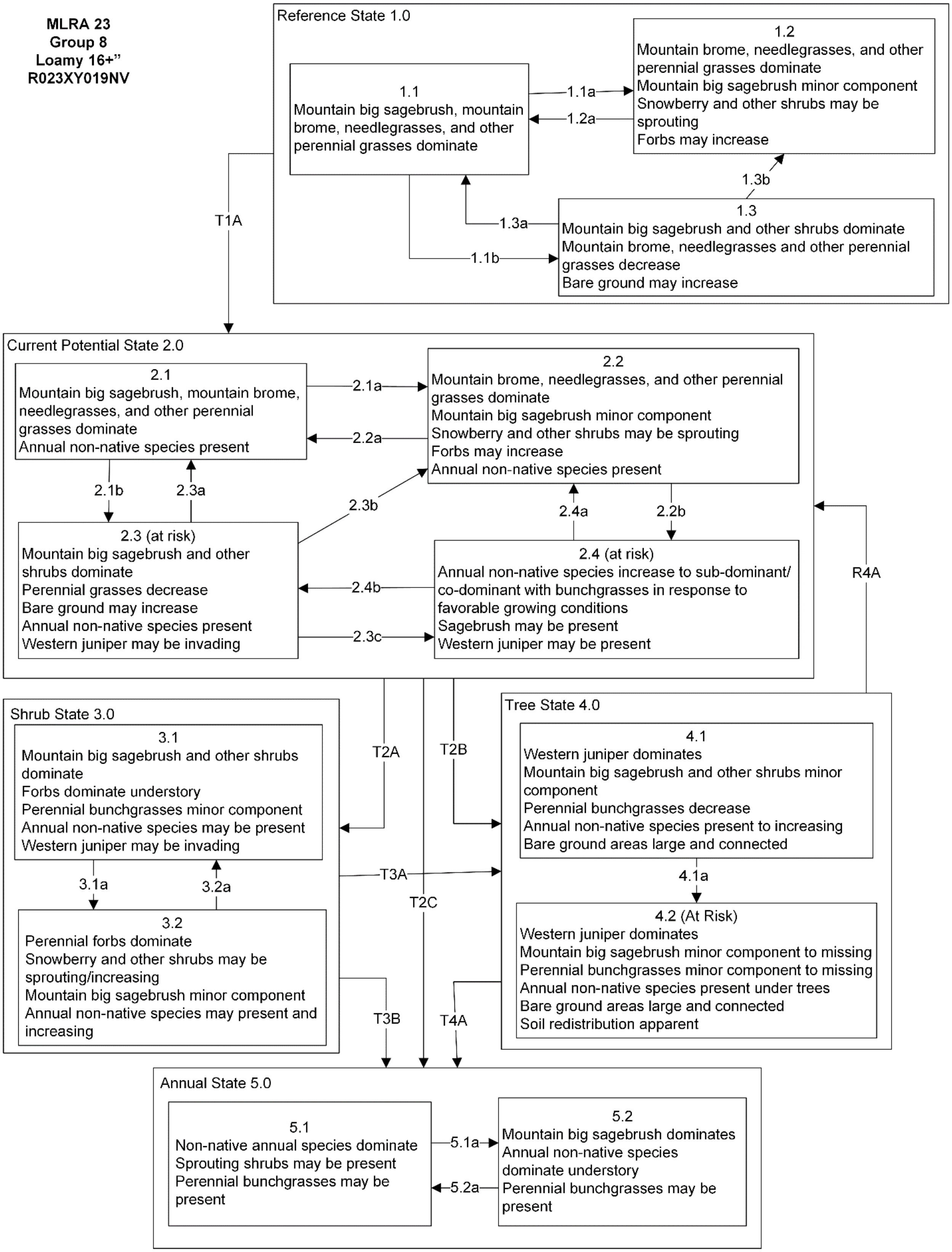
This site is less productive than the modal site at 1500 lbs/ac in normal years and is found in elevations between 6500 and 7500 ft. The plant community is dominated by mountain big sagebrush, mountain brome, needlegrasses and Idaho fescue. The soils on this site are from residuum and colluvium derived from volcanic or mixed rocks. The soils are moderately deep and well drained. Available water capacity is moderate to high. The surface layer is moderately coarse to medium textured and is 12 inches or more in thickness to the subsoil or underlying material. Subsoils are moderately coarse to moderately fine textured and may be slightly acidic. Some soils are very gravelly throughout. This site provides a cool, moist environment for plant growth because of the elevations and steep, relatively cool, aspects where it occurs. Runoff from this site is medium and the potential for sheet and rill erosion is moderate to high depending on slope. This site can be invaded by pinyon and juniper where it occurs near these woodlands. This site does not have an annual state, but has been seen with Phase II Western and/or Utah juniper so it does have a tree state. This site is a 4-state model.

Granitic Slope 16+" (023XY048NV):

This site is significantly less productive than the modal site with 1100 lbs/ac in normal years. The plant community is dominated by mountain brome with lesser amounts of basin wildrye, needlegrasses and Idaho fescue. Mountain big sagebrush is the dominant shrub. The soils of this site have formed in residuum from granitic rock sources. These soils have a shallow effective rooting zone, with depth to weathered bedrock beginning at about 8 inches. Soil textures are coarse and moderately coarse near the surface and in the subsoil. These soils have a very low available water capacity. Soil reaction ranges from slightly acidic near the surface to neutral in the subsoil. The soils are well drained, runoff is rapid to very rapid, and permeability is moderately rapid. This site has a two state model because it was never seen in a shrub state, tree state, or with significant annual grasses to warrant an annual state.

Modal State and Transition Model for MLRA 23 Group 8:

MLRA 23
Group 8
Loamy 16+”
R023XY019NV



MLRA 23
Group 8
Loamy 16+"
R023XY019NV

Reference State 1.0
1.1a: 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.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub reestablishment.
1.3a: Low severity fire, herbivory or combinations reduces sagebrush.
1.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs.

Transition T1A: Introduction of non-native annual species.

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: 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 creates sagebrush/ grass mosaic, herbivory, or combinations. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community. Brush management with minimal soil disturbance reduces black sagebrush.
2.3c: Late spring moisture that favors the germination and production of non-native, annual grasses. May be a transitory plant community.
2.4a: Rainfall pattern and growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Rainfall pattern and growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: Time and lack of fire allows juniper to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.
Transition T2C: Severe fire and/or multiple fires.

Shrub State 3.0
3.1a: High severity fire; brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (may take many years).

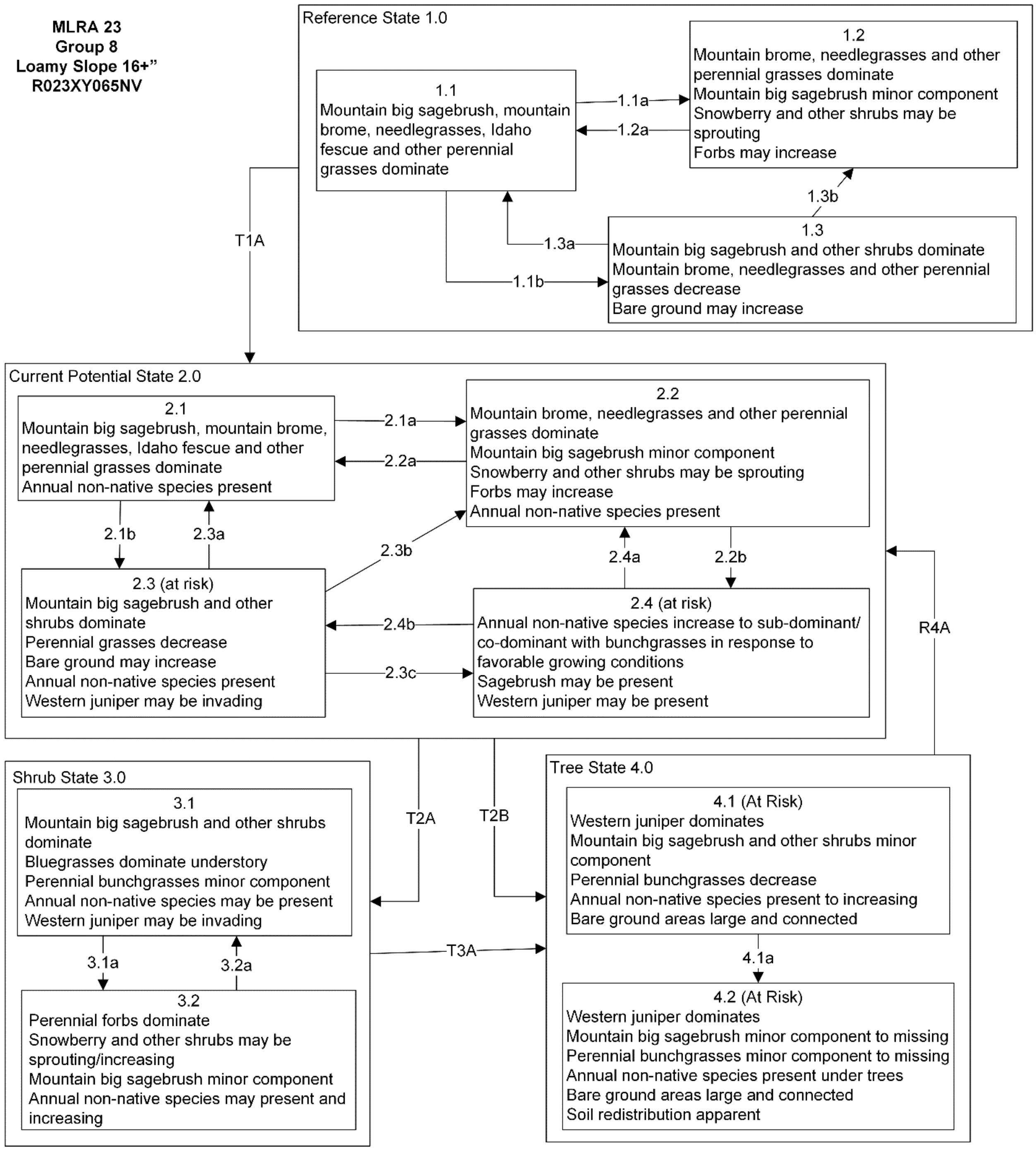
Transition T3A: Time and lack of fire allows juniper to establish and dominate site resources.
Transition T3B: High-severity fire or multiple fires and/or treatments that disturb the soil surface in the presence of non-native annual grasses. (5.1).

Tree State 4.0
4.1a: Time without disturbance allows maturation of the tree community.

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (4.1).
Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (5.1).

Annual State 5.0
5.1a: Time without disturbance may allow for sagebrush to increase.
5.2a: Fire.

Additional State and Transition Models for MRLA 23 Group 8:



MLRA 23
Group 8
Loamy Slope 16+"
R023XY065NV

Reference State 1.0
1.1a: 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.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub reestablishment.
1.3a: Low severity fire, herbivory or combinations reduces sagebrush.
1.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs.

Transition T1A: Introduction of non-native annual species.

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: 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 creates sagebrush/ grass mosaic, herbivory, or combinations. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community. Brush management with minimal soil disturbance reduces black sagebrush.
2.3c: Late spring moisture that favors the germination and production of non-native, annual grasses. May be a transitory plant community.
2.4a: Rainfall pattern and growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Rainfall pattern and growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: Time and lack of fire allows Western juniper to establish and overtop the sagebrush, dominating site resources; may be coupled with inappropriate grazing management.

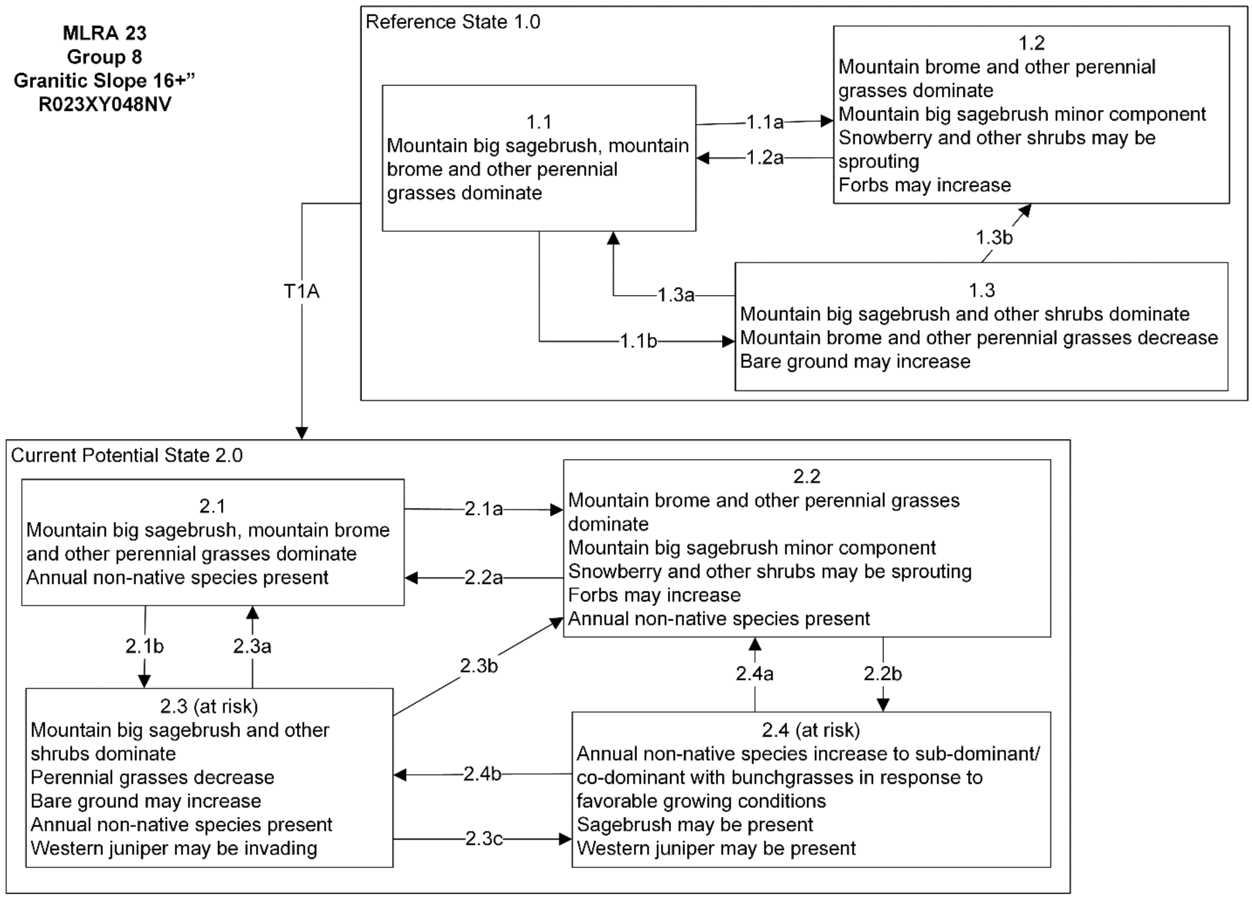
Shrub State 3.0
3.1a: High severity fire; brush management with minimal soil disturbance.
3.2a: Time and lack of disturbance (unlikely/may take many years).

Transition T3A: Time and lack of fire allows juniper to establish and dominate site resources.

Tree State 4.0
4.1a: Time without disturbance allows maturation of the tree community.

Restoration R4A: Tree removal would decrease tree cover and allow for the understory to recover (4.1).

MLRA 23
Group 8
Granitic Slope 16+"
R023XY048NV



MLRA 23
Group 8
Granitic Slope 16+"
R023XY048NV

Reference State 1.0
1.1a: 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.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory may also reduce perennial understory.
1.2a: Time and lack of disturbance allows for shrub reestablishment.
1.3a: Low severity fire, herbivory or combinations reduces sagebrush.
1.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs.

Transition T1A: Introduction of non-native annual species.

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: 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 creates sagebrush/ grass mosaic, herbivory, or combinations. Brush management with minimal soil disturbance.
2.3b: High severity fire significantly reduces sagebrush and leads to early/mid-seral community. Brush management with minimal soil disturbance reduces black sagebrush.
2.3c: Late spring moisture that favors the germination and production of non-native, annual grasses. May be a transitory plant community.
2.4a: Rainfall pattern and growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.
2.4b: Rainfall pattern and growing season conditions favoring perennial bunchgrass production and reduced cheatgrass production.

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<u>Group 9: Wyoming big sagebrush and Thurber's needlegrass</u>

Description of MLRA 23 DRG 9:

Disturbance Response Group (DRG) 9 consists of sixteen ecological sites. The California ecological site Stony Loam 9-12" (023XF082CA) correlates with the Nevada ecological site Loamy 10-12" (023XY020NV). California site Loamy Upland 9-12" (023XF091CA) correlates most closely with the Nevada ecological site Loamy 8-10" (023XY006NV). These sites range in precipitation from 8 to 14 inches. The elevation range of this group is 3,900 to 7,000 feet. Slopes range widely from 2 to 75 percent. Soils on these sites vary greatly depending on slope, aspect, parent material, and elevation. These soils are typically derived from alluvium from mixed or granitic rock sources. These soils range from shallow to very deep and are and well drained. They are typically modified with gravels, cobbles, rocks, and stones throughout the profile. These soils can be susceptible to wind erosion with reduced vegetative cover. Sites within this disturbance response group are characterized by a dominance of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis)*, and Thurber's needlegrass (*Achnatherum thurberianum)*. Other common shrubs include mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), spiny hopsage (*Grayia spinosa*) and rabbitbrush (*Chrysothamnus* sp. and *Ericameria* sp.). Bluebunch wheatgrass (*Pseudoroegnaria spicata)*, basin wildrye (*Leymus cinereus*), Indian ricegrass (*Achnatherum hymenoides*) and other needlegrasses (*Achnatherum* sp.) are also important species on these sites. Forbs make up a minor component of the production and include buckwheats (*Eriogonum* sp.) and balsamroot (*Balsamhoriza* sp.). Annual production on Nevada sites ranges from 450 to 900 lb/acre in normal years. The annual production for both California sites is 600 lb/acre in a normal year.

Disturbance Response Group 9 Ecological sites:

Loamy 8-10" – Modal	R023XY006NV
Loamy Slope 10-14"	R023XY039NV
Loamy 10-12"	R023XY020NV
Loamy Fan 8-10"	R023XY097NV
Granitic Loam 10-12"	R023XY057NV
Granitic Loam 8-10"	R023XY068NV
Droughty Loam 8-10"	R023XY038NV
Granitic South Slope 8-12"	R023XY049NV
Loamy Fan 10-12"	R023XY082NV
Granitic Fan 8-10"	R023XY040NV
Sandy 8-12"	R023XY051NV
Channery Hill 8-10"	R023XY099NV
Stony Slope 8-10"	R023XY101NV
Gravelly Clay Slope 10-12"	R023XY102NV
Stony Loam 9-12"	R023XF082CA
Loamy Upland 9-12"	R023XF091CA

Modal Site:

The Loamy 8-10" 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 and piedmont slopes on all exposures. Slopes range from 2 to 30 percent, but slope gradients of 4 to 15 percent are most typical. Elevations range from 4500 to 5500 feet. Average annual precipitation is 8 to 10 inches. The soils in this site typically have a sub-surface layer that is restrictive to root development within 12 to 20 inches of the soil surface. Some soils have light colored, vesicular surface layers. The plant community is dominated by Thurber's needlegrass and Wyoming big sagebrush. Indian ricegrass and Webber needlegrass (*Achnatherum webberi*) are important species associated with this site. Annual production is 600 lb/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 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 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 (Dobrowolski et al. 1990).

In the Great Basin, the majority of annual precipitation occurs 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. The timing of precipitation and water availability within the soil profile can alter species composition and productivity (Bates et al. 2006).

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 increases on silty soil surfaces. A weak argillic horizon will promote production of bluebunch wheatgrass. 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. Sandberg bluegrass 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 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.

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).

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.

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 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.

At the upper range of this group's precipitation range, there is potential for infilling by Utah juniper (*Juniperus osteosperma*). 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).

The ecological sites in this DRG have low resilience to disturbance and low resistance to invasion. Resilience increases with elevation, aspect, increased precipitation, and increased nutrient availability.

Five possible stable states have been identified for the Loamy 8-10" ecological site. Differences in resilience to disturbance for the remaining ecological sites contained within this DRG are described at the end of this document.

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:

Wyoming big sagebrush communities historically had low fuel loads. 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), however newer research suggests longer return intervals. Davies et al. (2006) suggest fire return intervals in Wyoming big sagebrush communities were around 50-100 years. More recently, Baker (2011) estimates fire rotation to be 200-350 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 50-120 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.

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).

Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below ground plant crowns. Indian ricegrass has 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 is necessary for reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage from fire but is more susceptible in drought years (Young 1983). Plant response will vary depending on season, fire severity, fire intensity and post-fire soil moisture availability.

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). Sandberg bluegrass may retard reestablishment of deeper rooted bunchgrass. 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.

The range and density of Utah juniper has increased since the middle of the nineteenth century (Tausch 1999, Miller and Tausch 2001). Causes for expansion of trees into sagebrush ecosystems include wildfire suppression, historic livestock grazing, and climate change (Bunting 1994).

Depending on fire severity, rabbitbrush 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 also increase to frequencies between 0.23 and 0.43 times a year; then even sprouting shrubs such as rabbitbrush will not survive (Whisenant 1990).

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.

Overgrazing leads to an increase in sagebrush and a decline in understory plants like Thurber's needlegrass. Squirreltail or Sandberg bluegrass will become the dominant understory species.

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 not part of the site concept, Utah juniper can invade and eventually dominate this site.

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).

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949, Britton et al. 1990) Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.

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.

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

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 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 9.

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. Management should focus on maintaining high plant species diversity, especially the perennial grasses and forbs to promote site resiliency.

Community Phase 1.1:
Wyoming big sagebrush, Thurber's needlegrass, and Indian ricegrass dominate the site. Bluebunch wheatgrass, Sandberg bluegrass, bottlebrush squirreltail and perennial forbs are also common on this site.

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 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. Sandberg bluegrass 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. Rabbitbrush, spiny hopsage and perennial grasses such as bluebunch wheatgrass, Indian ricegrass and squirreltail are common. Wyoming big sagebrush is killed by fire, therefore decreasing within the burned community. Sagebrush could still be present in unburned patches. Thurber's needlegrass can experience high mortality from fire and may be reduced in the community for several years.

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:
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. Sandberg bluegrass will likely increase in the understory and may be the dominant grass on the site.

Loamy 10-12 (023XY020NV) Phase 1.3 T. K. Stringham, August 2014

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 reduces or eliminates the overstory of sagebrush and allows the perennial bunchgrasses to dominate the site. Fires in the reference state 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, medusahead, mustard and halogeton.

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. The presence of invasive weeds alters the fuel type in this state, making it less resistant to disturbance. Non-native annual grasses and forbs tend to senesce and dry out early in the season, making them highly flammable during the dry part of summer. This increases the likelihood of fire, leading to positive feedbacks: flammable plants lead to fire, which allows more annual flammable plants to grow. Recommended management: maintain high diversity of desired species to promote organic matter inputs and prevent the dispersal and seed production of the non-native invasive species.

Community Phase 2.1:
Wyoming big sagebrush, Thurber’s needlegrass and Indian ricegrass dominate the site. Bluebunch wheatgrass, Sandberg bluegrass, squirreltail and perennial forbs are also common on this site. Non-native annual species are present in minor amounts.

Loamy Slope 10-14 (023XY039NV) Phase 2.1 T. K. Stringham, August 2014

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 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. Grass species dominate. Perennial bunchgrasses such as bluebunch wheatgrass, Thurber's needlegrass, squirreltail, and Indian ricegrass are common. Rabbitbrush, spiny hopsage, and horsebrush may be sprouting. Wyoming big sagebrush is killed by fire, therefore may be eliminated from 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 visual aspect for a number of years following wildfire.

Loamy 10-12 (R023XY020NV) Phase 2.2 T. K. Stringham, June 2015

Community Phase Pathway 2.2a, from phase 2.2 to 2.1:
Absence of disturbance over time allows the sagebrush to recover. Grazing management that favors shrubs may speed this process.

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:
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. Sandberg bluegrass will likely increase in the understory and may be the dominant grass on the site. Utah and/or Western juniper may be present. Annual non-native species present.

Gravelly Clay Slope 10-12 (R023XY102NV) Phase 2.3 T. K. Stringham, June 2014

Loamy 10-12 (023XY020NV) Phase 2.3 T. K. Stringham, August 2014

Loamy 8-10 (23XY006) Phase 2.3 P. Novak-Echenique, May 2015

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 reduces or eliminates the overstory of sagebrush and allows the perennial bunchgrasses to dominate the site. Fires may 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:
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 2.4 (at risk):
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.

Loamy Slope 10-14 (R023XY039NV) Phase 2.4 T.K. Stringham, August 2016

Stony Loam 9-12" (023XF082CA) Phase 2.4, T.K. Stringham, June 2017

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:
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: 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 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 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.

Shrub State 3.0:

This state has two community phases: a Wyoming 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. Sandberg bluegrass 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 Sandberg bluegrass understory dominate site resources such that soil water, nutrient capture, nutrient cycling and soil organic matter are temporally and spatially redistributed. Restoration from this site is unlikely; brush treatments and range seeding may be unsuccessful and can result in crossing a threshold to an annual state.

Community Phase 3.1:
Wyoming big sagebrush dominates overstory and rabbitbrush may be a significant component. Sandberg bluegrass dominates the understory and squirreltail may also be a significant component of the plant community. Utah and/or Western juniper may be present or increasing. Annual non-native species are present to increasing. Understory may be sparse, with bare ground increasing. Seeded species may be present.

Droughty Loam 8-10 (R023XY038NV) Phase 3.1 T.K. Stringham, June 2014

Loamy 8-10 (R023XY006NV) Phase 3.1 T.K. Stringham, June 2014

Loamy 10-12 (R023XY020NV) Phase 3.1 T.K. Stringham, May 2015.

Stony Slope 8-10" (R023XY101NV) Phase 3.1 T.K. Stringham, August 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 the Sandberg bluegrass, 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 Sandberg bluegrass to dominate the site.

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

Granitic Loam 10-12 (R023XY057NV) Phase 3.2 D. Snyder, July 2016

Loamy 10-12 (R023XY020NV) Phase 3.2 T.K. Stringham, May 2015

Community Phase Pathway 3.2a, from phase 3.2 to 3.1:
Absence of disturbance over time would allow 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 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.

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

Brush removal, herbicide of Sandberg bluegrass and seeding of crested wheatgrass 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 site. This state is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard in the understory. Sagebrush and/or rabbitbrush may dominate the overstory. Annual non-native species and squirreltail dominate the understory. Targeted grazing could be used to reduce the annual non-native species.

Community Phase 4.1:
Annual non-native plants such as cheatgrass, medusahead, or tansy mustard 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 allow shrubs to regenerate. Occurrence of this pathway is unlikely.

Granitic Loam 8-10 (R023XY068NV) Phase 4.1 D. Snyder, July 2016

Loamy 10-12 (R023XY020NV) Phase 4.1 T.K. Stringham, May 2015

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

Granitic Loam 8-10 (R023XY068NV) Phase 4.2 D. Snyder, July 2016

Granitic South Slope 12-14" (R023XY042NV) Phase 4.2, P. Novak-Echenique, August 2016

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

Seeded State 5.0:

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. Forage kochia, Wyoming big sagebrush, and forbs (native and non-native) may be present. Conservation practices such as brush management and prescribed grazing should be used to maintain the perennial bunchgrasses and other desirable species.

Community Phase 5.1:
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.

Loamy 8-10 (R023XY006NV) Phase 5.1 P. Novak-Echenique, May 2015

Sandy 8-12" (R023XY051NV) Phase 5.1 P. Novak-Echenique, May 2015

Community Phase Pathway 5.1a, from phase 5.1 to 5.2:
Time and lack of disturbance. May be coupled with inappropriate grazing management.

Community Phase 5.2:

Wyoming big sagebrush increases and is codominant with seeded grass species. Seeded wheatgrass species dominate understory. Annual non-native species may be present in trace amounts.

Sandy 8-12" (023XY051NV) Phase 5.2 T.K. Stringham, August 2014

Community Phase Pathway 5.2a, from phase 5.2 to 5.1:
Fire, brush management and/or Aroga moth infestation reduces sagebrush overstory and allows seeded wheatgrasses or other seeded grasses to increase.

Community Phase Pathway 5.2b, from phase 5.2 to 5.3:
Continued inappropriate grazing management reduces bunchgrasses and increases density of sagebrush. This transition may take decades.

Community Phase 5.3 (at risk):
Sagebrush becomes the dominant plant. Perennial bunchgrasses in the understory are reduced due to increased competition with shrubs. Annual non-native species may be increasing. Utah juniper may be present.

Sandy 8-12 (023XY051NV) Phase 5.3 T. K. Stringham, August 2014

Community Phase Pathway 5.3a, from phase 5.3 to 5.1:
Fire or brush management with minimal soil disturbance would reduce sagebrush to trace amounts and allow the perennial understory to increase.

T5A: Transition from Seeded State 5.0 (Community Phase 5.3) 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.

Potential Resilience Differences with other Ecological Sites:

Loamy Slope 10-14" (023XY039NV):

This site is dominated by bluebunch wheatgrass with Thurber's needlegrass as a subdominant component. It occurs on steep sideslopes ranging from 15 to over 50%. The soils in this site are shallow to moderately deep and well drained. Surface soils are medium textured and usually more than ten inches thick to a fine textured subsoil. A mollic epipedon is typically present. There are usually high amounts of gravels, cobbles and stones on the surface. Some soils are modified with high volumes of rock fragments through the soil profile. Soils are neutral to moderately alkaline with soil reaction increasing with depth. Permeability is moderate and available water capacity is low to moderate. Runoff is medium to rapid and the potential for sheet and rill erosion is moderate but will vary with slope gradient. Production varies from 450 lb/ac to 1000 lb/ac, with 700 lb/ac in normal years. This site has a tree state (6.0), making it a 6-state model. See below for more information on the Group 9 Tree State 6.0.

Loamy 10-12" (023XY020NV):

This site is dominated by bluebunch wheatgrass with Thurber's needlegrass as a subdominant component. This site is more productive than the modal site with production varying from 600 lb/ac to 1100 lb/ac, with 900 lb/ac in normal years. The soils in this site are generally moderately deep to deep and have formed in mixed alluvium, or colluvium and/or residuum from volcanic parent materials. Surface soils are moderately-fine to medium textured and usually more than ten inches thick to the subsoil or underlying material. A mollic epipedon is typically present. Permeability is moderate and the soils are well drained. Available water capacity is low to moderate. Soil reaction increases with depth in soil profile. 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 varies with slope gradient. This site has a tree state (6.0), making it a 6-state model. See below for more information on the Group 9 Tree State 6.0.

Loamy Fan 8-10" (023XY097NV):

This site is dominated by basin wildrye in Reference condition. With long-term inappropriate grazing management, basin wildrye will be reduced and more grazing tolerant grasses like Thurber's needlegrass and squirreltail will increase. Basin big sagebrush is codominant with Wyoming big sagebrush on this site. Surface soil textures on this site are generally fine to very fine sandy loams. Many areas receive additional moisture as run-in from higher landscapes. Annual production on this site is higher than the modal site, ranging from 500 – 1000 lb/ac, 700 lb/ac in normal years. This site's STM is similar to the modal site with 5 stable states.

Granitic Loam 10-12" (023XY057NV):

This site has less precipitation and a stronger component of bluebunch wheatgrass than the modal site. The soils of this site have formed in residuum or alluvium derived from granitic rock sources. These soils are generally moderately deep and are coarse textured throughout the soil profile with a low available water capacity. Soil reaction ranges from slightly acidic at the surface to neutral in the subsoil. The soils are well drained, runoff is medium, and permeability is moderately rapid. The plant community is dominated by Thurber's needlegrass, bluebunch wheatgrass and Wyoming big sagebrush. Production is slightly higher than the modal site and varies from 300 lb/ac to 700 lb/ac with 400 lb/ac in normal years. This site's STM is similar to the modal site with 5 stable states.

Granitic Loam 8-10" (023XY068NV):

This site has a similar plant community to the modal site, but with a greater presence of needleandthread. The soils of this site have formed in residuum or alluvium derived from granitic rock sources. These soils are generally moderately deep and are coarse textured throughout the soil profile with a low available water capacity. Soil reaction ranges from slightly acidic at the surface to neutral in the subsoil. The soils are well drained, runoff is medium, and permeability is moderately rapid. Production rates vary from 400 lb/ac to 800 lb/ac, with 600 lb/ac in normal years. This site's STM is similar to the modal site with 5 stable states

Droughty Loam 8-10" (023XY038NV):

In addition to Wyoming big sagebrush, spiny hopsage is a significant component on this site. Dominant grasses include Indian ricegrass and desert needlegrass. This site is drier than other sites in this group, but maintains production of 450 lb/ac in normal years. These soils generally have an effective rooting depth of less than 20 inches. Bedrock, or a strongly cemented duripan, restricts deeper root penetration in most soils. Other soils have sand or gravel layers within 20 inches of the surface that restrict root development. Many soils are modified with a high volume of gravel, cobbles and stones. These soil properties contribute to a very low available water capacity. This site differs from the modal site, it will not likely have a seeded state or tree state due to the soil type. This is a four state model. This site was not seen on site visits.

Granitic South Slope 8-12" (023XY049NV):

This site is slightly more productive, ranging from 500 to 900 lb/ac. The plant community is dominated by Wyoming big sagebrush with an understory dominated by bluebunch wheatgrass and Thurber's needlegrass. The soils of this site have formed in residuum derived from granitic rocks. This site occurs on smooth to convex shoulders and sideslopes of hills and lower mountains on predominantly southerly aspects. Slopes are greater than the modal site, ranging from 15 to 75 percent, but slope gradients of 30 to 50 percent are most typical. This site has not been seen on site visits, but likely has the same STM as the modal site.

Loamy Fan 10-12" (023XY082NV):

This site occurs on axial-stream floodplains and inset fans. The soils on this site are very deep, well drained silt or very fine sandy loams that have formed in alluvium from mixed rock sources. They have medium runoff and are moderately permeable. Soils in this site receive additional moisture as run-in from higher landscapes. This site occurs on more moderate slopes than the modal site and is more productive than the modal site, ranging from 600 lb/ac to 1200 lb/ac. This plant community is dominated by bluegrasses, needlegrasses, and Wyoming or Basin big sagebrush. This site has not been seen on site visits, but likely has the same STM as the modal site.

Granitic Fan 8-10” (023XY040NV):

This site occurs on convex summits and back slopes of erosional fan remnants and on inset fans with smooth, rolling topography. Slopes are more gradual than the modal site. The soils on this site have formed in alluvium derived from granitic rocks. These soils are deep to very deep and well drained. Soils are moderately coarse textured and soil reaction is neutral to moderately alkaline. Because of soil depth and high intake rate, most of the available moisture is held within the soil profile and available for plant use. With a reduced vegetation cover, these soils are susceptible to wind erosion. Production is higher than the modal site, ranging from 600 lb/ac to 1000 lb/ac. The plant community is dominated by big sagebrush, basin wildrye, and Thurber’s needlegrass. This site has not been seen on site visits, but likely has the same STM as the modal site.

Sandy 8-12” (023XY051NV):

This site occurs on lower fan remnants, lake terraces, and lake plains that have been covered with a surface layer of sand. Soils are deep to very deep and excessively drained. The coarse textured surface soils are usually at least 20 inches in depth. Because of rapid intake and deep percolation of water, the loss of soil moisture due to evaporation is reduced and runoff is negligible. These conditions allow deep rooted plants to grow vigorously under arid climatic conditions. The soils are extremely susceptible to wind erosion and small "blow-out" spots are common. The plant community is dominated by Indian ricegrass, needleandthread, and basin and Wyoming big sagebrush. Annual production ranges from 600-100 lb/ac with 800 lb/ac in normal years. This site’s STM is similar to the modal site with 5 stable states.

Channery Hill 8-10” (023XY099NV):

This site’s dominant grass is Indian ricegrass. Subdominant plants include thickspike wheatgrass and squawapple (*Peraphyllum ramosissimum*). The soils on this site are shallow to bedrock or have a subsoil layer restrictive to root development at a very shallow depth. The available water capacity is low. There are very high amounts (>50%) of thin, coarse, rock fragments averaging over 3 inches in diameter on the soil surface. Plant production is slightly lower than the modal site, ranging from 200 - 800 lb/ac with 500 lb/ac in normal years. This site’s STM is similar to the modal site with 5 stable states. This site was not seen on site visits.

Stony Slope 8-10” (023XY101NV):

The dominant grass on this site is desert needlegrass. This site occurs on summits and back slopes of low hills, predominantly on south-facing aspects, with a wide range of slopes. The soils on this site are shallow to moderately deep and well drained. The surface soils are moderately coarse to medium textured. Available water capacity is low. There are very high amounts of coarse rock fragments (cobbles and stones) on the soil surface. Runoff is medium and the potential for sheet and rill erosion is moderate to high depending on slope. Production is slightly higher than the modal site, ranging from

450 to 900 lb/ac with 700 lb/ac in normal years. This site's STM is similar to the modal site with 5 stable states. This site was not seen on site visits.

Gravelly Clay Slope 10-12" (023XY102NV):

The plant community is dominated by bluebunch wheatgrass, Thurber's needlegrass, Wyoming big sagebrush and Nevada greasebush (*Glossopetalon spinescens var. aridum)*. Utah juniper is also prevalent on this site and exists in the Reference State. The soils in this site are typically shallow to moderately deep and well drained. Surface soils are medium textured. Subsoils are medium to moderately-fine textured and the soil profile is modified with 35 to over 50 percent rock fragments, by volume. Infiltration is moderate and permeability is medium. The available water capacity is low. Runoff is medium and the potential for sheet and rill erosion is moderate to high depending on slope gradient. This site is not likely to have a seeded state or tree state. This site has a four state model.

Stony Loam 9-12" (023XF082CA):

This California ecological site is correlated most closely to the Loamy 10-12" (023XY020NV) site in Nevada. This site is dominated by Wyoming big sagebrush and mountain big sagebrush, with a small component of antelope bitterbrush and little horsebrush (*Tetradymia glabrata)*. Bluebunch wheatgrass is the dominant grass, with Thurber's needlegrass in smaller amounts. Trace amounts of western juniper is part of the cite concept, and a Tree State is possible. Basin wildrye may be present. This site is more productive than the modal site with production ranging from 600-1200 lb/ac, and 600 lb/ac in normal years. As with many of the CA ecological sites evaluated in this report, it is a broad site concept and may vary significantly at the high and low ends of its precipitation range. This site has a tree state (6.0), making it a 6-state model. See below for more information on the Group 9 Tree State 6.0.

Loamy Upland 9-12" (R023XF091CA):

This California Ecological site correlates most closely to the modal site in this group, the Loamy 8-10" (023XY006NV) site. This site is characterized by soils with moderately deep effective rooting depths of more than 14 inches but is a broad upland site concept. Basin big sagebrush or Wyoming sagebrush and black greasewood can dominate the overstory, while the understory is dominated by basin wildrye, Thurber's needlegrass, and needleandthread. Basin wildrye may be overstated in the ecological site description for this site and may occur in smaller inclusions on the landscape. The community is less productive than modal site, with an estimate of 900 lb/ac in a normal year. This site has the same STM as the modal with 5 stable states.

Tree State 6.0 Narrative

This section is separated from the primary Group narrative because it has only been found to occur in three sites: Loamy Slope 10-14", Loamy 10-12", and its sister site in California, Stony Loam 9-12". These sites occur in close proximity to woodland ecological sites. In the absence of disturbance, juniper seedlings mature and may dominate the site.

T2C: Transition from Current Potential State 2.0 to Tree State 6.0

Trigger: Time and lack of disturbance or management action allows Utah juniper and/or western 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 number of live shrubs. Minimal recruitment of new shrub cohorts.

T3B: Transition from Shrub State 3.0 to Tree State 6.0:

Trigger: Absence of disturbance over time allows 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 juniper and/or western 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.

Tree State 6.0:

This state is characterized by a dominance of Utah and/or western 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 and soil organic matter distribution and cycling have been spatially and temporally altered.

Community Phase 6.1:
Utah and/or western juniper dominate. Big sagebrush and other shrubs are a minor component. Perennial bunchgrasses decrease and only shade tolerant species remain. Annual non-native species may be present under trees. Bare ground areas are large and connected.

Community Phase Pathway 6.1a, from Phase 6.1 to 6.2:
Time without disturbance allows for maturation of the tree community.

Community Phase 6.2:

Utah and/or western juniper dominate the overstory. Big sagebrush minor is a component and may be missing. Shrub skeletons are present. If perennial grasses are surviving, shade-tolerant species are dominant. Annual non-native species may be present under trees. Bare ground areas large and connected. Soil redistribution is apparent as rills and water flow patterns.

T4A: Transition from Tree State 6.0 to Annual State 5.0:

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.

R6A: Restoration from Tree State 6.0 to Current Potential State 2.0:

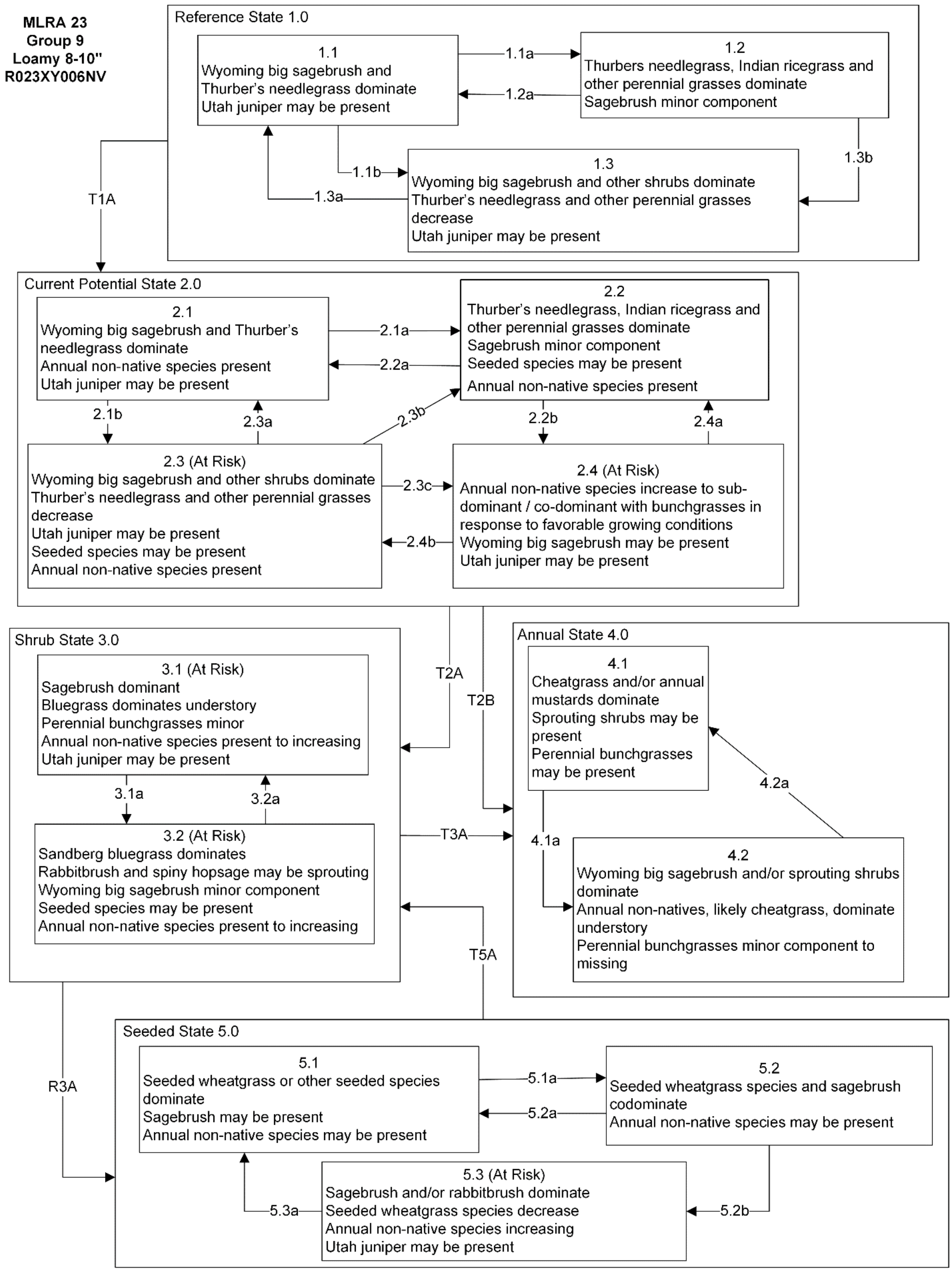
Tree removal with minimum soil disturbance such as hand felling or mastication within community phase 6.1 when native grasses are still present and there are few non-native annual grasses. This treatment may be combined with seeding of native species to assist with recovery.

R6B: Restoration from Tree State 6.0 to Seeded State 5.0:

Tree removal with minimum soil disturbance such as hand felling or mastication within community phase 6.1 when native grasses are still present. This treatment is combined with seeding of wheatgrass species to assist with recovery.

Loamy 10-12 (R023XY020NV) site after tree removal. P. Novak-Echenique, December 2017

Modal State and Transition Model for Group 9 in MRLA 3:


MLRA 23
Group 9
Loamy 8-10"
R023XY006NV
Reference State 1.0
1.1
Wyoming big sagebrush and
Thurber's needlegrass dominate
Utah juniper may be present
1.1a
1.2a
1.2
Thurbers needlegrass, Indian ricegrass and
other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush and other shrubs dominate
Thurber's needlegrass and other perennial grasses
decrease
Utah juniper may be present
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush and Thurber's
needlegrass dominate
Annual non-native species present
Utah juniper may be present
2.1a
2.2a
2.2
Thurber's needlegrass, Indian ricegrass and
other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Thurber's needlegrass and other perennial grasses
decrease
Utah juniper may be present
Seeded species may be present
Annual non-native species present
2.3c
2.4b
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
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah juniper may be present
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T3A
T5A
Annual State 4.0
4.1
Cheatgrass and/or annual
mustards dominate
Sprouting shrubs may be
present
Perennial bunchgrasses
may be present
4.2a
4.1a
4.2
Wyoming big sagebrush and/or sprouting shrubs
dominate
Annual non-natives, likely cheatgrass, dominate
understory
Perennial bunchgrasses minor component to
missing
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species
dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush
codominate
Annual non-native species may be present
5.3a
5.2b
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah juniper may be present

MLRA 23
Group 9
Loamy 8-10"
R023XY006NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1). Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

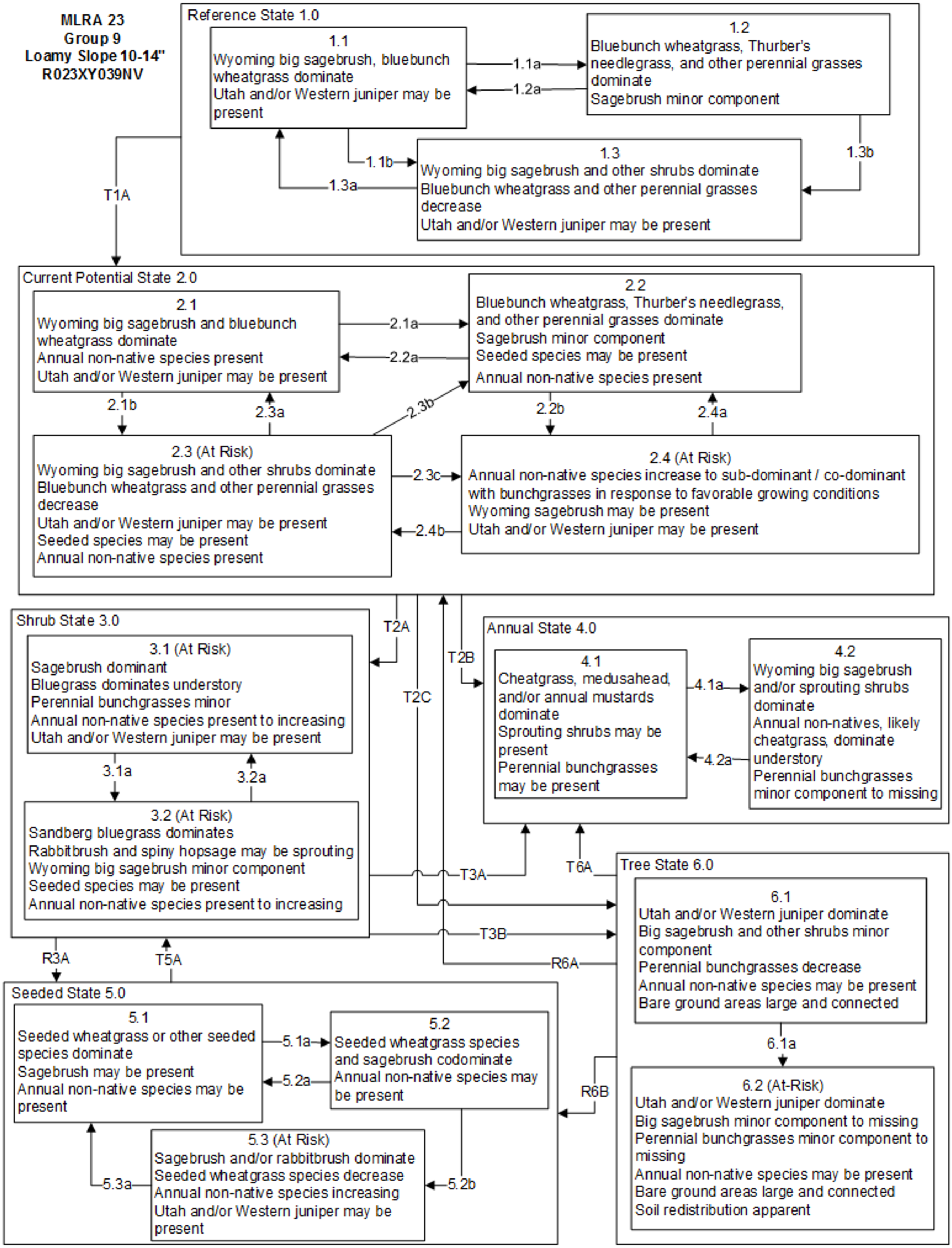
Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 9 in MRLA 23:



MLRA 23
Group 9
Loamy Slope 10-14"
R023XY039NV
Reference State 1.0
1.1
Wyoming big sagebrush, bluebunch wheatgrass dominate
Utah and/or Western juniper may be present
1.1a
1.2a
1.2
Bluebunch wheatgrass, Thurber's needlegrass, and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush and other shrubs dominate
Bluebunch wheatgrass and other perennial grasses decrease
Utah and/or Western juniper may be present
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush and bluebunch wheatgrass dominate
Annual non-native species present
Utah and/or Western juniper may be present
2.1a
2.2a
2.2
Bluebunch wheatgrass, Thurber's needlegrass, and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Bluebunch wheatgrass and other perennial grasses decrease
Utah and/or Western juniper may be present
Seeded species may be present
Annual non-native species present
2.3c
2.4b
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Wyoming sagebrush may be present
Utah and/or Western juniper may be present
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah and/or Western juniper may be present
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
Annual State 4.0
4.1
Cheatgrass, medusahead, and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.1a
4.2a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
T3A
T6A
T3B
R6A
R3A
T5A
Tree State 6.0
6.1
Utah and/or Western juniper dominate
Big sagebrush and other shrubs minor component
Perennial bunchgrasses decrease
Annual non-native species may be present
Bare ground areas large and connected
6.1a
6.2 (At-Risk)
Utah and/or Western juniper dominate
Big sagebrush minor component to missing
Perennial bunchgrasses minor component to missing
Annual non-native species may be present
Bare ground areas large and connected
Soil redistribution apparent
R6B
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3a
5.2b
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah and/or Western juniper may be present

MLRA 23
Group 9
Loamy Slope 10-14"
R023XY039NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).
Transition T2C: Time and lack of disturbance or management allows juniper to dominate and/or grazing management that reduces herbaceous understory competition.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

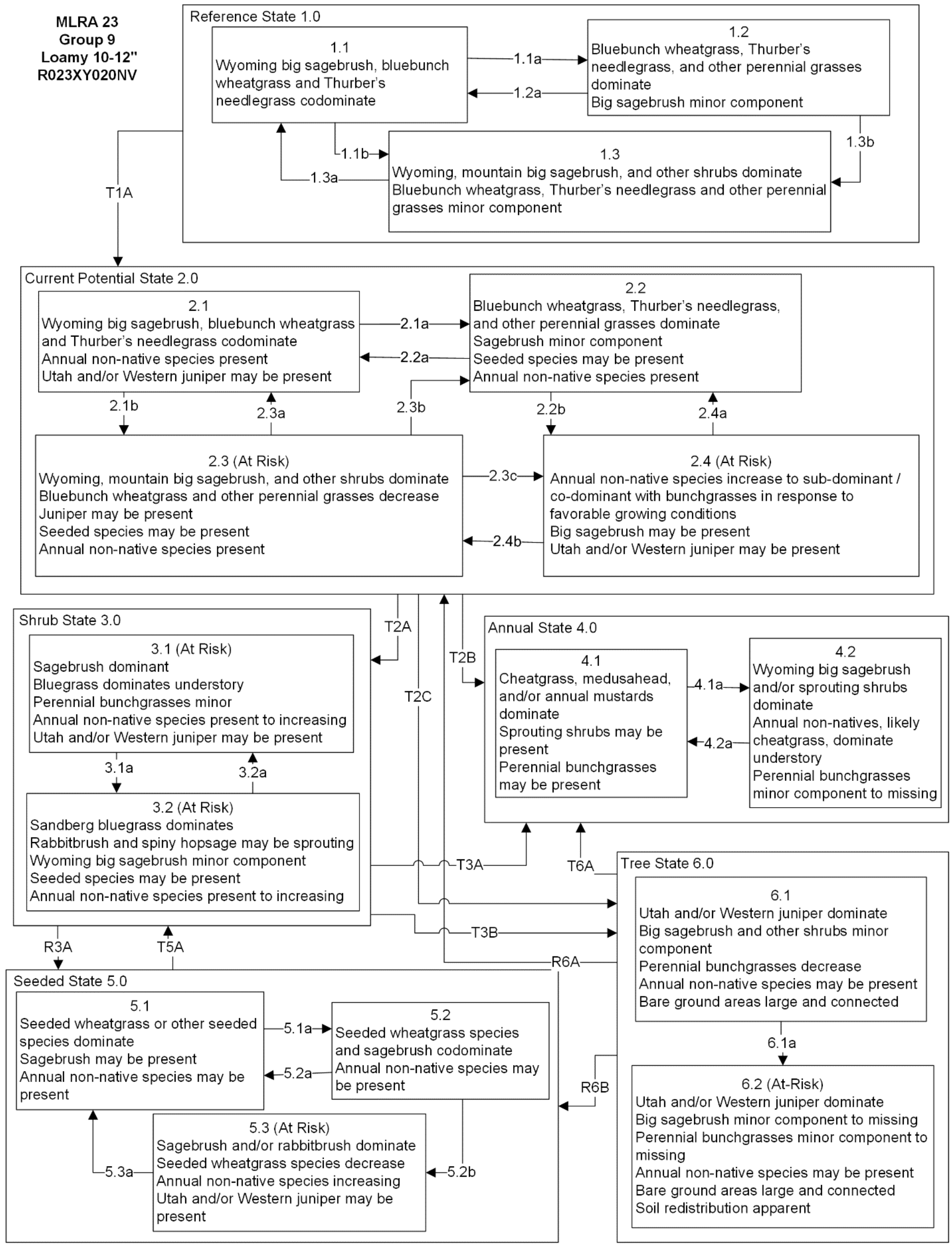
Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Transition T3B: Time and lack of disturbance allows for juniper to establish.
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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.

Tree State 6.0 Community Phase Pathways:
6.1a: Time without disturbance allows maturation of tree community.

Transition T6A: Catastrophic fire would eliminate or reduce trees (4.1), or tree removal when annuals are present.
Restoration R6A: Tree removal with minimal soil disturbance with native grasses present and seeding.
Restoration R6B: Tree removal with minimal soil disturbance with native grasses present and seeding of wheatgrass species.


MLRA 23
Group 9
Loamy 10-12"
R023XY020NV
Reference State 1.0
1.1
Wyoming big sagebrush, bluebunch wheatgrass and Thurber's needlegrass codominate
1.1a
1.2a
1.2
Bluebunch wheatgrass, Thurber's needlegrass, and other perennial grasses dominate
Big sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming, mountain big sagebrush, and other shrubs dominate
Bluebunch wheatgrass, Thurber's needlegrass and other perennial grasses minor component
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush, bluebunch wheatgrass and Thurber's needlegrass codominate
Annual non-native species present
Utah and/or Western juniper may be present
2.1a
2.2a
2.2
Bluebunch wheatgrass, Thurber's needlegrass, and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming, mountain big sagebrush, and other shrubs dominate
Bluebunch wheatgrass and other perennial grasses decrease
Juniper may be present
Seeded species may be present
Annual non-native species present
2.3c
2.4b
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Utah and/or Western juniper may be present
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah and/or Western juniper may be present
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
Annual State 4.0
4.1
Cheatgrass, medusahead, and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.1a
4.2a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
T3A
T6A
T3B
R6A
Tree State 6.0
6.1
Utah and/or Western juniper dominate
Big sagebrush and other shrubs minor component
Perennial bunchgrasses decrease
Annual non-native species may be present
Bare ground areas large and connected
6.1a
6.2 (At-Risk)
Utah and/or Western juniper dominate
Big sagebrush minor component to missing
Perennial bunchgrasses minor component to missing
Annual non-native species may be present
Bare ground areas large and connected
Soil redistribution apparent
R3A
T5A
R6B
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah and/or Western juniper may be present
5.3a
5.2b

MLRA 23
Group 9
Loamy 10-12"
R023XY020NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).
Transition T2C: Time and lack of disturbance or management allows juniper to dominate and/or grazing management that reduces herbaceous understory competition.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

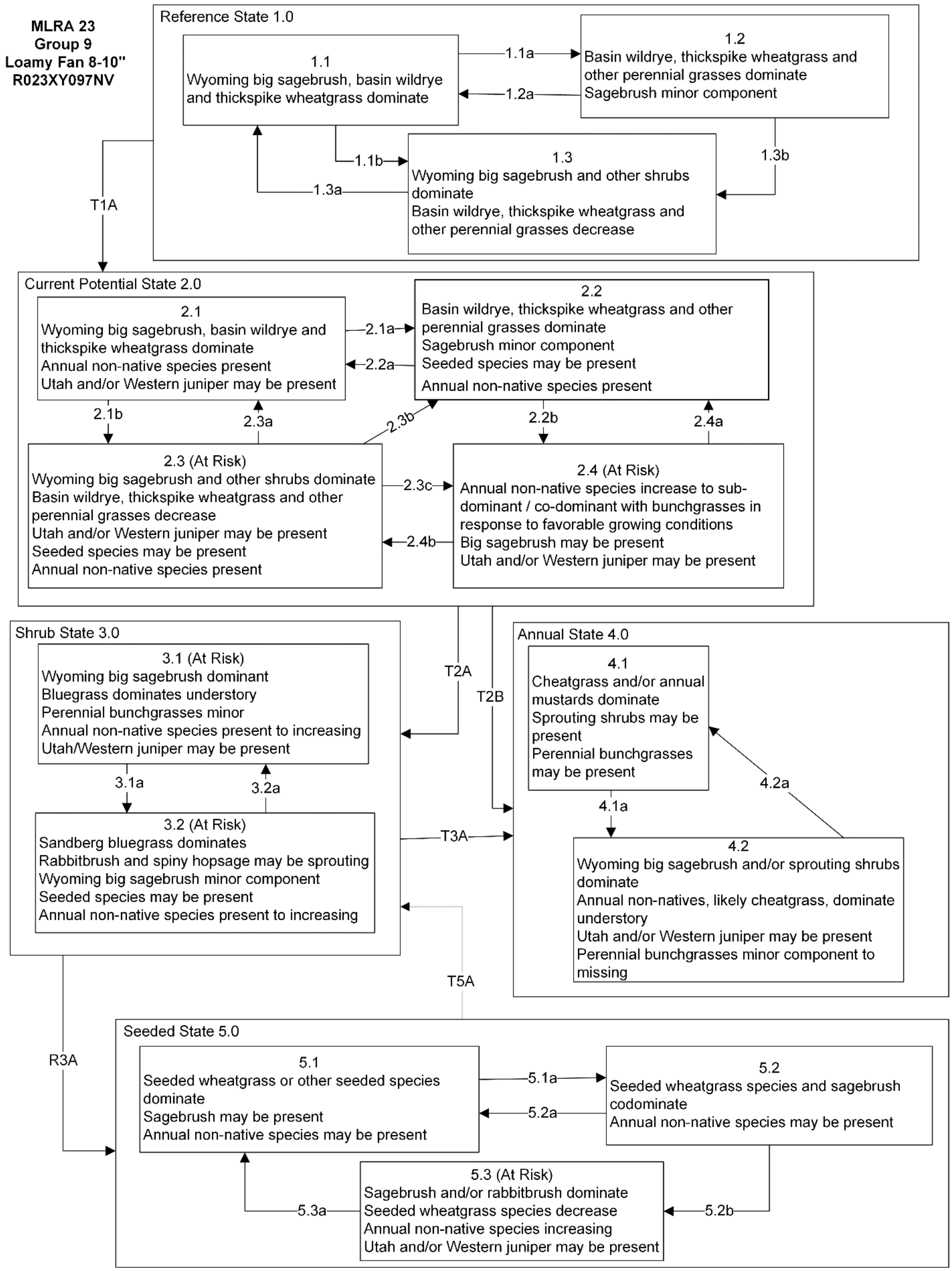
Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Transition T3B: Time and lack of disturbance allows for juniper to establish.
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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.

Tree State 6.0 Community Phase Pathways:
6.1a: Time without disturbance allows maturation of tree community.

Transition T6A: Catastrophic fire would eliminate or reduce trees (4.1), or tree removal when annuals are present.
Restoration R6A: Tree removal with minimal soil disturbance with native grasses present and seeding.
Restoration R6B: Tree removal with minimal soil disturbance with native grasses present and seeding of wheatgrass species.


MLRA 23
Group 9
Loamy Fan 8-10"
R023XY097NV
Reference State 1.0
1.1
Wyoming big sagebrush, basin wildrye and thickspike wheatgrass dominate
1.1a
1.2a
1.2
Basin wildrye, thickspike wheatgrass and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush and other shrubs dominate
Basin wildrye, thickspike wheatgrass and other perennial grasses decrease
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush, basin wildrye and thickspike wheatgrass dominate
Annual non-native species present
Utah and/or Western juniper may be present
2.1a
2.2a
2.2
Basin wildrye, thickspike wheatgrass and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Basin wildrye, thickspike wheatgrass and other perennial grasses decrease
Utah and/or Western juniper may be present
Seeded species may be present
Annual non-native species present
2.3c
2.4b
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Utah and/or Western juniper may be present
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah/Western juniper may be present
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T3A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.1a
4.2a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Utah and/or Western juniper may be present
Perennial bunchgrasses minor component to missing
T5A
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3a
5.2b
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah and/or Western juniper may be present

MLRA 23
Group 9
Loamy Fan 8-10"
R023XY097NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

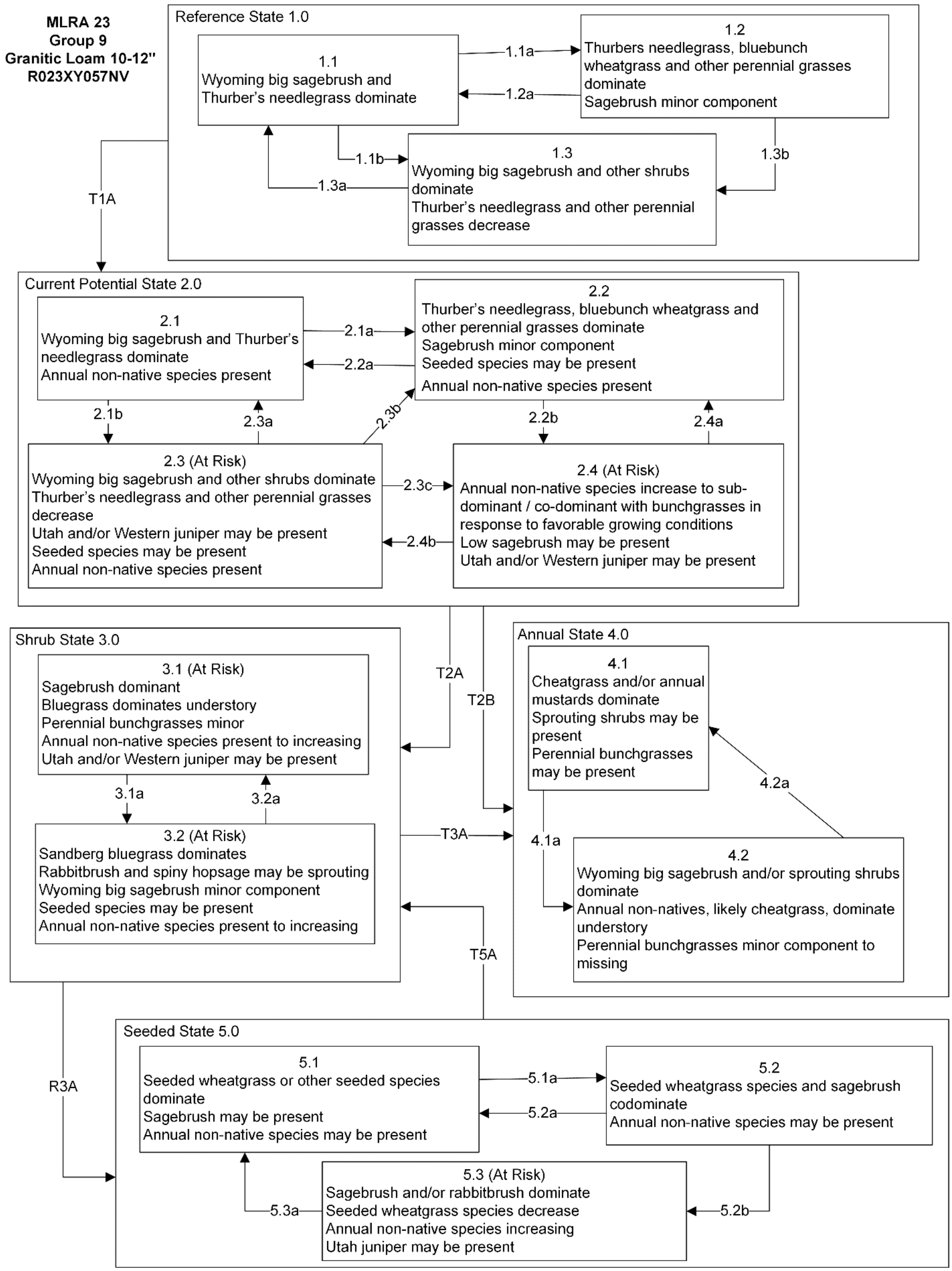
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Granitic Loam 10-12"
R023XY057NV
Reference State 1.0
1.1
Wyoming big sagebrush and
Thurber's needlegrass dominate
1.2
Thurbers needlegrass, bluebunch wheatgrass and other perennial grasses dominate
Sagebrush minor component
1.3
Wyoming big sagebrush and other shrubs dominate
Thurber's needlegrass and other perennial grasses decrease
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush and Thurber's needlegrass dominate
Annual non-native species present
2.2
Thurber's needlegrass, bluebunch wheatgrass and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Thurber's needlegrass and other perennial grasses decrease
Utah and/or Western juniper may be present
Seeded species 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
Utah and/or Western 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)
Sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah and/or Western juniper may be present
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
3.1a
3.2a
T3A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
4.1a
4.2a
T5A
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah juniper may be present
5.1a
5.2a
5.2b
5.3a

MLRA 23
Group 9
Granitic Loam 10-12"
R023XY057NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1). Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

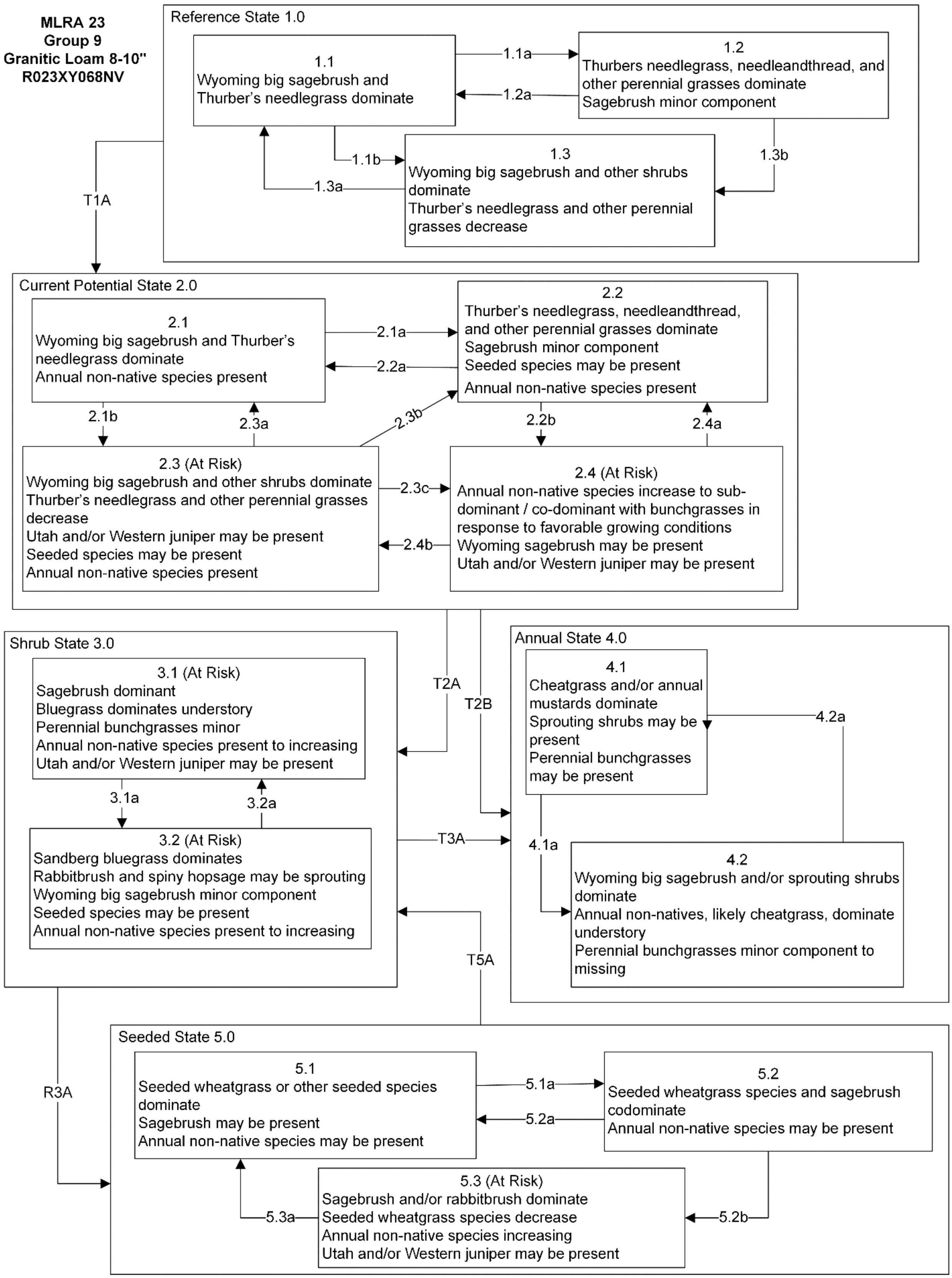
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Granitic Loam 8-10"
R023XY068NV
Reference State 1.0
1.1
Wyoming big sagebrush and Thurber's needlegrass dominate
1.1a
1.2a
1.2
Thurbers needlegrass, needleandthread, and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush and other shrubs dominate
Thurber's needlegrass and other perennial grasses decrease
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush and Thurber's needlegrass dominate
Annual non-native species present
2.1a
2.2a
2.2
Thurber's needlegrass, needleandthread, and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Thurber's needlegrass and other perennial grasses decrease
Utah and/or Western juniper may be present
Seeded species may be present
Annual non-native species present
2.3c
2.4b
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Wyoming sagebrush may be present
Utah and/or Western juniper may be present
Shrub State 3.0
3.1 (At Risk)
Sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah and/or Western juniper may be present
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T2A
T2B
T3A
T5A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2a
4.1a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah and/or Western juniper may be present
5.3a
5.2b

MLRA 23
Group 9
Granitic Loam 8-10"
R023XY068NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

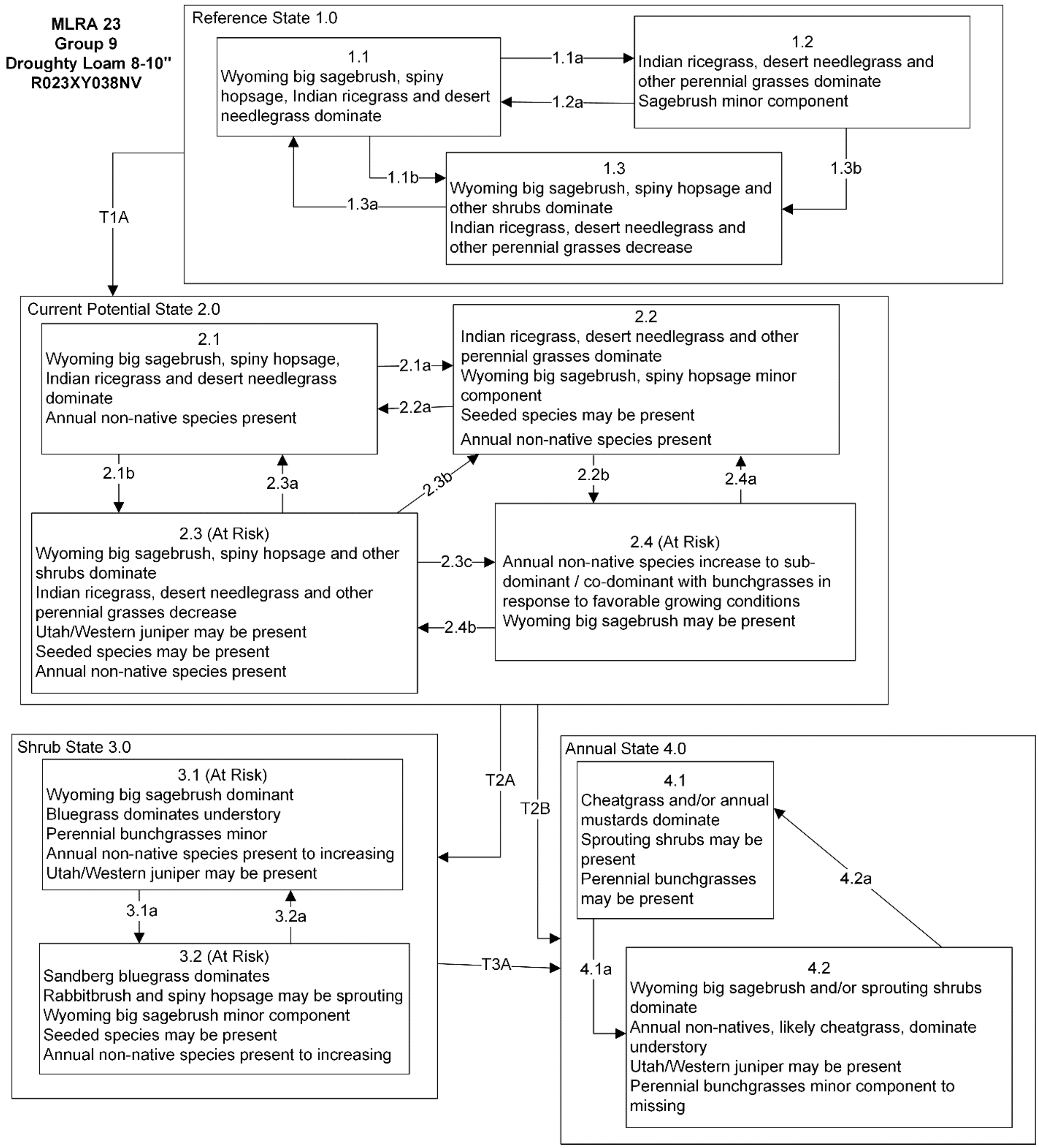
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Droughty Loam 8-10"
R023XY038NV
Reference State 1.0
1.1
Wyoming big sagebrush, spiny hopsage, Indian ricegrass and desert needlegrass dominate
1.1a
1.2a
1.2
Indian ricegrass, desert needlegrass and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush, spiny hopsage and other shrubs dominate
Indian ricegrass, desert needlegrass and other perennial grasses decrease
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush, spiny hopsage, Indian ricegrass and desert needlegrass dominate
Annual non-native species present
2.1a
2.2a
2.2
Indian ricegrass, desert needlegrass and other perennial grasses dominate
Wyoming big sagebrush, spiny hopsage minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush, spiny hopsage and other shrubs dominate
Indian ricegrass, desert needlegrass and other perennial grasses decrease
Utah/Western juniper may be present
Seeded species may be present
Annual non-native species present
2.3c
2.4b
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
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah/Western juniper may be present
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T2A
T2B
T3A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2a
4.1a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Utah/Western juniper may be present
Perennial bunchgrasses minor component to missing

MLRA 23
Group 9
Droughty Loam 8-10"
R023XY038NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

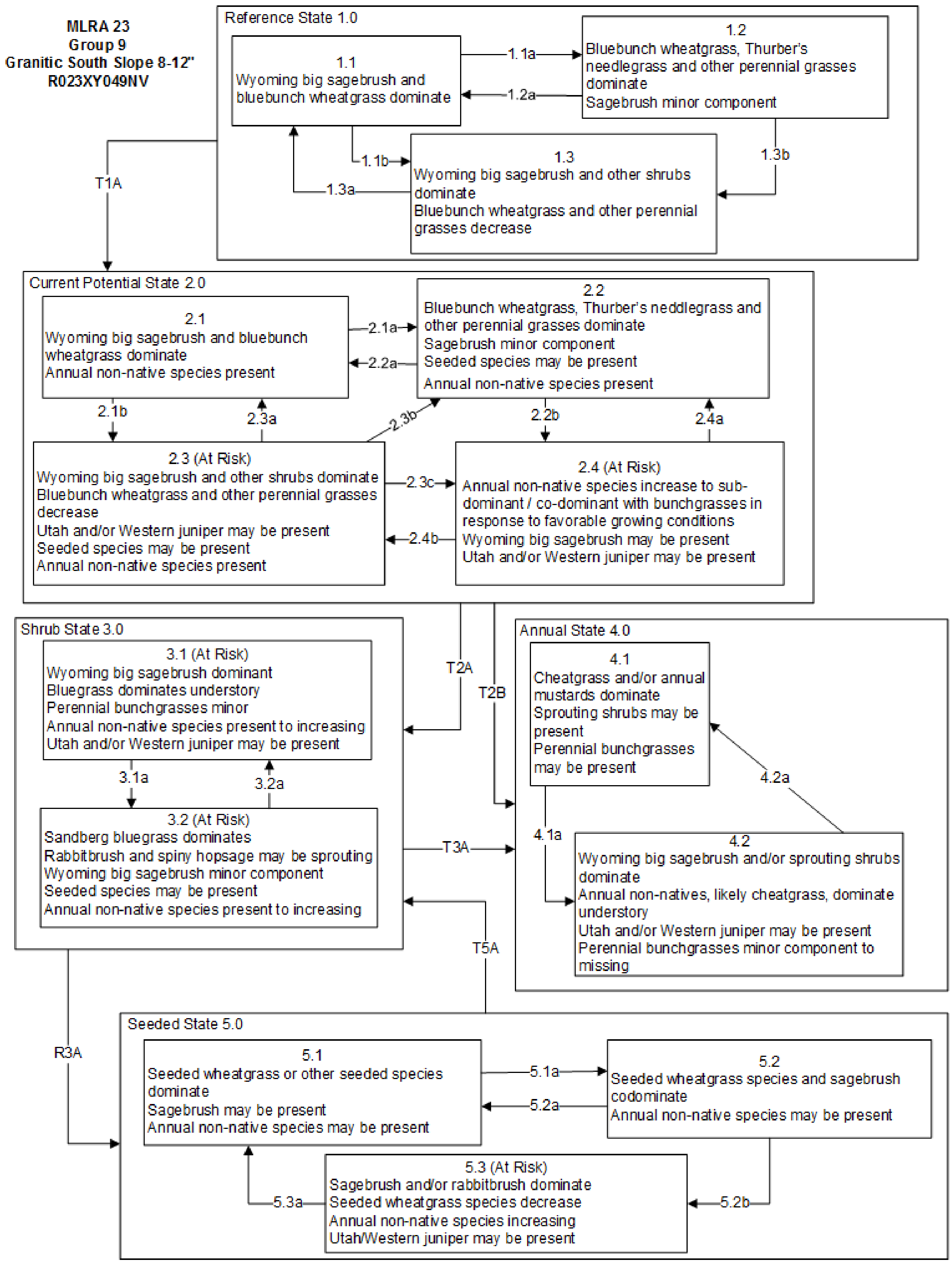
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic; non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing and/or drought will reduce perennial bunchgrasses.
2.2a: 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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).



MLRA 23
Group 9
Granitic South Slope 8-12"
R023XY049NV
Reference State 1.0
1.1
Wyoming big sagebrush and bluebunch wheatgrass dominate
1.1a
1.2a
1.2
Bluebunch wheatgrass, Thurber's needlegrass and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush and other shrubs dominate
Bluebunch wheatgrass and other perennial grasses decrease
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush and bluebunch wheatgrass dominate
Annual non-native species present
2.1a
2.2a
2.2
Bluebunch wheatgrass, Thurber's neddlegrass and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Bluebunch wheatgrass and other perennial grasses decrease
Utah and/or Western juniper may be present
Seeded species may be present
Annual non-native species present
2.3c
2.4b
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 and/or Western juniper may be present
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah and/or Western juniper may be present
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T3A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2a
4.1a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Utah and/or Western juniper may be present
Perennial bunchgrasses minor component to missing
T5A
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3a
5.2b
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah/Western juniper may be present

MLRA 23
Group 9
Granitic South Slope 8-12"
R023XY049NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

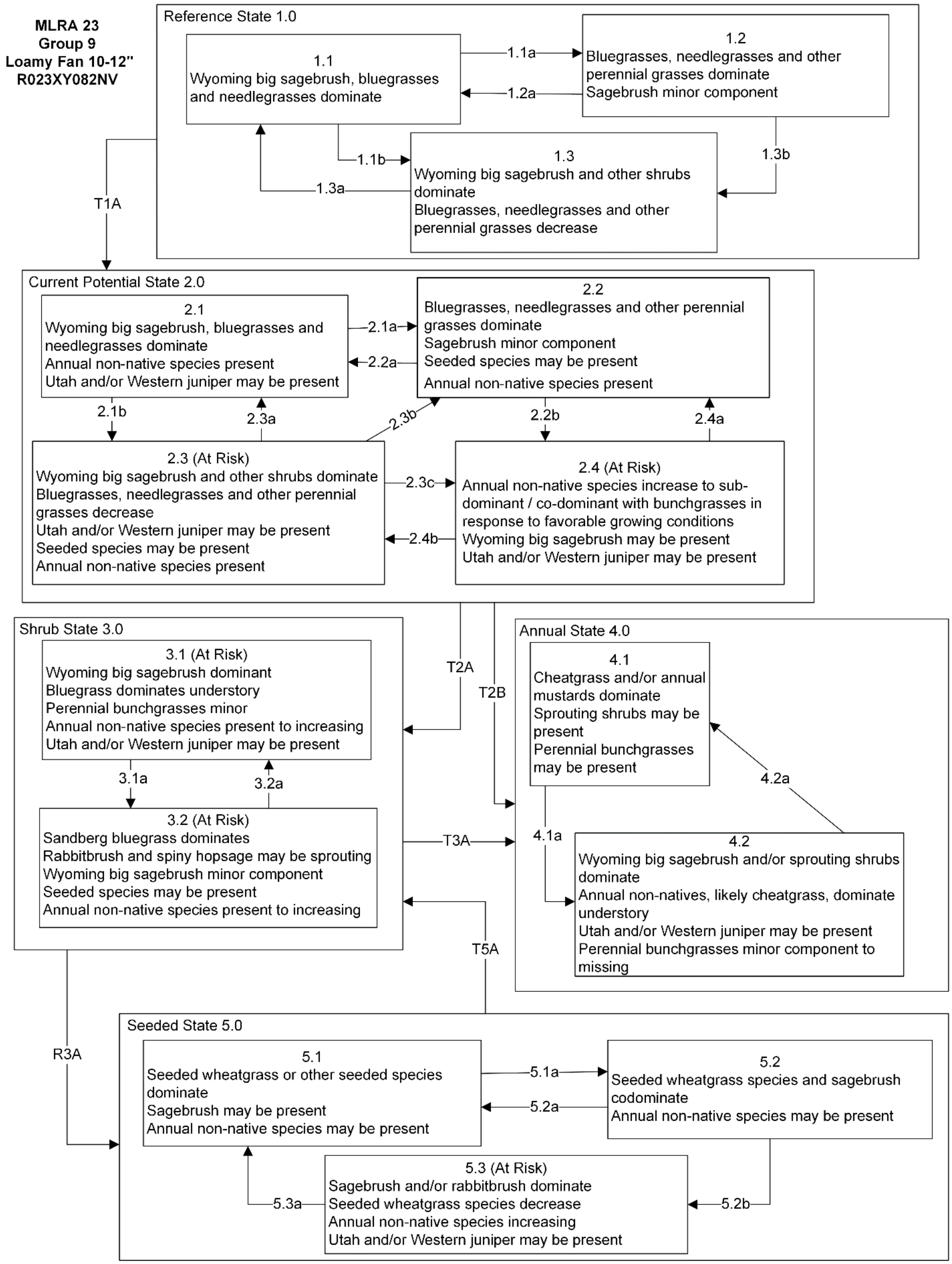
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Loamy Fan 10-12"
R023XY082NV
Reference State 1.0
1.1
Wyoming big sagebrush, bluegrasses and needlegrasses dominate
1.1a
1.2a
1.2
Bluegrasses, needlegrasses and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush and other shrubs dominate
Bluegrasses, needlegrasses and other perennial grasses decrease
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush, bluegrasses and needlegrasses dominate
Annual non-native species present
Utah and/or Western juniper may be present
2.1a
2.2a
2.2
Bluegrasses, needlegrasses and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Bluegrasses, needlegrasses and other perennial grasses decrease
Utah and/or Western juniper may be present
Seeded species may be present
Annual non-native species present
2.3c
2.4b
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 and/or Western juniper may be present
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah and/or Western juniper may be present
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T3A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.1a
4.2a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Utah and/or Western juniper may be present
Perennial bunchgrasses minor component to missing
T5A
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah and/or Western juniper may be present
5.3a
5.2b

MLRA 23
Group 9
Loamy Fan 10-12"
R023XY082NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

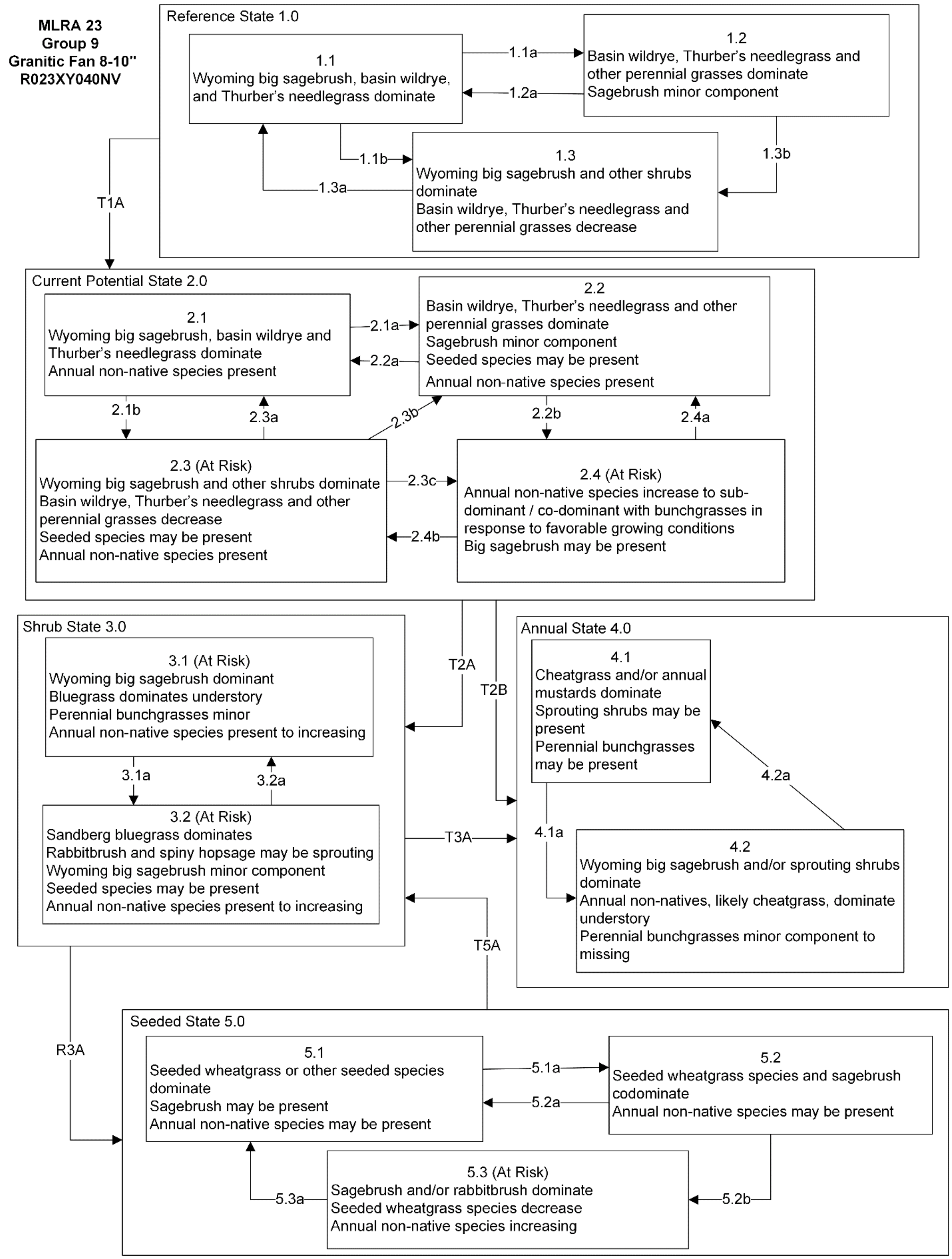
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Granitic Fan 8-10"
R023XY040NV
Reference State 1.0
1.1
Wyoming big sagebrush, basin wildrye, and Thurber's needlegrass dominate
1.1a
1.2a
1.2
Basin wildrye, Thurber's needlegrass and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush and other shrubs dominate
Basin wildrye, Thurber's needlegrass and other perennial grasses decrease
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush, basin wildrye and Thurber's needlegrass dominate
Annual non-native species present
2.1a
2.2a
2.2
Basin wildrye, Thurber's needlegrass and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Basin wildrye, Thurber's needlegrass and other perennial grasses decrease
Seeded species may be present
Annual non-native species present
2.3c
2.4b
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T2A
T2B
T3A
T5A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2a
4.1a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3a
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
5.2b

MLRA 23
Group 9
Granitic Fan 8-10"
R023XY040NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1). Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

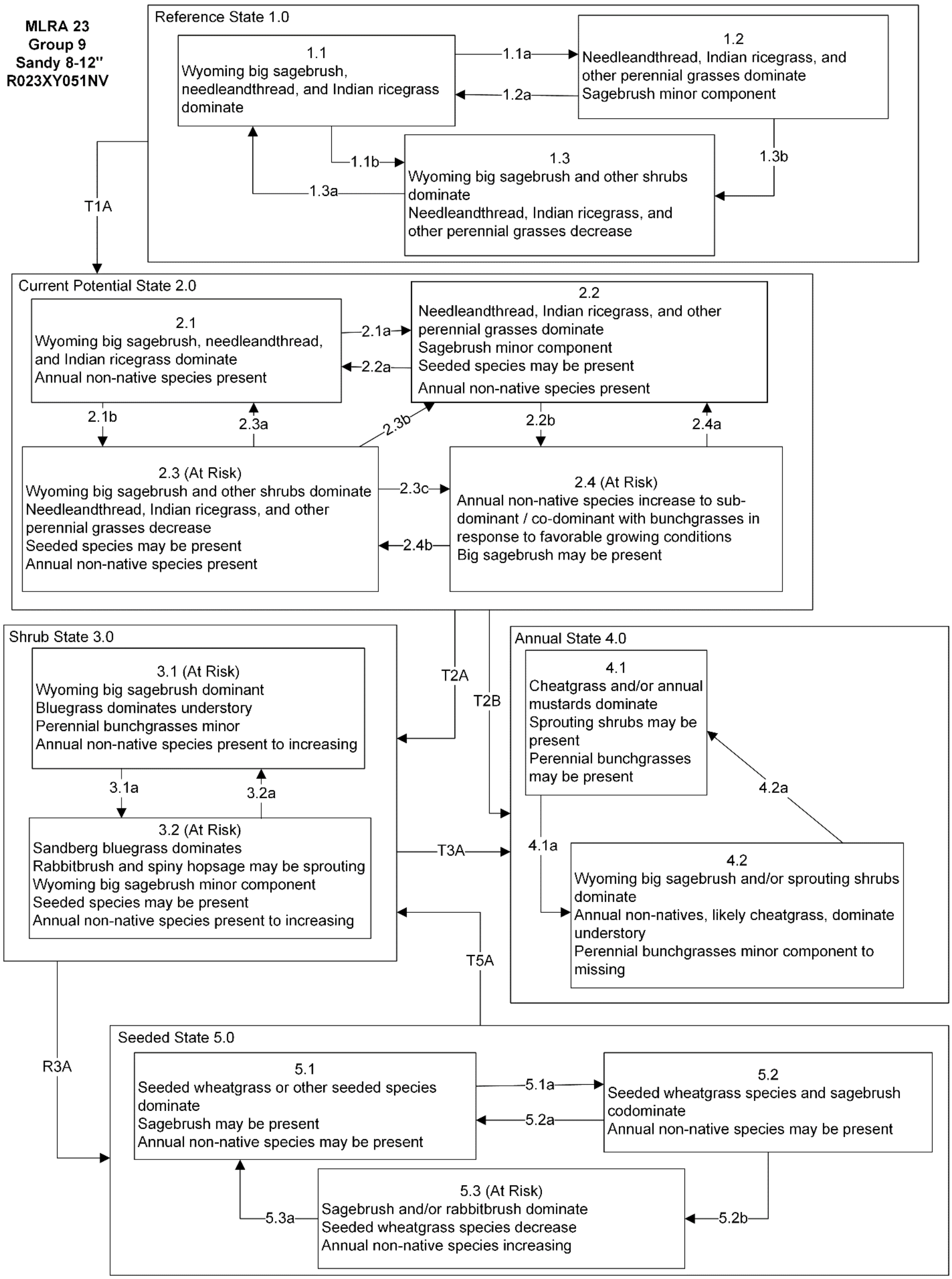
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Sandy 8-12"
R023XY051NV
Reference State 1.0
1.1
Wyoming big sagebrush, needleandthread, and Indian ricegrass dominate
1.1a
1.2a
1.2
Needleandthread, Indian ricegrass, and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush and other shrubs dominate
Needleandthread, Indian ricegrass, and other perennial grasses decrease
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush, needleandthread, and Indian ricegrass dominate
Annual non-native species present
2.1a
2.2a
2.2
Needleandthread, Indian ricegrass, and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Needleandthread, Indian ricegrass, and other perennial grasses decrease
Seeded species may be present
Annual non-native species present
2.3c
2.4b
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
T2A
T2B
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T3A
T5A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2a
4.1a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3a
5.2b
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing

MLRA 23
Group 9
Sandy 8-12"
R023XY051NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

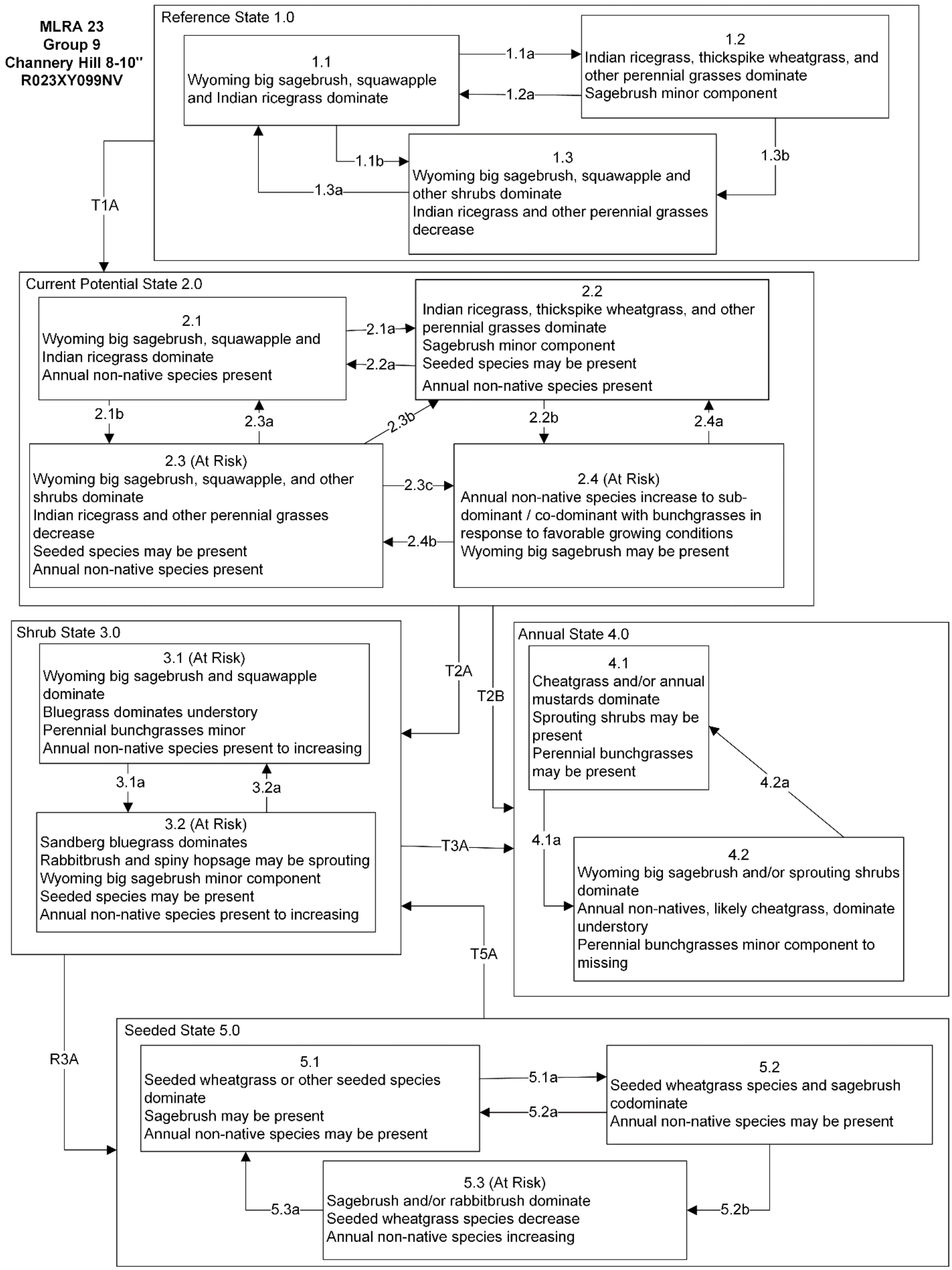
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Channery Hill 8-10"
R023XY099NV
Reference State 1.0
1.1
Wyoming big sagebrush, squawapple and Indian ricegrass dominate
1.1a
1.2a
1.2
Indian ricegrass, thickspike wheatgrass, and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush, squawapple and other shrubs dominate
Indian ricegrass and other perennial grasses decrease
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush, squawapple and Indian ricegrass dominate
Annual non-native species present
2.1a
2.2a
2.2
Indian ricegrass, thickspike wheatgrass, and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush, squawapple, and other shrubs dominate
Indian ricegrass and other perennial grasses decrease
Seeded species may be present
Annual non-native species present
2.3c
2.4b
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
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush and squawapple dominate
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T2A
T2B
T3A
T5A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2a
4.1a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3a
5.2b
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing

MLRA 23
Group 9
Channery Hill 8-10"
R023XY099NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

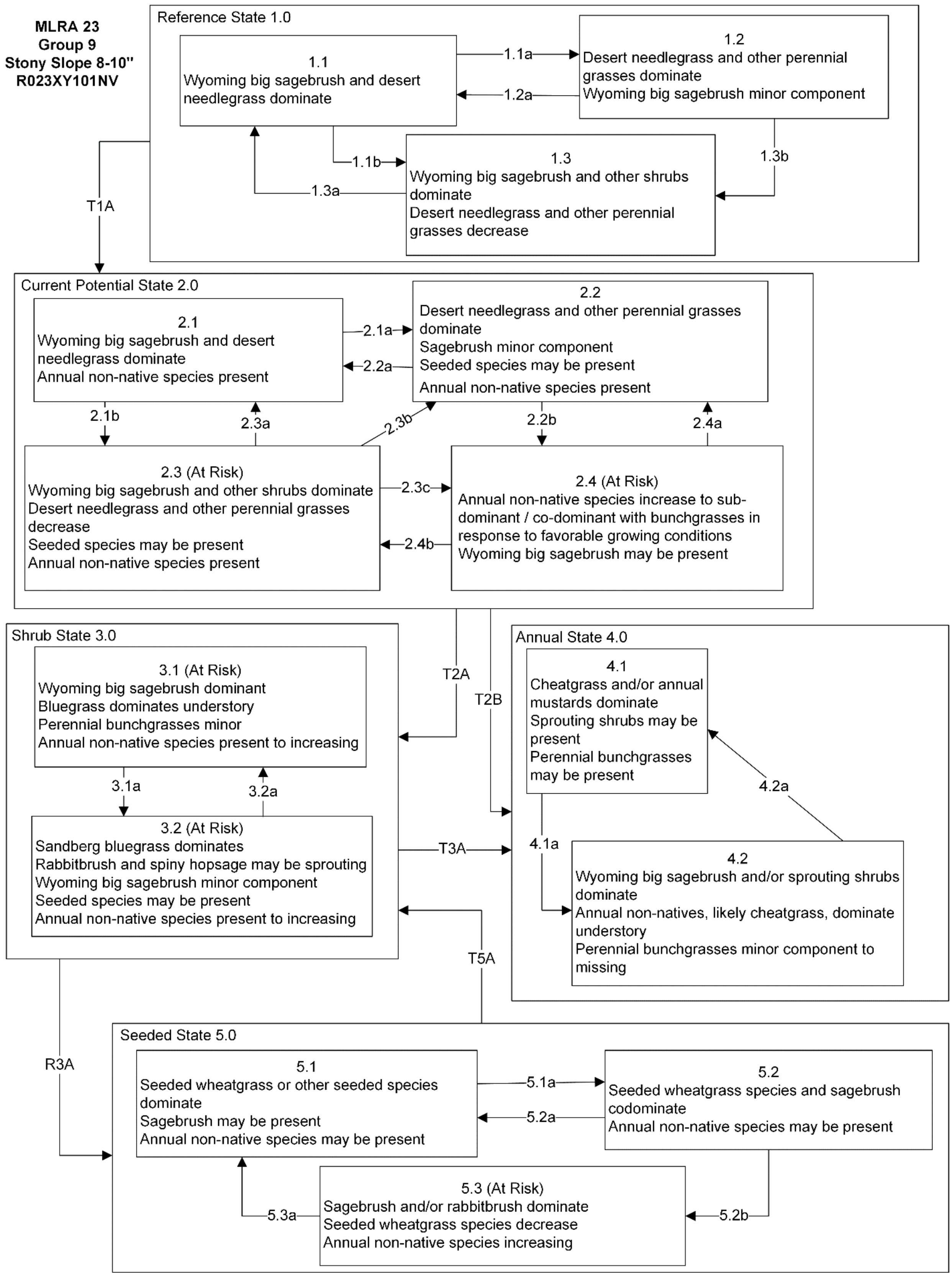
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Stony Slope 8-10"
R023XY101NV
Reference State 1.0
1.1
Wyoming big sagebrush and desert needlegrass dominate
1.2
Desert needlegrass and other perennial grasses dominate
Wyoming big sagebrush minor component
1.3
Wyoming big sagebrush and other shrubs dominate
Desert needlegrass and other perennial grasses decrease
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush and desert needlegrass dominate
Annual non-native species present
2.2
Desert needlegrass and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.3 (At Risk)
Wyoming big sagebrush and other shrubs dominate
Desert needlegrass and other perennial grasses decrease
Seeded species 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
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 dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
3.1a
3.2a
T3A
T5A
R3A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
4.1a
4.2a
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
5.1a
5.2a
5.3a
5.2b

MLRA 23
Group 9
Stony Slope 8-10"
R023XY101NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

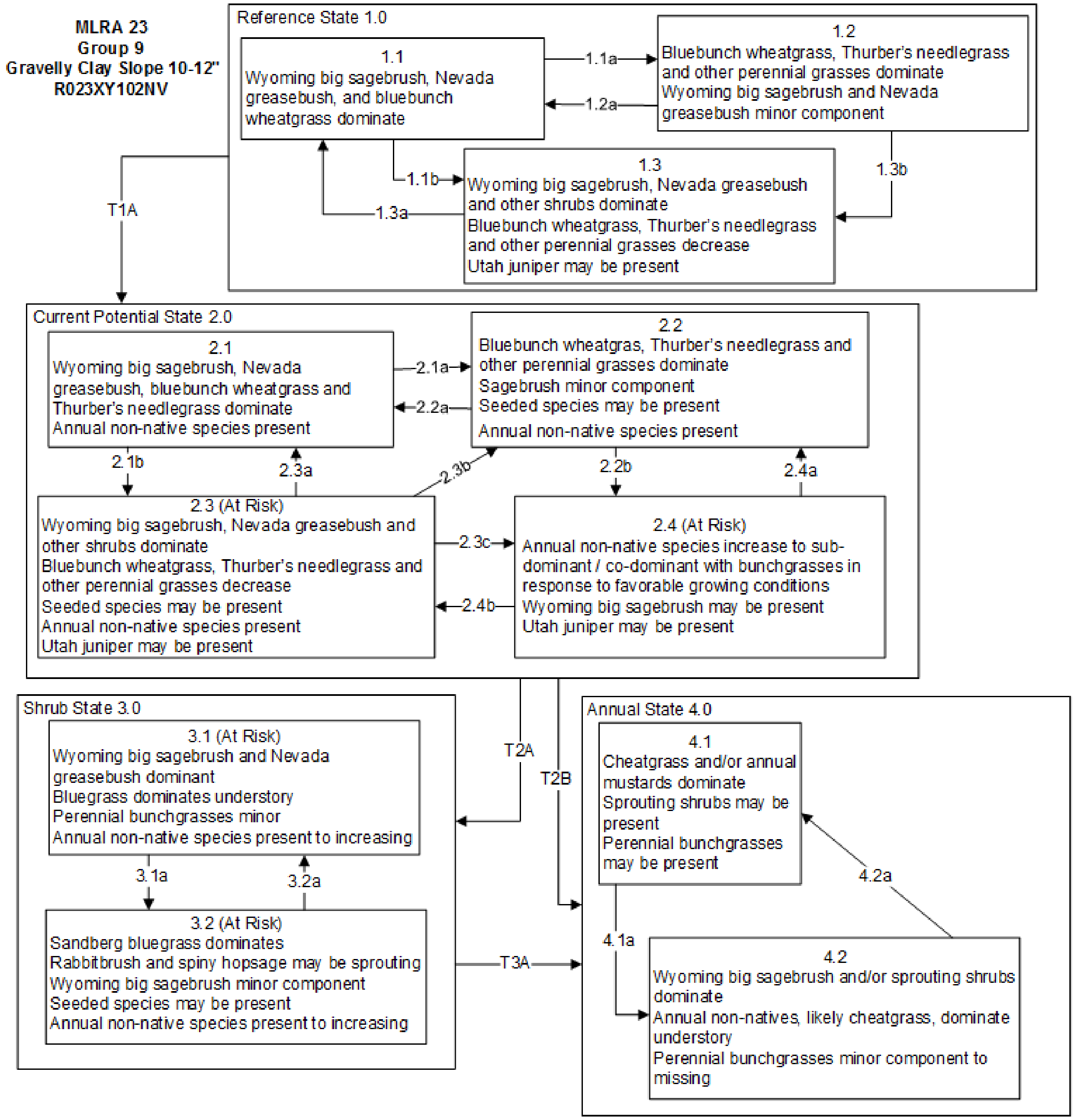
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Gravelly Clay Slope 10-12"
R023XY102NV
Reference State 1.0
1.1
Wyoming big sagebrush, Nevada greasebush, and bluebunch wheatgrass dominate
1.1a
1.2a
1.2
Bluebunch wheatgrass, Thurber's needlegrass and other perennial grasses dominate
Wyoming big sagebrush and Nevada greasebush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush, Nevada greasebush and other shrubs dominate
Bluebunch wheatgrass, Thurber's needlegrass and other perennial grasses decrease
Utah juniper may be present
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush, Nevada greasebush, bluebunch wheatgrass and Thurber's needlegrass dominate
Annual non-native species present
2.1a
2.2a
2.2
Bluebunch wheatgras, Thurber's needlegrass and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Wyoming big sagebrush, Nevada greasebush and other shrubs dominate
Bluebunch wheatgrass, Thurber's needlegrass and other perennial grasses decrease
Seeded species may be present
Annual non-native species present
Utah juniper may be present
2.3c
2.4b
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
T2A
T2B
Shrub State 3.0
3.1 (At Risk)
Wyoming big sagebrush and Nevada greasebush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T3A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.1a
4.2a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing

MLRA 23
Group 9
Gravelly Clay Slope 10-12"
R023XY102NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

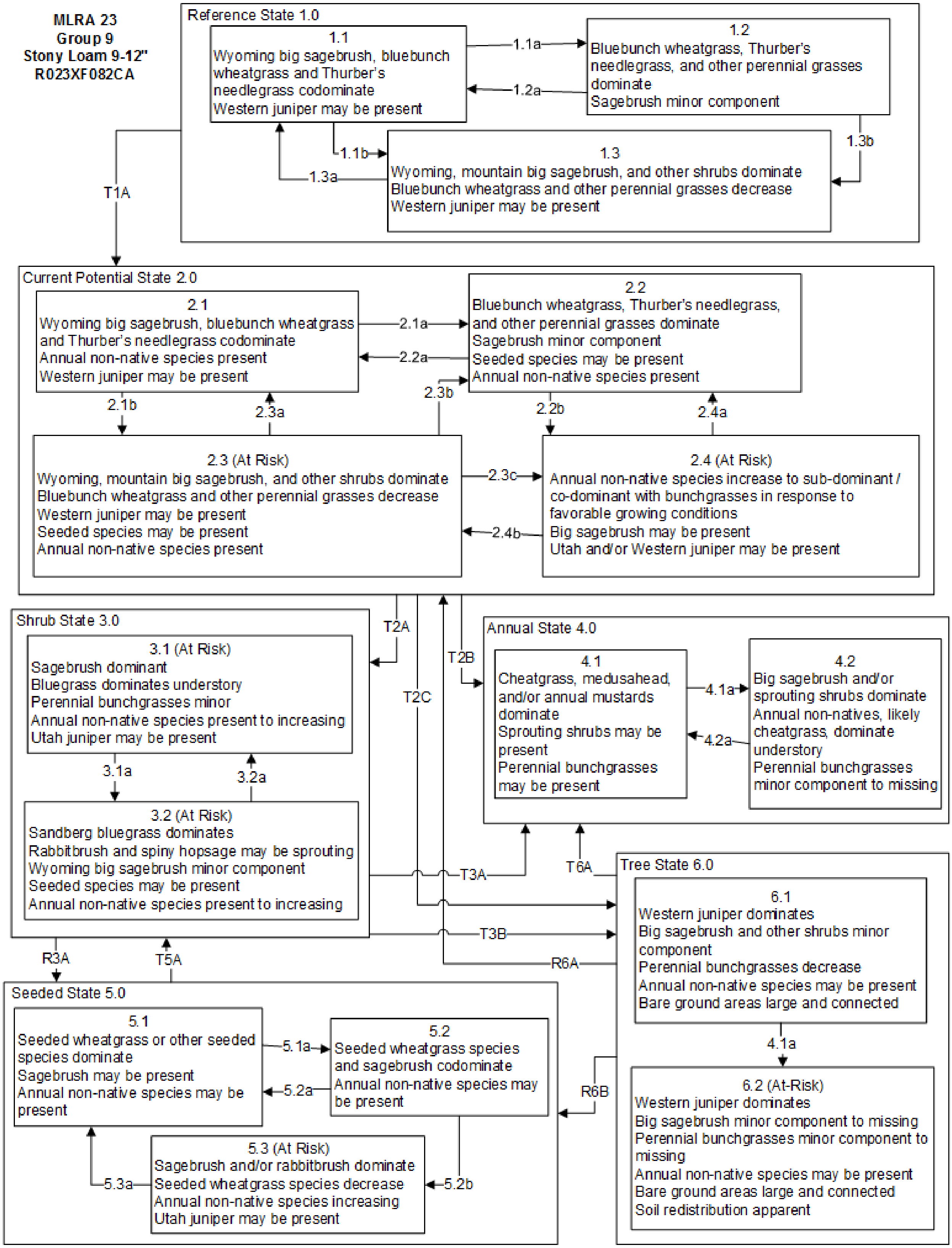
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic; non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing and/or drought will reduce perennial bunchgrasses.
2.2a: 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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).



MLRA 23
Group 9
Stony Loam 9-12"
R023XF082CA
Reference State 1.0
1.1
Wyoming big sagebrush, bluebunch wheatgrass and Thurber's needlegrass codominate
Western juniper may be present
1.2
Bluebunch wheatgrass, Thurber's needlegrass, and other perennial grasses dominate
Sagebrush minor component
1.3
Wyoming, mountain big sagebrush, and other shrubs dominate
Bluebunch wheatgrass and other perennial grasses decrease
Western juniper may be present
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Wyoming big sagebrush, bluebunch wheatgrass and Thurber's needlegrass codominate
Annual non-native species present
Western juniper may be present
2.2
Bluebunch wheatgrass, Thurber's needlegrass, and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.3 (At Risk)
Wyoming, mountain big sagebrush, and other shrubs dominate
Bluebunch wheatgrass and other perennial grasses decrease
Western juniper may be present
Seeded species 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
Big sagebrush may be present
Utah and/or Western juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.2b
2.4a
2.3c
2.4b
T2A
T2B
T2C
Shrub State 3.0
3.1 (At Risk)
Sagebrush dominant
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah juniper may be present
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
3.1a
3.2a
Annual State 4.0
4.1
Cheatgrass, medusahead, and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2
Big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
4.1a
4.2a
T3A
T6A
T3B
R6A
R3A
T5A
Tree State 6.0
6.1
Western juniper dominates
Big sagebrush and other shrubs minor component
Perennial bunchgrasses decrease
Annual non-native species may be present
Bare ground areas large and connected
4.1a
6.2 (At-Risk)
Western juniper dominates
Big sagebrush minor component to missing
Perennial bunchgrasses minor component to missing
Annual non-native species may be present
Bare ground areas large and connected
Soil redistribution apparent
R6B
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah juniper may be present
5.1a
5.2a
5.2b
5.3a

MLRA 23
Group 9
Stony Loam 9-12"
R023XF082CA

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1) Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

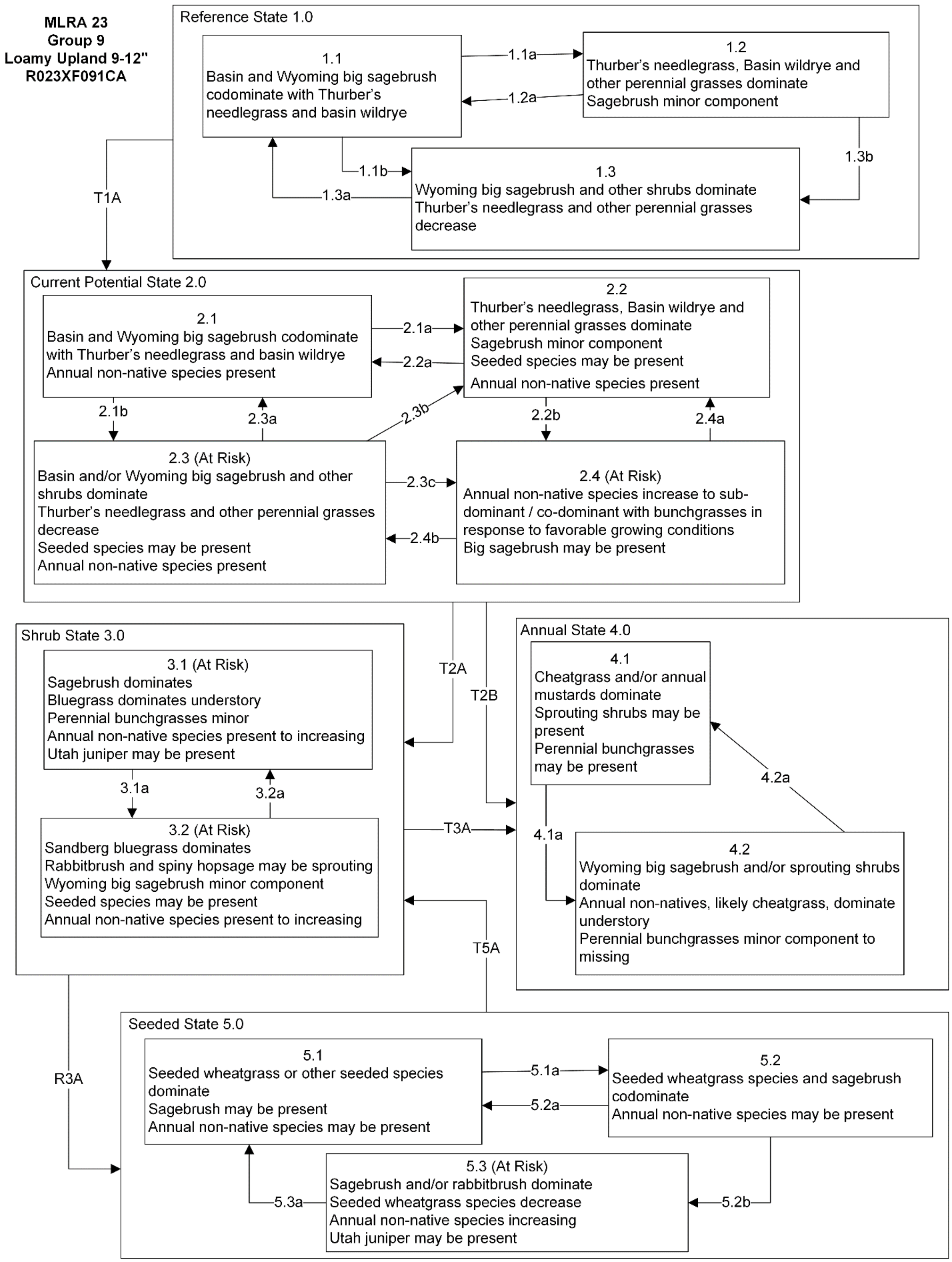
Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 23
Group 9
Loamy Upland 9-12"
R023XF091CA
Reference State 1.0
1.1
Basin and Wyoming big sagebrush codominate with Thurber's needlegrass and basin wildrye
1.1a
1.2a
1.2
Thurber's needlegrass, Basin wildrye and other perennial grasses dominate
Sagebrush minor component
1.1b
1.3a
1.3b
1.3
Wyoming big sagebrush and other shrubs dominate
Thurber's needlegrass and other perennial grasses decrease
T1A
Current Potential State 2.0
2.1
Basin and Wyoming big sagebrush codominate with Thurber's needlegrass and basin wildrye
Annual non-native species present
2.1a
2.2a
2.2
Thurber's needlegrass, Basin wildrye and other perennial grasses dominate
Sagebrush minor component
Seeded species may be present
Annual non-native species present
2.1b
2.3a
2.3b
2.2b
2.4a
2.3 (At Risk)
Basin and/or Wyoming big sagebrush and other shrubs dominate
Thurber's needlegrass and other perennial grasses decrease
Seeded species may be present
Annual non-native species present
2.3c
2.4b
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Big sagebrush may be present
Shrub State 3.0
3.1 (At Risk)
Sagebrush dominates
Bluegrass dominates understory
Perennial bunchgrasses minor
Annual non-native species present to increasing
Utah juniper may be present
3.1a
3.2a
3.2 (At Risk)
Sandberg bluegrass dominates
Rabbitbrush and spiny hopsage may be sprouting
Wyoming big sagebrush minor component
Seeded species may be present
Annual non-native species present to increasing
T2A
T2B
T3A
T5A
Annual State 4.0
4.1
Cheatgrass and/or annual mustards dominate
Sprouting shrubs may be present
Perennial bunchgrasses may be present
4.2a
4.1a
4.2
Wyoming big sagebrush and/or sprouting shrubs dominate
Annual non-natives, likely cheatgrass, dominate understory
Perennial bunchgrasses minor component to missing
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3a
5.2b
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah juniper may be present

MLRA 23
Group 9
Loamy Upland 9-12"
R023XF091CA
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire and/or Aroga moth infestation creates grass/sagebrush mosaic.
1.1b: Time and lack of disturbance such as fire. Excessive herbivory and/or drought will reduce perennial bunchgrasses.
1.2a: Time and lack of disturbance and/or herbivory that allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: 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 species such as cheatgrass.

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 favoring shrub dominance and reducing perennial bunchgrasses and/or drought (3.1). Fire (3.2).
Transition T2B: Fire (4.1) or inappropriate grazing management in the presence on non-native annual species (4.2).

Shrub State 3.0 Community Phase Pathways
3.1a: Fire, Aroga moth, brush management (aerial herbicide application), and/or late-fall/winter grazing causing mechanical damage to sagebrush.
3.2a: Time and lack of disturbance (an unlikely/slow transition).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance (an unlikely/slow transition).
4.2a: Fire.

Transition T3A: Fire (4.1) or inappropriate grazing management (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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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Group 10: Low production Wyoming and Lahontan sagebrush sites with sparse juniper

Description of MLRA 23 DRG 10:

Disturbance Response Group (DRG) 10 consists of seven ecological sites. The precipitation zone for these sites ranges from 8 to 14 inches. The elevation range for this group is from 4,200 to 7,000 ft. Slopes range from 8 to 75 percent. Soils in this group are generally very shallow and have formed in residuum and colluvium from extrusive igneous rocks. The soil surface is medium in texture. Permeability is moderate and the soils are well drained. Available water capacity is very low. The soils on these sites typically have high amounts of gravel and/or cobbles on the surface which provide a stabilizing effect on surface erosion conditions. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and/or Lahontan sagebrush (little sagebrush) (*Artemisia arbuscula* ssp. *longicaulis*). Many sites in this group tend to have a sparse savanna-like overstory of Western and/or Utah juniper. The understory is dominated by deep-rooted cool season perennial bunchgrasses such as Thurber's needlegrass (*Achnatherum therberianum*), desert needlegrass (*Achnatherum speciosum*), bluebunch wheatgrass (*Pseudoroegneria spicata)*, Indian ricegrass (*Achnatherum hymenoides*) and salmon wildrye (*Leymus salinus*). The production on these sites ranges from 100 to 350 lbs/ac in normal years.

This group is united by its low annual production, high percentage of bare ground, and ability to support needlegrass species. The sites with juniper have slightly different dynamics. Wyoming sagebrush and Lahontan sagebrush differ in terms of palatability. There is some evidence, based on site visits for this project, that sagebrush may have been misidentified in the initial correlation of these ecological sites. Lahontan 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. During our visits to these sites for this project, we used the black light test (Winward and Tisdale 1969, Rosentreter 2005) to verify sagebrush species. Many sites visited, including some NRCS Type Locations, had Lahontan sagebrush as the dominant shrub. Due to the differences in palatability between Wyoming big sagebrush and Lahontan, as well as potential soil differences, we recommend a reevaluation of the ecological sites in this MLRA 23 group. We've left them together due to resilience similarities, however this group may need to be revisited.

Disturbance Response Group 10 – ecological sites:

Gravelly Clay 8-10" Modal	R023XY047NV
Loamy Hill 10-14"	R023XY076NV
Chalky Knoll	R023XY088NV
South Slope 8-12"	R023XY030NV
Shallow Granitic Hill 10-14"	R023XY063NV
Shallow Loam 10-14"	R023XY077NV
Shallow Hill 10-14"	R023XY075NV

Modal Site:

The Gravelly Clay 8-10" (023XY047NV) ecological site is the modal site for this group. This site occurs on summits and sideslopes of low hills, fan piedmont remnants, and lower elevation plateaus. Slopes range from 2 to 50 percent, but slope gradients of 8 to 30 percent are most typical. Elevations are 4,500 to 5,800 feet. Average annual precipitation is 8 to 12 inches. These soils are typically very shallow and well drained. Some soils have moderate to high amounts of gravel on the surface. The available water capacity is low due to shallow soil depth and/or rock fragments within the soil profile. More sunlight is received on the steep, south-facing, sideslopes of this site than on adjacent landscapes and the soils tend to warm and promote plant growth earlier in the spring. These soils have high potential for sheet and rill erosion and often evidence signs of active erosion, i.e. rills, shallow gullies and pedestalled plants. The plant community is dominated by Lahontan sagebrush and Thurber's needlegrass, with the presence of other perennial grasses such as Indian ricegrass, Sandberg bluegrass, bottlebrush squirreltail, and perennial forbs. Ephedra (*Ephedra spp.)* and spiny hopage *(Grayia spinosa)* may be present on this site. Production ranges from 150 to 400 lbs/acre on this site, with 275 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 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 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). However, community types with low sagebrush as the dominant shrub may only have available rooting depths of 71 to 81 cm due to a restrictive horizon (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).

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 the preceding winter's snowmelt. 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).

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 (Windward 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 perennial bunchgrasses that are dominant include Thurber's needlegrass, Indian ricegrass and bottlebrush squirreltail. 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.

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 (Longland and Young 1993, 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). When sagebrush stands are decadent and even-aged, aroga investations are more likely to be a stand-replacing event (Longland and Young 1995).

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 states have been identified for this DRG.

Annual Invasive Grasses:

High elevations in the Great Basin remain relatively uninvaded by cheatgrass (Bradley and Mustard 2006) and exhibit low risk of invasion (Suring et al. 2005). However, changing climate along with local adaptations of cheatgrass at the "invasion edge" are creating more opportunities for invasion in areas previously undisturbed by these plants (Leger et al. 2009, Bradley 2009). Cheatgrass invasions are being recorded at higher elevations (Mealor et al. 2012, Bradley 2009) and risk of invasion should be considered in post-fire rehabilitation planning. Across a variety of elevations, a healthy native perennial herbaceous community, coupled with management that reduces litter and seed banks, are the most effective tool to reduce cheatgrass invasions (Chambers et al. 2007, Jones et al. 2015).

Cheatgrass is a cool-season annual grass that maintains an advantage over native plants, in part because it is a 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). Cheatgrass originated from Eurasia and both were first reported in North America in the late 1800s (Mack and Pyke 1983, Furbush 1953).

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.

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 (Agropyron cristatum) and Sandberg bluegrass (Poa secunda) 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 (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 (Pseudoroegneria spicata) 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). Both mature medusahead and cheatgrass are 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:

To date, we have not been able to find specific research on the fire response of Lahontan sagebrush. It likely behaves similarly to low sagebrush, however. Low sagebrush is killed by fire and does not sprout (Tisdale and Hironaka 1984). 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).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).

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 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 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.

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). Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage from fire but is more susceptible in drought years (Young 1983). Plant response will vary depending on season, fire severity, fire intensity and post-fire soil moisture availability.

Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below ground plant crowns. Indian ricegrass has 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 is necessary for reestablishment of Indian ricegrass. Grazing management following fire to promote seed production and establishment of seedlings is important.

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). Sandberg bluegrass may inhibit reestablishment of deep rooted bunchgrasses. 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.

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 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:

Throughout two years of site visits for this report, Lahontan sagebrush was observed in a heavily-browsed state on this ecological site and others in this DRG. This recently differentiated subspecies of low sagebrush (Winward and McArthur 1995) is moderately to highly palatable to browse species (McArthur 2005 and Rosentreter 2005). Dwarf sagebrush species such as Lahontan sagebrush, low sagebrush, and black sagebrush are preferred by mule deer for browse among the sagebrush species.

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).

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, was found to reduce herbage production and root mass thus potentially lowering the competitive ability of this needlegrass (Ganskopp 1988).

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949, Britton et al. 1990) Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.

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.

State and Transition Model Narrative 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 23 Disturbance Response Group 10.

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:
Lahontan sagebrush and Thurber’s needlegrass dominate the site. Indian ricegrass, Sandberg bluegrass and perennial forbs are also common on this site.

Community Phase Pathway 1.1a, from phase 1.1 to 1.2:
Fire reduces or eliminates the overstory of sagebrush and allows the perennial bunchgrasses to dominate the site. Fires may 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 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. Lahontan sagebrush is considered to have moderate to high palatability and may be reduced in the overstory depending on type of grazer, time and period of grazing.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community phase. Ephedra (*Ephedra* sp.), shadscale (*Atriplex confertifolia*), spiny hopsage (*Grayia spinosa)* and perennial grasses such as Thurber’s needlegrass, Indian ricegrass, bottlebrush squirreltail, and Sandberg bluegrass are common. Lahontan sagebrush is killed by fire, therefore decreasing within the burned community. Sagebrush could still be present in unburned patches. Thurber’s needlegrass may experience high mortality from fire and may be reduced in the community for several years.

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Time and lack of disturbance allows sagebrush or other shrubs to reestablish and increase in size and density.

Community Phase 1.3:
Lahontan 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.

Chalky Knoll (R023XY088NV) Phase 1.3 T.K. Stringham, July 2015

Chalky Knoll (R023XY088NV) Phase 1.3 T.K. Stringham, July 2015

Community Phase Pathway 1.3a, from phase 1.3 to 1.1:
A low severity fire, 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:
A high severity fire would decrease or eliminate the overstory of sagebrush and allow 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, mustard (*Descurainia* sp.) and halogeton (*Halogeton glomeratus*).
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:
Lahontan sagebrush and Thurber's needlegrass dominate the site. Indian ricegrass, Sandberg bluegrass, bottlebrush squirreltail and perennial forbs are also common on this site. 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 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. Lahontan sagebrush is considered to have moderate to high palatability and may be reduced in the overstory depending on type of grazer, time and period of grazing. Heavy spring grazing will favor an increase in Wyoming big sagebrush but may decrease Lahontan 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. Ephedra, spiny hopsage, shadscale, and perennial bunchgrasses such as Indian ricegrass and bottblebrush squirreltail are common. Lahontan sagebrush is killed by fire, therefore decreasing within the burned community. Sagebrush could still be present in unburned patches. 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. Sprouting shrubs 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 sagebrush and other shrubs to recover and increase in size and density.

Community Phase 2.3:
Lahontan 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. Annual non-native species are present in the understory.

South Slope 8-12 (R023XY030NV) Phase 2.3 T.K. Stringham, June 2014

Community Phase Pathway 2.3a, from phase 2.3 to 2.1:
Low severity fire or Aroga moth infestation creates a 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 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.

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 or a failed range seeding 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

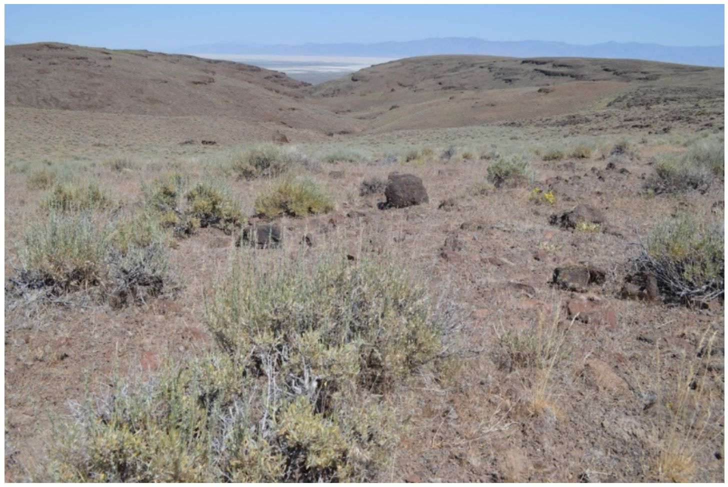
This state has two community phases: a Lahontan sagebrush dominated phase and a sprouting shrub dominated phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. Sagebrush dominates the overstory and other shrubs may be a significant component. 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:
Lahontan sagebrush dominates overstory and other shrubs may be a significant component. Deep-rooted perennial bunchgrasses in the understory may be present in trace amounts or absent from the community. Annual non-native species are present to increasing. Understory may be sparse, with bare ground increasing.

Gravelly Clay 8-10 (R023XY047NV) Phase 3.1 T.K. Stringham, June 2014

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. Heavy fall grazing causing mechanical damage to shrubs, and/or brush treatments with minimal soil disturbance, would greatly reduce the overstory shrubs.

Community Phase 3.2
Sandberg bluegrass dominates the site, while ephedra and other sprouting shrubs increase. Lahontan sagebrush and perennial bunchgrasses may be a minor component. Annual non-native species may be present and increasing.



Gravelly Clay 8-10 (R023XY047NV) Phase 3.2 T.K. Stringham, June 2014

Community Phase Pathway 3.2a, from phase 3.2 to 3.1:
Absence of disturbance over time and/or grazing management that favors the establishment and growth of sagebrush would allow 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 shrub overstory 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.

Annual State 4.0

An abiotic threshold has been crossed and state dynamics are driven by fire and time. The understory of this community is dominated by annual non-native species such as cheatgrass and tansy mustard. Resiliency has declined and further degradation from shorter fire return intervals facilitates the dominance of these annual species. Sagebrush and/or rabbitbrush may dominate the overstory.

Community Phase 4.1:
Annual non-native plants such as cheatgrass or tansy mustard dominate the site. This phase may have seeded species present if resulting from a failed seeding attempt or a minor shrub component.

Gravelly Clay 8-10 (R023XY047NV) Phase 4.1 T.K. Stringham, June 2014

Community Phase Pathway 4.1a, from phase 4.1 to 4.2:
Time and a lack of disturbance will allow recovery of Lahontan sagebrush and/or other shrubs. This community phase pathway is unlikely to occur.

Community Phase 4.2:
Lahontan sagebrush and/or shadscale dominate the overstory. Annual non-native species such as cheatgrass, dominate the understory. Bare ground may be present and increasing.

Community Phase Pathway 4.2a, from phase 4.2 to 4.1:
Fire, brush management, or Aroga moth infestation will reduce or eliminate the sagebrush component on this site and allow annual non-natives to dominate.

Potential Resilience Differences with other Ecological Sites:

Loamy Hill 10-14" (R023XY076NV):

This site is more productive than the modal site with 350 lbs/ac in normal years. This site occurs on summits and sideslopes of hills and low elevation plateaus and mountains. Although the site may be found on all aspects, at lower elevation the site is restricted to north-facing slopes. This site occurs at higher elevations than the modal site at 5000 to 7000 ft. The soils are very similar to the modal site but this site's grass community is dominated by Salmon wildrye (*Leymus salinas ssp. salmonis)* and bottlebrush squirreltail. This shrub community on this site is dominated by Wyoming big sagebrush and may have Utah juniper with a canopy cover up to 10%. This model is similar to the modal site with four stable states.

Chalky Knoll (R023XY088NV):

This site is slightly less productive than the modal site with 200 lbs/ac in normal years. This site occurs on shoulders and backslopes of plateaus, rock pediments, and low hills on all aspects. The soils on this site are similar to the modal site with shallow depths and potential for moderate to severe sheet and rill erosion depending on the steepness of the slope. This grass community is dominated by Indian ricegrass and bottlebrush squirreltail, with basin wildrye and Thurber's needlegrass subdominant. The shrub community is dominated by Wyoming big sagebrush. This model is similar to the modal site with four stable states.

South Slope 8-12" (R023XY030NV):

This site is slightly more productive than the modal site with 300 lbs/ac in normal years. This site occurs on steep sideslopes of hills and plateaus on southerly aspects. The soils are typically shallow to very shallow, well drained and low available water capacity. Some soils have moderate to high amounts of gravel on the surface. More sunlight is received on the steep, south-facing, sideslopes of this site and the soils tend to warm and promote plant growth earlier in the spring but also have high evapotranspiration potentials. These soils have high potential for sheet and rill erosion and often evidence signs of active erosion. Desert needlegrass and bluebunch wheatgrass are codominant bunchgrasses in this site's plant community. This site is written to have Wyoming big sagebrush, but site visits indicate a Lahontan sagebrush/antelope bitterbrush dominated community is possible, with the possibility of an Eroded State. This model is similar to the modal site with four stable states.

Shallow Granitic Hill 10-14" (R023XY063NV)

This site is slightly less productive than the modal site with 250 lbs/ac in normal years. The soils in this site are very shallow, well drained, and formed in residuum and colluvium from granitic rocks with additions of calcareous aeolian material. Similar to the modal site, these soils have a very low available water capacity and potential for sheet and rill erosion is high. The plant community is similar to the modal site but with more purple sage (*Salvia dorrii*) and the potential for mature Utah juniper with canopy cover less than 15% and trees averaging less than 12 feet in height. This model is similar to the modal site with four stable states.

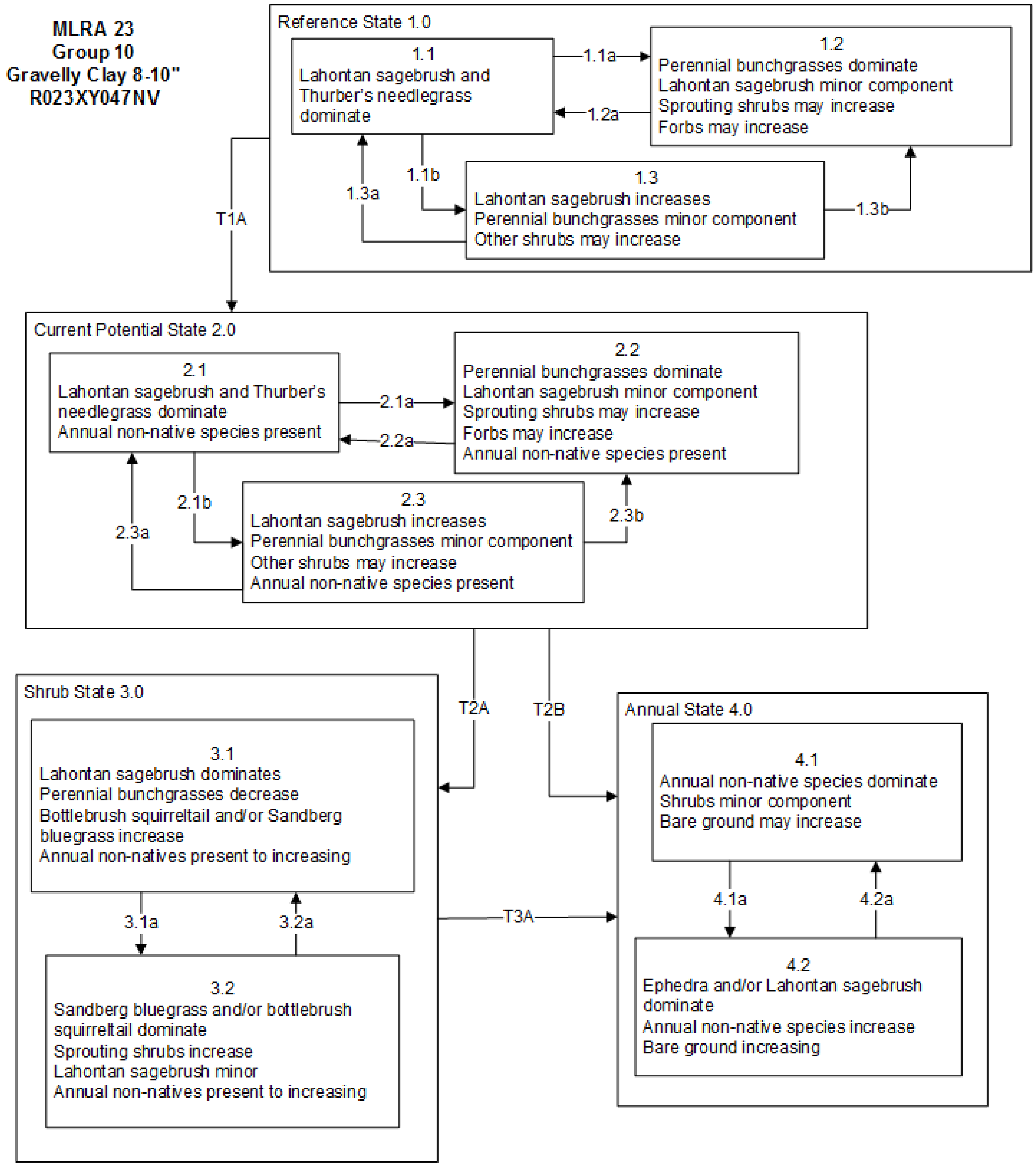
Shallow Loam 10-14” (R023XY077NV):

This site is less productive than the modal site with 100 lbs/ac in normal years. This site occurs on summits, sideslopes of hills and low elevation plateaus and mountains but is found on higher elevations than the modal site at 5000 to 6500 feet with an average annual precipitation from 10 to 14 inches. The soils on this site behave similarly to the modal site with shallow depths and high runoff potential but the plant community is dominated by Wyoming sagebrush and Salmon wildrye. Utah juniper is also present on this site up to 10% canopy cover. This model is similar to the modal site with four stable states.

Shallow Hill 10-14" (R023XY075NV)

This site is slightly less productive than the modal site with 200 lbs/ac in normal years. This site is typically found on 30 to 50 percent slopes at elevations from 5000 to 6500 feet with 10 to 12 inches of average annual production. The soils of this site are similar to the modal site with shallow depths and high runoff potential but the grass community is dominated by Salmon wildrye rather than Thurber’s needlegrass. The shrub community is dominated by Lahontan sagebrush. Utah juniper is also present on this site up to 5% canopy cover. This model is similar to the modal site with four stable states.

Modal State and Transition Model for MLRA 23 Group 10:



MLRA 23
Group 10
Gravelly Clay 8-10"
R023XY047NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass and mustards.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire or Aroga moth infestation creates grass/sagebrush 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 such as fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community.

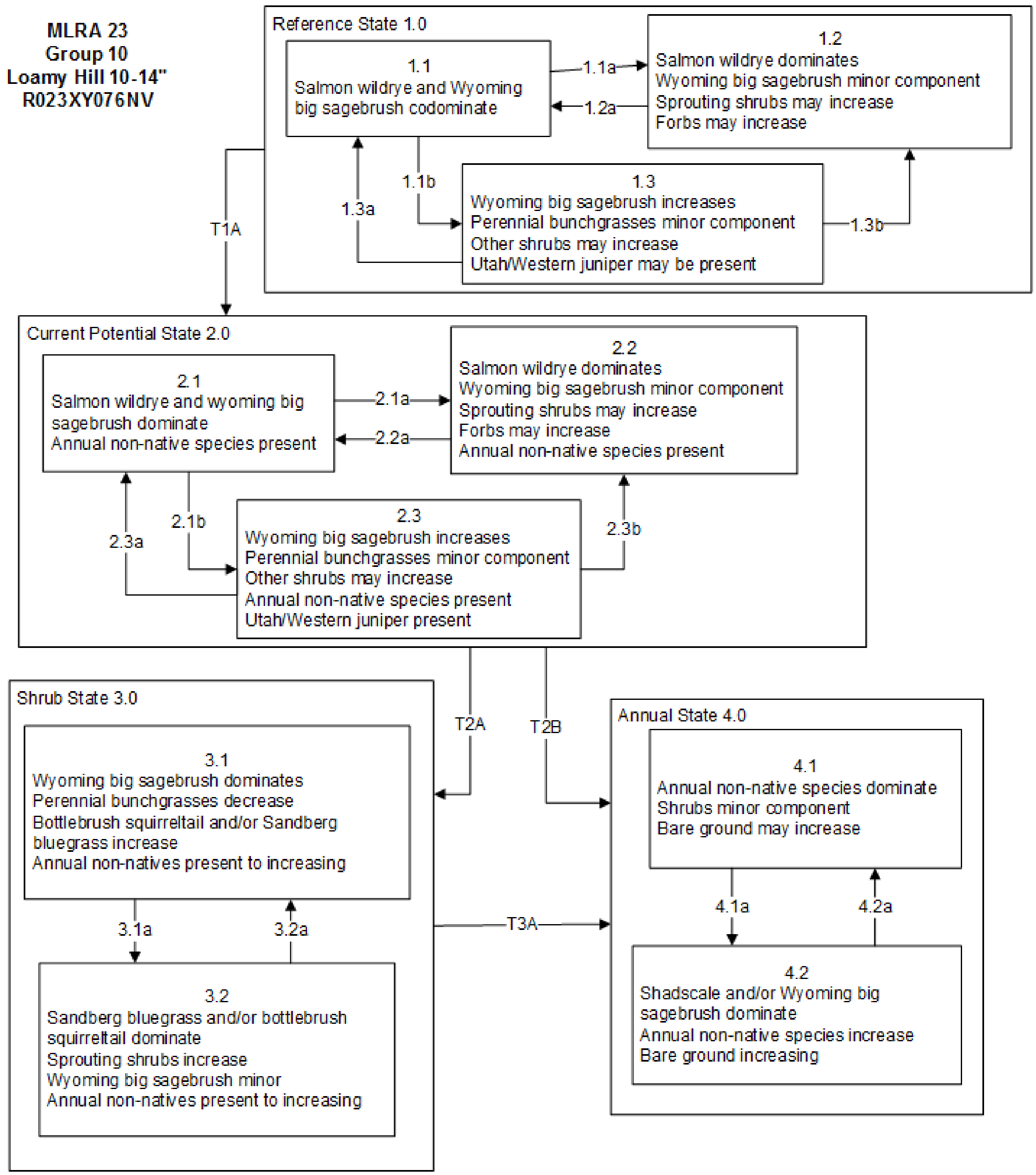
Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: High severity fire and/or soil disturbance (4.1).

Shrub state 3.0 Community Phase Pathways
3.1a: High severity fire (3.2).

Transition T3A: Catastrophic fire, soil disturbance and/or concentrated use (ex: livestock gathering area) (4.1). Inappropriate grazing management in the presence of non-native annual species (4.2).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of fire, unlikely to occur.
4.2a: Fire.

Additional State and Transition Models for MRLA 23 Group 10:



MLRA 23
Group 10
Loamy Hill 10-14"
R023XY076NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass and mustards.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire or Aroga moth infestation creates grass/sagebrush 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 such as fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community.

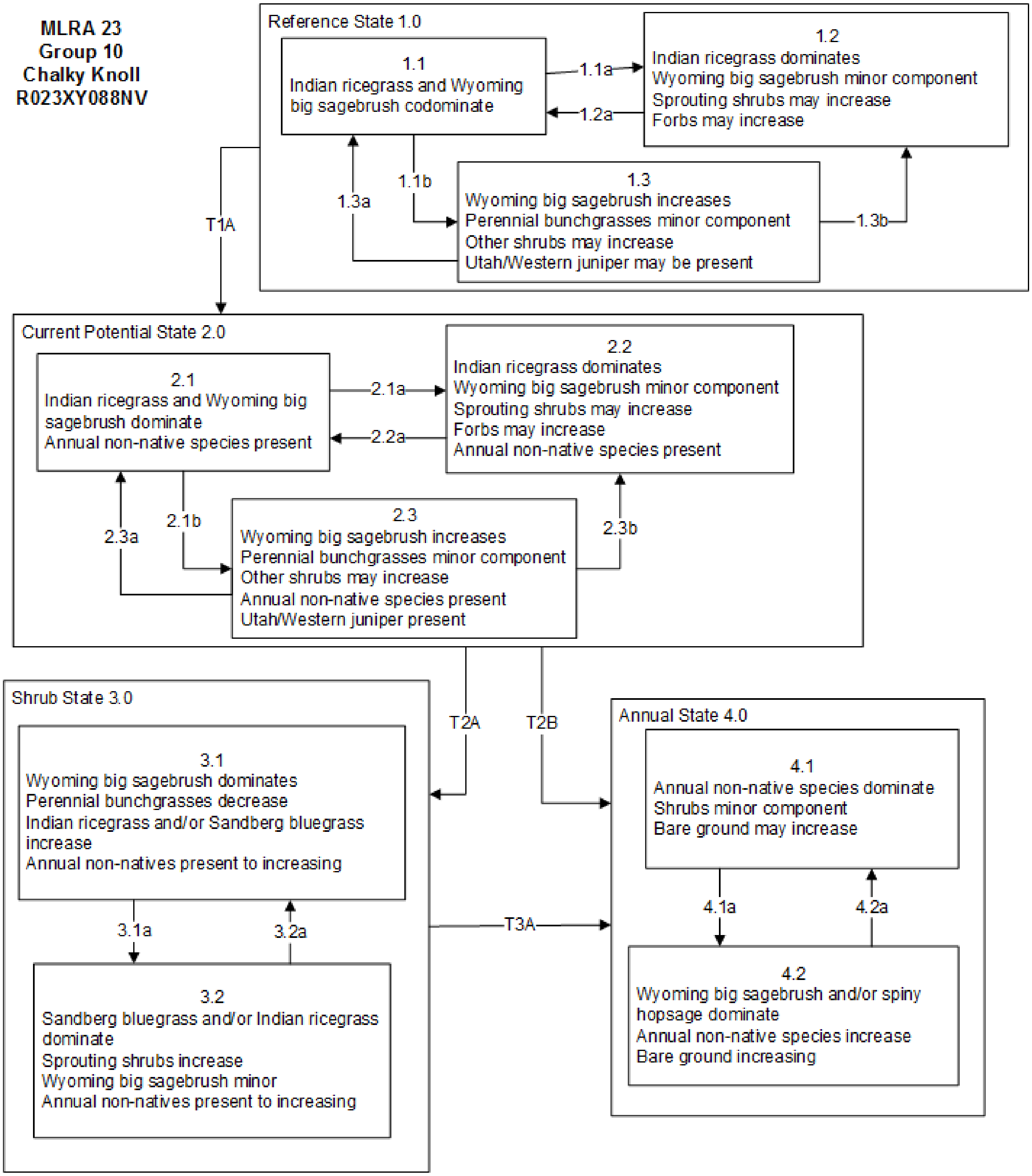
Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: High severity fire and/or soil disturbance (4.1).

Shrub state 3.0 Community Phase Pathways
3.1a: High severity fire (3.2).

Transition T3A: Catastrophic fire, soil disturbance and/or concentrated use (ex: livestock gathering area) (4.1). Inappropriate grazing management in the presence of non-native annual species (4.2).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of fire, unlikely to occur.
4.2a: Fire.

MLRA 23
Group 10
Chalky Knoll
R023XY088NV



MLRA 23
Group 10
Chalky Knoll
R023XY088NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass and mustards.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire or Aroga moth infestation creates grass/sagebrush 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 such as fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community.

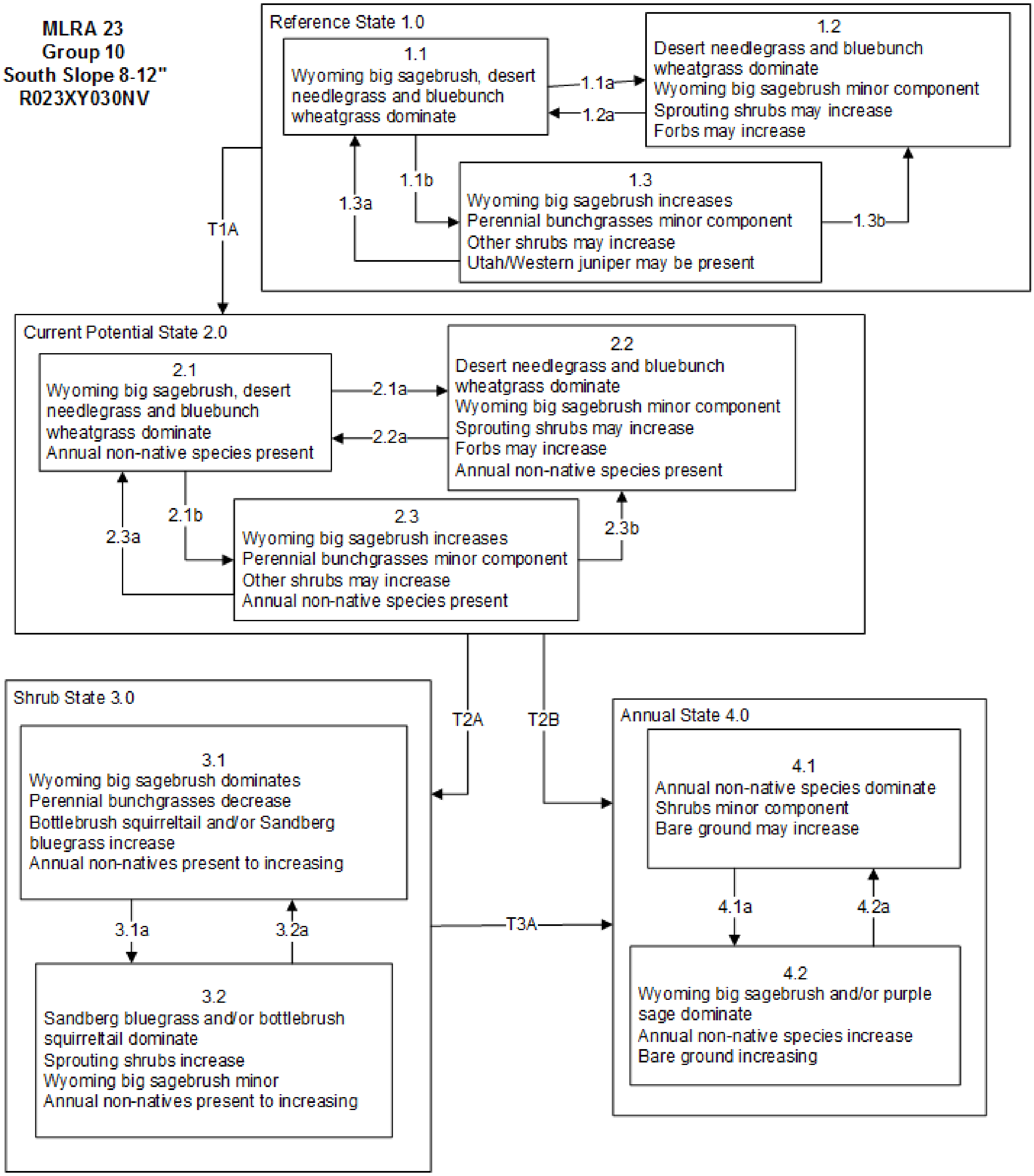
Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: High severity fire and/or soil disturbance (4.1).

Shrub state 3.0 Community Phase Pathways
3.1a: High severity fire (3.2).

Transition T3A: Catastrophic fire, soil disturbance and/or concentrated use (ex: livestock gathering area) (4.1). Inappropriate grazing management in the presence of non-native annual species (4.2).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of fire, unlikely to occur.
4.2a: Fire.

MLRA 23
Group 10
South Slope 8-12"
R023XY030NV



MLRA 23
Group 10
South Slope 8-12"
R023XY030NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass and mustards.
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire or Aroga moth infestation creates grass/sagebrush 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 such as fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community.

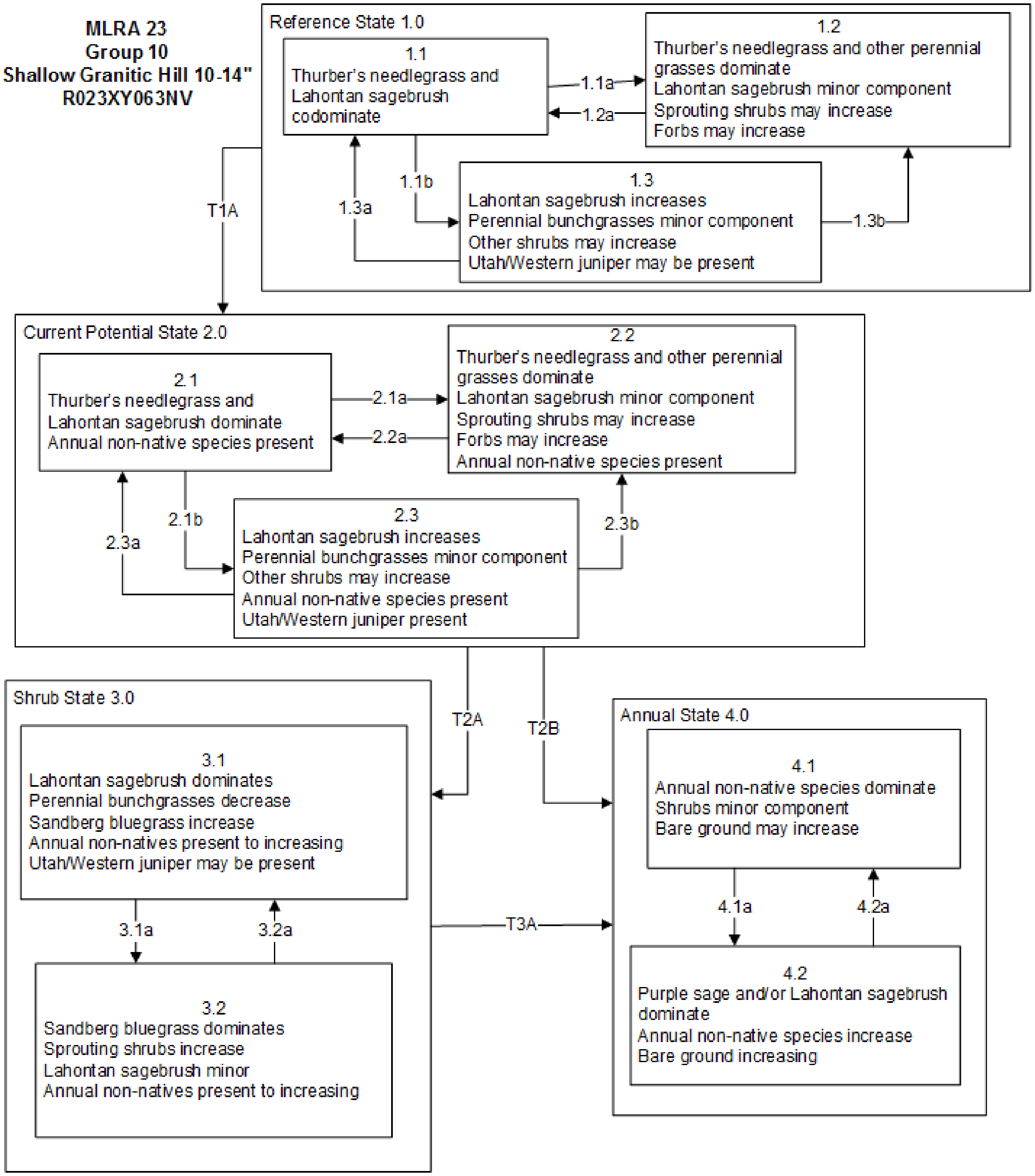
Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: High severity fire and/or soil disturbance (4.1).

Shrub state 3.0 Community Phase Pathways
3.1a: High severity fire (3.2).

Transition T3A: Catastrophic fire, soil disturbance and/or concentrated use (ex: livestock gathering area) (4.1). Inappropriate grazing management in the presence of non-native annual species (4.2).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of fire, unlikely to occur.
4.2a: Fire.

MLRA 23
Group 10
Shallow Granitic Hill 10-14"
R023XY063NV



MLRA 23
Group 10
Shallow Granitic Hill 10-14"
R023XY063NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass and mustards.

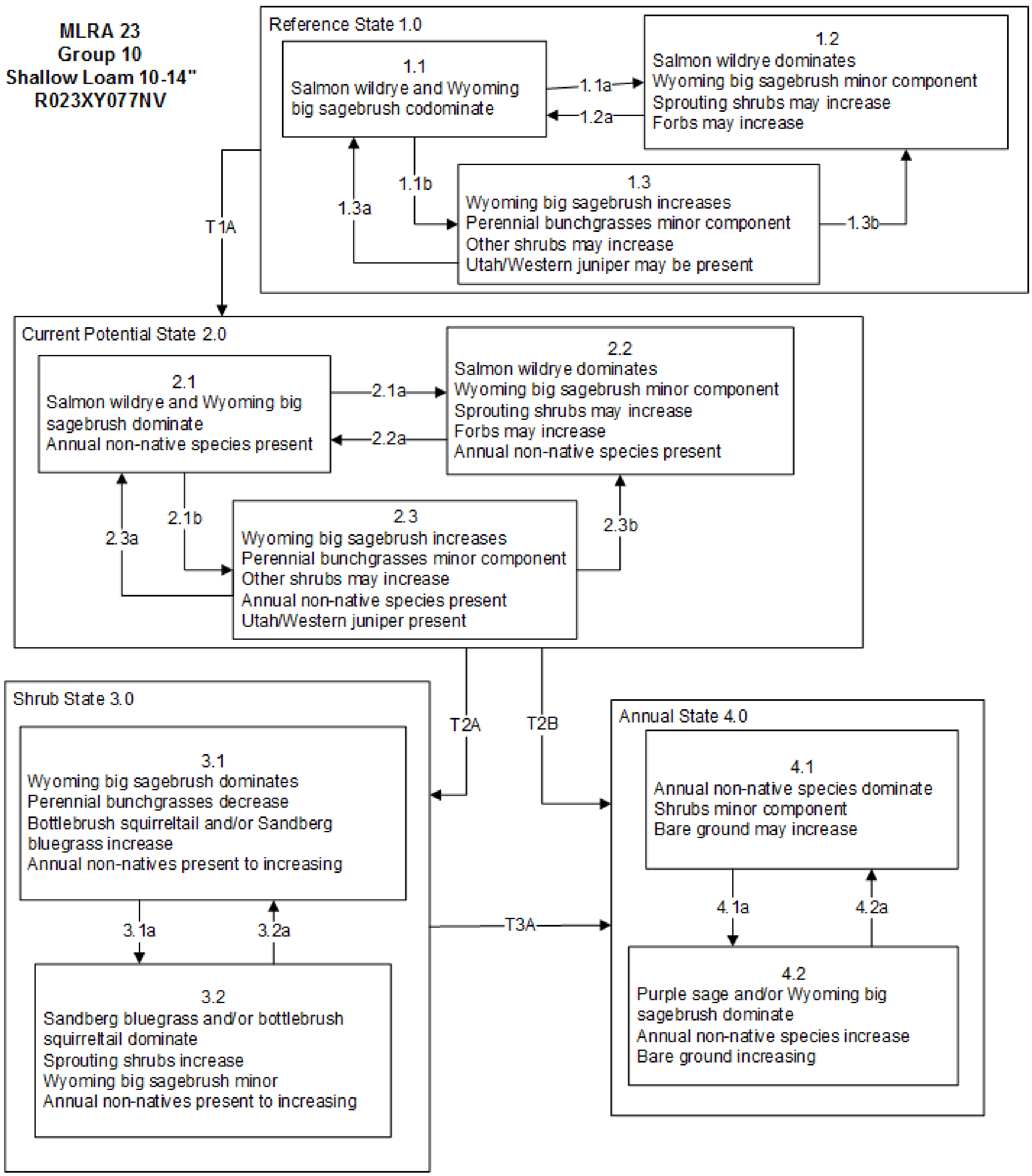
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire or Aroga moth infestation creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: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

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: High severity fire and/or soil disturbance (4.1).

Shrub state 3.0 Community Phase Pathways
3.1a: High severity fire (3.2).

Transition T3A: Catastrophic fire, soil disturbance and/or concentrated use (ex: livestock gathering area) (4.1). Inappropriate grazing management in the presence of non-native annual species (4.2).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of fire, unlikely to occur.
4.2a: Fire.



MLRA 23
Group 10
Shallow Loam 10-14"
R023XY077NV
Reference State 1.0
1.1
Salmon wildrye and Wyoming big sagebrush codominate
1.2
Salmon wildrye dominates
Wyoming big sagebrush minor component
Sprouting shrubs may increase
Forbs may increase
1.3
Wyoming big sagebrush increases
Perennial bunchgrasses minor component
Other shrubs may increase
Utah/Western juniper may be present
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Salmon wildrye and Wyoming big sagebrush dominate
Annual non-native species present
2.2
Salmon wildrye dominates
Wyoming big sagebrush minor component
Sprouting shrubs may increase
Forbs may increase
Annual non-native species present
2.3
Wyoming big sagebrush increases
Perennial bunchgrasses minor component
Other shrubs may increase
Annual non-native species present
Utah/Western juniper present
2.1a
2.2a
2.1b
2.3a
2.3b
T2A
T2B
Shrub State 3.0
3.1
Wyoming big sagebrush dominates
Perennial bunchgrasses decrease
Bottlebrush squirreltail and/or Sandberg bluegrass increase
Annual non-natives present to increasing
3.2
Sandberg bluegrass and/or bottlebrush squirreltail dominate
Sprouting shrubs increase
Wyoming big sagebrush minor
Annual non-natives present to increasing
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Shrubs minor component
Bare ground may increase
4.2
Purple sage and/or Wyoming big sagebrush dominate
Annual non-native species increase
Bare ground increasing
4.1a
4.2a

MLRA 23
Group 10
Shallow Loam 10-14"
R023XY077NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass and mustards.

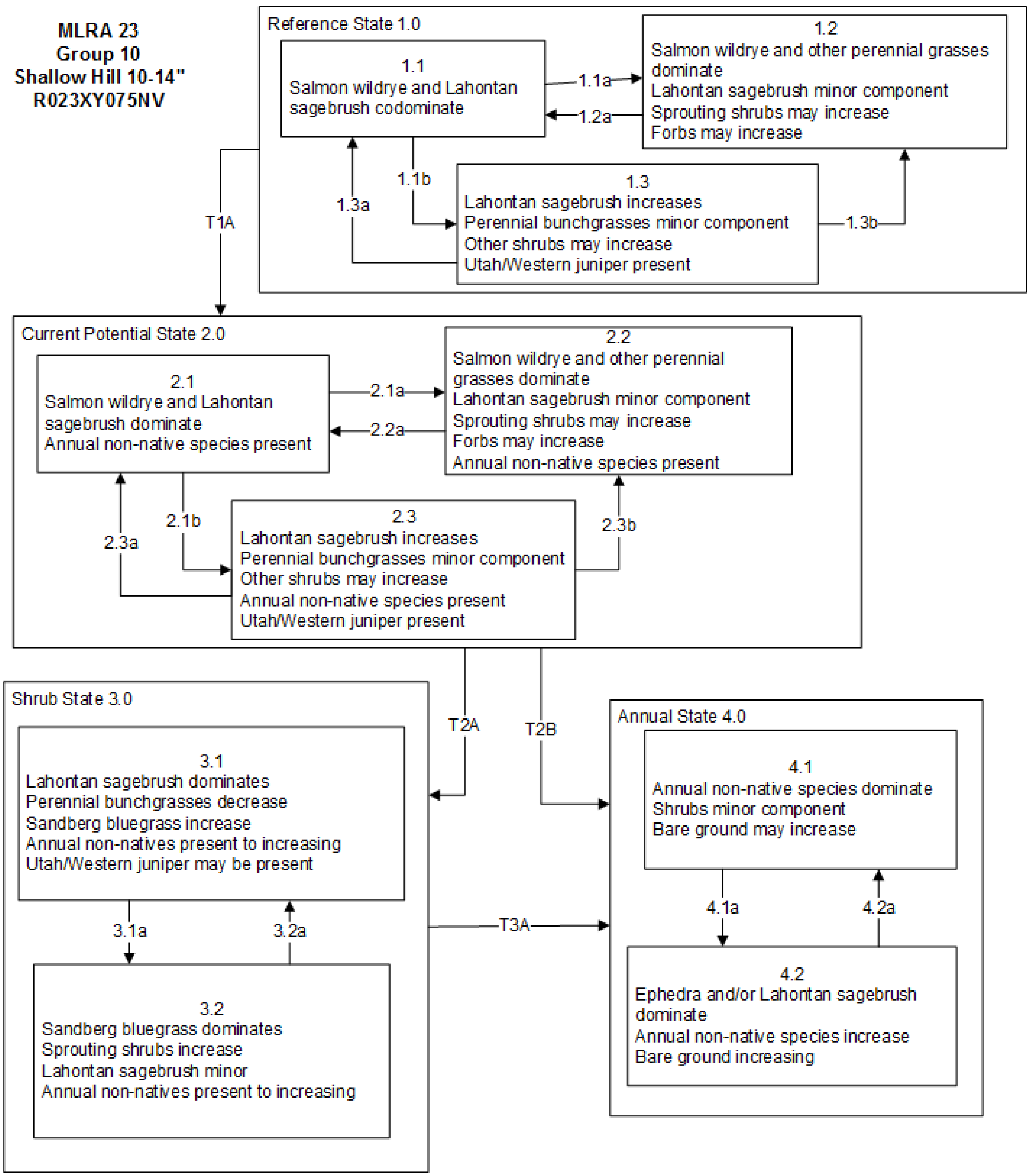
Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire or Aroga moth infestation creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.1b: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

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: High severity fire and/or soil disturbance (4.1).

Shrub state 3.0 Community Phase Pathways
3.1a: High severity fire (3.2).

Transition T3A: Catastrophic fire, soil disturbance and/or concentrated use (ex: livestock gathering area) (4.1). Inappropriate grazing management in the presence of non-native annual species (4.2).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of fire, unlikely to occur.
4.2a: Fire.


MLRA 23
Group 10
Shallow Hill 10-14"
R023XY075NV
Reference State 1.0
1.1
Salmon wildrye and Lahontan sagebrush codominate
1.2
Salmon wildrye and other perennial grasses dominate
Lahontan sagebrush minor component
Sprouting shrubs may increase
Forbs may increase
1.3
Lahontan sagebrush increases
Perennial bunchgrasses minor component
Other shrubs may increase
Utah/Western juniper present
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Salmon wildrye and Lahontan sagebrush dominate
Annual non-native species present
2.2
Salmon wildrye and other perennial grasses dominate
Lahontan sagebrush minor component
Sprouting shrubs may increase
Forbs may increase
Annual non-native species present
2.3
Lahontan sagebrush increases
Perennial bunchgrasses minor component
Other shrubs may increase
Annual non-native species present
Utah/Western juniper present
2.1a
2.2a
2.1b
2.3a
2.3b
T2A
T2B
Shrub State 3.0
3.1
Lahontan sagebrush dominates
Perennial bunchgrasses decrease
Sandberg bluegrass increase
Annual non-natives present to increasing
Utah/Western juniper may be present
3.2
Sandberg bluegrass dominates
Sprouting shrubs increase
Lahontan sagebrush minor
Annual non-natives present to increasing
3.1a
3.2a
T3A
Annual State 4.0
4.1
Annual non-native species dominate
Shrubs minor component
Bare ground may increase
4.2
Ephedra and/or Lahontan sagebrush dominate
Annual non-native species increase
Bare ground increasing
4.1a
4.2a

MLRA 23
Group 10
Shallow Hill 10-14"
R023XY075NV

Reference State 1.0 Community Phase Pathways
1.1a: Low severity fire or Aroga moth infestation 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 may also decrease perennial understory.
1.2a: Time and lack of disturbance allows for shrub regeneration.
1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.
1.3b: High severity fire significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass and mustards.

Current Potential State 2.0 Community Phase Pathways
2.1a: Low severity fire or Aroga moth infestation creates grass/sagebrush 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 such as fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush.
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community.

Transition T2A: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: High severity fire and/or soil disturbance (4.1).

Shrub state 3.0 Community Phase Pathways
3.1a: High severity fire (3.2).

Transition T3A: Catastrophic fire, soil disturbance and/or concentrated use (ex: livestock gathering area) (4.1). Inappropriate grazing management in the presence of non-native annual species (4.2).

Annual State 4.0 Community Phase Pathways
4.1a: Time and lack of fire, unlikely to occur.
4.2a: Fire.

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Group 12: Seasonally flooded closed clayey basins

Description of MLRA 23 DRG 12:

Disturbance Response Group (DRG) 12 consists of three related ecological sites, Wet Clay Basin (023XY023NV), Clay Basin (023XY003NV), and Clay Floodplain (023XF092CA). The California ecological site Clay Floodplain correlates with the Nevada ecological site Clay Basin. 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. 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 10 to 14 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. The understory is dominated by mat muhly (*Muhlenbergia richardsonis*), Nevada bluegrass (*Poa nevadensis*), basin wildrye *(Leymus cinereus)*, and creeping wildrye (*Elymus triticoides*). In the wetter Wet Clay Basin site, suncup *(Camissonia tanacetifolia),* dock (*Rumex spp.)*, spikerush (*Eleocharis spp.)*, and sedges *(Carex spp.)* may be dominant. In dry areas, the shrub component is dominated by silver sagebrush *(Artemisia cana)*. The Nevada production on these sites ranges from 400 to 1100 lb/ac in normal years but may be as low as 0 when the Wet Clay Basin is ponded in wet years. Normal year annual production in the California Clay Floodplain site is 1100 lb/ac. Oftenties, these sites exist in close proximity, with the sagebrush-dominated Clay Basin existing in the margins around the Wet Clay Basin site. Shallow groundwater hydrology heavily influences both of these ecological sites.

Disturbance Response Group 12 – ecological sites

Wet Clay Basin Modal	R023XY023NV
Clay Basin	R023XY003NV
Clay Floodplain	R023XF092CA

Modal:

The Wet Clay Basin (023XY023NV) ecological site is the modal site for this group. This site occurs on nearly level enclosed basins. Slopes range from 0 to 4 percent, but slope gradients of 0 to 2 percent are most typical. Elevations are 5500 to 7500 feet. Average annual precipitation is 10 to 14 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 species that can tolerate seasonal ponding: Mat muhly, suncup, sedges, spikerush, and rushes. Silver sagebrush may be present, and povtertyweed (*Iva axillaris)* may become dominant in dry areas. Production ranges from 0 lb/ac in wet, ponded years, to 1,500 lb/ac in drier years. Normal year annual production is 400 lb/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 influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The dominant grass is 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).

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. Four possible alternative stable states have been identified for this ecological site.

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. The Wet Clay Basin ecological site in MLRA 23 is often found embedded within a larger landscape of Lahontan sagebrush (*Artemisia arbuscula ssp. longicaulis).* 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.

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.

Creeping or beardless wildrye, a minor component on this site, may increase after fire due to its aggressive creeping rhizomes (Monsen et al. 2004). Nevada bluegrass 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 build up 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, 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).

The dominant forb on this site, suncup, is unlikely to be affected by fire because it is low-growing and dries up relatively early in the season, before fire is a risk. Povertyweed, a native perennial, rhizomatous forb, will increase following fire due to its prolific seed production and resprouting ability. Povertyweed possesses characteristics of early seral species capable of rapidly increasing within disturbed sites (Whitson et al. 1999).

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. 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% (Monson et al. 2004). In today's botanical climate, 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.

Povertyweed is a weedy, native, perennial forb with early seral characteristics such as high seed production allowing it to spread rapidly in disturbed areas (Whitson et al. 1999). Reduction in the perennial grass component or increases in bare ground through excessive mechanical damage to the perennial grasses or soil during wet periods could facilitate an expansion of povertyweed.

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 plants and potentially silver sagebrush and an increase in weedy annual and perennial forbs.

View of four Wet Clay Basin sites, all with small dugout ponds or "dirt troughs". Located off Buckhorn Road in northwest Nevada, near 40.906 N, -119.884 S. The light colored spots are the ponds, which hold water into the growing season while letting surrounding land dry out by lowering the water table. Map data: Google 2018.

A close-up Google Earth view of a Wet Clay Basin site with dug out ponds, seen in the upper right of the above photo. Ponds may be round or rectangular, with berms surrounding at least one side. Map data: Google 2018.

Wet Clay Basin (023XY023NV) dugout trough, D. Snyder, October 2018

State and Transition Model Narrative 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 23 Disturbance Response Group 12.

Reference State 1.0:

The Reference State 1.0 represents the natural range of variability under pristine conditions. The reference state has two general community phases: a forb-grass dominant phase and a shrub-grass 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 drought cycles.

Community Phase 1.1:
Suncup, mat muhly, sedges, spikerush, and other perennial forbs dominate the site. Site is seasonally ponded, with vegetation coming in as the water dries up.

Community Phase Pathway 1.1a, from phase 1.1 to 1.2:
Drought and/or inappropriate herbivory will reduce forbs and wetland-obligates like sedges and rushes. Rhizomatous grasses increase, silver sagebrush may be present. Povertyweed may increase.

Community Phase 1.2:
Mat muhly, povertyweed, and rhizomatous grasses increase.

Community Phase Pathway 1.2a, from phase 1.2 to 1.1:
Release from drought allows sedges, rushes, and suncup 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.

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. 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 The presence of nonnative grasses and forbs reduces resiliency because it reduces resource availability for native species.

Community Phase 2.1:
Suncup, mat muhly, sedges, spikerush, and other perennial forbs dominate the site. Site is seasonally ponded, with vegetation coming in as the water dries up. Annual/perennial weedy native and non-native species present.

Wet Clay Basin (023XY023NV) Phase 2.1 T. K. Stringham, August 2014

Wet Clay Basin (023XY023NV) Phase 2.1 T. K. Stringham, August 2014

Wet Clay Basin (R023XY023NV) Phase 2.1 T. K. Stringham, June 2015

Wet Clay Basin (R023XY023NV) Phase 2.1 (*Eleocharis dominant)* D. Snyder, October 2018

Community Phase Pathway 2.1a, from phase 2.1 to 2.2:
Drought and/or inappropriate herbivory will reduce forbs and wetland-obligates like sedges and rushes. Mat muhly and silver sagebrush increase. Povertyweed may increase.

Community Phase 2.2:
Povertyweed and dock may increase. Annual/perennial weedy native and non-native species increase. Silver sagebrush may be present along edges of site or in dry areas.

Clay Basin (R023XY003NV) Phase 2.2 T.K. Stringham, June 2014

Community Phase Pathway 2.2a, from phase 2.2 to 2.1:
Release from drought allows sedges, rushes, and suncup to return to dominance.

Community Phase Pathway 2.2b, from phase 2.2 to 2.3:
Continued chronic drought and/or inappropriate grazing facilitate an increase in silver sagebrush, rabbitbrush, and weedy species. All grasses and grass-likes decline in production.

Community Phase 2.3:
Silver sagebrush increases. Rabbitbrush may increase. All grasses and grass-likes decrease. Annual/perennial weedy native and non-native species increase.

Clay Basin (023XY003NV) Phase 2.3 T.K. Stringham, August 2014

Community Phase Pathway 2.3a, from phase 2.3 to 2.2:
Fire or release from long-term drought reduces sagebrush. Release from grazing pressure allows understory species to recover over time.

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 perennial grass density results in a decrease in organic matter inputs and subsequent decline in soil water holding capacity.

Threshold: Loss of deep-rooted perennial bunchgrasses changes spatial and temporal nutrient cycling and nutrient redistribution, and reduces soil organic matter. The seedbank for understory forbs and grasses disappears.

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

Trigger: Long-term drought coupled with severe trampling or inappropriate grazing management. Off-site or on-site water development that reduces the amount of time this site ponds.

Slow variables: Reduced occurrence and duration of annual ponding.

Threshold: Site is dry enough to allow annual weedy species to dominate year after year; the seedbank of native perennial plants is depleted; hydrology is unable to return to normal.

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. Weedy species like povertyweed and non-native annual species increase. Bare ground is extensive.

Clay Basin (023XY003NV) Phase 3.1 T.K. Stringham, August 2014

Wet Clay Basin (023XY023NV) Phase 3.1 D. Snyder, April 2018

Wet Clay Basin (023XY023NV) Phase 3.1 with dug out pond. D. Snyder, April 2018

Annual State 4.0:

This state has one community phase dominated by annual non-native species like Russian thistle (*Salsola tragus)* and blue mustard (*Chorispora tenella*). Sagebrush and/or rabbitbrush may dominate the overstory. Annual non-native species and weedy natives like povertyweed dominate the understory when the site is dry. The extent of the annual component may be exacerbated by extended drought or surface alterations that lower the water table.

Community Phase 4.1:
Annual non-native species dominate the site. Sagebrush and native vegetation may be present in trace amounts. This state rarely ponds, oftentimes because of water diversions, dug out ponds, or groundwater pumping.

Wet Clay Basin (023XY023NV) Annual State with Russian thistle. T.K. Stringham, August 2014

Wet Clay Basin (23XY023NV) Annual State with blue mustard T.K. Stringham, October 2018

Potential Resilience Differences with other Ecological Sites:

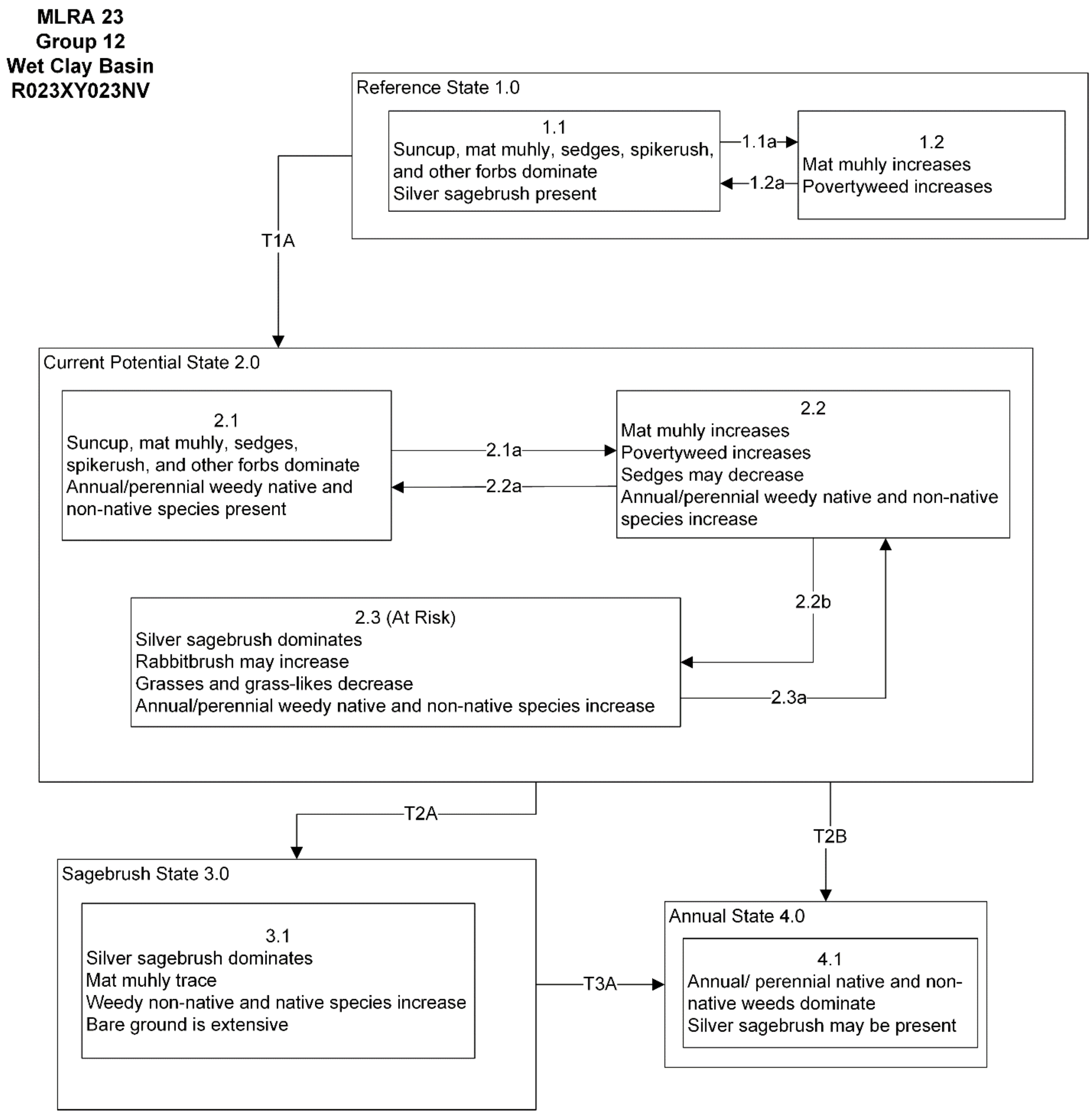
Clay Basin (R023XY003NV):

Clay Basin sites typically surround Wet Clay Basin sites. The site has slightly greater slopes (up to 2%) and have a greater depth to the water table. Clay basin sites typically do not pond water except during wet years, but depth to a seasonally high water table is typically less than 3 feet. Because of this, Clay Basin sites are more productive with 1500 lb/ac in normal years. The plant community is dominated by Nevada bluegrass, basin wildrye and creeping wildrye. Silver sagebrush may be a significant component and may be dominant depending on site history and recent climate. This site has three stable states: Reference, Current Potential, and Shrub. While the plant species and pathways are slightly different for this site, the site is like the Wet Clay Basin in that it is highly driven by hydrologic changes. Due to the higher productivity of this site, it is more likely to be affected by fire during dry periods. After fire, silver sagebrush will sprout. During long-term drought events, silver sagebrush will be a larger component.

Clay Floodplain (R023XF092CA):

This California ecological site correlates most closely to the Clay Basin (023XY003NV) site in Nevada. It is more productive than the modal with an average of 1100 lb/ac in normal years. Like the Clay Basin site, the Clay Floodplain may stand alone or may surround the wetter Wet Clay Basin site that is more frequently flooded. This site is also dominated by Nevada bluegrass but can see an increase in silver sagebrush with long-term drought or long-term inappropriate grazing management.

Modal State and Transition Model for Group 12 in MRLA 23:



MLRA 23
Group 12
Wet Clay Basin
R023XY023NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Drought that reduces seasonal ponding will reduce suncup, sedges, and rushes and increase grasses and silver sagebrush. Povertyweed may increase. May be coupled with herbivory.
1.2a: Release from long-term drought allows suncup, sedges, and rushes to return to dominance.

Transition T1A: Introduction of weedy species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Drought reduces suncup, sedges, and rushes and increases grasses and silver sagebrush.
2.2a: Release from long-term drought allows understory species to recover over time.
2.2b: Continued chronic drought coupled with inappropriate grazing management facilitates an increase in silver sagebrush, rabbitbrush and weedy species while all grasses decline in production.
2.3a: Fire, release from long-term drought, or release from grazing pressure allows understory species to recover.

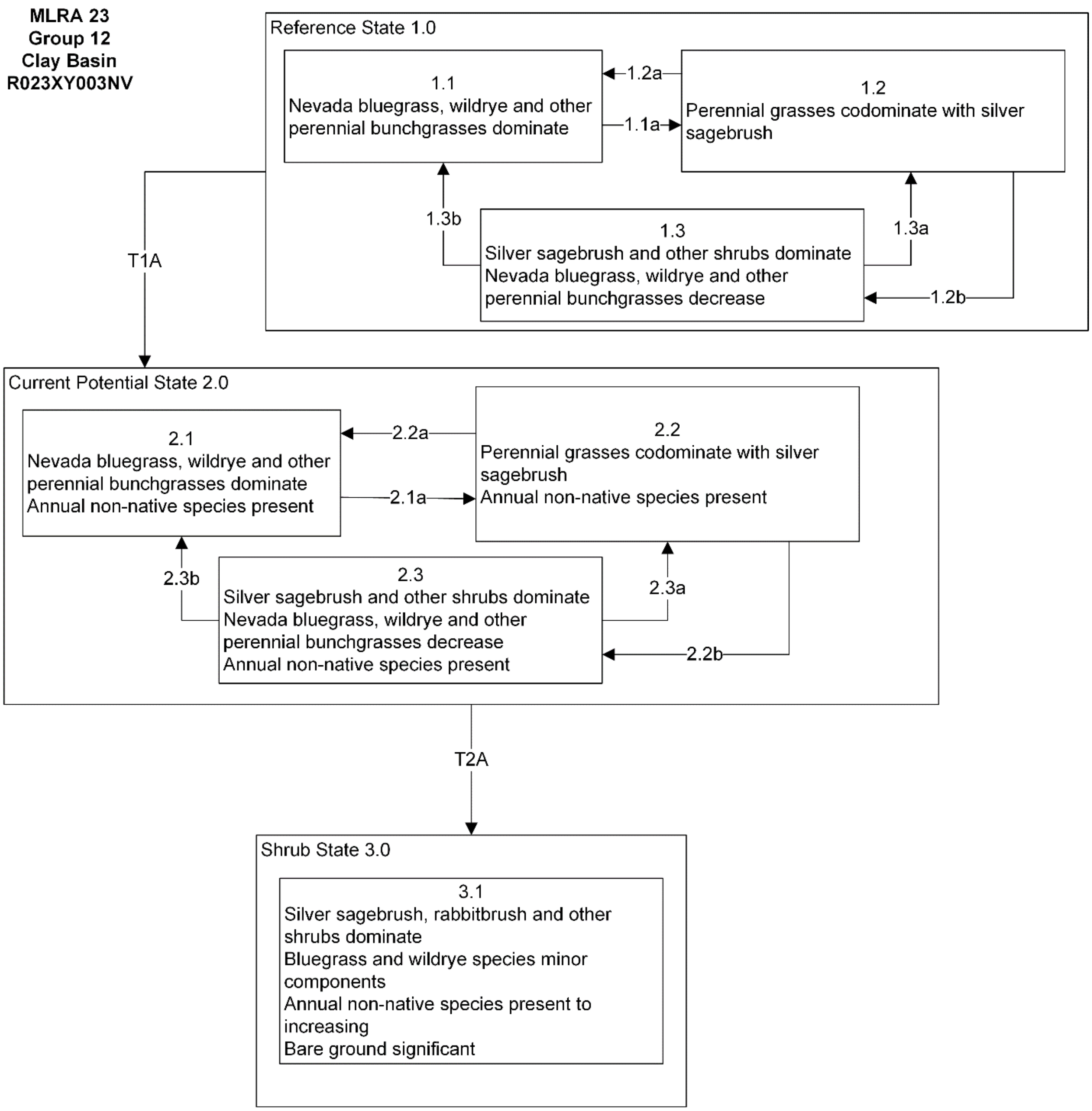
Transition T2A: Long-term chronic drought, may be coupled with inappropriate grazing management. Extent of this phase may be exacerbated by surface alterations that lower the water table.
Transition T2B: Long-term chronic drought, coupled with at least one of the following: inappropriate grazing management, severe trampling, off-site or on-site water diversion, or combinations of these disturbances. Hydrology has permanently changed.

Shrub State 3.0 Community Phase Pathways
None.

Transition T3A: Long-term chronic drought, inappropriate grazing management coupled with severe trampling, off-site or on-site water diversion, repeated fire, or combinations of these disturbances. Hydrology has permanently changed.

Annual State 4.0 Community Phase Pathways
None.

Alternative State and Transition Models for Group 12 in MRLA 23:



MLRA 23
Group 12
Clay Basin
R023XY003NV
KEY

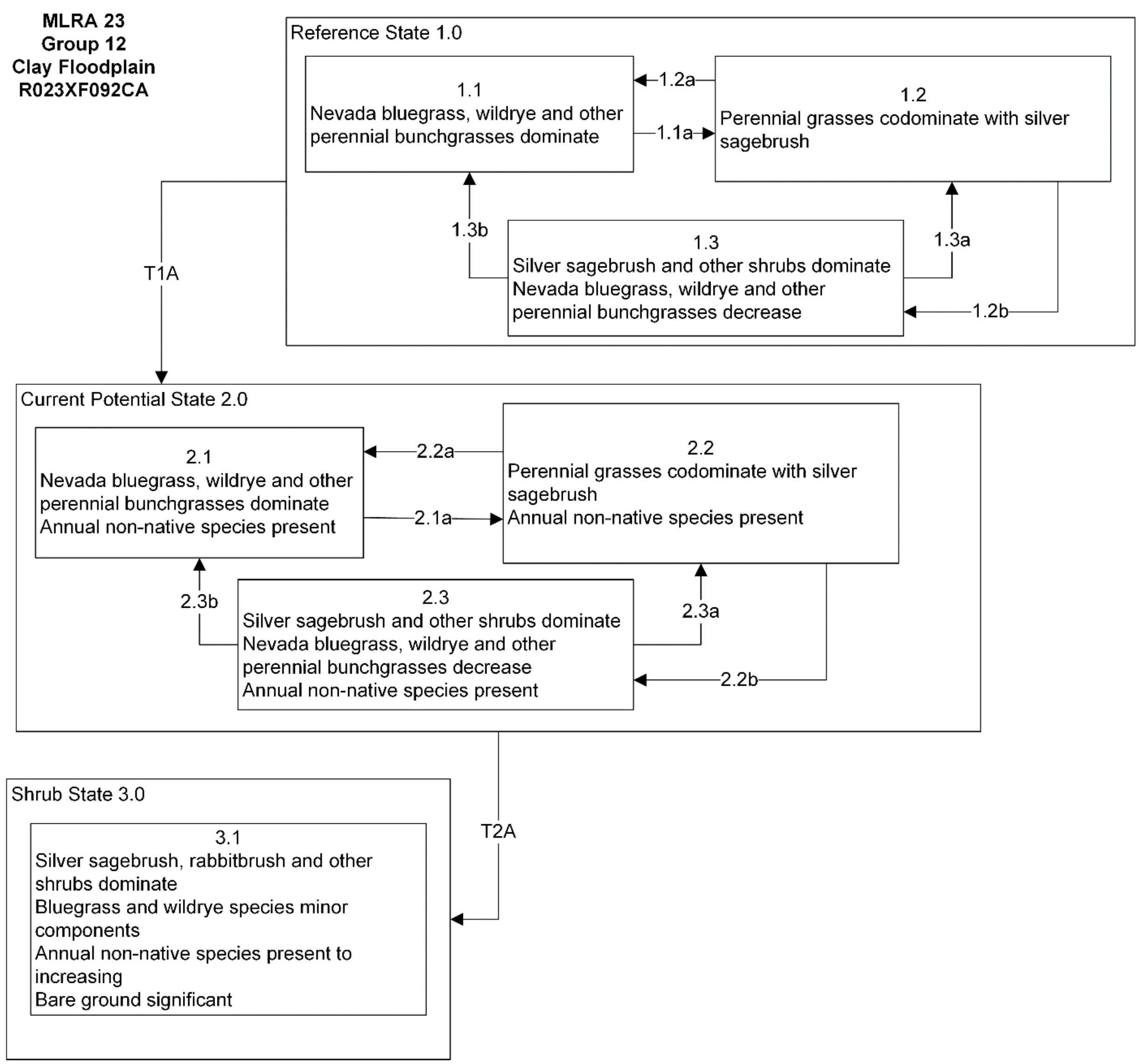
Reference State 1.0 Community Phase Pathways:
1.1a: Drought allows silver sagebrush to increase.
1.2a: Release from drought reduces sagebrush cover.
1.2b: Long-term drought coupled with excessive herbivory.
1.3a: Release from drought, low severity fire, or release from herbivory reduces sagebrush and releases understory herbaceous species.
1.3b: Fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways:
2.1a: Drought allows silver sagebrush to increase.
2.2a: Release from drought reduces sagebrush cover.
2.2b: Long-term drought coupled with excessive herbivory.
2.3a: Release from drought, low severity fire, or release from herbivory reduces sagebrush and releases understory herbaceous species.
2.3b: Fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses

Transition T2A: Long-term chronic drought (or surface alteration that lowers water table), coupled with inappropriate grazing management (3.1).

Shrub State 3.0 Community Phase Pathways:
None.


MLRA 23
Group 12
Clay Floodplain
R023XF092CA
Reference State 1.0
1.1
Nevada bluegrass, wildrye and other perennial bunchgrasses dominate
1.2
Perennial grasses codominate with silver sagebrush
1.3
Silver sagebrush and other shrubs dominate
Nevada bluegrass, wildrye and other perennial bunchgrasses decrease
1.1a
1.2a
1.2b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Nevada bluegrass, wildrye and other perennial bunchgrasses dominate
Annual non-native species present
2.2
Perennial grasses codominate with silver sagebrush
Annual non-native species present
2.3
Silver sagebrush and other shrubs dominate
Nevada bluegrass, wildrye and other perennial bunchgrasses decrease
Annual non-native species present
2.1a
2.2a
2.2b
2.3a
2.3b
T2A
Shrub State 3.0
3.1
Silver sagebrush, rabbitbrush and other shrubs dominate
Bluegrass and wildrye species minor components
Annual non-native species present to increasing
Bare ground significant

MLRA 23
Group 12
Clay Floodplain
R023XF092CA
KEY

Reference State 1.0 Community Phase Pathways:
1.1a: Drought allows silver sagebrush to increase.
1.2a: Release from drought reduces sagebrush cover.
1.2b: Long-term drought coupled with excessive herbivory.
1.3a: Release from drought, low severity fire, or release from herbivory reduces sagebrush and releases understory herbaceous species.
1.3b: Fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses and forbs.

Transition T1A: Introduction of non-native annual species.

Current Potential State 2.0 Community Phase Pathways:
2.1a: Drought allows silver sagebrush to increase.
2.2a: Release from drought reduces sagebrush cover.
2.2b: Long-term drought coupled with excessive herbivory.
2.3a: Release from drought, low severity fire, or release from herbivory reduces sagebrush and releases understory herbaceous species.
2.3b: Fire significantly reduces sagebrush and leads to early/mid-seral community, dominated by grasses

Transition T2A: Long-term chronic drought (or surface alteration that lowers water table), coupled with inappropriate grazing management (3.1).

Shrub State 3.0 Community Phase Pathways:
None.

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Group 13: Black sagebrush

Description of MLRA 23 DRG 13:

Disturbance Response Group (DRG) 13 consists of two ecological sites, Shallow Calcareous Loam 8-12" (023XY052NV), and Very Shallow Stony Loam 9-12" (023XF087CA). The California ecological site Very Shallow Stony Loam 9-12" correlates with the Nevada ecological site Shallow Calcareous Loam 8-12". The precipitation zone for this site ranges from 8 to 12 inches. The elevation range for this group is from 4,500 to 6,000 ft. Slopes range from 4 to 15 percent. The soils in are typically less than 20 inches deep and moderately to strongly calcareous. Soil reaction increases with soil depth. Most soils are modified with high volumes of coarse fragments throughout the soil profile. Rock fragments in the profile and on the soil surface, occupy plant growing space and reduce the soil moisture holding capacity. The available water capacity is low. Runoff is medium to rapid and the potential for sheet and rill erosion is moderate to high, depending upon slope. The shrub component is dominated by black sagebrush (*Artemisia nova A. Nelson*) with bluebunch wheatgrass (*Pseudoroegneria spicata)* and Thurber's needlegrass (*Achnatherum thurberianum*) in the understory. Utah juniper may be present on this site. The annual production on the Nevada site ranges from 300 to 700 lbs/ac, with 500 lbs/ac in normal years whereas the California site production ranges from 200 to 600 lbs/ac, with 400 lbs/ac in a normal year.

Disturbance Response Group 13 Ecological sites:

Shallow Calcareous Loam 10-14"	023XY052NV
Very Shallow Stony Loam 9-12"	023XF087CA

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 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 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 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 or 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 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 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 perennial bunchgrasses that are co-dominant with the shrubs include bluebunch wheatgrass and Thurber's needlegrass. Webber needlegrass (*Achnatherum webberi*), bottlebrush squirreltail (*Elymus elymoides*), needleandthread (*Heterostipa comata*), and Sandberg bluegrass (*Poa secunda*) are other important grass species. Grasses 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 range and density of Utah juniper has increased since the middle of the nineteenth century (Tausch 1999, Miller and Tausch 2001). Causes for expansion of Utah 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 this was frequent enough to inhibit the encroachment of Utah juniper 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 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 sprouting shrubs.

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 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:

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).

Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage from fire but is more susceptible in drought years (Young 1983). Plant response will vary depending on season, fire severity, fire intensity and post-fire soil moisture availability.

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).

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. 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 (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).

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).

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 for 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).

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949, Britton et al. 1990) Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.

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).

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.

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.

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 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 23 Disturbance Response Group 13.

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, herbivory, and/or insect or disease attack. Utah juniper may be present on the site, but will only occur as scattered trees and will not dominate the site.

Community Phase 1.1:
Black sagebrush, bluebunch wheatgrass, and Thurber's needlegrass co-dominate the site. Utah juniper may be present in the community in small amounts.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
A low severity fire would decrease the overstory of sagebrush and allow the understory perennial grasses to increase. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring facilitating 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:
Absence of disturbance over time, significant herbivory, chronic drought or combinations of these would allow the sagebrush overstory to increase and dominate the site. This will generally cause a reduction in perennial bunch grasses; however Sandberg bluegrass may increase in the

understory depending on the timing and intensity of herbivory. Heavy spring utilization will favor an increase in sagebrush.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early seral community phase. Indian ricegrass and needle and thread will increase and dominate the community. Sprouting shrubs such as Douglas' rabbitbrush, spiny hopsage, and shadscale may increase. Black sagebrush may still be present in unburned patches. Forbs may increase post-fire but will likely return to pre-burn levels within a few years.

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

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. Scattered Utah juniper trees may be present on the site.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
Low severity fire results in a mosaic pattern of shrubs and grass. Fall and/or winter herbivory may cause mechanical damage to shrubs and reduces shrub density.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Fire would decrease or eliminate the overstory of sagebrush and lead to early/mid-seral community, dominated by grasses and forbs. 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 weeds, such as cheatgrass, mustard (*Descurainia* sp.), and halogeton (*Halogeton glomeratus*).
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. It has similar community phases with the addition of the 2.4 at-risk 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. 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 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 compositionally similar to the Reference State Community Phase 1.1 with the presence non-native species in trace amounts. Black sagebrush, bluebunch wheatgrass, Thurber's needlegrass dominate the site. Utah juniper may be present.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
A low severity fire would decrease the overstory of sagebrush and allow the understory perennial grasses to increase. Fires are typically low severity resulting in a mosaic pattern due to low fuel loads. A fire following an unusually wet spring facilitating an increase in fine fuels may be more severe and reduce sagebrush cover to trace amounts.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Absence of disturbance over time, chronic drought, inappropriate grazing management or combinations of these would allow the sagebrush overstory to increase and dominate the site. Inappropriate grazing management reduces deep-rooted perennial bunchgrasses. The grazing-tolerant Sandberg bluegrass may increase.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early seral community where annual non-native species are present. Bluebunch wheatgrass and Thurber's needlegrass dominate. Depending on fire severity, patches of intact sagebrush may remain. Rabbitbrush or other sprouting shrubs may be increasing. Shadscale may increase. 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 2.1:
Absence of disturbance over time 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 Pathway 2.2b, from Phase 2.2 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 2.3:
Black 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. Sandberg's bluegrass will likely increase in the understory and may be co-dominant with the deep rooted bunchgrasses. Utah juniper may be

present and without management will likely increase. Annual non-native species are stable or increasing. This community is at risk of crossing a threshold to the Shrub State, Tree State, or Annual State.

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 would decrease or eliminate the overstory of sagebrush and allow 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. Non-native annual species present.

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:
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.

Community Phase Pathway 2.4a, from Phase 2.4 to 2.1:
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 2.2:
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: 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 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 Utah juniper and/or western 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 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: 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.

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

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 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 has two community phases: a black big sagebrush phase and Sandberg bluegrass phase. This state is a product of many years of heavy grazing during time periods harmful to perennial bunchgrasses. 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:
Black sagebrush dominates this site. Perennial bunchgrasses in the understory are significantly reduced or absent. Sandberg bluegrass may be the dominant grass. Utah juniper may be present or increasing. Bare ground is significant.

Shallow Calcareous Loam 8-12" (023XY052NV) Phase 3.1. P. Novak-Echenique, May 2015

Shallow Calcareous Loam 8-12" (023XY052NV) 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 Sandberg bluegrass to dominate the site.

Community Phase 3.2:
Sandberg bluegrass and sprouting shrubs such as shadscale and rabbitbrush increase. Perennial bunchgrasses are minor component. Seeded wheatgrasses may be present. Annual non-native species are stable to increasing. Bare ground may be significant.

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

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

Trigger: Absence of disturbance over time allows 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 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.

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

Trigger: Severe fire or elimination of grass understory, followed by subsequent invasion by annual non-native species.
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.

Tree State 4.0:

This state is characterized by a dominance of Utah 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. This state has two community phases.

Community Phase 4.1:
Utah juniper dominate. Black sagebrush, other shrubs, and perennial bunchgrasses decrease. Seeded wheatgrasses may be present. Annual non-native species are present. Bare ground is significant.

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Time and lack of disturbance allows maturation of tree community.

Community Phase 4.2:
Utah juniper dominate. Black sagebrush is a minor component or missing. Perennial bunchgrasses are minor component. Seeded wheatgrasses may be present. Annual non-native species are present. Bare ground is significant.

T4A: Transition from Tree State 4.0 to Annual State 5.0:

Trigger: Catastrophic crown fire would reduce or eliminate trees to transition the site to 5.1. Tree removal when annual non-natives such as cheatgrass are present would also transition the site to state 5.0.
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.

Annual State 5.0:

This state has one community phase dominated by annual non-native species. This state is characterized by the dominance of annual non-native species such as cheatgrass, medusahead, or mustard in the understory. Sagebrush and/or rabbitbrush may dominate the overstory. Annual non-native species and squirreltail dominate the understory.

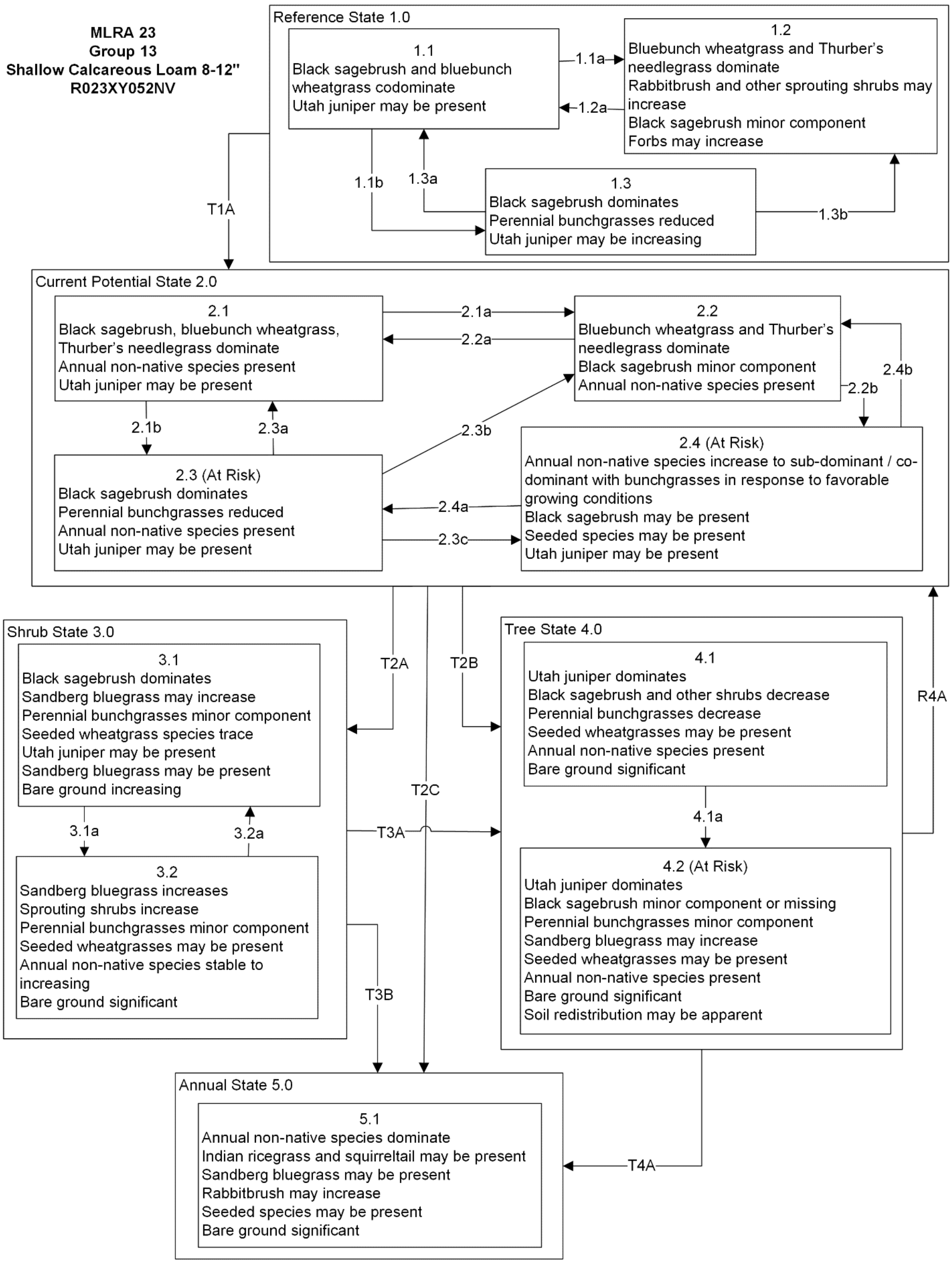
Community Phase 5.1:
Annuals dominate; Sandberg bluegrass and perennial forbs may still be present in trace amounts. Shrubs may still dominate the overstory. Annual nonnative species control understory dynamics and fire behavior.

Potential Resilience Differences with other Ecological Sites:

Very Shallow Stony Loam 9-12" (023XF087CA):

This site occurs on escarpments as inclusions on among moderately deep and deep soils on all aspects. The plant community is very similar to the correlating Nevada site, and is dominated by bluebunch wheatgrass, black sagebrush, and Thurber's needlegrass with a production range of 200 lbs/ac to 600 lbs/ac. This site has five stable states.

Modal State and Transition Model for Group 13 in MRLA 23:


MLRA 23
Group 13
Shallow Calcareous Loam 8-12"
R023XY052NV
Reference State 1.0
1.1
Black sagebrush and bluebunch wheatgrass codominate
Utah juniper may be present
1.1a
1.2a
1.2
Bluebunch wheatgrass and Thurber's needlegrass dominate
Rabbitbrush and other sprouting shrubs may increase
Black sagebrush minor component
Forbs may increase
1.1b
1.3a
1.3
Black sagebrush dominates
Perennial bunchgrasses reduced
Utah juniper may be increasing
1.3b
T1A
Current Potential State 2.0
2.1
Black sagebrush, bluebunch wheatgrass, Thurber's needlegrass dominate
Annual non-native species present
Utah juniper may be present
2.1a
2.2a
2.2
Bluebunch wheatgrass and Thurber's needlegrass dominate
Black sagebrush minor component
Annual non-native species present
2.4b
2.2b
2.1b
2.3a
2.3b
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with bunchgrasses in response to favorable growing conditions
Black sagebrush may be present
Seeded species may be present
Utah juniper may be present
2.3 (At Risk)
Black sagebrush dominates
Perennial bunchgrasses reduced
Annual non-native species present
Utah juniper may be present
2.4a
2.3c
Shrub State 3.0
3.1
Black sagebrush dominates
Sandberg bluegrass may increase
Perennial bunchgrasses minor component
Seeded wheatgrass species trace
Utah juniper may be present
Sandberg bluegrass may be present
Bare ground increasing
T2A
T2B
Tree State 4.0
4.1
Utah juniper dominates
Black sagebrush and other shrubs decrease
Perennial bunchgrasses decrease
Seeded wheatgrasses may be present
Annual non-native species present
Bare ground significant
R4A
T2C
3.1a
3.2a
T3A
4.1a
3.2
Sandberg bluegrass increases
Sprouting shrubs increase
Perennial bunchgrasses minor component
Seeded wheatgrasses may be present
Annual non-native species stable to increasing
Bare ground significant
T3B
4.2 (At Risk)
Utah juniper dominates
Black sagebrush minor component or missing
Perennial bunchgrasses minor component
Sandberg bluegrass may increase
Seeded wheatgrasses may be present
Annual non-native species present
Bare ground significant
Soil redistribution may be apparent
Annual State 5.0
5.1
Annual non-native species dominate
Indian ricegrass and squirreltail may be present
Sandberg bluegrass may be present
Rabbitbrush may increase
Seeded species may be present
Bare ground significant
T4A

MLRA 23
Group 13
Shallow Calcareous Loam 8-12"
R023XY052NV
KEY

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 resulting in a mosaic pattern, fall/winter herbivory may cause mechanical damage to shrubs and reduce shrub density.
1.3b: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.

Current Potential State 2.0 Community Phase Pathways
2.1a: 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; non-native annual species present.
2.1b: Time and lack of disturbance such fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub regeneration.
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 resulting in a mosaic pattern. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.3c: Fall and spring growing season conditions that favor the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Rainfall pattern favoring perennial bunchgrass production and reduced cheatgrass production (less than normal spring with higher than normal summer precipitation).
2.4b: Rainfall pattern favoring perennial bunchgrass production and reduced cheatgrass production (less than normal spring with higher than normal summer precipitation).

Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).
Transition T2B: Time and lack of disturbance allows for maturation of trees, may be coupled with inappropriate grazing management (4.1).
Transition T2C: High severity fire, failed seeding.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance.

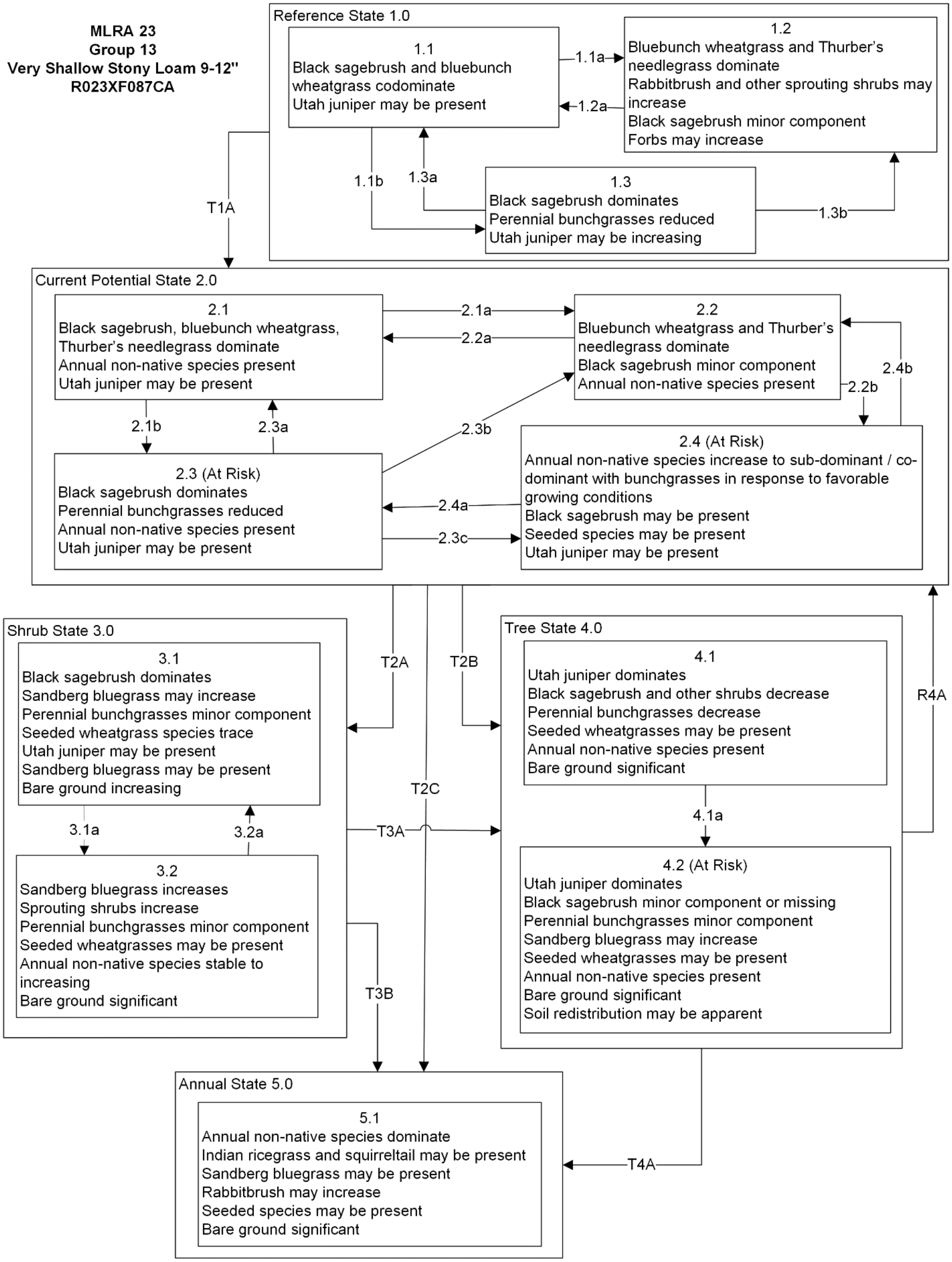
Transition T3A: Time and lack of disturbance allows for tree maturation; may be coupled with inappropriate grazing management (4.1).
Transition T3B: Catastrophic fire and/or soil disturbing treatments (5.1).

Tree State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance allows maturation of tree community.

Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (5.1).

Restoration R4A: Tree removal with minimal soil disturbance and seeding of desired species.

Alternate State and Transition Model for Group 13 in MRLA 23:


MLRA 23
Group 13
Very Shallow Stony Loam 9-12"
R023XF087CA
Reference State 1.0
1.1
Black sagebrush and bluebunch wheatgrass codominate
Utah juniper may be present
1.2
Bluebunch wheatgrass and Thurber's needlegrass dominate
Rabbitbrush and other sprouting shrubs may increase
Black sagebrush minor component
Forbs may increase
1.3
Black sagebrush dominates
Perennial bunchgrasses reduced
Utah juniper may be increasing
1.1a
1.2a
1.1b
1.3a
1.3b
T1A
Current Potential State 2.0
2.1
Black sagebrush, bluebunch wheatgrass, Thurber's needlegrass dominate
Annual non-native species present
Utah juniper may be present
2.2
Bluebunch wheatgrass and Thurber's needlegrass dominate
Black sagebrush minor component
Annual non-native species present
2.3 (At Risk)
Black sagebrush dominates
Perennial bunchgrasses reduced
Annual non-native species present
Utah juniper 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
Black sagebrush may be present
Seeded species may be present
Utah juniper may be present
2.1a
2.2a
2.1b
2.3a
2.3b
2.2b
2.4b
2.4a
2.3c
Shrub State 3.0
3.1
Black sagebrush dominates
Sandberg bluegrass may increase
Perennial bunchgrasses minor component
Seeded wheatgrass species trace
Utah juniper may be present
Sandberg bluegrass may be present
Bare ground increasing
3.2
Sandberg bluegrass increases
Sprouting shrubs increase
Perennial bunchgrasses minor component
Seeded wheatgrasses may be present
Annual non-native species stable to increasing
Bare ground significant
3.1a
3.2a
T2A
T2B
T2C
T3A
T3B
Tree State 4.0
4.1
Utah juniper dominates
Black sagebrush and other shrubs decrease
Perennial bunchgrasses decrease
Seeded wheatgrasses may be present
Annual non-native species present
Bare ground significant
4.1a
4.2 (At Risk)
Utah juniper dominates
Black sagebrush minor component or missing
Perennial bunchgrasses minor component
Sandberg bluegrass may increase
Seeded wheatgrasses may be present
Annual non-native species present
Bare ground significant
Soil redistribution may be apparent
R4A
Annual State 5.0
5.1
Annual non-native species dominate
Indian ricegrass and squirreltail may be present
Sandberg bluegrass may be present
Rabbitbrush may increase
Seeded species may be present
Bare ground significant
T4A

MLRA 23
Group 13
Very Shallow Stony Loam 9-12"
R023XF087CA
KEY

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 resulting in a mosaic pattern, fall/winter herbivory may cause mechanical damage to shrubs and reduce shrub density.
1.3b: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community, dominated by grasses and forbs.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.

Current Potential State 2.0 Community Phase Pathways
2.1a: 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; non-native annual species present.
2.1b: Time and lack of disturbance such fire or drought. Inappropriate grazing management may also reduce perennial understory.
2.2a: Time and lack of disturbance allows for shrub regeneration.
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 resulting in a mosaic pattern. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native annual species present.
2.3c: Fall and spring growing season conditions that favor the germination and production of non-native annual grasses. 2.4 may be a transitory plant community.
2.4a: Rainfall pattern favoring perennial bunchgrass production and reduced cheatgrass production (less than normal spring with higher than normal summer precipitation).
2.4b: Rainfall pattern favoring perennial bunchgrass production and reduced cheatgrass production (less than normal spring with higher than normal summer precipitation).

Transition T2A: Inappropriate grazing management (3.1). Fire or brush treatment; may be coupled with inappropriate grazing management (3.2).
Transition T2B: Time and lack of disturbance allows for maturation of trees, may be coupled with inappropriate grazing management (4.1).
Transition T2C: High severity fire, failed seeding.

Shrub State 3.0 Community Phase Pathways
3.1a: Fire or brush management (i.e. mowing) with minimal soil disturbance.
3.2a: Time and lack of disturbance.

Transition T3A: Time and lack of disturbance allows for tree maturation; may be coupled with inappropriate grazing management (4.1).
Transition T3B: Catastrophic fire and/or soil disturbing treatments (5.1).

Tree State 4.0 Community Phase Pathways
4.1a: Time and lack of disturbance allows maturation of tree community.

Transition T4A: Catastrophic fire and/or inappropriate tree removal practices (5.1).

Restoration R4A: Tree removal with minimal soil disturbance and seeding of desired species.

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Group 14: Stabilized sand dunes with sagebrush and saltbrush

Description of MLRA 23 DRG 14:

Disturbance Response Group (DRG) 14 consists of one ecological site: Dunes 8-10" (023XY011NV). The precipitation zone for this site ranges from 8 to 10 inches. The elevation range for this group is from 4,500 to 5,000 ft. Slopes range from 2 to 30 percent. The soils of this site are windblown, fine and very fine sands, typically more than 40 inches in depth. Soils are very susceptible to wind erosion and may have small "blow out" areas. The soil profile is excessively drained and free of salts. Because of rapid soil intake and deep percolation of water, the loss of soil moisture due to evaporation is reduced and runoff is negligible. These conditions allow deep rooted plants to grow vigorously under arid climatic conditions. The potential native plant community for this site varies depending on precipitation, elevation and landform. The shrub overstory component is dominated by basin big sagebrush (*Artemisia tridentata ssp. tridentata)* and spiny hopsage (*Grayia spinosa*). The understory is dominated by Indian ricegrass (*Achnatherum hymenoides*), basin wildrye (*Leymus cinereus*), thickspike wheatgrass (*Elymus lanceolatus*), and needle and thread (*Hesperostipa comata*). The production on this site ranges from 400 to 900 lbs/acre, with 700 lb/ac in normal years.

Disturbance Response Group 14 – Ecological Sites:

Dunes 8-10" – Modal R023XY011NV

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 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 reached 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).

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 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 or 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).

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 (Longland and Young 1995, 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). When sagebrush stands are decadent and even-aged, aroga investations are more likely to be a stand-replacing event (Longland and Young 1995).

Indian ricegrass is the dominant grass on this site. Indian ricegrass is a deep-rooted, cool season perennial bunchgrass that is adapted primarily to sandy soils. Grasses generally have 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. General 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 states have been identified for this DRG.

Annual Invasive Grasses:

The species most likely to invade these sites are cheatgrass and medusahead, however medusahead is more commonly found in clayey soils, so it may never become dominant on this sandy dune site. This narrative will focus on cheatgrass. 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.

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:

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).

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).

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).

Indian ricegrass is fairly fire tolerant (Wright 1985), which is likely due to its low culm density and below ground plant crowns. Indian ricegrass has 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 is necessary for reestablishment of Indian ricegrass. It is important to manage grazing following fire in a way that promotes seed production and establishment of seedlings.

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 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).

Livestock/Wildlife Grazing Interpretations:

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).

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).

Indian ricegrass is a deep-rooted, cool season perennial bunchgrass that is adapted primarily to sandy soils. Indian ricegrass is a preferred forage species for livestock and wildlife (Booth et al. 1980, Cook 1962). 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. However, Cook and Child (1971) 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 (Cook and Child 1971, Pearson 1964); however, utilization of less than 60% is recommended.

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).

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 Group 14:

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 14.

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 two general community phases: a shrub-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:
The community is dominated by Indian ricegrass and basin big sagebrush. Spiny hopsage, basin wildrye, thickspike wheatgrass, needle and thread grass, and perennial forbs are also common on this site.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Time and lack of disturbance allows shrubs to increase. Chronic drought reduces grass production.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early seral community phase. Big sagebrush, spiny hopsage and other shrubs increase. Perennial grasses are reduced.

Community Phase Pathway 1.2a, from Phase 1.2 to 1.1:
Low severity fire results in a mosaic pattern with an increase in grasses. Release from drought may allow Indian ricegrass to increase in production. Fall and/or winter herbivory may cause mechanical damage to shrubs and reduce shrub density.

Dunes 8-10 (023XY011NV) Phase 1.2 T.K. Stringham August 2014

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 halogeton (*Halogeton glomeratus*).
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. 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 two 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:
The community is dominated by Indian ricegrass and basin big sagebrush. Spiny hopsage, basin wildrye, thickspike wheatgrass, needle and thread grass, and perennial forbs are also common on this site. Annual non-native species present.

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
Time and lack of disturbance allows shrubs to increase. Chronic drought reduces grass production.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early seral community phase. Big sagebrush, spiny hopsage and other shrubs increase. Perennial grasses are reduced. Annual non-native species are present.

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Low severity fire resulting in a mosaic pattern, with an increase in grasses. Release from drought may allow Indian ricegrass to increase in production. Fall and/or winter herbivory may cause mechanical damage to shrubs and reduce shrub density.

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 in the presence of annual grasses leads to plant community phase 4.1.
Slow variables: Increased production and cover of non-native annual species. The change in dominance from perennial grasses to annual grasses reduces decreasing organic matter inputs from deep-rooted perennial bunchgrasses root turnover, resulting in reductions in soil water availability for perennial bunchgrasses.
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 has two community phases: a Basin 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. 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:
Big sagebrush dominates. Indian ricegrass and other perennial grasses in the understory are reduced. Annual non-native species are present to increasing. Understory may be sparse, with bare ground increasing.

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire and/or brush treatment would decrease or eliminate the overstory of sagebrush.

Community Phase 3.2:
Sprouting shrubs dominate the overstory. Perennial bunchgrasses may be a minor component. Annual non-native species are present to increasing.

Dunes 8-10" (023XY011NV) Shrub State 3.0 T.K. Stringham, August 2014

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

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

Trigger: Fire in the presence of annual grasses eliminates the shrub overstory and transition to community phase 4.1.
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.

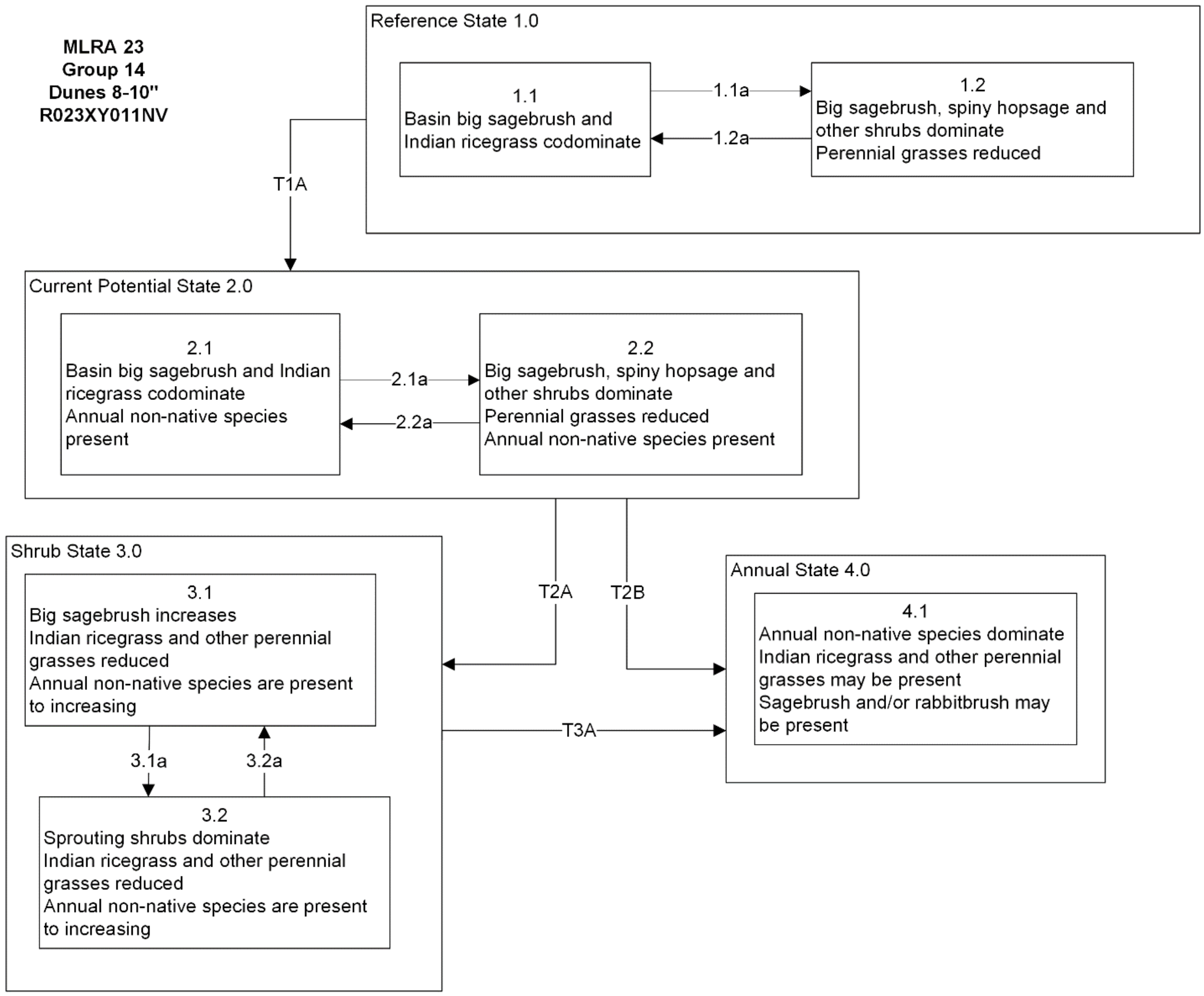
Annual State 4.0

This state has one community phase dominated by annual non-native species. This state is characterized by the dominance of annual non-native species such as cheatgrass and tansy mustard in the understory. Sagebrush and/or rabbitbrush may dominate the overstory. Annual non-native species and squirreltail dominate the understory.

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. Sagebrush and/or rabbitbrush may be present.

Dunes 8-10" (R023XY011NV) Annual State 4.0 T.K. Stringham, June 2017

Modal State and Transition Model for Group 14 in MRLA 23:



MLRA 23
Group 14
Dunes 8-10"
R023XY011NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: Time and lack of disturbance, may be coupled with drought.
1.2a: Low severity fire resulting in a mosaic pattern, fall/winter herbivory may cause mechanical damage to shrubs and reduce shrub density.

Transition T1A: Introduction of non-native species.

Current Potential State 2.0 Community Phase Pathways
2.1a: Time and lack of disturbance, may be coupled with drought.
2.2a: Low severity fire resulting in a mosaic pattern, fall/winter herbivory may cause mechanical damage to shrubs and reduce shrub density.

Transition T2A: Inappropriate grazing management (3.1), fire and/or brush treatment may be coupled with inappropriate grazing management (3.2).
Transition T2B: Fire in the presence of non-native annual species.

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

Transition T3A: Fire.

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Group 15: Sagebrush with rhizomatous grasses

Description of MLRA 23 DRG 15:

Disturbance Response Group (DRG) 15 consists of two ecological sites, Clayey 10-14” (R023XY033NV) and Clay Upland 9-16” (R023XF084CA). The California ecological site, Clay Upland 9-16”, encompasses a wide precipitation range suggesting the site concept is too broad. The Clay Upland 9-16” ecological site has been verified as similar to the Nevada ecological site Clayey 10-14” only within the lower precipitation range represented by the Nevada site concept. Therefore the precipitation zone for this group ranges from 9 to 14 inches. The elevation range for this group is from 4,200 to 6,000 feet with typical slope gradients that range from 2 to 4 percent. The soils in this site are typically moderately deep to deep and underlain by basalt parent material with clay textured surface soils. The thin surface layers are underlain by heavy clay subsoils having strong to massive structure. The fine textured soils swell on wetting then shrink and crack upon drying. When dry, the soils have wide cracks into which the granulated surface layers tend to slough. Upon wetting the cracks close. This continual, active, soil movement damages the root system of many plants. Infiltration of water is restricted once the surface soils are saturated and the site is subject to loss of water by runoff and evaporation. These soils normally have a high percentage of gravels and cobbles on the surface which occupy plant growing space yet provide a stabilizing effect on surface erosion conditions. Pedestalling of plants is common due to the high shrink-swell characteristics of the clay soils. Wind erosion potential is slight.

The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*) and basin big sagebrush (*A. tridentata spp. tridentata)*. Lahontan sagebrush (Artemisia arbuscula ssp. longicaulis) occasionally occurs on the Clay Upland 9-16” California site. The understory is dominated by western wheatgrass (*Pascopyrum smithii*), thickspike wheatgrass (*Elymus lanceolatus*), bottlebrush squirreltail (*Elymus elymoides*), creeping wildrye (*Leymus triticoides*) and perennial forbs. The Nevada site production ranges from 350 to 800 lbs/acre, with 600 lbs/acre in a normal year whereas the California site production ranges from 500 to 900 lbs/acre with 700 lbs/acre in a normal year. Consideration of the broad precipitation range for the California site should also be applied to the production values. Likely the production amounts associated with the lower precipitation end of the Clay Upland 9-16” site are more closely aligned with the Clayey 10-14” Nevada ecological site.

Disturbance Response Group 15 Ecological sites:

Clayey 10-14” – Modal	023XY033NV
Clay Upland 9-16”	023XF084CA

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 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).

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 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 or 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).

Wyoming big sagebrush is the most drought tolerant of the big sagebrush's, and generally occurs in warmer and drier sites on shallower, sometimes saline soils. Lahontan sagebrush, a subspecies of low sagebrush (*A. arbuscula*), found primarily in northwestern Nevada and adjacent California and Oregon, prefers soils with low available water-holding capacities and a shallow depth to an argillic horizon and/or bedrock (Winward and McArthur 1995). All of these subspecies of sagebrush are long-lived; therefore it is not necessary for new individuals to recruit every year for perpetuation of the stand (Tisdale and Hironaka 1981). Infrequent large recruitment events and simultaneous low, continuous recruitment is the foundation of population maintenance (Noy-Meir 1973). Survival of the seedlings is, however, 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).

Rhizomatous grasses, primarily western wheatgrass, thickspike wheatgrass, and creeping wildrye dominate this DRG. The dominant bunchgrass is bottlebrush squirreltail. The heavy clay soils with shrink swell characteristics are largely responsible for the type of grasses growing on these sites. Rhizomatous grasses are well adapted to disturbed soils and the shrink swell properties within the rooting zone promote establishment through rhizome breakage and expansion of plants.

Bottlebrush squirreltail is a short-lived (5-7 years) bunchgrass. The plant produces large quantities of viable seed that is windblown. This life history strategy has proven successful at maintaining stands of bottlebrush squirreltail and in reseeding depleted range (Tisdale and Hironaka 1981). It is adapted to a wide range of ecological and topographical conditions. This species can be found from 2,000 to 11,500 feet in elevation, in areas receiving as little as 5 inches of rain annually, and in various soil types (Monsen et al. 2004). Populations from different locations in the western U.S. exhibit wide ranges in germination and maturation times. Experimental field plantings have documented leaf growth starting in mid- to late March and seed ripening occurring between late June and the first week of July (Hironaka and Tisdale 1973). Seed is produced in abundant quantities, and germination occurs rapidly at high rates under a wide temperature range (Young and Evans 1977). Germination typically occurs in the fall when moisture conditions are favorable, and seedlings overwinter starting growth again in March (Davison 2004). This life history strategy, plus the ability of the root system to continue growth at low temperatures during winter enables bottlebrush squirreltail to compete with cheatgrass and medusahead (Tisdale and Hironaka 1981). Early growth, high seed production and high germination rates along with wind dispersed seed heads make it a successful species for increasing on heavily grazed, depleted rangelands. There is evidence that squirreltail plants growing in the presence of cheatgrass have adapted traits to more successfully compete with this annual grass (Ferguson et al. 2015). Seeds collected from these wild-grown plants are less negatively affected by cheatgrass competition because they are able to grow larger root systems (Ferguson et al. 2015, Atwater et al. 2015). In a restoration experiment, plants that were small in stature and earlier flowering period had greater success in establishment (Kulpa and Leger 2013). Bottlebrush squirreltail shows increasing promise as a restoration plant.

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 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 increasers 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 follow label directions and in sensitive habitat areas potentially install test plots before broad scale herbicide application is initiated.

Fire Ecology:

This DRG is dominated by Wyoming and basin big sagebrush, often occurring in equal proportions on the landscape. Changes if fire frequency have occurred because of fire supporession, livestock grazing, OHV use, and invasive annual grass invasions. 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 and basin big sagebrush are killed by fire and only regenerate from seed. Because of the time needed to produce seed, frequent fires can eliminate sagebrush from a landscape (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 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). Big sagebrush may require 50-120 or more years to recover after fire (Baker 2006). 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 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). Rhizomatous grasses, such as western wheatgrass, also respond to timing and intensity of the fire. White and Currie (1983) found that dormant season fire increased western wheatgrass cover whereas growing season burning had no impact on basal cover. In Nevada, western wheatgrass increased in frequency after fire and above ground biomass increased more than seven times pre-burn levels during the first season following fire (Bushey 1987).

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. It exhibits the ability to germinate in the late fall and very early spring at a wide range of temperatures making it a strong competitor with cheatgrass (Arredondo et al. 1998). 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 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:

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). Lahontan sagebrush, on the other hand, is considered preferred browse by mule deer (Clements and Young 1997) and is noted as often having a hedged appearance indicating high palatability by many species (McArthur 2005).

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 provides an opportunity for Sandberg bluegrass or bottlebrush squirreltail 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 and/or bottlebrush squirreltail 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, bottlebrush squirreltail or annual invasive grasses 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).

State and Transition Model Narrative 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 23 Disturbance Response Group 15.

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:
The community is dominated by big sagebrush, western wheatgrass, thickspike wheatgrass, and squirreltail. Perennial forbs and other grasses make up smaller components.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Low severity fire will decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site, creating a grass/sagebrush mosaic. A fire following an unusually wet spring may be more severe and reduce sagebrush to trace amounts.

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 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 to mid-seral community phase. Rhizomatous wheatgrasses and other perennial grasses dominate. Patches of big sagebrush mat be intact but area minor component. Rabbitbrush and other sprouting shrubs may increase.

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

Community Phase 1.3:
Sagebrush increases in the absence of disturbance. Decadent sagebrush dominates the overstory and 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 combination of the two would decrease or eliminate the overstory of sagebrush and create a sagebrush/grass mosaic.

Community Phase Pathway 1.3b, from Phase 1.3 to 1.2:
Low severity fire and/or Aroga moth infestation may reduce the overstory of sagebrush and allow the perennial bunchgrass to dominate the site.

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 halogeton (*Halogeton glomeratus*).
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:

This community phase is similar to the Reference State Community Phase 1.1, with the presence of non-native annual species in trace amounts. Big sagebrush, western wheatgrass, thickspike wheatgrass, and other perennial grasses dominate the 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, 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 to mid-seral community phase where annual non-native species are present. Sagebrush is present in trace amounts; Rhizomatous wheatgrasses and other perennial grasses dominate. Rabbitbrush may be sprouting or dominant in the community. 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 over time, or grazing management that favors shrubs allows the shrub component to recover.

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. 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.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.2:
A change in grazing management that reduces shrubs will allow 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. 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 low 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 2.1:
Fire would decrease or eliminate the overstory of sagebrush and allow the understory of 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 the 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:
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 2.4 (At Risk):
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.

Clay Upland 9-16" (023XF084CA, similar site to Nevada's Clayey 10-14")
Bottlebrush squirreltail dominant by weight
Phase 2.4, T.K. Stringham, May 2017

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:
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 nutrient 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.

Shrub State 3.0:

This state has two community phases; a big sagebrush and a sprouting shrub 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 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:
Sagebrush and/or rabbitbrush dominates overstory and other shrubs may be a significant component. Perennial bunchgrasses are minor component. Annual non-native species are present to increasing. Understory may be sparse, with bare ground increasing.

Community Phase Pathway 3.1a, from Phase 3.1 to 3.2:
Fire, heavy fall grazing, and/or brush treatments with minimal soil disturbance causing mechanical damage to shrubs would decrease or eliminate the overstory of sagebrush to trace amounts and allow bunchgrasses to dominate the site.

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 would allow 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 shrub overstory 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.

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

Brush removal, herbicide of Sandberg bluegrass and seeding of crested wheatgrass and/or other highly competitive non-native species or native cultivars. This pathway may be achieved in a post-fire seeding.

Annual State 4.0:

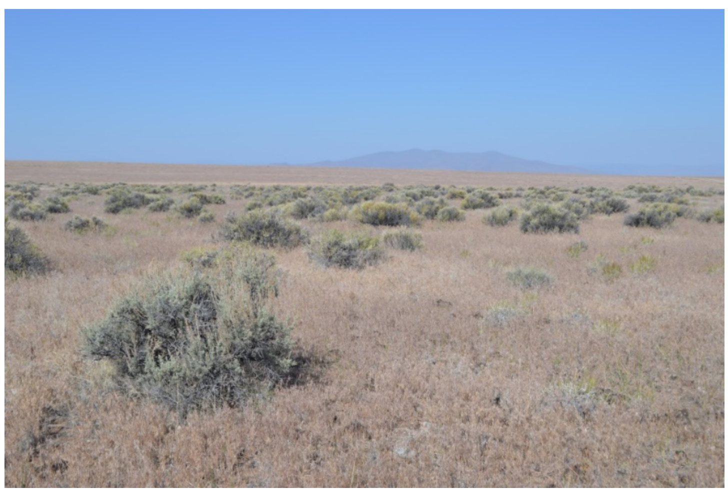
An abiotic threshold has been crossed and state dynamics are driven by fire and time. The herbaceous understory is dominated by annual non-native species such as cheatgrass, medusahead, and tansy mustard. Sagebrush and/or rabbitbrush may dominate the overstory, however resiliency has declined and further degradation from frequent fire will facilitate a cheatgrass/medusahead and sprouting shrub community. The fire return interval is shortened due to the dominance of cheatgrass in the understory and frequent fire drives site dynamics.

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. Perennial bunchgrasses and forbs may still be present in trace amounts. Surface erosion may increase with summer convection storms; increased pedestalling of plants, rill formation, or extensive water flow paths identify these events.


Clayey 10-14 (R023XY033NV) State 4.0 T. Stringham June 2014

Community Phase Pathway 4.1a, from Phase 4.1 to 4.2:
Time and lack of fire allows shrubs to establish and grow to dominate the overstory. This pathway is unlikely to occur.

Community Phase 4.2:
Shrubs dominate the overstory. Sagebrush, horsebrush, rabbitbrush, and/or other sprouting shrubs may dominate. Annual non-native species dominate understory. Seeded species may be present.


Clayey 10-14 (R023XY033NV) Phase 4.2 T.K. Stringham, June 2014

Community Phase Pathway 4.2a, from Phase 4.2 to 4.1:
Fire eliminates the shrub overstory. Annuals such as cheatgrass and medusahead increase after fire and dominate the site.

Seeded State 5.0:

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. Grass species may include crested wheatgrass (*Agropyron cristatum),* Russian wildrye (*Psathyrostachys juncea*), and slender wheatgrass (Elymus trachycaulus). Forage kochia, big sagebrush, and forbs (native and non-native) may be present. Conservation practices such as brush management and prescribed grazing should be used to maintain the perennial bunchgrasses and other desirable species.

Community Phase 5.1:
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.

Clay Upland 9-16" (R023XF084CA, similar site to the Nevada Clayey 10-14")
Bottlebrush squirreltail, Russian wildrye, slender wheatgrass dominate
Seeded State 5.1 T.K. Stringham, October 2018

Community Phase Pathway 5.1a, from phase 5.1 to 5.2:
Time and lack of disturbance. May be coupled with inappropriate grazing management.

Community Phase 5.2:
Wyoming big sagebrush increases and is codominant with seeded grass species. Seeded wheatgrass species dominate understory. Annual non-native species may be present in trace amounts.

Community Phase Pathway 5.2a, from phase 5.2 to 5.1:
Fire, brush management, and/or Aroga moth infestation reduces sagebrush overstory and allows seeded wheatgrasses or other seeded grasses to increase.

Community Phase Pathway 5.2b, from phase 5.2 to 5.3:
Continued inappropriate grazing management reduces bunchgrasses and increases density of sagebrush. This transition may take decades.

Community Phase 5.3 (at risk):
Sagebrush becomes the dominant plant. Perennial bunchgrasses in the understory are reduced due to increased competition with shrubs. Annual non-native species may be increasing. Utah juniper may be present.

Community Phase Pathway 5.3a, from phase 5.3 to 5.1:
Fire or brush management with minimal soil disturbance would reduce sagebrush to trace amounts and allow the perennial understory to increase.

T5A: Transition from Seeded State 5.0 (Community Phase 5.3) to Shrub State 3.0:

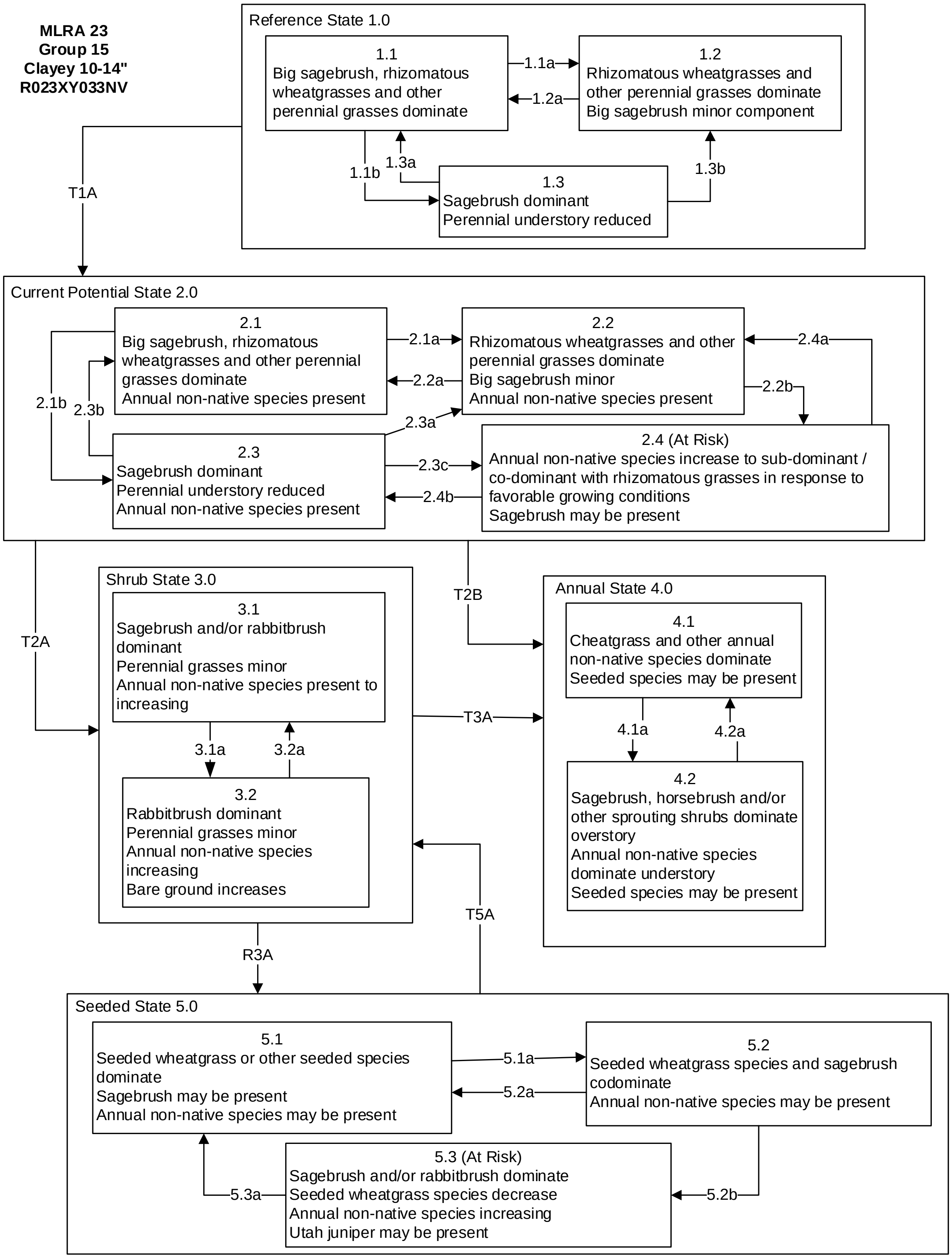
Trigger: Inappropriate, long-term grazing of perennial bunchgrasses during growing season would favor shrubs and initiate transition to Community Phase 3.1. Fire would cause a transition to Community Phase 3.2.
Slow variables: Long term decrease in deep-rooted perennial grass density, resulting in a 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.

Potential Resilience Differences with other Ecological Sites:

Clay Upland 9-16” (023XF084CA):

This site occurs on upland plateaus with soils that are characterized by surface shrink-swell fracturing. The plant community is very similar to the correlating NV modal site with an overstory of big sagebrush, little horsebrush, and an understory of bottlebrush squirreltail, western wheatgrass, and beardless wildrye. It is less productive, ranging from 500 lbs/ac to 900 lbs/ac, with 700 lbs/ac in normal years.

Modal State and Transition Model for Group 15 in MRLA 23:



MLRA 23
Group 15
Clayey 10-14"
R023XY033NV

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 may also decrease 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 or Aroga moth infestation resulting in a mosaic pattern.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.

Current Potential State 2.0 Community Phase Pathways
2.1a: 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; non-native annual species present.
2.1b: Time and lack of disturbance such as fire or drought. Inappropriate grazing management 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: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire 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: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: High severity fire and/or soil disturbance (4.1). Inappropriate grazing that favors shrubs in the presence of non-native annual species (4.2).

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

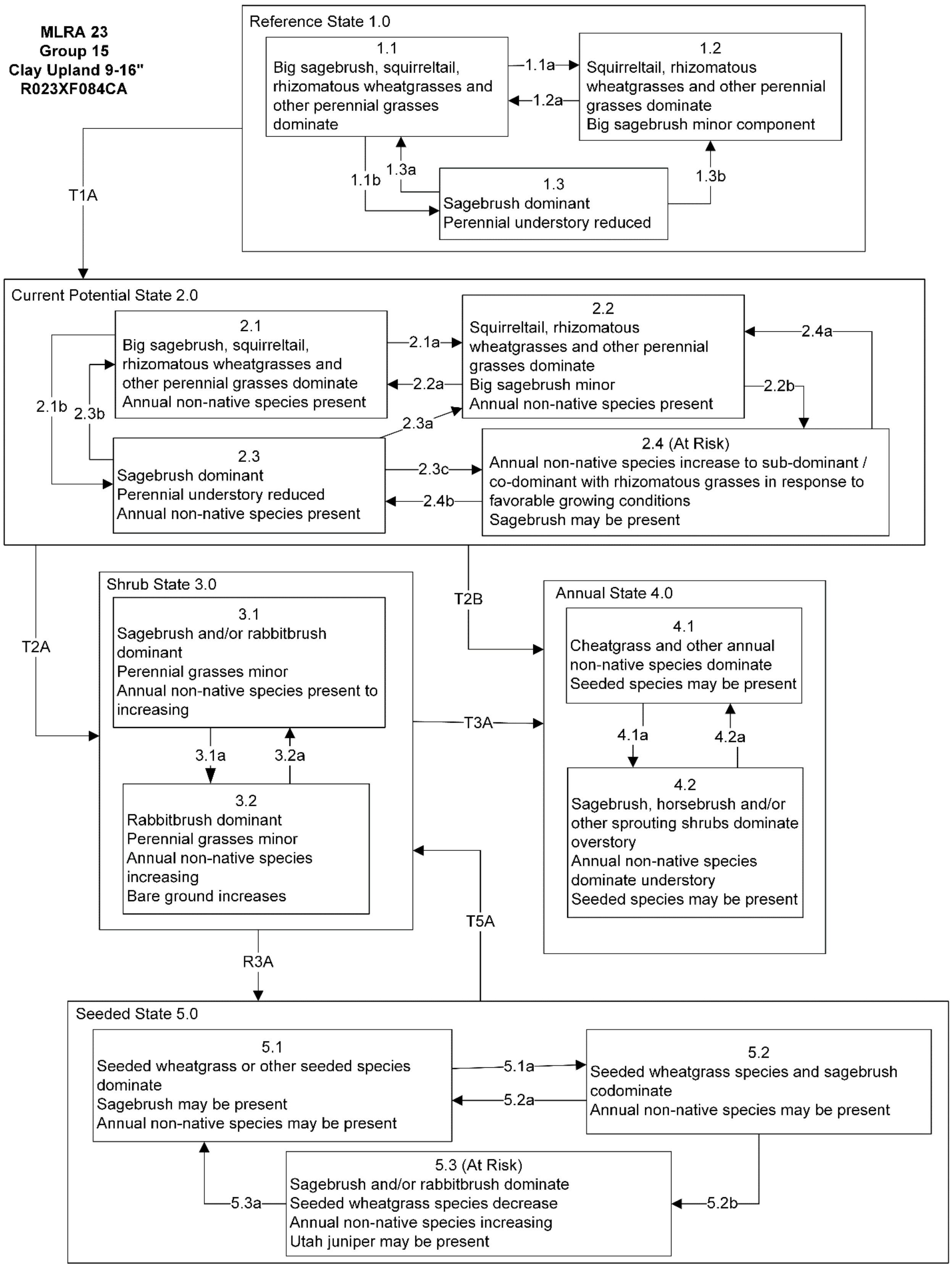
Transition T3A: Catastrophic fire and/or soil disturbance (4.1). Inappropriate grazing management in the presence of non-native annual species (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

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

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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 15 in MRLA 23:


MLRA 23
Group 15
Clay Upland 9-16"
R023XF084CA
Reference State 1.0
1.1
Big sagebrush, squirreltail, rhizomatous wheatgrasses and other perennial grasses dominate
1.1a
1.2a
1.2
Squirreltail, rhizomatous wheatgrasses and other perennial grasses dominate
Big sagebrush minor component
1.1b
1.3a
1.3
Sagebrush dominant
Perennial understory reduced
1.3b
T1A
Current Potential State 2.0
2.1
Big sagebrush, squirreltail, rhizomatous wheatgrasses and other perennial grasses dominate
Annual non-native species present
2.1a
2.2a
2.2
Squirreltail, rhizomatous wheatgrasses and other perennial grasses dominate
Big sagebrush minor
Annual non-native species present
2.4a
2.2b
2.1b
2.3b
2.3a
2.3
Sagebrush dominant
Perennial understory reduced
Annual non-native species present
2.3c
2.4b
2.4 (At Risk)
Annual non-native species increase to sub-dominant / co-dominant with rhizomatous grasses in response to favorable growing conditions
Sagebrush may be present
T2A
T2B
Shrub State 3.0
3.1
Sagebrush and/or rabbitbrush dominant
Perennial grasses minor
Annual non-native species present to increasing
3.1a
3.2a
3.2
Rabbitbrush dominant
Perennial grasses minor
Annual non-native species increasing
Bare ground increases
T3A
Annual State 4.0
4.1
Cheatgrass and other annual non-native species dominate
Seeded species may be present
4.1a
4.2a
4.2
Sagebrush, horsebrush and/or other sprouting shrubs dominate overstory
Annual non-native species dominate understory
Seeded species may be present
T5A
R3A
Seeded State 5.0
5.1
Seeded wheatgrass or other seeded species dominate
Sagebrush may be present
Annual non-native species may be present
5.1a
5.2a
5.2
Seeded wheatgrass species and sagebrush codominate
Annual non-native species may be present
5.3a
5.3 (At Risk)
Sagebrush and/or rabbitbrush dominate
Seeded wheatgrass species decrease
Annual non-native species increasing
Utah juniper may be present
5.2b

MLRA 23
Group 15
Clay Upland 9-16"
R023XF084CA
KEY

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 may also decrease 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 or Aroga moth infestation resulting in a mosaic pattern.

Transition T1A: Introduction of non-native species such as bulbous bluegrass, cheatgrass and thistles.

Current Potential State 2.0 Community Phase Pathways
2.1a: 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; non-native annual species present.
2.1b: Time and lack of disturbance such as fire or drought. Inappropriate grazing management 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: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire 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: Time and lack of disturbance and/or inappropriate grazing management (3.1).
Transition T2B: High severity fire and/or soil disturbance (4.1). Inappropriate grazing that favors shrubs in the presence of non-native annual species (4.2).

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

Transition T3A: Catastrophic fire and/or soil disturbance (4.1). Inappropriate grazing management in the presence of non-native annual species (4.2).
Restoration R3A: Brush management, combined with seeding of desired species.

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

Seeded State 5.0 Community Phase Pathways
5.1a: Time and lack of disturbance may be coupled with inappropriate grazing management.
5.2a: Low severity fire.
5.2b: Inappropriate grazing management reduces bunchgrasses and increases density of sagebrush; usually a slow transition.
5.3a: Fire or brush treatment with minimal soil disturbance.

Transition T5A: 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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Group 16: Seasonally flooded areas with basin wildrye

Description of MLRA 23 DRG 16:

Disturbance Response Group (DRG) 16 consists of six ecological sites. There are two California ecological sites in this group. California site Loamy Bottom 9-16" correlates to Nevada's Loamy Bottom 8-12". This group is united because all of the sites are influenced by a seasonally high water table, and most sites are found adjacent to streams, in the terrace position. The precipitation zone for these sites ranges from 6 to 16 inches. The elevation range for this group is from 4,500 to 8,000 ft. Slopes range from 0 to 8 percent. Soils in this group are generally deep to very deep and may be dark or light colored. These soils are moderately well drained to somewhat poorly drained and have a seasonally high water table at depths of 30 to 60 inches. Additional moisture is added to the sites from stream flooding or run-in from higher elevations. These soils are subject to periodic flooding. Runoff is slow to very slow and there may be brief ponding in depressional areas. Sheet and rill erosion potential is slight and overland flow patterns are typically not evident. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by big sagebrush (*Artemisia tridentata*), black greasewood (*Sarcobatus vermiculatus*), silver sagebrush (*Artemisia cana*) or other shrubs. The understory is dominated by basin wildrye (*Leymus cinereus*), Nevada bluegrass (*Poa nevadensis)*, western wheatgrass (*Pascopyrum smithii*), and creeping wildrye (*Leymus triticoides*). Poverty weed (*Iva axillaris*) increases with disturbance. The production on the Nevada sites ranges from 1200 to 4500 lb/acre in normal years. For the California Loamy Bottom site, annual production averages 4500 lb/ac.

Loamy Bottom - Site Classification Issue

Currently, the Loamy Bottom 8-12", Loamy Bottom 12-16", and Dry Meadow ecological sites are stand-alone ecological sites. In many instances, these have been incorrectly identified as unique sites, when in reality they are alternative stable states of the Wet Meadow (023XY089NV) ecological site. We did not model the Wet Meadow site for this report because riparian ecological sites are outside the scope of this project. The plant community typically described in the Loamy Bottom ecological site is dominated by basin wildrye and either sagebrush or rabbitbrush. This plant community can occur as a result of stream channel entrenchment that has lowered a water table that once supported a wet meadow community of wetland obligate plants. This change in shallow groundwater availability is permanent, therefore represents a separate stable state. Stream channel restoration (headcut repair, etc.) is necessary to repair the hydrology of these sites.

We recommend reevaluation of the ecological sites in this group, since many are mapped near incised stream channels, dry washes, or near dug-out reservoirs that indicate significant hydrological alteration may have occurred in the past. Additional evidence for this can be found in the soils these sites have been correlated to. The Dry Floodplain, Loamy Bottom 8-12, and Dry Meadow sites have all been correlated at least once to the soil great group, Endoaquolls. This same great group is correlated to the Wet Meadow ecological site. Oftentimes these soils are appended with a "drained" modifier, but the ecological site loses the history of the system because it ignores the Reference State of the Wet Meadow.

In this report, we group these sites because they do behave similarly in the drained state. Further investigation into the soils of this group is warranted to verify or refute this hypothesis at specific locations.

Disturbance Response Group 16 – Ecological Sites:

Dry Floodplain – Modal	R023XY005NV
Saline Bottom	R023XY010NV
Loamy Bottom 8-12”	R023XY009NV
Dry Meadow	R023XY013NV
Loamy Bottom 12-16”	R023XY056NV
Loamy Bottom 9-16”	R023XF088CA

Modal Site:

The Dry Floodplain (023XY005NV) ecological site is the modal site for this group. This site occurs on the outer margins of axial-stream flood plains, fan skirts and along intermittent drainageways. Slopes gradients of 0 to 2 percent are most typical. Elevations range from 4500 to 6000 feet. Average annual precipitation is 8 to 12 inches. The soils in this site are deep, light colored, silty to clayey in texture and are moderately slow to slowly permeable. A seasonally high water table within 5 feet of the surface is usually present in the early spring. These soils are subject to periodic flooding. The plant community is dominated by basin wildrye and basin big sagebrush (*Artemisia tridentata sp. tridentata*) with a lesser component of western wheatgrass. Black greasewood is present on this site. Production ranges from 1300 to 3000 lb/ac with normal year production estimated at 2000 lb/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 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 1m 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.

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 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). 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 et al. 2004). With continued site degradation, rubber rabbitbrush (*Ericameria nauseosa*) becomes the dominant plant.

Basin wildrye is a large, cool-season, perennial bunchgrass with an extensive deep, coarse fibrous, weakly rhizomatous, root system (Reynolds and Fraley 1989, Zschaechner 1985). Clumps may reach up to six feet in height (Ogle et al. 2012). 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. 2012, Perryman and Skinner 2007).

Although no longer considered a different species than Sandberg's bluegrass, ecologically speaking Nevada bluegrass occupies a different ecological niche and is not as grazing tolerant as Sandberg bluegrass. The species occurs throughout an unusually wide elevational range from a few hundred feet above sea level to near 11,000 feet in Colorado. It is often found along partially shaded stream banks and creek bottoms, irrigated fields and meadows and where moisture is plentiful has produced a good enough stand to be hayed (USDA 1988).

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).

The ecological sites in this DRG have moderate resilience to disturbance and resistance to invasion. A primary disturbance on these ecological sites is drought, fire, flooding, Aroga infestation (*Aroga websteri*), and channel incision or other disturbance leading to a lowered seasonal water table. This facilitates an increase in shrubs and a decrease in basin wildrye. Troublesome non-native weeds such as broadleaved pepperweed (or tall whitetop, *Lepidium latifolium*), hoary cress (or whitetop, *Cardaria draba*), scotch cottonthistle *(Onopordum acanthium*), or bull thistle (*Cirsium vulgare)* are potential invaders on this site. Three possible states have been identified for this DRG.

Hydrology:

The typical seasonally high water table occurs at depths within 60 inches of the surface which allows for significant production of basin wildrye. Seasonally high water tables have been found 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 water pumping will decrease basin wildrye production and establishment while sagebrush, black greasewood, rabbitbrush, and invasive weeds increase. Farming and abandonment may facilitate the creation of surface vesicular crust, increased surface ponding and decreased infiltration; which leads to dominance by sprouting shrubs with a weedy understory.

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 Mendle 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 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).

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:

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, rabbitbrush and black greasewood 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 inland saltgrass expansion and/or povertyweed 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 1988).

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. 1975). Less palatable species such as black greasewood, rabbitbrush and inland salt grass increased in dominance along with invasive non-native/weedy species such as povertyweed, Russian thistle, mustards and cheatgrass (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). Thus, inadequate rest and recovery from defoliation can cause a decrease in basin wildrye and an increase in rabbitbrush and black greasewood, along with inland saltgrass and non-native weeds (Young et al. 1975, Roundy 1985). Additionally, natural Great Basin wildrye seed viability has been found to be low and seedlings lack 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 suggesting that establishment of natural basin wildrye seedlings occurs only during years of unusually high precipitation. Therefore, reestablishment of a stand that has been decimated by grazing may be episodic.

Nevada bluegrass is an important forage source because it is one of the first grasses to resume growth in the spring and is palatable. The grass rates as excellent forage for cattle and horses, good to excellent for sheep, good for elk and fair to good for deer. This grass, with the exception of Sandberg bluegrass, is the most drought tolerant of the bluegrasses. Remarkably deep, extensive, and fibrous roots enable this plant to grow on rather dry sites and to endure extended droughts. Unlike the related Sandberg bluegrass, this plant succumbs to heavy grazing and trampling and has been reduced in extent on many western ranges due to over-utilization. (USDA 1988).

Basin big sagebrush/basin wildrye communities provide cover and food for large ungulates, upland game birds, and smaller wildlife. Because of its tall, heavy growth, basin wildrye provides forage for elk (*Cervus canadensis*) and other big game in the winter when snow cover is more than two feet (Plummer et al. 1968).

Wild ungulates use basin big sagebrush for cover and feed. Mule deer, pronghorn (*Antilocarpra americana*) and elk will browse basin big sagebrush from autumn through early spring (Wambolt et al. 1994). Early and midseral basin big sagebrush provide forage and protection from predators for mule deer (Wildlife Action Plan Team 2012). Mule deer preference for the shrub varies seasonally. Basin big sagebrush was used more by mule deer populations in Oregon and Utah in winter than by the same populations in fall. (Sheehy and Winward 1981, Welch et al. 1981) This could be because basin big sagebrush is consumed as a last resort plant and browsed when plants considered more palatable were no longer available (Welch et al. 1981). Elk and pronghorn antelope will browse basin big sagebrush in areas where mountain and Wyoming sagebrush are unavailable (Beale and Smith 1970, Wambolt 1996).

A study by Brown et al. (1977) determined that desert bighorn sheep preferred big sagebrush over other shrub types; however, the variety was not noted.

These plants communities provide cover and food for smaller desert wildlife such as lagomorphs and rodents. Pygmy rabbits (*Brachylagus idahoensis*) rely on tall basin big sagebrush for shelter and food throughout the year (Green and Flinders 1980, White et al. 1982, Wildlife Action Plan Team 2012). A study by Larrison and Johnson (1973) captured deer mice (*Peromyscus maniculatus*) in big sagebrush communities more than any other plant community, suggesting the mice prefer these plant communities for cover over other plant communities.

Basin big sagebrush serves as valuable habitat for native birds. Studies have suggested that sage grouse use basin big sagebrush for cover and food where mountain and Wyoming big sagebrush are absent (Welch et al. 1991). Birds such as Brewer's sparrows (*Spizella breweri*) are considered dependent on sagebrush communities for cover and will nest in basin big sagebrush. Thus when basin big sagebrush communities are converted to agriculture fields, Brewer's sparrow populations can decline due to loss of habitat (Knick et al. 2003). In fact, mature basin big sagebrush act as nesting structures, protection from predators and thermal cover for Greater sage grouse (*Centrocercus urophasianus*), the loggerhead shrike (*Lanius ludovicianus*), the sage sparrow (*Artemisiospiza nevadensis*), Brewer's sparrow and sage thrasher (*Oreoscoptes montanus*) (Wildlife Action Plan Team 2012). The plant also acts as important cover for game-birds such as the gray partridge (*Perdix perdix*), mountain quail (*Oreotyx pictus*), and mourning doves *(Zenaida macroura*), as well as passerines such as, towhees (Pipilo spp.) and finches *(Haemorhous* spp.), that occur on arid range lands in the West (Dobbs et al. 2012, Booth 1985).

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.

State and Transition Model Narrative for 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 23 disturbance response group 16.

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:
Basin wildrye, western wheatgrass, 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 rhizomatous grasses to dominate the site. Due to the productivity of these sites, fires would typically eliminate or severely reduce the sagebrush component. A severe infestation of Aroga moth could also cause a large decrease in sagebrush 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 allows sagebrush to increase and become decadent. Long-term drought, herbivory, or combinations of these would cause a decline in perennial bunchgrasses and fine fuels and lead to a reduced fire frequency allowing big sagebrush and/or rubber rabbitbrush to dominate the site.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community phase. 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.

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

Community Phase 1.3:
Big sagebrush and rabbitbrush increase 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. Povertyweed, squirreltail, and/or inland saltgrass increase.

Community Phase Pathway 1.3a, from Phase 1.3 to 1.1:
A low severity fire, Aroga moth or combination would reduce the sagebrush overstory and create a sagebrush/grass mosaic with sagebrush and perennial bunchgrasses co-dominant.

Community Phase Pathway 1.3b, 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.

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 or perennial species, such as cheatgrass, mustard (*Descurainia* sp.),halogeton (*Halogeton glomeratus*), hoary cress, scotch thistle and bull thistle.

Slow variables: Over time, the 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. 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 same three general community phases. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. 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 within the range of site variability 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 phase is similar to the Reference State Community Phase 1.1, with the presence of some non-native weedy species. Basin wildrye, western wheatgrass and basin big sagebrush dominate the site. Non-native species are present in minor amounts.

Dry Floodplain (R023XY005NV) Phase 2.1, 5-10 years post-fire
T.K. Stringham, July 2015

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 typically remove the majority of the big sagebrush overstory due the large amount of fine fuel produced by this site. 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 are likely to increase after fire.

Community Phase Pathway 2.1b, from Phase 2.1 to 2.3:
Time, long-term drought, grazing management or a combination of these that favors shrubs would allow sagebrush and rubber rabbitbrush 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 phase. Basin wildrye, western wheatgrass, and other perennial bunchgrasses dominate the site. Sagebrush is present in trace amounts. Depending on fire severity or intensity of Aroga moth infestations, patches of intact sagebrush may remain. Non-native species generally respond well after fire and may be stable or increasing within the community. Rabbitbrush may be sprouting and/or dominant in overstory. Seeded species may be present.

Dry Floodplain (R023XY005NV) Phase 2.2 T.K. Stringham, July 2015

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 big sagebrush may 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 management, or from both. Rabbitbrush may be a significant component. Povertyweed, squirreltail, and/or inland saltgrass increase. Non-natives species may be stable or increasing due to lack of competition with perennial bunchgrasses. This site is susceptible to further degradation from inappropriate grazing management, drought, fire and hydrologic change.

Loamy Bottom 9-10” (023XF088CA) Phase 2.3, T.K. Stringham, May 2017

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
A low severity fire, Aroga moth infestation, brush management with minimal soil disturbance, or late fall/winter grazing would decrease sagebrush and allow the perennial bunchgrass understory to increase.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.1:
High severity fire would decrease or eliminate the overstory of sagebrush and allow the perennial bunchgrasses to dominate the site. Rabbitbrush may increase.

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 shrub growth and establishment. Alteration in the hydrology of the site may also cause an increase in sagebrush; with gullying of floodplain surface the seasonally high water table is dropped and may cause a decrease in perennial bunchgrasses. Community Phase 3.1.

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. Loss of seasonally high water table.

Shrub State 3.0:

This state has one community phase: a big sagebrush-dominated phase likely with a significant component of rubber rabbitbrush. This state is a product of many years of heavy grazing during periods harmful to perennial bunchgrasses and/or hydrologic modification resulting in a lowered water table. Inland saltgrass and/or povertyweed may become the dominate understory. 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:

Basin big sagebrush dominates 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. Rabbitbrush may be a significant component. Deep-rooted perennial bunchgrasses may be present in trace amounts or absent from the community. Inland saltgrass and non-native species increase. Bare ground is significant.

Saline Bottom (R023XY010NV) Phase 3.1 P. Novak-Echenique, May 2015

Dry Floodplain (R023XY005NV) Phase 3.1 T. K. Stringham, July 2015

Dry Floodplain (R023XY005NV) Phase 3.1 T. K. Stringham, June 2014

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 gully formation has occurred. Engineered structures may be required. See USDA, NRCS National Engineering Handbook (2008).

Potential Resilience Differences with other Ecological Sites:

Loamy Bottom 8-12 (R023XY009NV):

Production on this site is higher than the modal site, ranging between 2500 to 7000 lb/acre. This site is dominated by basin big sagebrush, and basin wildrye. It has a higher seasonal water table, at 30-60 inches. There is evidence that this ecological site may truly be a phase of the Wet Meadow (23XY089NV) site, which was not modeled as part of this report. This sagebrush-basin wildrye plant community often occurs as a result of stream channel entrenchment that has lowered a water table that once supported a poorly drained wet meadow community. This change in natural soil drainage is permanent and therefore a new ecological site potential is recognized for the degraded meadow community. This site has the same STM as the modal site with 3 stable states.

Saline Bottom (R023XY010NV):

This site occurs on smooth, nearly level to concave, basin floors, lakeplains, and axial-stream floodplains with slopes of less than 2 percent. This site is dominated by basin wildrye, Nevada bluegrass, inland saltgrass (*Distichlis spicata*) and black greasewood (*Sarcobatus vermiculatus*). Sagebrush is not a significant component of this site. Shadscale (*Atriplex confertifolia)*, rubber rabbitbrush (*Ericameria nauseosa),* and Torrey's quailbush (*Atriplex torreyi)* may also be present. This site is slightly less productive than the modal site with 1000 to 2200 lb/ac. These soils are strongly salt and sodium affected in the upper profile with soil reaction and salt and sodium concentrations usually decreasing with depth. The seasonal depth to a water table is more shallow, at 20 to 60 inches. Wetting of these soil dilutes their salt/sodium concentrations and the degree of salinity and alkalinity fluctuates throughout the year. Seed viability, germination, and available water capacity is reduced due to the saline-alkaline condition of these soils. This site has the same STM as the modal site with 3 stable states.

Dry Meadow (R023XY013NV):

This site also occurs on floodplains and drainage ways but is also often associated with low-flow seeps and springs. It is dominated by Nevada bluegrass and forbs like yarrow *(Achillea spp.)*, iris *(Iris missouriensis),* cinquefoil *(Potentilla*), and other mesic forbs. This site has a seasonally high water table within 20 inches of the soil surface in the spring. Soils are deep and very dark in color. This site is slightly less productive than the modal site with 1700 lb/ac in normal years. Baltic rush may increase with inappropriate grazing management. This site has a similar STM with 3 stable states.

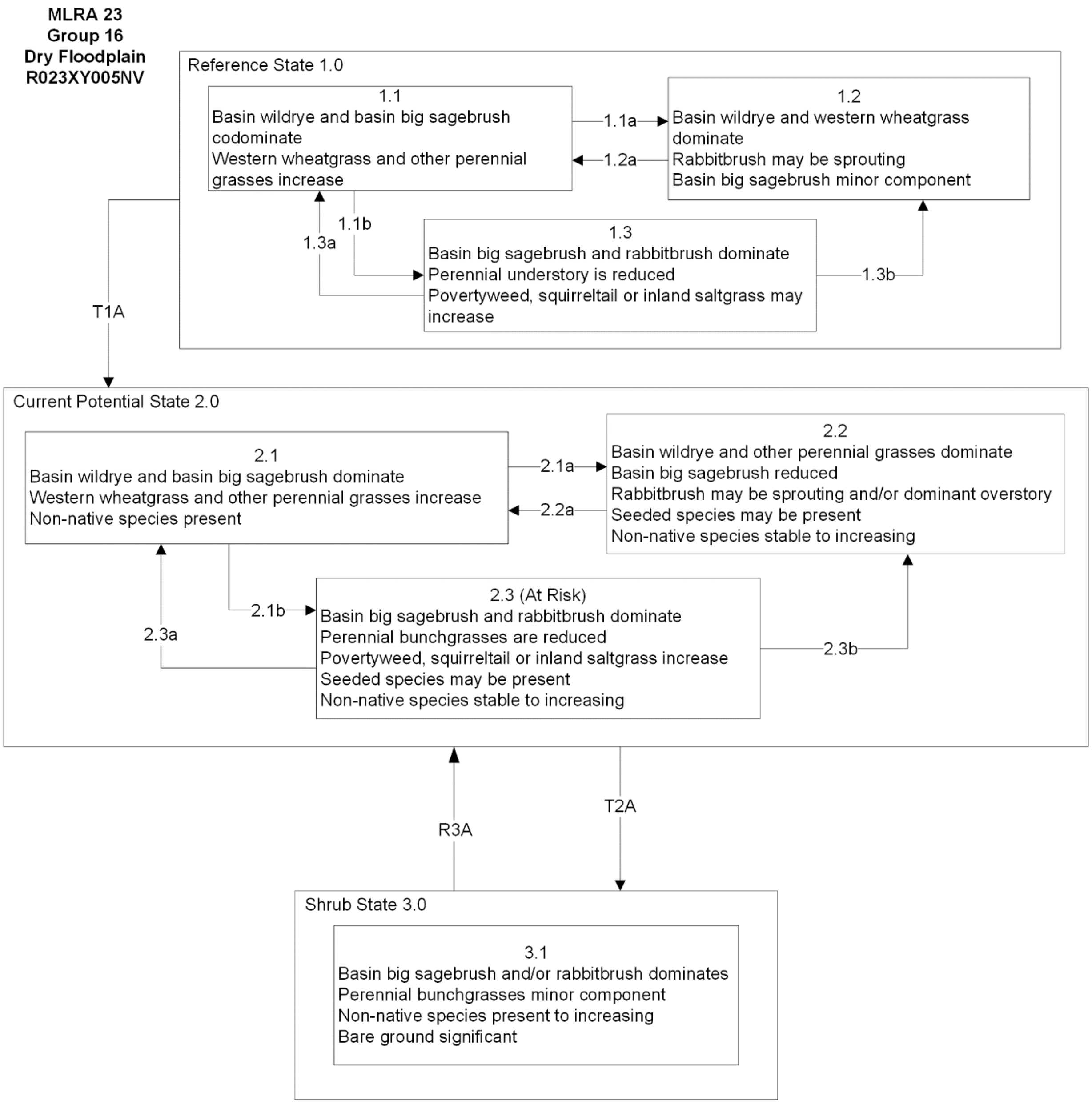
Loamy Bottom 12-16" (R023XY056NV):

Mountain big sagebrush (*Artemisia tridentata var. vaseyana)* is the most common shrub on this site, however rubber rabbitbrush (*Ericameria nauseosa), willow* (*Salix spp),* and Wood's rose (*Rosa woodsii)* may be present. Average production on a normal year is 1,700 lbs. per acre. This DRG was not seen during site visits and is mapped on fewer than 300 acres in MLRA 23. There is also no recorded Type Location for this site. The state and transition model is modeled after an MLRA 28 ecological site with similar characteristics.

Loamy Bottom 9-16” (R023XF088CA):

This California Ecological site correlates most closely to the Nevada Loamy Bottom 8-12” (023XY009NV) site. Its composition and production are very similar to the Nevada site. It is characterized by periodic spring flooding or run-in moisture on deep, loamy, fertile recent alluvium near streams. Basin wildrye is the dominant species, and basin big sagebrush is the dominant shrub. Black greasewood is a minor component of this site. This site has the same STM as the modal site with 3 stable states.

Modal State and Transition Model for Group 16 in MRLA 23:



MLRA 23
Group 16
Dry Floodplain
R023XY005NV
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, forbs and sprouting shrubs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also decrease perennial understory.
1.2a: Time and lack of disturbance allow for shrub regeneration.
1.3a: Low severity fire, Aroga moth, or combinations will reduce big sagebrush and allow grass species to increase resulting in a mosaic plant community pattern.
1.3b: High severity fire significantly reduces sagebrush cover, leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass, hoary cress and thistles.

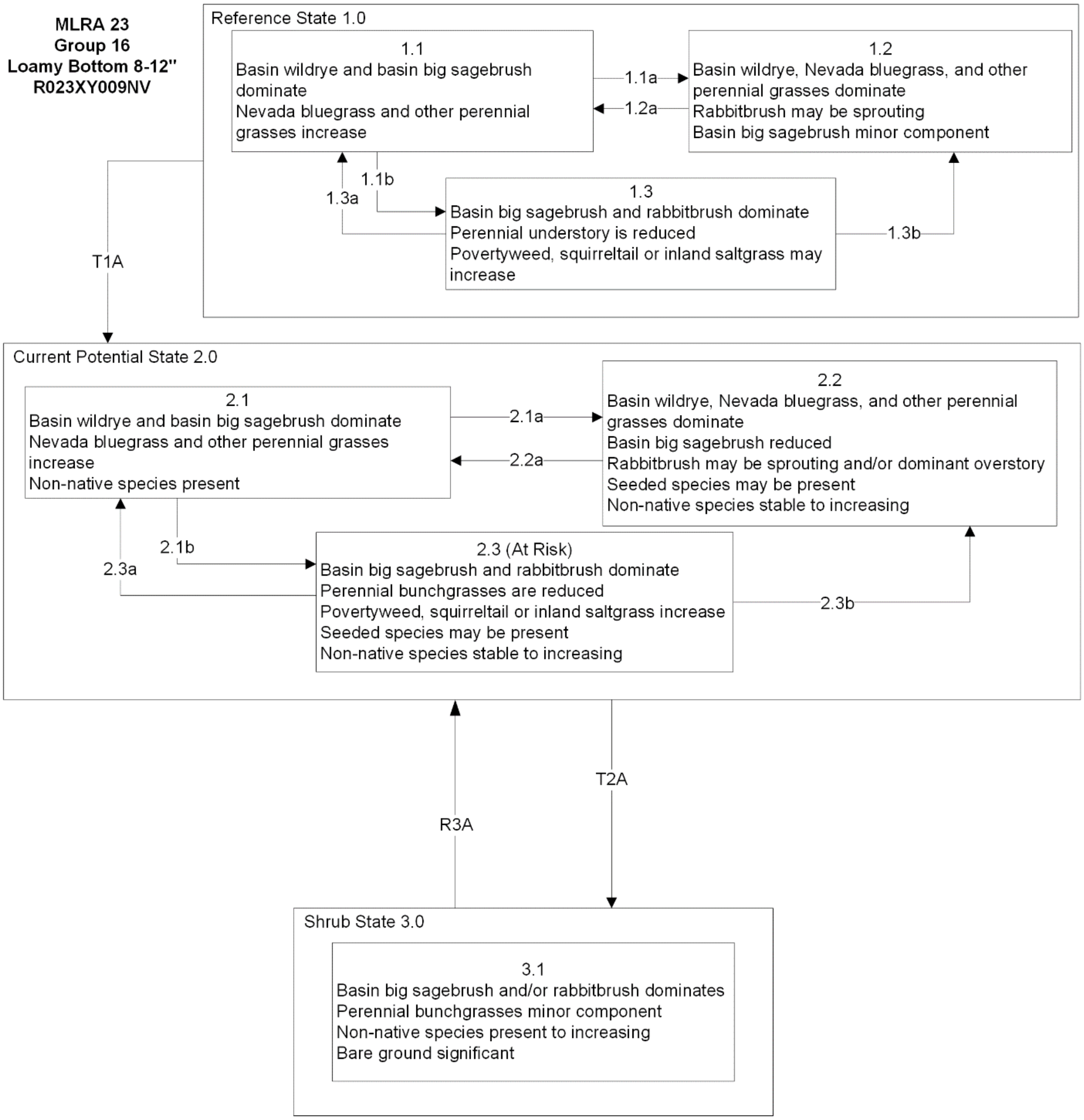
Current Potential State 2.0 Community Phase Pathways
2.1a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-native species present
2.1b: Time and lack of disturbance such as fire or drought. Inappropriate grazing management may also reduce perennial understory and favor shrub overstory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community.

Transition T2A: Time and lack of disturbance, may be coupled with grazing management and/or hydrologic changes that favor shrubs over perennial grasses. (3.1).

Shrub state 3.0 Community Phase Pathways
None.

Restoration Pathway R3A: Mechanical/chemical brush treatment coupled with herbicide. Gully plugs or other hydrologic modifiers may be necessary to restore hydrologic function.

Additional State and Transition Models for Group 16 in MRLA 23:



MLRA 23
Group 16
Loamy Bottom 8-12"
R023XY009NV
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, forbs and sprouting shrubs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also decrease perennial understory.
1.2a: Time and lack of disturbance allow for shrub regeneration.
1.3a: Low severity fire, Aroga moth, or combinations will reduce big sagebrush and allow grass species to increase resulting in a mosaic plant community pattern.
1.3b: High severity fire significantly reduces sagebrush cover, leading to early/mid-seral community.

Transition T1A: Introduction of non-native species such as cheatgrass, hoary cress and thistles.

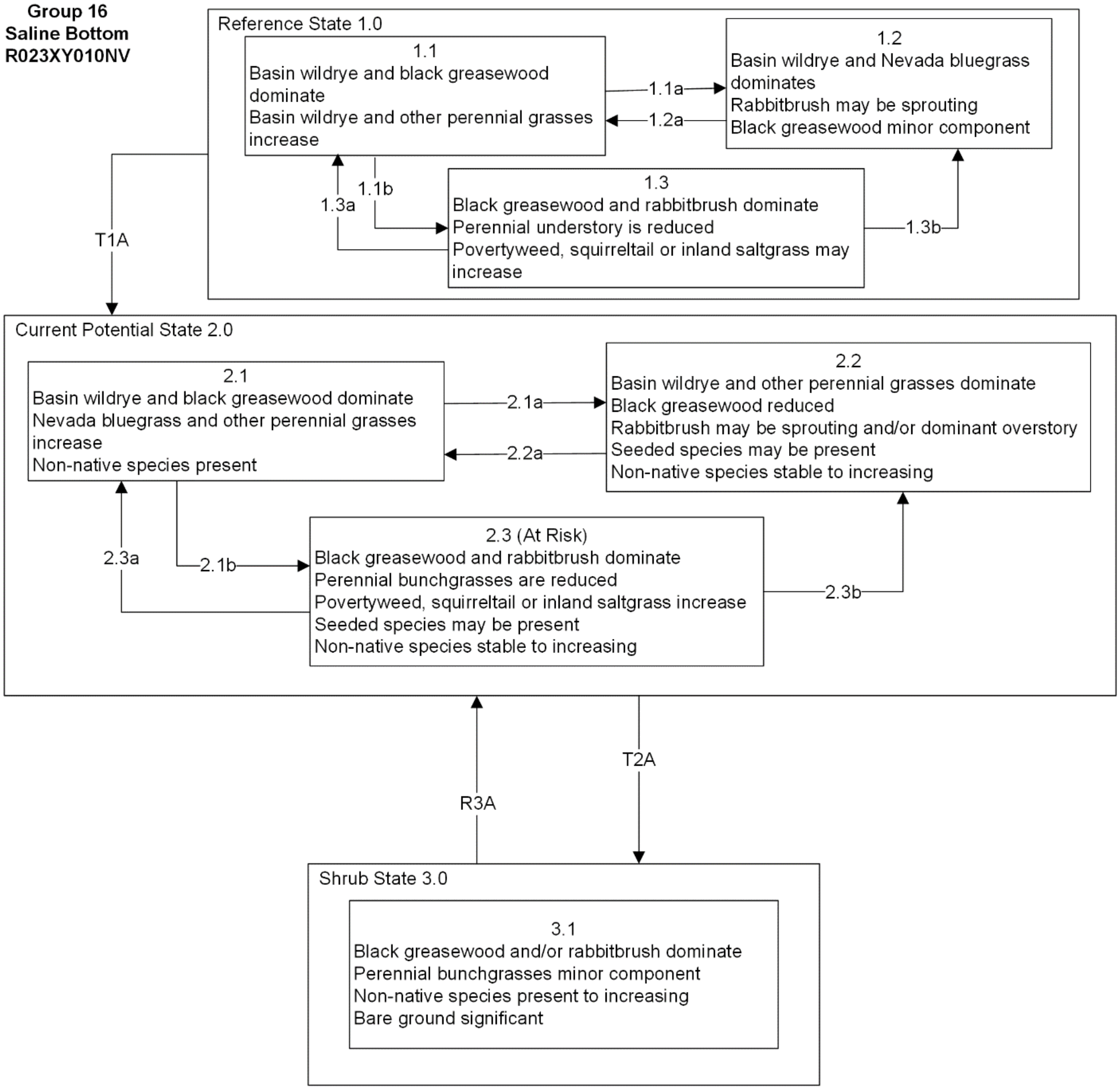
Current Potential State 2.0 Community Phase Pathways
2.1a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-nativel species present
2.1b: Time and lack of disturbance such as fire or drought. Inappropriate grazing management may also reduce perennial understoryand favor shrub overstory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community.

Transition T2A: Time and lack of disturbance, may be coupled with grazing management and/or hydrologic changes that favor shrubs over perennial grasses. (3.1).

Shrub state 3.0 Community Phase Pathways
None.

Restoration Pathway R3A: Mechanical/chemical brush treatment coupled with herbicide. Gully plugs or other hydrologic modifiers may be necessary to restore hydrologic function.

MLRA 23
Group 16
Saline Bottom
R023XY010NV



MLRA 23
Group 16
Saline Bottom 8-10"
R023XY010NV
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, forbs and sprouting shrubs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also decrease perennial understory.
1.2a: Time and lack of disturbance allow for shrub regeneration.
1.3a: Low severity fire, Aroga moth, or combinations will reduce big sagebrush and allow grass species to increase resulting in a mosaic plant community pattern.
1.3b: High severity fire significantly reduces sagebrush cover, leading to early/mid-seral community.

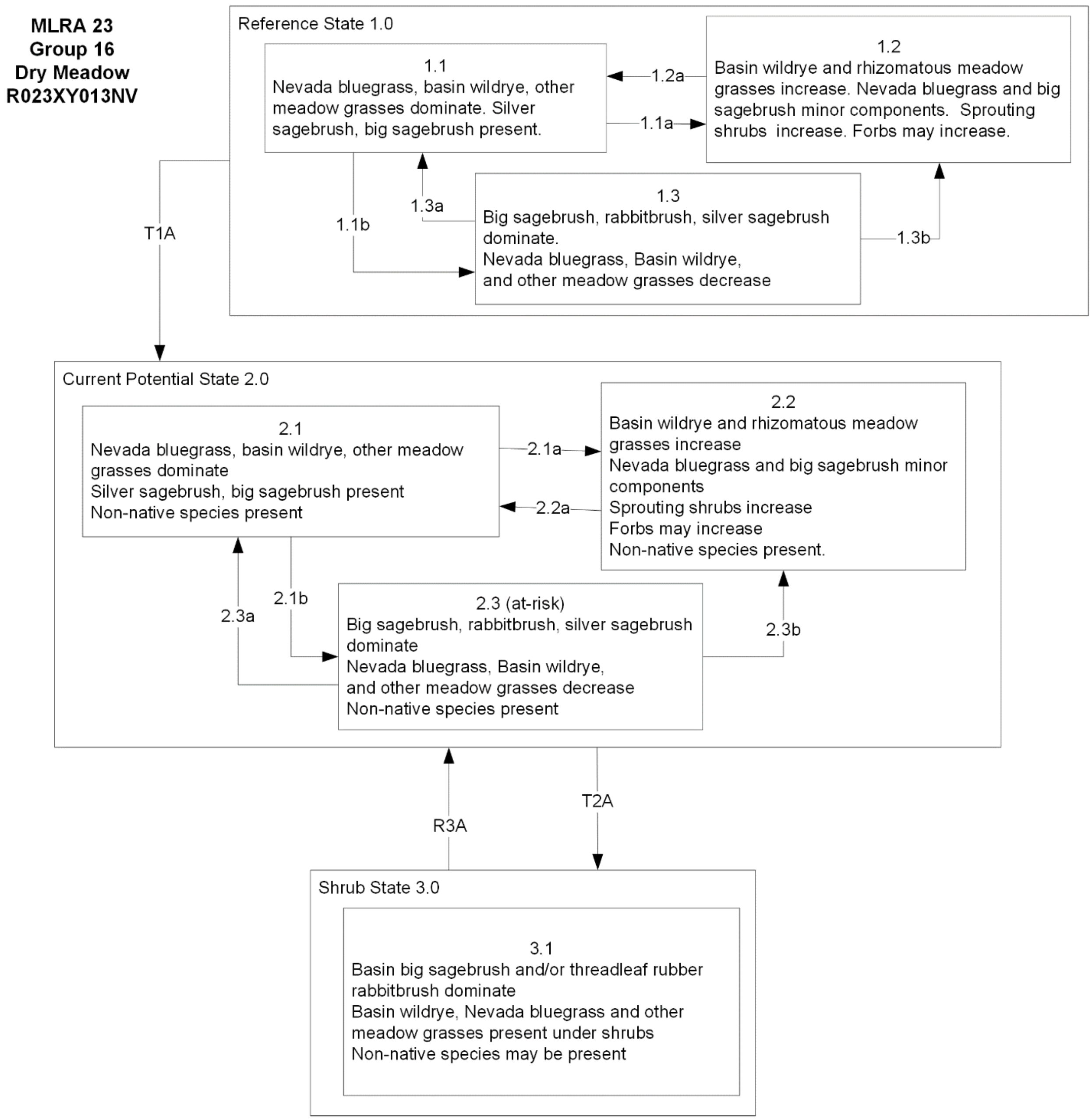
Transition T1A: Introduction of non-native species such as cheatgrass, hoary cress and thistles.

Current Potential State 2.0 Community Phase Pathways
2.1a: Fire significantly reduces sagebrush cover and leads to early/mid-seral community dominated by grasses and forbs; non-nativel species present
2.1b: Time and lack of disturbance such as fire or drought. Inappropriate grazing management may also reduce perennial understoryand favor shrub overstory.
2.2a: Time and lack of disturbance allows for regeneration of sagebrush
2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush management with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces sagebrush cover leading to early mid-seral community.

Transition T2A: Time and lack of disturbance, may be coupled with grazing management and/or hydrologic changes that favor shrubs over perennial grasses. (3.1).

Shrub state 3.0 Community Phase Pathways
None.

Restoration Pathway R3A: Mechanical/chemical brush treatment coupled with herbicide. Gully plugs or other hydrologic modifiers may be necessary to restore hydrologic function.


MLRA 23
Group 16
Dry Meadow
R023XY013NV
Reference State 1.0
1.1
Nevada bluegrass, basin wildrye, other meadow grasses dominate. Silver sagebrush, big sagebrush present.
1.2a
1.1a
1.2
Basin wildrye and rhizomatous meadow grasses increase. Nevada bluegrass and big sagebrush minor components. Sprouting shrubs increase. Forbs may increase.
1.1b
1.3a
1.3
Big sagebrush, rabbitbrush, silver sagebrush dominate.
Nevada bluegrass, Basin wildrye, and other meadow grasses decrease
1.3b
T1A
Current Potential State 2.0
2.1
Nevada bluegrass, basin wildrye, other meadow grasses dominate
Silver sagebrush, big sagebrush present
Non-native species present
2.1a
2.2a
2.2
Basin wildrye and rhizomatous meadow grasses increase
Nevada bluegrass and big sagebrush minor components
Sprouting shrubs increase
Forbs may increase
Non-native species present.
2.1b
2.3a
2.3 (at-risk)
Big sagebrush, rabbitbrush, silver sagebrush dominate
Nevada bluegrass, Basin wildrye, and other meadow grasses decrease
Non-native species present
2.3b
R3A
T2A
Shrub State 3.0
3.1
Basin big sagebrush and/or threadleaf rubber rabbitbrush dominate
Basin wildrye, Nevada bluegrass and other meadow grasses present under shrubs
Non-native species may be present

MLRA 23
Group 16
Dry Meadow
R023XY013NV
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces big sagebrush cover and leads to early/mid-seral community dominated by grasses, forbs and sprouting shrubs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also decrease perennial understory and favor shrub overstory.
1.2a: Time and lack of disturbance allows for big sagebrush regeneration.
1.3a: A low severity fire, Aroga moth, or combinations will reduce some of the big sagebrush overstory and allow grass species to increase.
1.3b: High severity fire significantly reduces big sagebrush cover and allows grass species to dominate.

Transition T1A: Introduction of non-native species.

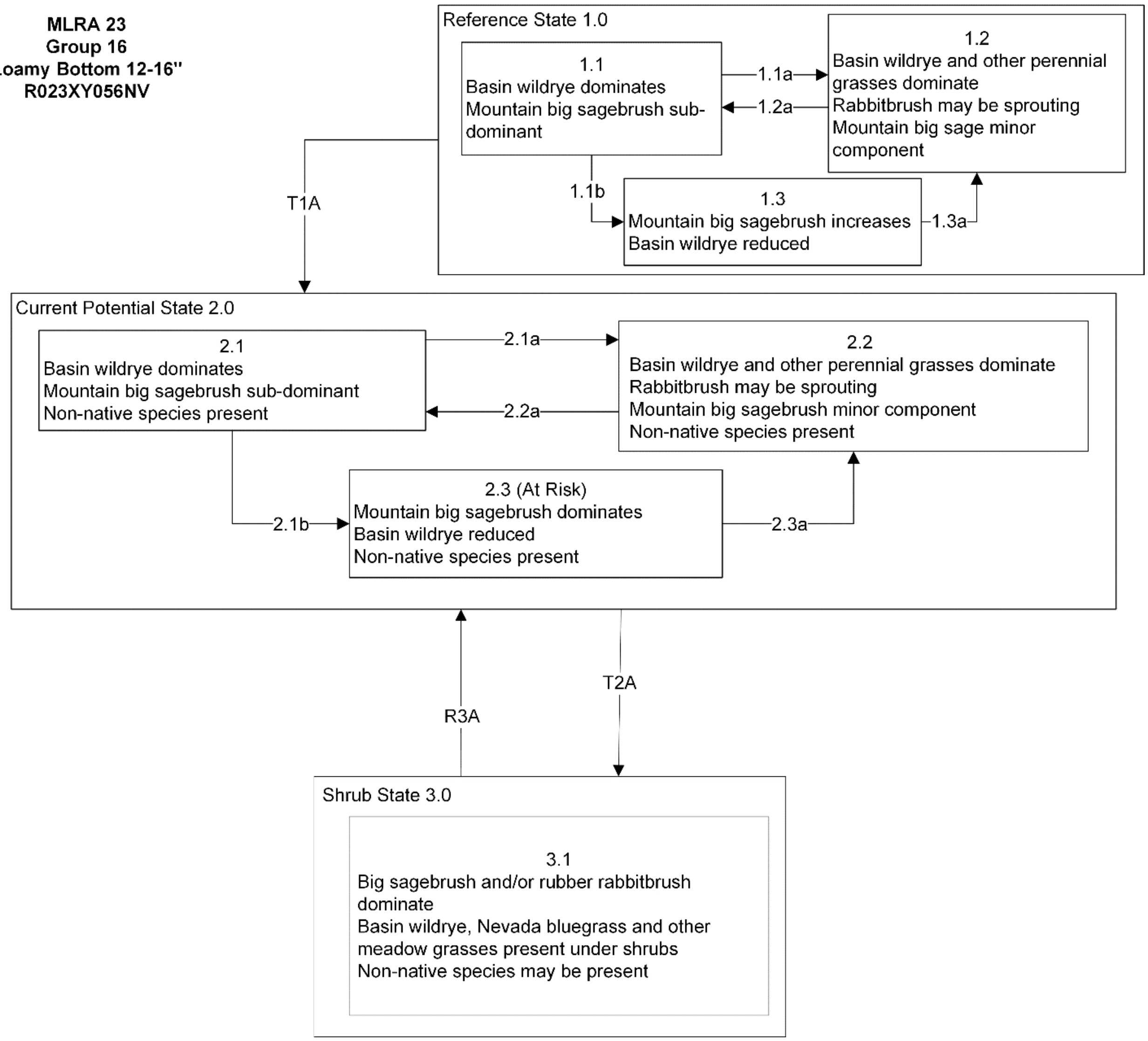
Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces big sagebrush cover and leads to early/mid-seral community dominated by grasses, forbs and sprouting shrubs. Non-native species present.
2.1b: Time and lack of disturbance such as fire or drought. Inappropriate grazing management may also reduce perennial understory and favor shrub overstory.
2.2a: Time and lack of disturbance allows for regeneration of big sagebrush.
2.3a: A low severity fire, Aroga moth, or combinations will reduce some of the big sagebrush overstory and allow grass species to increase. May also be caused by brush management with minimal soil disturbance or late-fall/winter grazing that causes mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces big sagebrush cover and allows grass species to dominate.

Transition T2A: Time and lack of disturbance, may be coupled with grazing management and/or hydrologic changes that favor shrubs over perennial grasses.

Shrub State 3.0 Community Phase Pathways
None.

Restoration Pathway R3A: Mechanical/chemical brush treatment coupled with herbicide. Gully plugs or other hydrologic modifiers may be necessary to restore hydrologic function.

MLRA 23
Group 16
Loamy Bottom 12-16"
R023XY056NV



MLRA 23
Group 16
Loamy Bottom 12-16"
R023XY056NV

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.

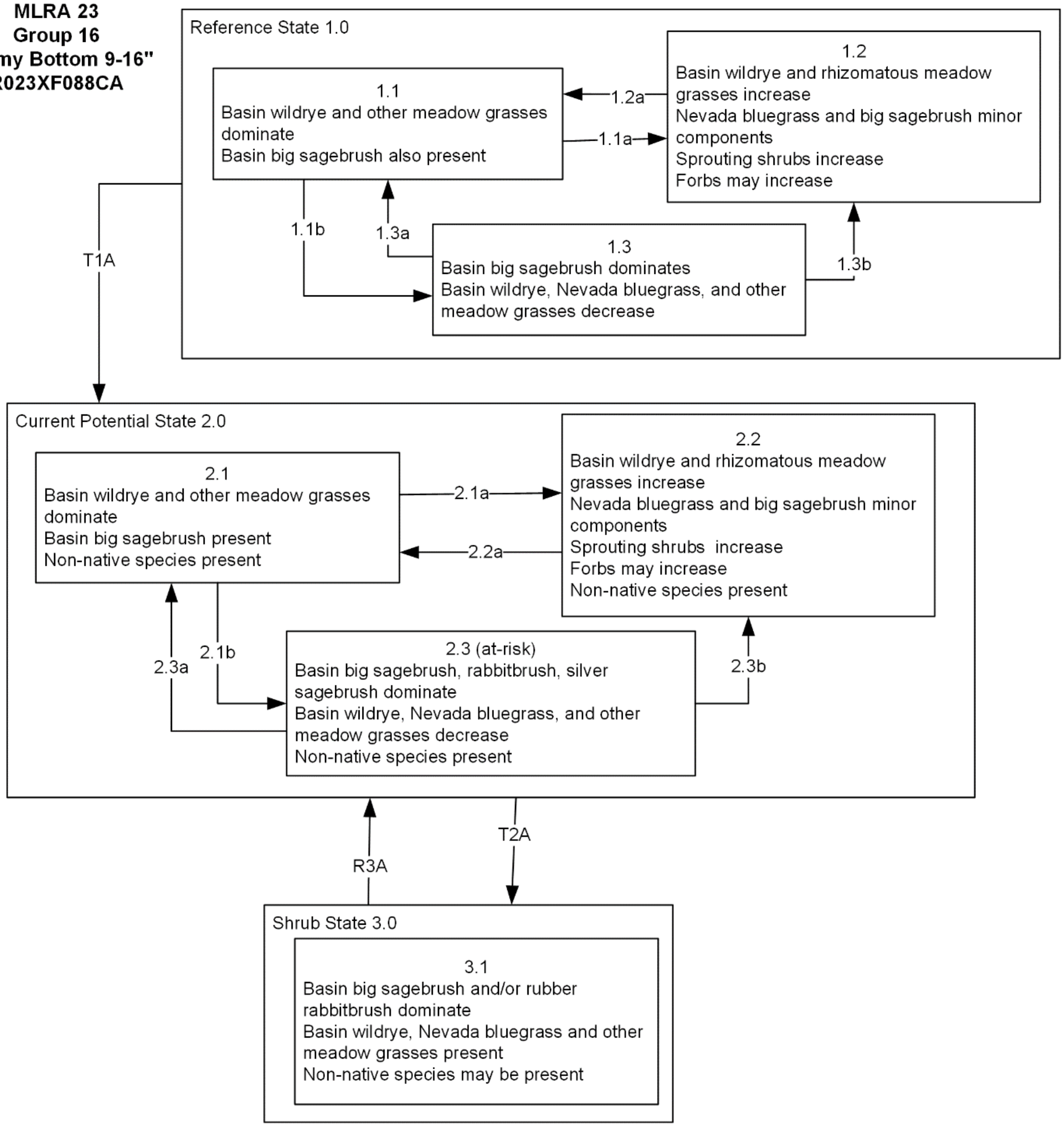
Current Potential State 2.0 Community Phase Pathways
2.1a: Fire creates grass/sagebrush mosaic. Aroga moth may also cause a large die-off in sagebrush; non-native annual species present.
2.1b: Time and lack of disturbance such as fire. Inappropriate grazing management, chronic drought or combinations 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: Time and lack of disturbance, may be coupled with grazing management and/or hydrologic changes that favor shrubs over perennial grasses.

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).

Restoration R3A: Mechanical/chemical brush treatment coupled with herbicide. Gully plugs or other hydrologic modifiers may be necessary to restore hydrologic function.

MLRA 23
Group 16
Loamy Bottom 9-16"
R023XF088CA



MLRA 23
Group 16
Loamy Bottom 9-16"
R023XF088CA
KEY

Reference State 1.0 Community Phase Pathways
1.1a: High severity fire significantly reduces big sagebrush cover and leads to early/mid-seral community dominated by grasses, forbs and sprouting shrubs.
1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also decrease perennial understory and favor shrub overstory.
1.2a: Time and lack of disturbance allows for big sagebrush regeneration.
1.3a: A low severity fire, Aroga moth, or combinations will reduce some of the big sagebrush overstory and allow grass species to increase.
1.3b: High severity fire significantly reduces big sagebrush cover and allows grass species to dominate.

Transition T1A: Introduction of non-native species.

Current Potential State 2.0 Community Phase Pathways
2.1a: High severity fire significantly reduces big sagebrush cover and leads to early/mid-seral community dominated by grasses, forbs and sprouting shrubs. Non-native species present.
2.1b: Time and lack of disturbance such as fire or drought. Inappropriate grazing management may also reduce perennial understory and favor shrub overstory.
2.2a: Time and lack of disturbance allows for regeneration of big sagebrush.
2.3a: A low severity fire, Aroga moth, or combinations will reduce some of the big sagebrush overstory and allow grass species to increase. May also be caused by brush management with minimal soil disturbance or late-fall/winter grazing that causes mechanical damage to sagebrush.
2.3b: High severity fire significantly reduces big sagebrush cover and allows grass species to dominate.

Transition T2A: Time and lack of disturbance, may be coupled with grazing management and/or hydrologic changes that favor shrubs over perennial grasses.

Shrub State 3.0 Community Phase Pathways
None.

Restoration Pathway R3A: Mechanical/chemical brush treatment coupled with herbicide. Gully plugs or other hydrologic modifiers may be necessary to restore hydrologic function.

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Group 17: Mountain mahogany and mountain big sagebrush

Description of MLRA 23 DRG 17:

Disturbance Response Group (DRG) 17 consists of two ecological sites. The precipitation zone for these sites ranges from 16 to 20 inches. The elevation range for this group is from 5,500 to 9,400 ft. Slopes range from 2 to 75 percent. Soils in this group are moderately deep to deep and well drained. Some soils are shallow and well drained. Available water capacity is moderate to high. These soils typically have high volumes of rock fragments throughout the soil profile. The runoff on these sites varies from low to severe. The potential for sheet and rill erosion is low but differs depending on slope. The potential native plant community for these sites varies depending on precipitation, elevation and landform. The shrub component is dominated by curl-leaf mountain mahogany (*Cercocarpus ledifolius*), mountain big sagebrush (*Artemisia tridentata*), and snowberry (*Symphoricarpos*). The understory in these sites is dominated by Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Pseudoroegneria spicata*), with varying amounts of needlegrass species (*Achnatherum spp.*) and perennial forbs. The production on these sites ranges from 900 to 1100 lb/ac in the understory (<4ft in height) in normal years. Including mahogany trees, the sites range from 1800-2000 lb/ac in normal years.

Disturbance Response Group 17 – Ecological Sites:

Mahogany Savanna - Modal	R023XY026NV
Granitic Mahogany Savanna	R023XY069NV

Modal Site:

The Mahogany Savanna (023XY026NV) ecological site is the modal site for this group. This site occurs on mountain and higher elevation plateau side slopes and summits. Slopes range from 4 to 75 percent, but slope gradients of 8 to 30 percent are typical. Elevations are 7500 to 9400 feet. Average annual precipitation is 16 to 20 inches. The soils in this site are moderately deep to deep and well drained. These soils typically have high volumes of rock fragments throughout the soil profile. Available water capacity is moderate. Runoff is medium to rapid and the potential for sheet and rill erosion is moderate to severe depending on slope. The plant community is dominated by curl-leaf mountain mahogany, mountain big sagebrush, Idaho fescue, bluebunch wheatgrass, and perennial forbs. Curl-leaf mountain mahogany canopy cover is less than 45% in this ecological site. Production ranges from 1200 to 2600 lb/acre on this site including the mahogany overstory. Understory (<4 ft in height) ranges from 600 to 1400 lb/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 influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

The Great Basin vegetative 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 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. 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.

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. 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 meters. General differences in root depth distributions between grasses and shrubs results in resource partitioning in this system.

Curl-leaf mountain mahogany is a multi-branched, evergreen shrub or tree extending from 3 to over 20 feet in height. The roots of mountain mahogany are spreading and limited by the depth to bedrock. Youngberg and Hu (1972) reported in an Oregon study that curl-leaf mountain mahogany produces nitrogen-fixing root nodules. They also reported that nodulated plants had the highest amounts of nitrogen in the leaves. It is the most widely distributed species of *Cercocarpus* and is the only species of the genus that extends as far north and west as Washington. Most often curl-leaf mountain mahogany stands occur on warm, dry, rocky ridges or outcrops where fire would be an infrequent occurrence (USDA 1937). 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.

Curl-leaf mahogany plants are long-lived and can reach 1,300+ years of age (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 few or no young curl-leaf mahogany (i.e., recruitment) in the understory (Schultz et al. 1990, 1991), despite high seed density beneath trees (Russell and Schupp 1998, Ibáñez and Schupp 2002). Intraspecific competition reduces the growth rates of all age classes below the potential growth rates for the species. Competition may also increase mortality in the younger plants.

Once germination occurs, the seedlings exhibit rapid 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. The mean top height was slightly less than 2.5 cm. Multiple sources (Ibáñez et al. 1998, 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. Some hypothesize that the light shading and hydraulic lift provided by sagebrush may create a microsite facilitating mahogany recruitment (Gruell et al. 1985, Ibáñez et al. 1998).

Mahogany stands are susceptible to drought, frost, and invasion by non-native species, especially cheatgrass (*Bromus tectorum*). Cheatgrass affects mahogany seedling growth by competing for water resources and nutrients in an area (Ross 1999).

Mountain 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 is dependent on adequate moisture conditions.

The perennial bunchgrasses that are co-dominant with the shrubs include bluebunch wheatgrass and Idaho fescue. 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 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.

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).

Cusick's bluegrass and/or muttongrass are found on this site. There is evidence that these two common names have been used interchangeably (Monsen et al. 2004) or are sometimes misidentified, 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).

The ecological sites in this DRG have moderate to high 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. Two possible alternative stable states have been identified for this DRG.

Fire Ecology:

The fire return interval in curl-leaf mountain mahogany dominated sites is not well documented, however a study Arno and Wilson (1986) suggested sites of curl-leaf mountain mahogany with ponderosa pine had fire return intervals of 13 to 22 years before 1900. Fire frequency most likely depends on surrounding vegetation. Most often curl-leaf mountain mahogany stands occur on warm, dry, rocky ridges or outcrops where fire would be an infrequent occurrence (USDA 1937). 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 will persist longest in rocky areas where it is protected from fire. Because of their thicker bark, mature trees can often survive low-severity fires (Gruell et al. 1985). Curl-leaf mountain mahogany is considered a weak sprouter after fire. It is usually moderately to severely damaged by severe fires and 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).

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). If balsamroot or mules ear is common before fire, these plants will increase after fire or with heavy grazing (Wright 1985).

Idaho fescue response to fire varies with condition and size of the plant, season and severity of fire, and ecological conditions. Idaho fescue can generally survive light-severity fires, but can be severely damaged by fire in all seasons (Wright et al. 1979, Wright 1985). Rapid burns have been found to leave little damage to root crowns, and new tillers are produced with onset of fall moisture (Johnson et al. 1994). However, another study found the dense, fine leaves of Idaho fescue provided enough fuel to burn for hours after a fire had passed, thereby killing or seriously injuring the plant regardless of the intensity of the fire (Wright et al. 1979). Rapid tillering can occur after fire when root crowns are not killed and soil moisture is favorable (Johnson et al. 1994, Robberecht and Defossé 1995).

Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. However, season and severity of the fire will influence plant response. Plant response will vary depending on post-fire soil moisture availability. Letterman needlegrass recovers well after fire (Monsen et al. 2004). Burning reduces the basal area and flower stalk production of Cusick’s bluegrass (Uresk et al. 1976). In the same study, burning enhanced the growth of bluebunch wheatgrass.

Livestock/Wildlife Grazing Interpretations:

Curl-leaf 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 curl-leaf mountain 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) curl-leaf mountain mahogany is consumed widely by mule deer throughout the year. In fact, mule deer fecal pellets were observed to contain curl-leaf mountain mahogany year-round, with the highest frequency of leaves found in winter (Gucker 2006). Mule deer will use curl-leaf mountain 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 1937).

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 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.

Idaho fescue is valuable forage for livestock and wildlife. It is an excellent forage grass and can withstand heavy trampling (USDA 1937). However, Idaho fescue decreases under heavy grazing by livestock (Eckert and Spencer 1987) and wildlife (Gaffney 1941).

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949, Britton et al. 1990) Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.

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 plant is especially important fall forage for big game. (Monsen et al. 2004). Lettermans needlegrass has been shown to increase under sheep grazing and decreases under light cattle and horse grazing (Bowns and Bagley 1986). It also declines when grazing is excluded for a long time (Turner 1969).

Cusick's bluegrass was the most palatable and preferred grass compared to Thurber's needlegrass and bluebunch wheatgrass in a 1975 grazing study, but was also 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.

State and Transition Model for 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 23 disturbance response group 17.

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 tree-shrub dominant phase, a sprouting shrub-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 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. Idaho fescue, bluebunch wheatgrass, and needlegrass 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 for 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 such as fire allows the mountain mahogany to increase. The shrub and herbaceous understory components decline due to increased shading from the trees.

Community Phase 1.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community phase. Snowberry and rabbitbrush are sprouting/increasing. Perennial grasses 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 such as fire allows the mountain mahogany and sagebrush to increase. Idaho fescue dominates the understory.

Community Phase 1.3:
Mahogany density will increase in the absence of disturbance. Shrubs and deep-rooted perennial bunchgrasses will be shaded out by the dense mahogany. Cusick’s bluegrass is more shade tolerant, however, and increases 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 (023XY026NV) Phase 1.3 T. K. Stringham, August 2014

Community Phase Pathway 1.3a, from 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.
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. It has similar community phases with the addition of the 2.4 at-risk community phase. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of invasive weeds. 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 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 curl-leaf mountain mahogany. Mountain big sagebrush and snowberry make up the shrub components of the understory. Idaho fescue, bluebunch

wheatgrass, and needlegrass are dominant perennial bunchgrasses. A diversity of other grasses and forbs exist in the understory. Annual non-native species like cheatgrass are present.

Mahogany Savanna (R023XY026NV) Phase 2.1 T. K. Stringham, June 2015

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 allows mahogany to become dominant with high canopy cover. Sagebrush is reduced due to competition and shading. Cusick's bluegrass increases because of increased shade from trees, while needlegrasses are reduced.

Community Phase 2.2:
This community phase is characteristic of a post-disturbance, early to mid-seral community phase. Snowberry and rabbitbrush are sprouting/increasing. Perennial grasses dominate. Mahogany and mountain big sagebrush may be present, but only in patches. Annual non-native species may increase after fire.

Mahogany Savanna (023XY026NV) Phase 2.2 T. K. Stringham, August 2014

Mahogany Savanna (R023XY026NV) Phase 2.2 T. K. Stringham, July 2015

Community Phase Pathway 2.2a, from Phase 2.2 to 2.1:
Time and lack of disturbance or fire, drought, inappropriate grazing management, or combinations of these.

Community Phase Pathway 2.2b, from Phase 2.2 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 will increase in production and density throughout the site. Perennial bunchgrasses may also increase in production. Livestock may use these small mahogany stands as bedding grounds, stressing understory vegetation and allowing annuals to increase.

Community Phase 2.3:
Mahogany density will increase in the absence of disturbance. Shrubs and deep-rooted perennial bunchgrasses will be shaded out by the dense mahogany. Cusick's bluegrass is more shade tolerant, however, and increases in the understory. Mahogany in dense stands will lose lower branches due to shading and/or herbivory, resulting in a more tree-like appearance. Annual species present in trace amounts in the understory.

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). 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. Livestock may use these small mahogany stands as bedding grounds, stressing understory vegetation and allowing annuals to increase.

Community Phase 2.4 (At Risk):
This community is at risk of crossing into an annual state; however we have not yet seen this group convert to an annual state. Native bunchgrasses dominate; however, annual non-native species such as cheatgrass may be sub-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.

Granitic Mahogany Savanna (R023XY069NV) Phase 2.4 (At Risk). D. Snyder, July 2016

Community Phase Pathway 2.4a, from phase 2.4 to 2.2:
Rainfall patterns favoring perennial bunchgrasses. Lower than normal spring precipitation followed by higher than normal summer precipitation will increase perennial bunchgrass production.

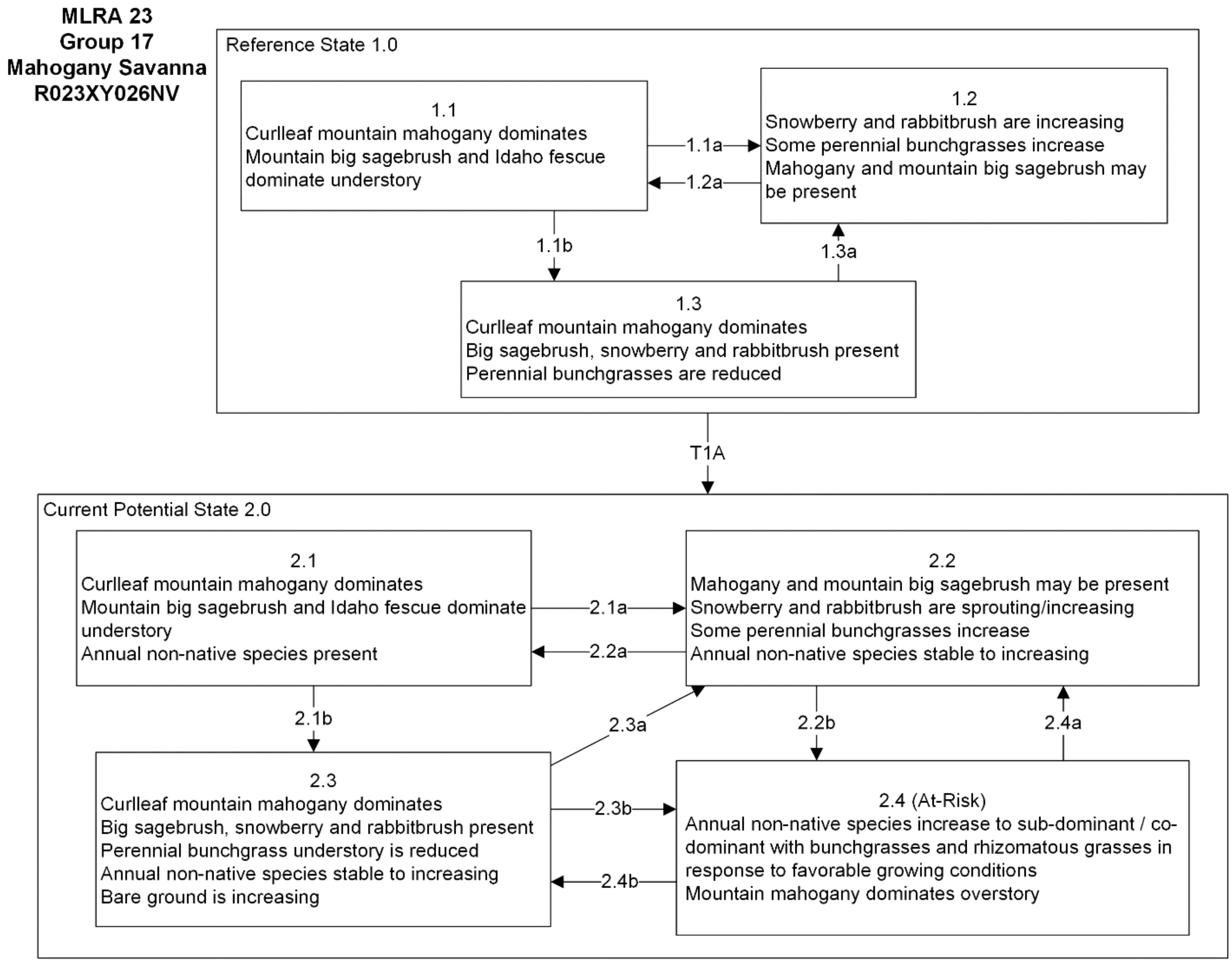
Community Phase Pathway 2.4b, from phase 2.4 to 2.3:
Rainfall patterns favoring perennial bunchgrasses. Lower than normal spring precipitation followed by higher than normal summer precipitation will increase perennial bunchgrass production.

Potential Resilience Differences with other Ecological Sites:

Granitic Mahogany Savanna (R023XY069NV):

This site is slightly less productive than the modal site with 1800 lbs/ac total production (including mahogany) in normal years. The soils of this site are shallow, well drained and have formed in residuum from granitic rock sources. There are high amounts of boulders, stones and cobbles on the surface. The soils have rapid runoff and are moderately permeable. Sheet and rill erosion potential is low. Canopy cover of mountain mahogany is less than 45 percent. The subdominant shrubs include mountain big sagebrush and antelope bitterbrush (*Purishia tridentata*). The grass community is dominated by Letterman's needlegrass (*Achantherum lettermanii*) and Nevada bluegrass (Poa nevadensis). During site visits, this site was seen in phase 2.4, indicating that it may be less resilient than the modal site and may be more at risk of an annual state, however an annual states was not seen during site visits. This site has two stable states.

Modal State and Transition Model for Group 17 in MRLA 23:



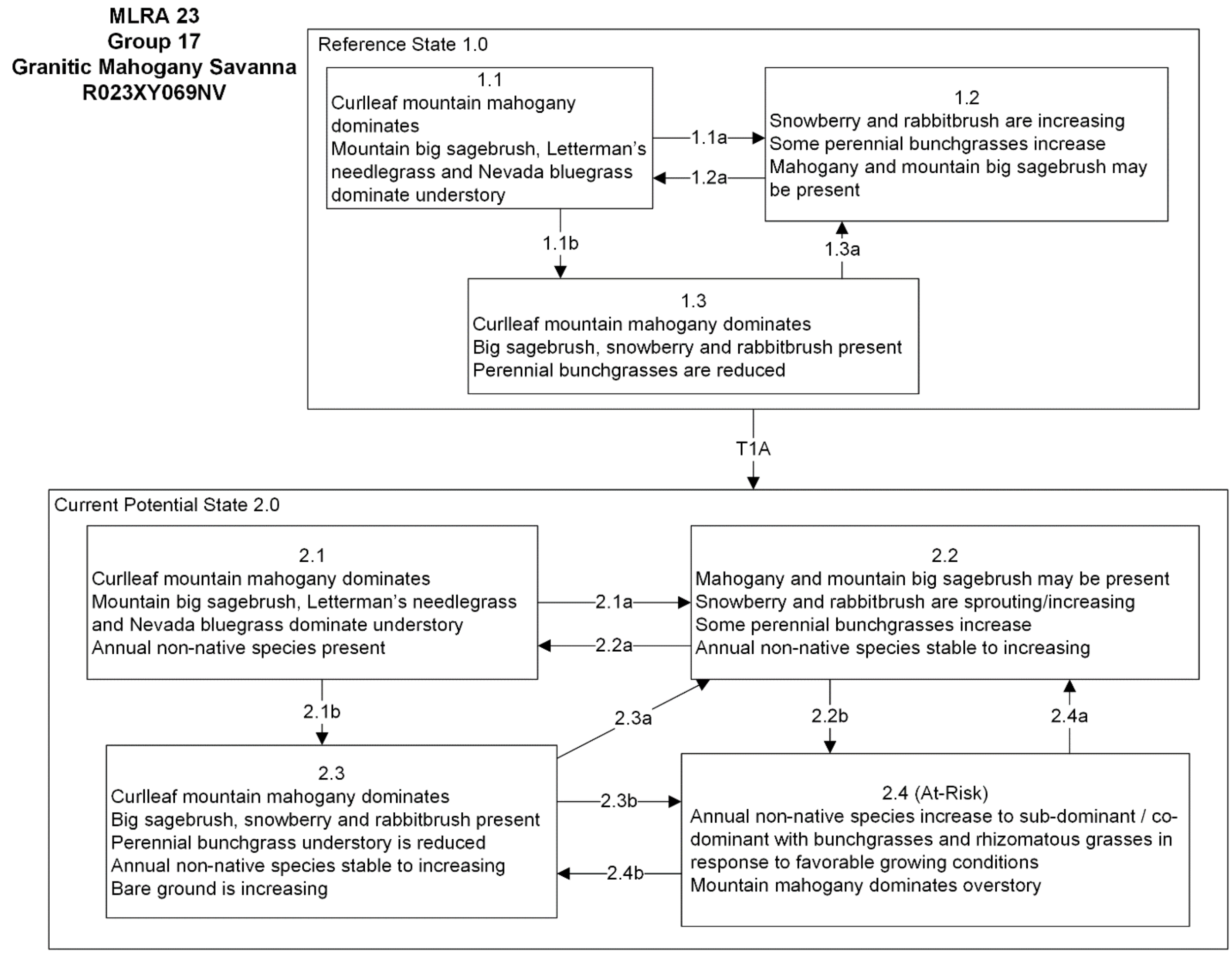
MLRA 23
Group 17
Mahogany Savanna
023XY026NV
KEY

Reference State 1.0 Community Pathways
1.1a: Low severity fire, snow loading, or insect damage reduces mahogany.
1.1b: Time and lack of disturbance allows mahogany to reach peak canopy cover. Cusick’s bluegrass increases with more shade.
1.2a: Time and lack of disturbance.
1.3a: Low severity fire, snow loading, or insect damage reduces mahogany.

Transition T1A: Introduction of non-native annual species.

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.

Alternate State and Transition Models for Group 17 in MRLA in 23:



MLRA 23
Group 17
Granitic Mahogany Savanna
R023XY069NV
KEY

Reference State 1.0 Community Pathways
1.1a: Low severity fire, snow loading, or insect damage reduces mahogany.
1.1b: Time and lack of disturbance allows mahogany to reach peak canopy cover. Cusick's bluegrass increases with more shade.
1.2a: Time and lack of disturbance.
1.3a: Low severity fire, snow loading, or insect damage reduces mahogany.

Transition T1A: Introduction of non-native annual species.

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.

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Group 18: Utah juniper with Thurber's needlegrass and various sagebrush species

Description of MLRA 23 DRG 18:

Disturbance Response Group (DRG) 18 consists of three ecological sites. The precipitation zone for these sites ranges from 8 to 14 inches. The elevation range for this group is from 4,500 to 6,500 ft. Slopes range from 4 to 75 percent. The soils are shallow to very shallow to bedrock and well drained. Available water holding capacity is very low, but trees and shrubs extend their roots into fractures in the bedrock, allowing them to utilize deep moisture. Large rock fragments provide a stabilizing effect on surface erosion conditions. The potential native plant community for these sites varies depending on precipitation, elevation, and landform. Theses site are old growth Utah juniper (*Juniperus osteosperma)* sites with Thurber's needlegrass (*Achnatherum thurberianum*) as the dominant understory grass. Dominant shrubs vary: low sagebrush (*Artemisia arbuscula*), Lahontan sagebrush (*Artemisia arbuscula* ssp. *longicaulis*), or Wyoming big sagebrush *(Artemisia tridentata ssp. wyomingensis*). Other understory grasses include desert needlegrass (*Achnatherum speciosum)* and Sandberg bluegrass (*Poa secunda*). Purple sage (*Salvia dorrii)* may be a significant part of the shrub understory. Under medium canopy cover (20-25%), understory production ranges from 100-450 lb/ac on these sites.
During our visits to all low sagebrush and Lahontan sagebrush sites for this project, 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 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 MLRA 23 ecological sites with these two species.

Disturbance Response Group 18 – Ecological Sites:

JUOS WSG: 0X0403 - Modal	F023XY035NV
JUOS WSG: 0R0409	F023XY045NV
JUOS WSG: 0R0402	F023XY046NV

Modal Site:

The JUOS WSG: 0X0403 (023XY035NV) ecological site is the modal site for this group. This woodland site occurs on plateau summits and lower mountain sideslopes on all aspects and is typically associated with areas of rock outcrop or talus. This site is found from 5500 to 6500 feet. Slopes range from 4 to 30 percent. Average annual precipitation is about 10 to 14 inches. Mean annual air temperature is 43 to 47 °F. The average growing season is 70 to 100 days. These soils have formed in residuum and colluvium from basalt. The soils are shallow to very shallow to bedrock and well drained. Surface soils are modified by high amounts of large stones and boulders. Soils are skeletal and typically have over 50 percent rock fragments, by volume, distributed throughout the soil profile. Runoff is slow to medium and the potential for sheet and rill erosion is slight to moderate depending on slope.

An overstory canopy cover of 20 to 30 percent was assumed to be representative of tree dominance for a mature forest in the Reference State for this model. 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 plant community is dominated by Utah juniper with an understory of low sagebrush, Thurber's needlegrass, and Sandberg bluegrass. In northwestern Nevada, Utah juniper hybridizes with Western juniper *(Juniperus occidentalis)* and this hybrid may be found on this site as well. Average understory production ranges from 250 to 450 lb/acre on this site under medium canopy cover (20-30%). 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 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 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 CO_2 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. 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).

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 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).

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. Tap roots 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, causing a decrease in understory perennial vegetation because of increased competition for water and sunlight. Additionally, there is evidence that phenolic compounds in juniper litter may have allelopathic effects on grass (Jameson 1970). Furthermore, 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). Additionally, 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 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.

Insects and diseases of western juniper are not well understood or studied (Eddleman et al. 1994). 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 10-15 years after infection. Seedlings and saplings are most susceptible to the parasite (Christopherson 2014). Other diseases affecting juniper are: witches'-broom (*Gymnosporangium* sp.) that may girdle and kill branches; 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).

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, 1969a). 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.

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). 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).

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 have low to moderate resilience to disturbance and resistance to invasion. Resilience increases with higher elevation, northerly aspect, increased precipitation, and nutrient availability. Four possible 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, H.C. 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:

Large fires were rare on these sites. Lightning-ignited fires were 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. Surface spread was more likely to occur in higher-density woodlands growing on more productive sites (Romme et al. 2009). 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). Limited data exists that describes fire histories across woodlands in the Great Basin. The infilling of younger trees into the old-growth stands and the expansion of trees into the surrounding sagebrush steppe ecological sites has increased the risk of loss of pre-settlement trees due to increased fire severity and size resulting from the increase in the abundance and landscape level continuity of fuels (Miller et al. 2008).

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). 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. To date, we have not been able to find specific research on the fire response of Lahontan sagebrush.

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 (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 (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).

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 (Carlton 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). 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).

Desert needlegrass is similar to Thurber's needlegrass and both are easily killed by fire. Desert needlegrass does not germinate well in the presence of non-native annual species such as cheatgrass. Herbicidal treatment of cheatgrass prior to desert needlegrass seeding can help establishment (Rafferty 2000).

Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage from fire but is more susceptible in drought years (Young 1983). Plant response will vary depending on season, fire severity, fire intensity and post-fire soil moisture availability.

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:

This group of ecological sites are 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 et al. 2005).

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 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 low sagebrush, rabbitbrush (Chrysothamnus spp.) and deep-rooted perennial forbs such as arrowleaf balsamroot *(Balsamorhiza* spp.) Annual non-native weedy species such as cheatgrass (*Bromus tectorum*) 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 this ecological site and others in this DRG. This recently differentiated subspecies of low sagebrush (Winward and McArthur 1995) is moderately to highly palatable to browse species (Rosentreter 2005, McArthur 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).

Antelope bitterbrush is a minor component on this site, but is a critical browse species for mule deer, antelope and elk and is often utilized heavily by domestic livestock (Wood 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 gazed 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. 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).

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949, Britton et al. 1990) Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife.

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 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 23 Disturbance Response Group 18.

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. 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 low sagebrush perennial bunchgrass understory characterize this phase. The visual aspect is dominated by Utah juniper which makes up 10-20 percent of the overstory canopy cover. 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. Low sagebrush is the primary understory shrub. Purple sage may be a significant shrub component. Forbs such as balsamroot are minor components. Overall, the understory is sparse with production ranging between 250 to 450 pounds per acre.

JUOS WSG: 0R0409 (F023XY045NV) Phase 1.1. D. Snyder, October 2018

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
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 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. 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. Juniper seedlings up to 20 inches in height may be present. Rabbitbrush may increase. Low 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. Low 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, as well as perennial bunchgrasses and shrubs.

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.

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 20%. The density and vigor of the low 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 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 low 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 1.1:
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 30%. 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 low sagebrush perennial bunchgrass understory. The visual aspect is dominated by Utah juniper which make up 10 to 20 percent of the overstory canopy cover. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Bluebunch wheatgrass and muttongrass are the most prevalent grasses in the understory. Low sagebrush is the primary understory shrub. Forbs such as goldenweed, phlox, and milkvetch are minor components. Overall, the understory is sparse with production ranging between 250 to 500 lbs. per acre.

JUOS WSG: 0R0402 (F023XY046NV) Phase 2.1, T. K. Stringham, June 2015

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. Bluebunch wheatgrass 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 20 inches in height

may be present. Low 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. Low 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, as well as perennial bunchgrasses and shrubs. 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.

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 20 percent. The density and vigor of the low 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, or to the Annual State 4.0 if it burns. This community phase is typically described as *early* Phase II woodland (Miller et al. 2008).

JUOS WSG: 0X0403 (F023XY035NV) Phase 2.4, T. K. Stringham, July 2015

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 low 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 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 Utah juniper in the overstory. This state is identifiable by 30 to over 50 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 competition from trees.

Community Phase 3.1:
Utah juniper dominate the aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and low 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 30 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).

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 dominate the aspect. Tree canopy cover exceeds 30 percent and may be as high as 50 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses, if present, exist in the drip line or under the canopy of trees. Low 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 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 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 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.

Community Phase 4.1:
Cheatgrass, mustards and other non-native annual species dominate the site. Trace amounts of perennial bunchgrasses may be present.

Potential Resilience Differences with other Ecological Sites:

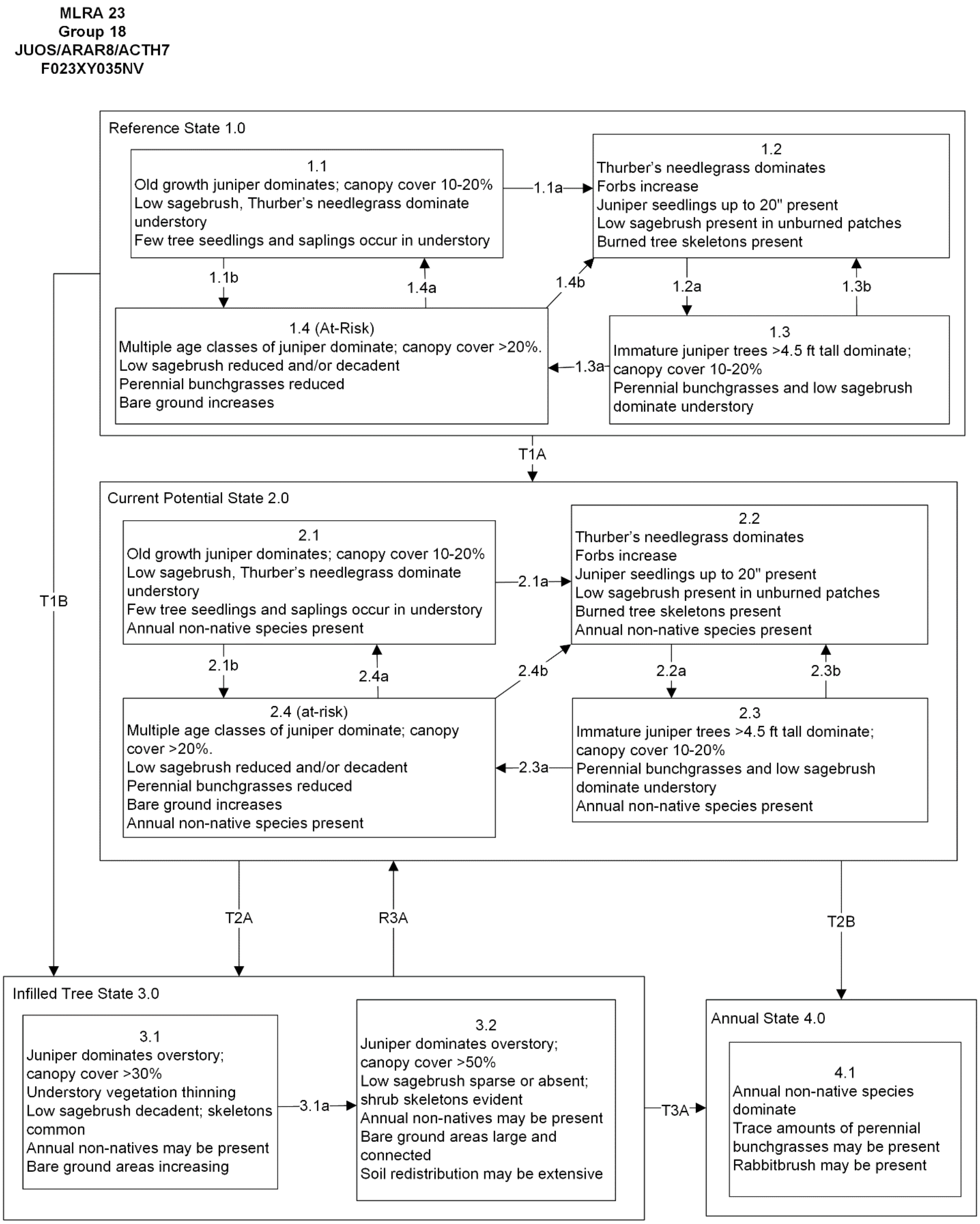
JUOS WSG: 0R0409 (F023XY045NV):

This site is less productive than the modal, with 100-350 lb/ac under medium canopy cover, and the dominant shrub on this site is Lahontan sagebrush. It carries a higher proportion of desert needlegrass, ephedra, and spiny hopsage (*Grayia spinosa)*. Annual precipitation range is 8-12 inches, and the site can be found from 4000-6000 feet in elevation. This site has a similar model with 4 stable states.

JUOS WSG: 0R0402 (F023XY046NV):

This site is less productive than the modal, with 100-350 lb/ac under medium canopy cover, and the dominant shrub on this site is Wyoming big sagebrush. It carries a higher proportion of desert needlegrass, ephedra, and spiny hopsage (*Grayia spinosa)*. Annual precipitation range is 8-12 inches, and the site can be found from 4000-6000 feet in elevation. This site has a similar model with 4 stable states.

Modal State and Transition Model for Group 18 in MRLA 23:



MLRA 23
Group 18
JUOS/ARAR8/ACTH7
F023XY035NV
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 allows younger trees to infill.
1.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire reduces or eliminates tree cover.
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 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 allows younger trees to infill.
2.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire reduces or eliminates tree cover.
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.

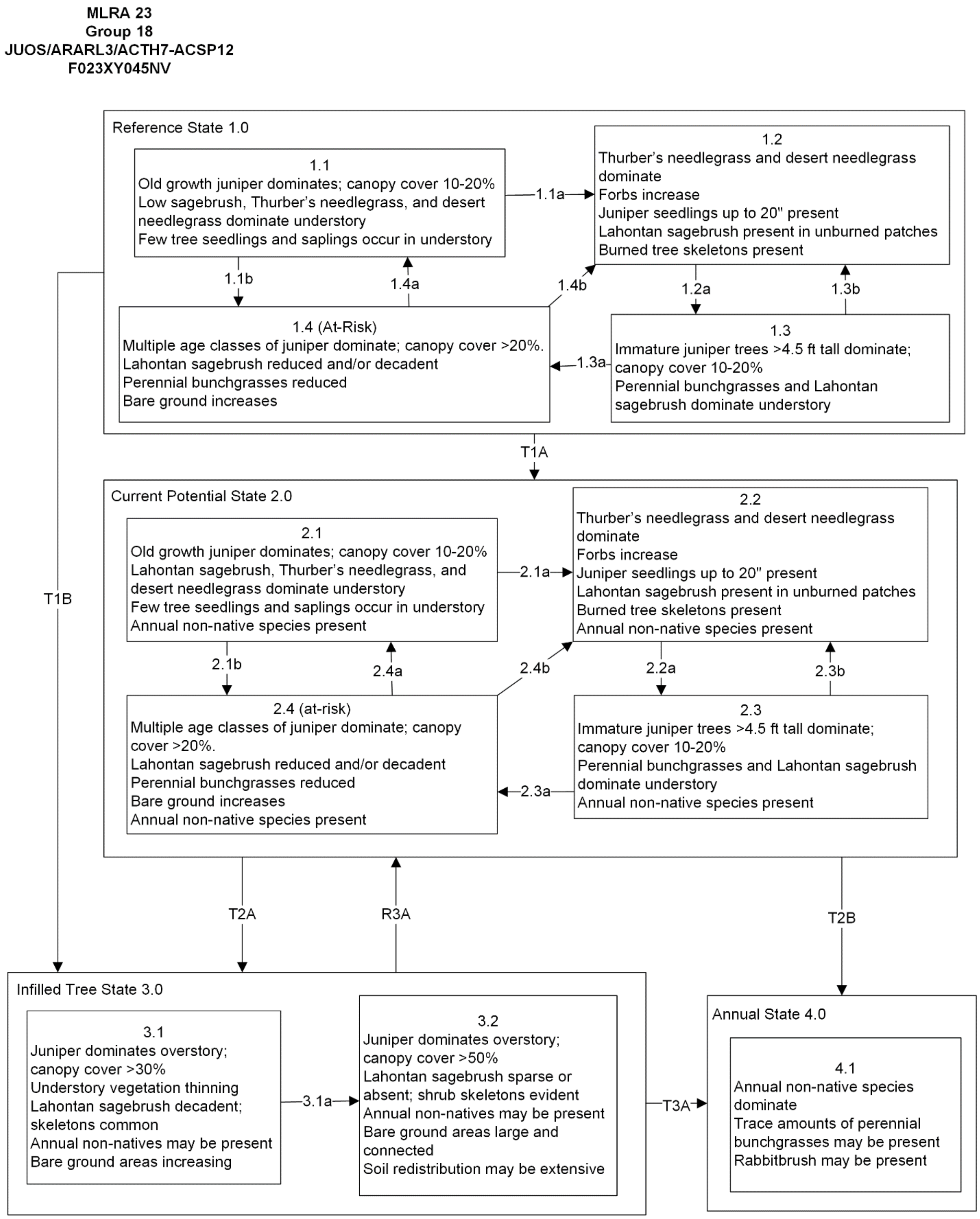
Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill and mature.

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.

Alternate State and Transition Models for Group 18 in MRLA 23:



MLRA 23
Group 18
JUOS/ARARL3/ACTH7-ACSP12
F023XY045NV
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 allows younger trees to infill.
1.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire reduces or eliminates tree cover.
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 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 allows younger trees to infill.
2.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire reduces or eliminates tree cover.
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.

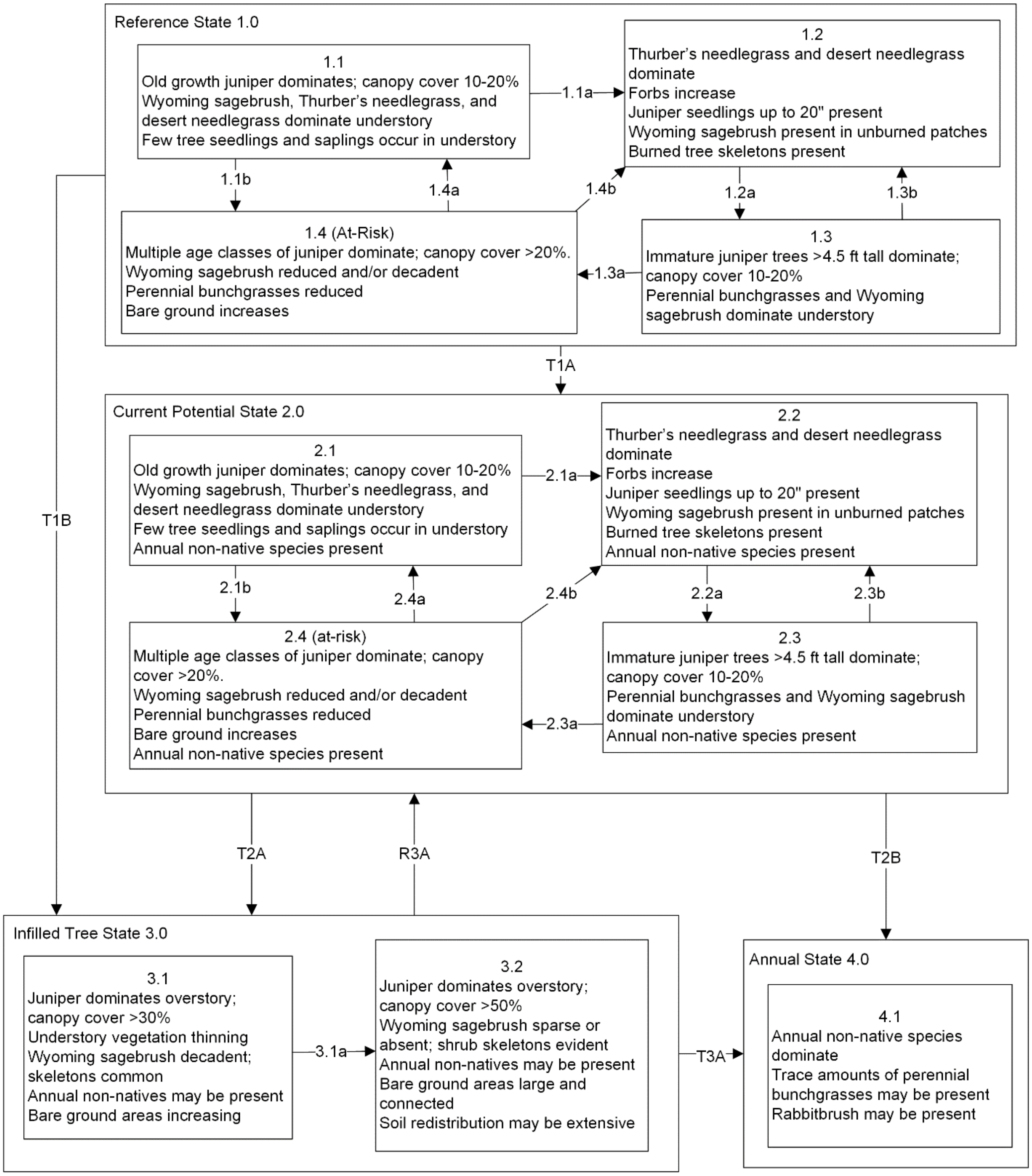
Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill and mature.

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 23
Group 18
JUOS/ARTRW8/ACTH7-ACSP12
F023XY046NV



MLRA 23
Grou/p 18
JUOS/ARTRW8ACTH7-ACSP12
F023XY046NV
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 allows younger trees to infill.
1.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire reduces or eliminates tree cover.
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 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 allows younger trees to infill.
2.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire reduces or eliminates tree cover.
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 and mature.

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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Group 19: Western juniper with low sagebrush and Idaho fescue

Description of MLRA 23 DRG 19:

Disturbance Response Group (DRG) 19 consists of two very similar ecological sites. The precipitation zone for these sites ranges from 10 to 16 inches. The elevation range for this group is from 5,800 to 7,500 ft. Slopes range from 2 to 30 percent. Soils formed in residuum or colluvium from volcanic rock sources and are shallow, with surface layers less than 5 inches thick to a heavy textured subsoil. These soils are typically skeletal with 35 to over 75 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 (Miller and Rose 1999). Cobbles and stones present at the soil surface occupy plant growing space, yet help to reduce evaporation and conserve soil moisture. Coarse fragments on the surface also provide a stabilizing effect on surface erosion conditions. Runoff is medium to rapid, and the potential for sheet and rill erosion is slight to moderate depending on slope. The potential native plant community for these sites varies depending on precipitation, elevation and landform. These sites are old growth Western juniper (*Juniperus occidentalis)* sites with an understory of low sagebrush (*Artemisia arbuscula*) and Idaho fescue (*Festuca idahoensis*). In the area where these sites are mapped – northwestern Nevada and northeastern California – Utah juniper (*Juniperus osteosperma)* is often found in mixed stands with western juniper, and the two species can hybridize. Bluebunch wheatgrass (*Pseudoroegneria spicata)*, Thurber's needlegrass (*Achnatherum thurberianum*), and Canby's bluegrass (*Poa secunda ssp. canbyi*) are other important species on this site. Under medium canopy cover (20-30%), understory production on these sites ranges from 200 to 500 lbs/acre.

Disturbance Response Group 19 – Ecological Sites:

JUOC/ARAR8/FEID-PSSPS - Modal	F023XY095NV
JUOC WSG: 0R2003	F023XY091NV

Modal Site:

The JUOC/ARAR8/FEID-PSSPS (023XY095NV) ecological site is the modal site for this group. This woodland site occurs on plateau summits and sideslopes on all aspects. Slopes range from 2 to 30 percent, but are typically 4 to 15 percent. Elevations are 6,200 to over 7,500 feet. Average annual precipitation is 12 to 16 inches. Mean annual air temperature is 42 to 45 °F. The average growing season is 70 to 100 days.

An overstory canopy cover of 20 to 30 percent was assumed to be representative of tree dominance for a mature forest in the Reference State for this model. However, research indicates a canopy cover of 5 to 20 percent is likely more appropriate to represent this site condition in pre-settlement condition (Miller and Rose 1999). 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 western and Utah juniper, low sagebrush, Idaho fescue, bluebunch wheatgrass, and Thurber's needlegrass. Under medium canopy cover (20-30%), understory production on ranges from 200 to 500 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 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 influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Western Juniper:

During the past 140 years, western juniper has been expanding within its geographic range at unprecedented rates compared to any other time period during the Holocene (Miller et al. 2005) and density of western juniper has increased since the middle of the nineteenth century (Tausch 1999, Miller and Tausch 2001). Western juniper woodlands in eastern Oregon with more than 10 percent canopy cover increased from 456,000 acres in 1936 to 2.2 million acres in 1988 (Gedney et al. 1999, Miller et al. 2005, Rowland et al. 2011). Causes for expansion of western juniper into sagebrush ecosystems include changes in the wildfire return interval, historic livestock grazing, and climate influences (Bunting 1994, Soulé et al. 2003, Tausch 1999, Miller et al. 2005). Mean fire return intervals prior to European settlement in mountain big sagebrush ecosystems were 15 to 25 years (Burkhardt and Tisdale 1976, Young and Evans 1981, Miller and Rose 1999, Ansley et al. 2000), frequent enough to inhibit the encroachment of western juniper into these big sagebrush cover types (Miller and Tausch 2001). Thus, trees were isolated to fire-safe areas such as rocky outcroppings and areas with low-productivity.

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. Tap roots 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 tree canopy cover, causing a decrease in understory plants like sagebrush (Bates et al. 2000, Miller et al. 2000, Johnsen 1962, Azuma et al. 2005). Furthermore, 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, Tausch 1999). Additionally, 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 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: 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.

Insects and diseases of western juniper are not well understood or studied (Eddleman et al. 1994). A fungus called Juniper Pocket Rot (*Pyrofomes demidoffi*), also known as white trunk rot (Eddleman et al. 1994 and Durham 2014) can kill Utah and Western 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 10-15 years after infection. Seedlings and saplings are most susceptible to the parasite (Christopherson 2014). Other diseases affecting juniper are: witches'-broom (*Gymnosporangium* sp.) that girdles and kills branches; 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).

Understory Dynamics:

The understory of 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). 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).

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).

Low sagebrush is fairly drought tolerant but also tolerates perched water tables during some portion of the growing season. Low sagebrush is also 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.

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. General differences in root depth distributions between grasses and shrubs result in resource partitioning in the understory.

The ecological sites in this DRG have 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.

Fire Ecology:

Large fires were rare on these sites. Lightning-ignited fires were common but typically did not affect more than a few individual trees (Miller and Rose 1999). Western juniper is intolerant of fire and historically survived in areas with minimal understory vegetation, due primarily to soil characteristics (Vasek and Thorne 1977, West 1984, Miller and Rose 1995). Therefore, the sites may not have carried fire, and when it did occur it was low intensity. With the increased suppression of wildfire and introduction of livestock grazing which reduces ground fuels and understory competition, regeneration and establishment of western juniper has expanded into sites previously dominated by big sagebrush (Burns and Honkala 1990). The expansion of western juniper has been well documented. In the Steens mountain range of southeastern Oregon, the expansion of western juniper coincides with Euro-American settlement. Probable causes of expansion include climate, altered fire frequencies and grazing of flammable ground fuels (Miller and Rose 1995). Fire resistance depends on age of the tree: seedlings, saplings and poles are highly vulnerable to fire. Mature trees have some resistance to fire due to lack of fuels near the trunk, relatively thick bark, and foliage which is fairly high above the ground (Burns and Honkala 1990).

Literature is sparse regarding historical fire return intervals in low sagebrush ecosystems, however Miller and Rose (1999) did a study in an Oregon low sagebrush and juniper site and identified only two extensive fires between 1700 and 1880. Both fire events were preceded by at least two years of above average growth on the trees.

Low sagebrush is killed by fire and does not sprout (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). Fire return intervals have been estimated at 100-200 years in black sagebrush dominated sites (Kitchen and McArthur 2007) and likely is similar in the low sagebrush ecosystem; however, historically fires were probably patchy due to the low productivity of these sites. 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).

Antelope bitterbrush can be found on these ecological sites and is moderately fire tolerant (McConnell and Smith 1977). It regenerates by seed and resprouting (Blaisdell and Mueggler 1956, McArthur et al. 1983) 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).

Idaho fescue, the dominant grass within this community, response to fire varies with condition and size of the plant, season and severity of fire, and ecological conditions. Mature Idaho fescue plants are commonly reported to be severely damaged by fire in all seasons (Wright et al. 1979). Initial mortality may be high (in excess of 75%) on severe burns, but usually varies from 20 to 50% (Barrington et al. 1989). Rapid burns have been found to leave little damage to root crowns, and new tillers are produced with onset of fall moisture (Johnson et al. 1994). However, Wright and others (1979) found the dense, fine leaves of Idaho fescue provided enough fuel to burn for hours after a fire had passed, thereby killing or seriously injuring the plant regardless of the intensity of the fire (Wright et al. 1979). Idaho fescue is commonly reported to be more sensitive to fire than the other prominent grass on this site, bluebunch wheatgrass (Conrad and Poulton 1966). However Robberecht and Defossé (1995) suggested the latter was more sensitive. They observed culm and biomass reduction with moderate fire severity in bluebunch wheatgrass, whereas a high fire severity was required for this reduction in Idaho fescue. Also, given the same fire severity treatment, post-fire culm production was initiated earlier and more rapidly in Idaho fescue (Robberecht and Defossé 1995).
Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage from fire but is more susceptible in drought years (Young 1983). Conversely, 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. Bluegrasses are a minor component of this ecological site and have been found to increase following fire likely due

to its low stature and productivity (Daubenmire 1975) and may retard reestablishment of deeper rooted bunchgrasses.

Livestock/Wildlife Grazing Interpretations:

This group of ecological sites are 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 et al. 2005).

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, 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).

Antelope bitterbrush, although a small component of 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.

Heavy grazing may lead to replacement of Idaho fescue with non-native species such as cheatgrass (Mueggler 1975). Bunchgrasses, in general, best tolerate light grazing after seed formation. Britton and others (1990) observed the effects of harvest date on basal area of 5 bunchgrasses in eastern Oregon, including Idaho fescue, and found grazing from August to October (after seed set) has the least impact on these bunchgrasses. Therefore, abusive grazing during the growing season will reduce perennial bunchgrasses, with the exception of Sandberg bluegrass (Tisdale and Hironaka 1981). Idaho fescue tolerates light to moderate grazing (Ganskopp and Bedell 1981) and is moderately resistant to trampling (Cole 1987). Idaho fescue has been found to decrease under heavy, repeated grazing by livestock (Eckert and Spencer 1986, Eckert and Spencer 1987, Mueggler 1975) and wildlife (Gaffney 1941). However, more recent research by Jaindl et al. (1994) suggests Idaho fescue exhibits overcompensation to single defoliation events (i.e., increased biomass production after herbivory) depending on the physiological stage of growth at the time of the grazing event.

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949, Britton et al. 1990) Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife

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).

Reduced bunchgrass vigor or density provides an opportunity for Sandberg bluegrass expansion. Sandberg bluegrass increases under grazing pressure (Tisdale and Hironaka 1981).

State and Transition Model Narrative 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 23 disturbance response group 19.

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. 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 low sagebrush perennial bunchgrass understory characterize this phase. Old-growth juniper have 5-20 % canopy cover. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Idaho fescue and bluebunch wheatgrass are the most prevalent grasses in the understory. Low sagebrush is the primary understory shrub. Forbs such as balsamroot are minor components. Overall, the understory is sparse with production ranging between 200 to 500 pounds per acre.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
A high-severity crown fire will eliminate or reduce the western 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 juvenile western juniper.

Community Phase 1.2:
This phase is characterized by a post-fire shrub and herbaceous community. Idaho fescue 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 up to 20 inches in height may be present. Rabbitbrush may increase. Low 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 western juniper component. Low 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, as well as perennial bunchgrasses and shrubs.

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 western juniper. Infilling by younger trees continues.

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 western juniper. The stand exhibits mixed age classes and canopy cover exceeds 20%. The density and vigor of the low 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 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 low 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 1.1:
A high-severity crown fire will eliminate or reduce the western 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 30%. 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:
Widely dispersed old-growth juniper trees with a low sagebrush perennial bunchgrass understory characterize this phase. Old-growth juniper have 5-20% canopy cover. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Idaho fescue and bluebunch wheatgrass are the most prevalent grasses in the understory. Low sagebrush is the primary understory shrub. Forbs such as goldenweed, phlox, and milkvetch are minor components. Overall, the understory is sparse with production ranging between 250 to 500 lbs. per acre.

JUOC/ARAR/PSSP/STTH (023XY091NV) Phase 2.1 T. K. Stringham, August 2014

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
A high-severity crown fire will eliminate or reduce the western 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 western juniper.

Community Phase 2.2:
This community phase is characterized by a post-fire shrub and herbaceous community. . Idaho fescue and bluebunch wheatgrass dominate. Forbs may increase post-fire but will likely return to pre-burn levels within a few years. Juniper seedlings up to 20 inches in height may be present. Low 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 western Juniper component. Low 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, as well as perennial bunchgrasses and shrubs. 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 western 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 western juniper. The stand exhibits mixed age classes and canopy cover exceeds 20 percent. The density and vigor of the low 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, or to the Annual State 4.0 if it burns. 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 low 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 western 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: Western juniper canopy cover is greater than 30%. 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 western juniper in the overstory. This state is identifiable by 30 to over 50 percent cover of western 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 competition from trees.

Community Phase 3.1:
Western juniper dominates the visual aspect. Understory vegetation is thinning. Perennial bunchgrasses are sparse and low 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 30 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).

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 western juniper. Infilling by younger trees continues.

Community Phase 3.2 (at risk):
Western juniper dominates the visual aspect. Tree canopy cover exceeds 30 percent and may be as high as 50 percent. Understory vegetation is sparse to absent. Perennial bunchgrasses, if present, exist in the drip line or under the canopy of trees. Low sagebrush skeletons are common or the sagebrush has been extinct long enough that only scattered limbs remain. Mat-forming forbs or Sandberg's bluegrass (*Poa secunda*) and other bluegrasses 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:

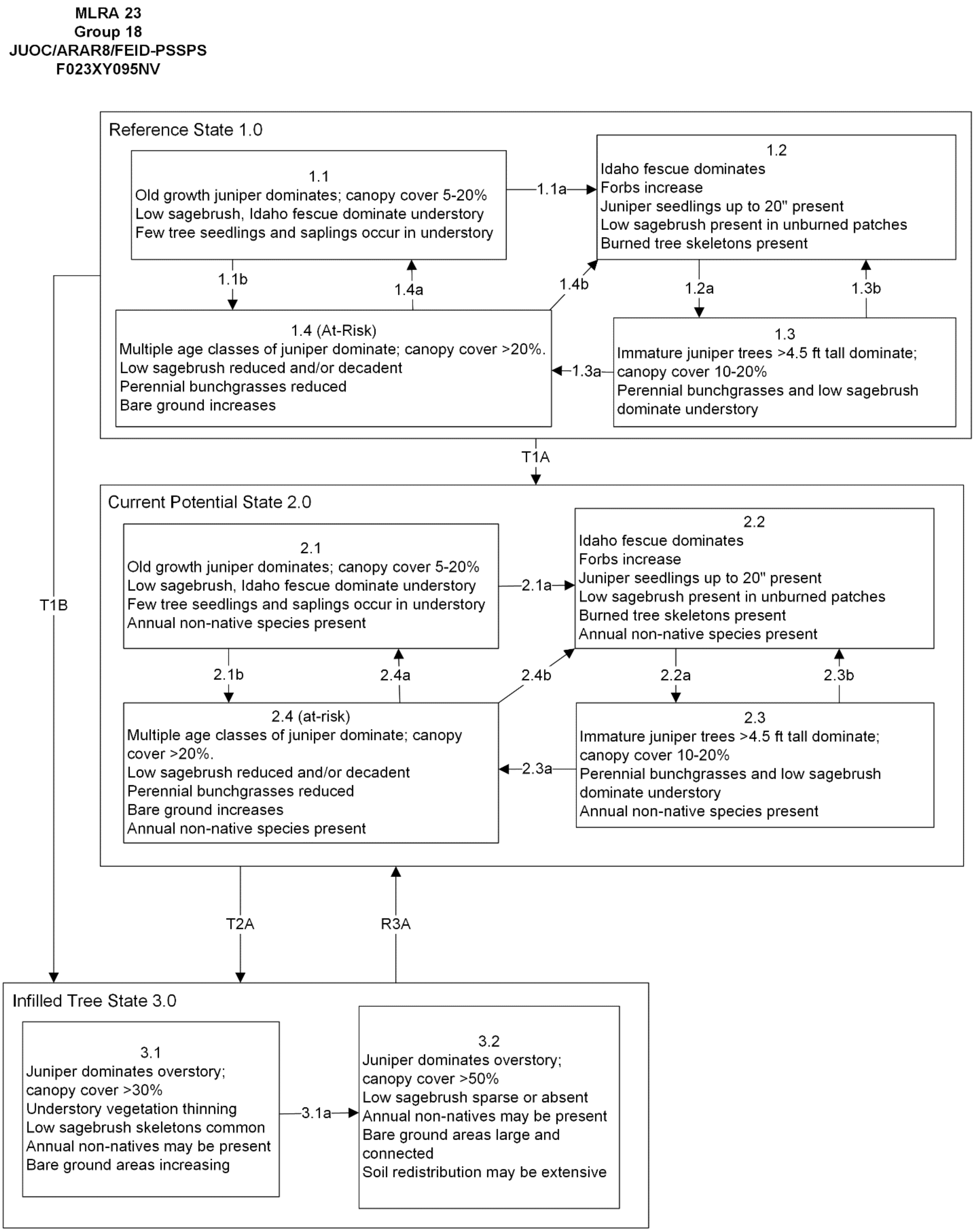
Manual or mechanical thinning of trees, coupled with seeding of desired native species. Probability of success is highest from community phase 3.1.

Potential Resilience Differences with other Ecological Sites:

JUOC/ARTRV/PSSPS (R023XY091NV):

This site has similar production to the modal site with 200-500 lbs/ac under medium canopy cover in normal years. It is found in lower elevations from 5800 to 6500 feet with average annual precipitation from 10 to 14 inches. This site has similar soils but a longer growing season from 90 to 120 days. The plant community is dominated by western and Utah juniper with an understory community of low sagebrush, bluebunch wheatgrass, Thurber's needlegrass and Canby's bluegrass. As written, this site is nearly identical to the modal site in this group, with a slight increase in bluebunch wheatgrass and Thurber's needlegrass. This site has four stable states.

Modal State and Transition Model for Group 19 in MRLA 23:



MLRA 23
Group 19
JUOC/ARAR8/FEID-PSSPS
F023XY095NV
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 allows younger trees to infill.
1.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire reduces or eliminates tree cover.
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 trees to dominate site resources; may be coupled with inappropriate grazing management that favors shrub and tree dominance.

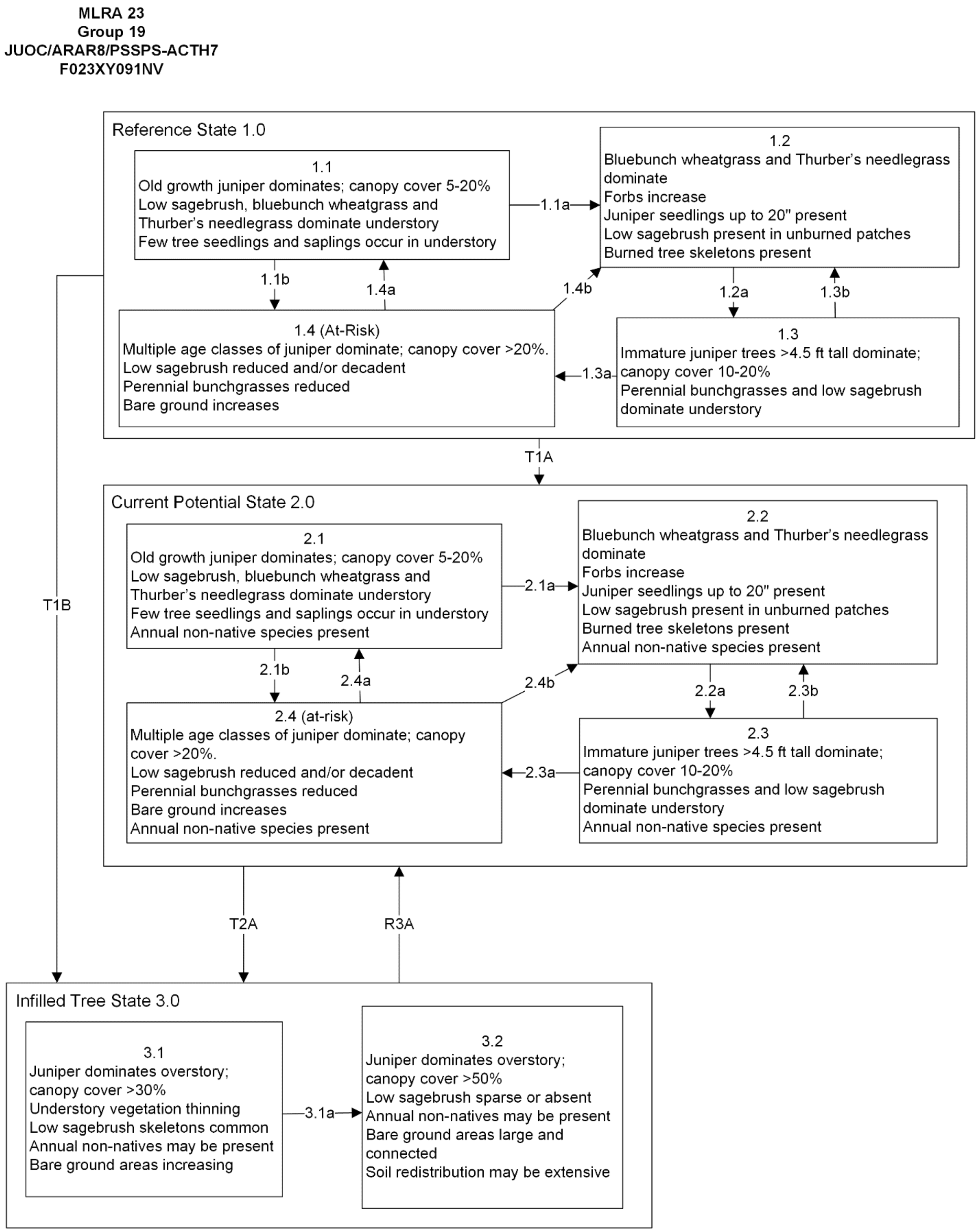
Current Potential State 1.0 Community Pathways
2.1a: High severity crown fire reduces or eliminates tree cover.
2.1b: Time and lack of disturbance allows younger trees to infill.
2.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire reduces or eliminates tree cover.
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 and mature.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

Additional State and Transition Models for Group 19 in MRLA 23:



MLRA 23
Group 19
JUOS/ARAR8/PSSPS-ACTH7
F023XY091NV
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 allows younger trees to infill.
1.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire reduces or eliminates tree cover.
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 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 allows younger trees to infill.
2.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire reduces or eliminates tree cover.
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 and mature.

Restoration Pathway R3A: Thinning of trees coupled with seeding. Success unlikely from phase 3.2.

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Group 20: Juniper and mountain big sagebrush

Description of MLRA 23 DRG 20:

Disturbance Response Group (DRG) 20 consists of two very similar ecological sites. The precipitation zone for these sites ranges from 10 to 14 inches. The elevation range for this group is from 5,500 to 7,500 ft. Slopes range from 8 to 75 percent. The sites in this group are found on backslopes of plateaus in association with big sagebrush ecological sites. Soils in this group are generally shallow to bedrock. Available water holding capacity is moderate to low, but trees and shrubs extend their roots into fractures in the bedrock allowing them to utilize deep moisture (Miller and Rose 1999).The potential native plant community for these sites varies depending on precipitation, elevation and landform. These sites are dominated by western juniper (*Juniperus occidentalis*) and/or Utah Juniper (*Juniperus osteosperma*). In the area where these sites are mapped – northwestern Nevada and northeastern California – Utah juniper is often found in mixed stands with Western juniper, and the two species can hybridize. The shrub component is dominated by mountain big sagebrush (*Artemisia tridentata sppo. vasayena*). The understory is dominated by bluebunch wheatgrass (*Pseudoroegneria spicata)* and Thurber's needlgrass (*Achnatherum thurberianum*). The production on these sites ranges from 300-700 lb/ac under medium canopy cover of trees.

Disturbance Response Group 20 – Ecological Sites:

JUOS WSG: 0R0401 – Modal	F023XY036NV
JUOC WSG: 1R2001	F023XY024NV

Modal Site:

The JUOS WSG: 0R0401 (023XY036NV) ecological site is the modal site for this group. This woodland site occurs on plateau and mountain sideslopes on all aspects. Slope gradients are generally from 15 to 50 percent. Elevations are from about 5500 to 7500 feet. Average annual precipitation is about 10 to 14 inches. Mean annual air temperature is 43 to 47 °F. The average growing season is 60 to 90 days. The soils are shallow to very shallow to granitic parent material and are well drained. Soils may be have a significant component of ash. Available water capacity is relatively low because of the shallow soil, but trees and shrubs extend their roots into fractures in the bedrock allowing them to utilize deep moisture. Surface soils typically have high amounts of large stones and boulders. Large rock fragments on the soil surface provide a stabilizing effect on surface erosion conditions. Runoff is medium to rapid and the potential for sheet and rill erosion is moderate to severe depending on slope.

An overstory canopy cover of 20 to 30 percent was assumed to be representative of tree dominance for a mature forest in the Reference State for this model. However, research indicates a canopy cover of 5 to 20 percent is likely more appropriate to represent this site condition in pre-settlement condition (Miller and Rose 1999). 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 western and/or Utah juniper, mountain big sagebrush, bluebunch wheatgrass, Thurber's needlegrass, and western needlegrass. Production ranges from 300-600 lbs/ac under mature forest canopy cover 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 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 influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

Juniper:

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 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 (Miller, R. F. 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. 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).

Utah juniper are long-lived tree species with wide ecological amplitudes (Tausch et al. 1981, West et al. 1998, Weisberg and Ko 2012). 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).

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. Tap roots 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 tree canopy cover, causing a decrease in understory plants like sagebrush (Bates et al. 2000, Miller et al. 2000, Johnsen 1962, Azuma et al. 2005). Furthermore, 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, Tausch 1999). Additionally, 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 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.

Insects and diseases of Utah and western juniper are not well understood or studied (Eddleman et al. 1994). 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 10-15 years after infection. Seedlings and saplings are most susceptible to the parasite (Christopherson 2014). Other diseases affecting juniper are: witches'-broom (*Gymnosporangium* sp.) that may girdle and kill branches; 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).

Understory dynamics:

The ecological sites in this DRG have understories 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). 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).

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).

Mountain 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 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).

The ecological sites in this DRG have low to moderate resilience to disturbance and resistance to invasion. Resilience increases with higher elevation, northerly aspect, increased precipitation, and nutrient availability. Four possible 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, H. C. 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 et al. 1983). 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:

Large fires were rare on these sites. Lightning-ignited fires were 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. With 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). Spreading, low-intensity surface fires had a very limited role in molding stand structure and dynamics. Surface spread was more likely to occur in higher-density woodlands growing on more productive sites (Romme et al. 2009). Pre-settlement fire return intervals in 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 a sparse understory very infrequently (Gruell 1999). Limited data exists that describes fire histories across woodlands in the Great Basin. The infilling of younger trees into old-growth stands and the expansion of trees into the surrounding sagebrush steppe communities has increased the risk of losing pre-settlement trees due to increased fire severity and size as a result of the increase in the abundance and 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 can survive low severity fires because they have foliage farther from the ground and thicker bark, but mortality occurs when 60% or more of the crown is scorched (Bradley et al. 1992).

Western juniper is generally intolerant of fire and historically survived in areas with minimal understory vegetation, due primarily to soil characteristics (Vasek and Thorne 1977, West 1984, Miller and Rose 1995). Therefore, the sites may not have carried fire, and when it did occur it was low intensity. With the increased suppression of wildfire and introduction of livestock grazing which reduces ground fuels and understory competition, regeneration and establishment of western juniper has expanded into sites previously dominated by big sagebrush (Burns and Honkala 1990). The expansion of western juniper has been well documented. In the Steens mountain range of southeastern Oregon, the expansion of western juniper coincides with Euro-American settlement. Probable causes of expansion include climate, altered fire frequencies and grazing of flammable ground fuels (Miller and Rose 1995). Fire resistance depends on age of the tree: seedlings, saplings and poles are highly vulnerable to fire. Mature trees have some resistance to fire due to lack of fuels near the trunk, relatively thick bark, and foliage which is fairly high above the ground (Burns and Honkala 1990).

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. 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. Western and Utah juniper reestablish by seed from nearby seed source or surviving seeds. Western and Utah juniper begin 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 (Everett and Ward 1984, Tausch and West 1988, Bradley et al. 1992). Juniper woodlands reach mature stage between 85 to 150 years after fire (Barney and Frischknecht 1974, Tausch and West 1988).

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).

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). 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).

Fire will remove aboveground biomass from bluebunch wheatgrass but plant mortality is generally low (Robberecht and Defossé 1995) because the buds are underground (Conrad and Poulton 1966) or protected by foliage. Uresk et al. (1976) reported burning increased vegetative and reproductive vigor of bluebunch wheatgrass. Thus, bluebunch wheatgrass is considered to experience slight damage from fire but is more susceptible in drought years (Young 1983). Conversely, 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. Bluegrasses are a minor component of this ecological site and have 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 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:

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 this site, however 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.

Bluebunch wheatgrass is moderately grazing tolerant and is very sensitive to defoliation during the active growth period (Blaisdell and Pechanec 1949, Laycock 1967, Anderson and Scherzinger 1975). Herbage and flower stalk production was reduced with clipping at all times during the growing season; however, clipping was most harmful during the boot stage (Blaisdell and Pechanec 1949, Britton et al. 1990) Tiller production and growth of bluebunch was greatly reduced when clipping was coupled with drought (Busso and Richards 1995). Mueggler (1975) estimated that low vigor bluebunch wheatgrass may need up to 8 years rest to recover. Although an important forage species, it is not always the preferred species by livestock and wildlife

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).

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 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 23 Disturbance Response Group 20.

Reference State 1.0:

The Reference State 1.0 is a 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 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:
Widely dispersed old-growth juniper trees with an understory of mountain big sagebrush and perennial bunchgrasses characterize this phase. The visual aspect is dominated by juniper, with 10-25 percent overstory canopy cover. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Bluebunch wheatgrass and Thurber’s needlegrass are the most prevalent grasses in the understory. Mountain big sagebrush is the primary understory shrub. Forbs such as arrowleaf balsamroot (*Balsamorhiza sagittat*a), phlox (*Phlox* spp.), and tapertip hawksbeard (*Crepis acuminata*) are minor components.

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
A high-severity crown fire will eliminate or reduce the juniper overstory and the shrub component. This allows 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 the gradual infilling of juniper.

Community Phase 1.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Bluebunch wheatgrass 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. Juniper

seedlings up to 20 inches 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 the gradual maturation of the Juniper 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 juniper trees averaging over 4.5 feet in height. Juniper 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 1.4:
Time without disturbance such as fire, long-term drought, or disease will allow the gradual maturation of juniper. Infilling by younger trees continues.

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 juniper. The stand exhibits mixed age classes and canopy cover exceeds 20 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. 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 20 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 juniper overstory and the shrub component which will allow 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: Juniper canopy cover is greater than 30 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 juniper trees with an understory of mountain big sagebrush and perennial bunchgrasses. The visual aspect is dominated by juniper which make up 10-25% of the overstory canopy cover. Trees have reached maximal or near maximal heights for the site and many tree crowns may be flat- or round-topped. Bluebunch wheatgrass and Thurber's needlegrass are the most prevalent grasses in the understory. Mountain big sagebrush is the primary understory shrub. Forbs such as arrowleaf balsamroot, phlox, and tapertip hawksbeard are minor components. Ground fires within this community are infrequent occurring on average every 15 to 25 years. This fire type will create a plant community mosaic that will include all/most of the following community phases within this state. Annual non-native species are present in trace amounts.

JUOC-ARTRV (F023XY024NV) Phase 2.1, T.K. Stringham, June 2015

Community Phase Pathway 2.1a, from Phase 2.1 to 2.2:
A high-severity crown fire will eliminate or reduce the juniper overstory and the shrub component. This allows 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 the gradual infilling of juniper.

Community Phase 2.2:
This community phase is characterized by a post-fire shrub and herbaceous community. Bluebunch wheatgrass 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 20 inches 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 the gradual maturation of the juniper 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 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, as well as perennial bunchgrasses and shrubs. Annual non-native species are present.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.4:
Time without disturbance such as fire, long-term drought, or disease will allow the gradual maturation of 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 juniper. The stand exhibits mixed age classes and canopy cover exceeds 20 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. 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).

JUOC-ARTRV (F023XY024NV) Phase 2.4, T.K. Stringham, July 2015

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 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 juniper overstory and the shrub component which will allow 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: Juniper 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 juniper in the overstory. This state is identifiable by >35 percent canopy cover of 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 competition from trees. Sagebrush skeletons can be found scattered throughout phases.

Community Phase 3.1:
Juniper dominates the visual 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 30 percent. 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).

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 the gradual maturation of juniper. Infilling by younger trees continues.

Community Phase 3.2:
Juniper dominates the visual aspect. Tree canopy cover exceeds 30 percent and may be as high as 50 percent. 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: Fire reduces the tree overstory and allows 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 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 may dominate the overstory. Annual non-native species dominate the understory.

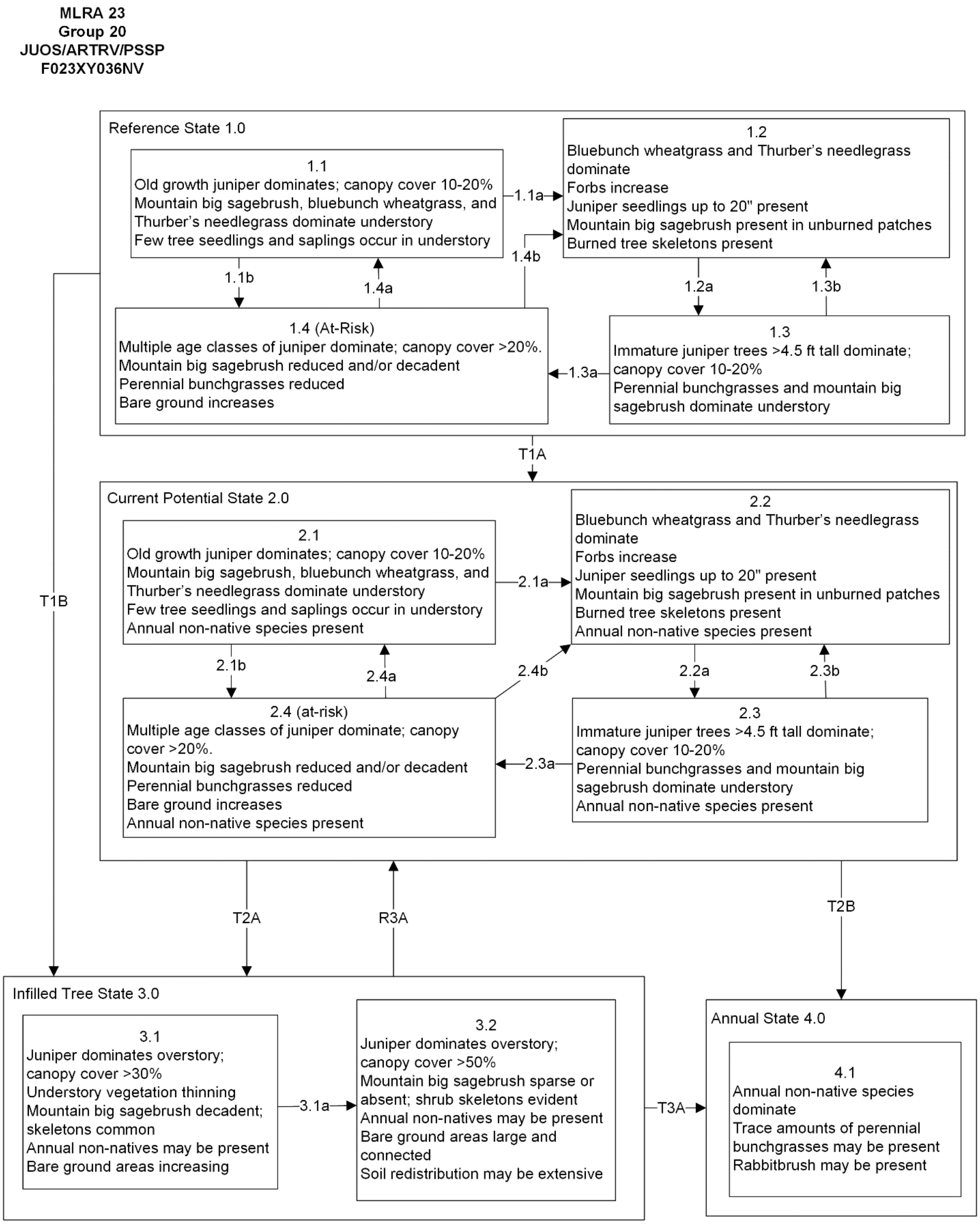
Community Phase 4.1:
Cheatgrass, mustards and other non-native annual species dominate the site. Trace amounts of perennial bunchgrasses may be present.

Potential Resilience Differences with other Ecological Sites:

JUOC WSG: 1R2001 (F023XY024NV)

This site is nearly identical to the modal site, however it grows on soils derived from volcanic rock sources and seems to grow a more diverse suite of grasses. The ecological site description indicates that this site may support a higher density of trees. It is more productive than the modal site in 0-10% juniper canopy cover at 800 lb/ac in normal years but is also less productive in 36-55% juniper canopy cover at 150 lb/ac in normal years. This site occurs as a secondary map unit component in association with big sagebrush sites: either Loamy Slope 10-14 (R023XY039NV) or South Slope 12-16 (R023XY016NV). This juniper site occurs on the upper part of plateau backslopes. High amounts of rock fragments are present at the soil surface, occupying plant growing space, yet helping conserve soil moisture. They are skeletal throughout the profile and have moderate to low water holding capacity. Runoff is medium to rapid and potential for sheet and rill erosion is moderate to severe depending on the slope. The plant community is similar to the modal site with western and/or Utah juniper dominating the overstory and mountain big sagebrush, bluebunch wheatgrass and Thurber’s needlegrass dominating the understory. This site has four stable states.

Modal State and Transition Model for Group 20 in MRLA 23:



MLRA 23
Group 20
JUOS/ARTRV/PSSP
F023XY036NV
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 allows younger trees to infill.
1.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire reduces or eliminates tree cover.
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 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 allows younger trees to infill.
2.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire reduces or eliminates tree cover.
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.

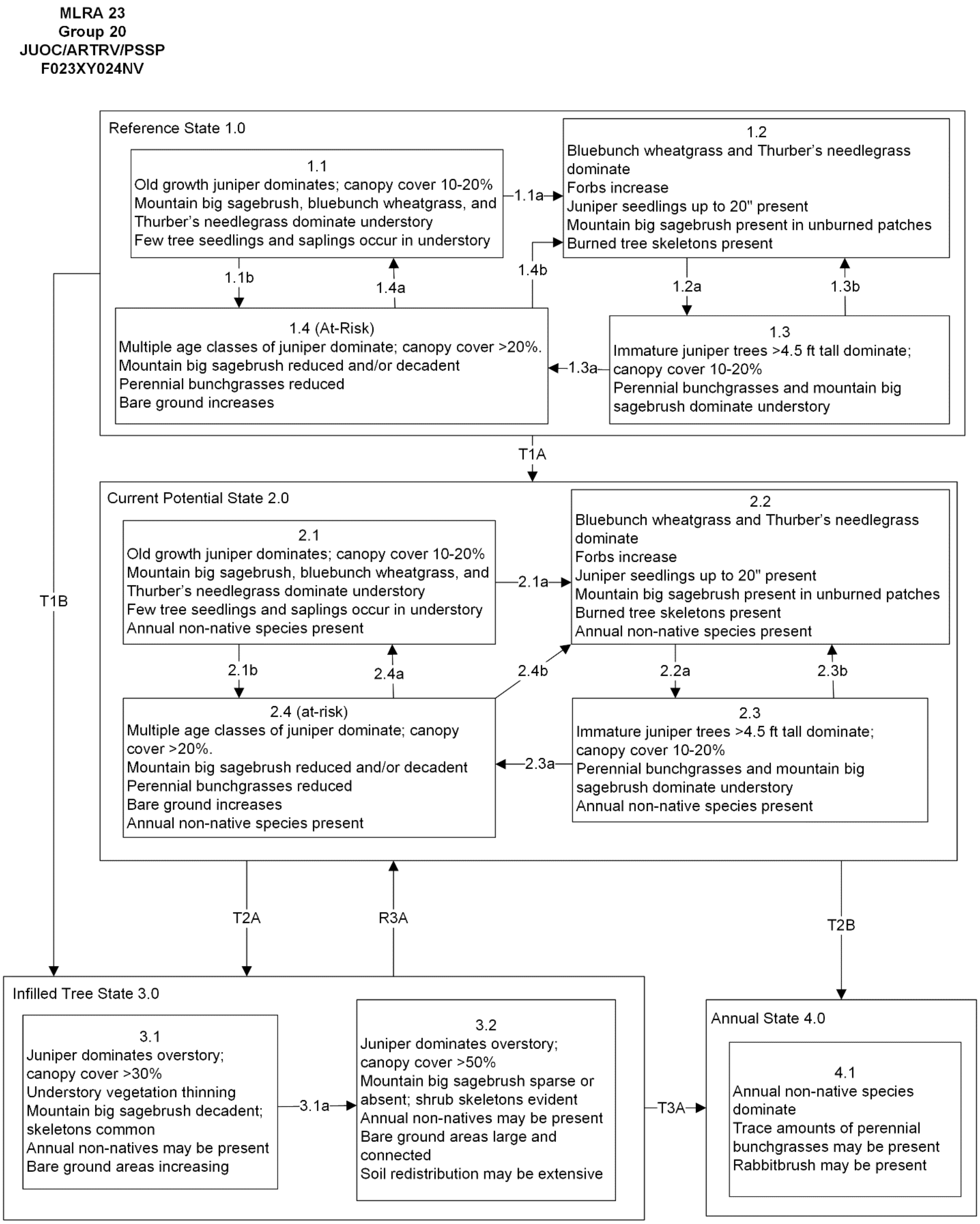
Infilled Tree State 3.0 Community Pathways
3.1a: Time and lack of disturbance such as fire, disease, or drought allows younger trees to infill and mature.

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.

Alternate State and Transition Models for Group 20 in MLRA 23:



MLRA 23
Group 20
JUOC/ARTRV/PSSP
F023XY024NV
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 allows younger trees to infill.
1.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
1.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
1.3b: Fire reduces or eliminates tree cover.
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 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 allows younger trees to infill.
2.2a: Time and lack of disturbance allows trees to reestablish. Excessive herbivory may also reduce perennial grass understory.
2.3a: Time and lack of disturbance allows trees to mature. Excessive herbivory may also reduce perennial grass understory.
2.3b: Fire reduces or eliminates tree cover.
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 and mature.

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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Group 23: Quaking Aspen

Description of MLRA 23 DRG 23:

Disturbance Response Group (DRG) 23 consists of two ecological sites. The precipitation zone for these sites ranges from 14 to over 20 inches. The elevation range for this group is from 6,000 to 9,500 ft. Slopes range from 4 to 75 percent. The soils in this site are moderately deep to very deep and well- to moderately well-drained. These soils have a thick, dark, medium-textured surface layer. Available water capacity is high. This site provides a cool, moist environment for plant growth because of the high elevations and northerly exposures where it occurs. Heavy snow accumulation on this site persists late into spring or early summer when the soil is not frozen. Snow, slowly melting during this period, is added to the soil moisture supply and is available to plants during the growing season. The potential native plant community for these sites varies depending on precipitation, elevation and landform. This site is dominated by quaking aspen (*Populus tremuloides*). The shrub component is dominated by mountain snowberry (*Symphoricarpos oreophilus*). The understory is dominated by mountain brome (*Bromus marginatus*), needlegrasses (*Achnatherum spp.),* and slender wheatgrass (*Elymus trachycaulus*). The average annual production in the understory of these sites ranges from 300 to 800 lb/ac in normal years.

Disturbance Response Group 23 – Ecological Sites:

POTR5 WSG:1R1701 – Modal	F023XY028NV
Aspen Thicket	R023XY027NV

Modal Site:

The POTR5 WSG:1R1701 (F023XY028NV) ecological site is the modal site for this group, as it has the most acres mapped. This woodland site occurs on cool, moist, smooth to concave mountain sideslopes of mostly northerly exposure. Slopes range from 4 to 75 percent, but are typically 15 to 50 percent. Elevations are 6000 to 9500 feet. Average annual precipitation is 16 or more inches. The soils are slightly acid and noncalcareous. Available water capacity is high. Some soils have cobbles or boulders on the surface and/or are skeletal with from 35 to 50 percent gravels and cobbles, by volume, distributed through the soil profile. Soil temperatures and evapo-transpiration potentials are limited during the growing season due to reduced insolation. The plant community is dominated by quaking aspen in the overstory, with mountain big sagebrush (*Artemisia tridentata Nutt. ssp. vaseyana*), mountain snowberry, mountain brome, and slender wheatgrass below. Understory annual production ranges from 400 to 800 lb/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 influence resilience include site productivity, species composition and structure, and population regulation and regeneration (Chambers et al. 2013).

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 typically found in nearly pure stands. 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-age 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). Quaking aspen is one of the most widely distributed forest plants in North America (Potter 1998). 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). Increased fire suppression, excessive browse pressure, and conifer encroachment threaten the structure of western aspen stands.

Conifer Dynamics:

Shading by conifer trees limits aspen regeneration (Bartos and Campbell 1998, Stringham et al. 2015). If the aspen stands exists near or intermixed with conifers like white fir, spruce, pinyon pine, or juniper, 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; 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 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). 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 (*Juniperus occidentalis)* 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).

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: a reference state, a current potential state and a tree state.

Fire Ecology:

Wildfire is recognized as a natural disturbance that influenced 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). 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). 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).

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).

Mountain big sagebrush, a minor component on these sites, 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).

Mountain 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 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 sprouts after fire (Conrad 1987) and grows more rapidly some other serviceberry species (Plummer et al. 1968). If balsamroot or mules ear is common before fire, these plants will increase after fire or with heavy grazing (Wright 1985).

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 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 have a less injurious effect on aspen sprouts than sheep, who more readily browse twigs (Sampson 1919), however cattle and sheep still use aspen significantly less than deer and elk (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 (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 big horn ram taken out of Clark County in 1952 (Guillion 1964).

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).

The forb community (*Lupinus spp.* and *Balsamorhiza sagitata*) found in aspen stands is important forage for sheep, cattle, deer, and elk (Beck and Peek 2005).

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 (*Alces alces*) browse the bark, branches and sprouts of quaking aspen year-round throughout the West (DeByle 1979, Howard 1996). Mule deer (*Odocoileus hemionus*) 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). Moose (*Alces americanus*) occasionally occur in Nevada but will feed on the bark of quaking aspen in winter, the saplings in spring, and leaves and branches the rest of the year (Shepperd et al. 2006). 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 round, but are more common in the associated coniferous forests (DeByle and Winokur 1985). A threatened species, the American Pika 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 borrowing. 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 9000 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. However; 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, conifer encroachment, improper livestock grazing, and browsing by big game species (Wildlife Action Plan Team 2012). Several fungi species cause the formation of large cankers on aspen trunks, roots and spots on leaves. The fungus *Marssonina* leaf-spot causes particular damage to the trees, leaving brown leaves on quaking aspen mid-summer throughout large portions of their habitat (Lanner 1984).

State and Transition Model Narrative 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 23 Disturbance Response Group 23.

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,

depending upon 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.

Aspen Thicket (R023XY027NV) Phase 1.1 T.K. Stringham, August 2016

Community Phase Pathway 1.1a, from Phase 1.1 to 1.2:
Fire, insects, disease, or wind reduce the mature aspen and allow 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 allows 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. Early growth of quaking aspen suckers ranges from less than 1 foot to more than 3 feet per year. In the absence of disturbance, suckers develop into saplings (to 4½ feet in height) with a range in canopy cover of about 5 to 15 percent. Vegetation consists of grasses, forbs and a few 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.

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. 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.

Community Phase Pathway 1.4a, from Phase 1.4 to 1.2:
Fire removes the mature aspen canopy and 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 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 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 and cheatgrass. 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, depending upon 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 communities, young juniper trees may begin to grow within the aspen stand in this phase.

Aspen Thicket (R023XY027NV) Phase 2.1 T. K. Stringham, June 2015

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. 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 suckers and saplings 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. Early growth of quaking aspen suckers ranges from less than 1 foot to more than 3 feet per. In the absence of disturbance, suckers develop into saplings (to 4½ feet in height) with a range in canopy cover of about 5 to 15 percent. Vegetation consists of grasses, forbs and a few shrubs in association with tree saplings. Non-native species are stable to increasing within the community.

View from canopy opening
POTR WSG:1R1701 (R023XY028NV) Phase 2.2 T. K. Stringham, June 2015

Interior view
POTR WSG:1R1701 (R023XY028NV) Phase 2.2 T. K. Stringham, June 2015

Community Phase Pathway 2.2a, from Phase 2.2 to 2.3:
Time and lack of disturbance, 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.

Community Phase Pathway 2.3a, from Phase 2.3 to 2.1:
Time and lack of disturbance allows the aspen suckers to mature.

Community Phase Pathway 2.3b, from Phase 2.3 to 2.2:
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. 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 juniper, Western juniper 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.

POTR WSG:1R1701 (R023XY028NV) Phase 2.4 At-Risk T.K. Stringham, August 2014

POTR WSG:1R1701 (R023XY028NV) Phase 2.4 At-Risk T.K. Stringham, August 2014

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 60% 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 Western juniper. 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. Western juniper is more flammable than aspen; if it burns in this state, aspen may not come back.

Community Phase 3.1:
Western juniper dominates 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.

POTR WSG:1R1701 (R023XY028NV) Phase 3.1 T.K. Stringham, August 2014

POTR WSG:1R1701 (R023XY028NV) Phase 3.1 T.K. Stringham, August 2014

R3A: Transition from Conifer State 3.0 to Current Potential 2.0:

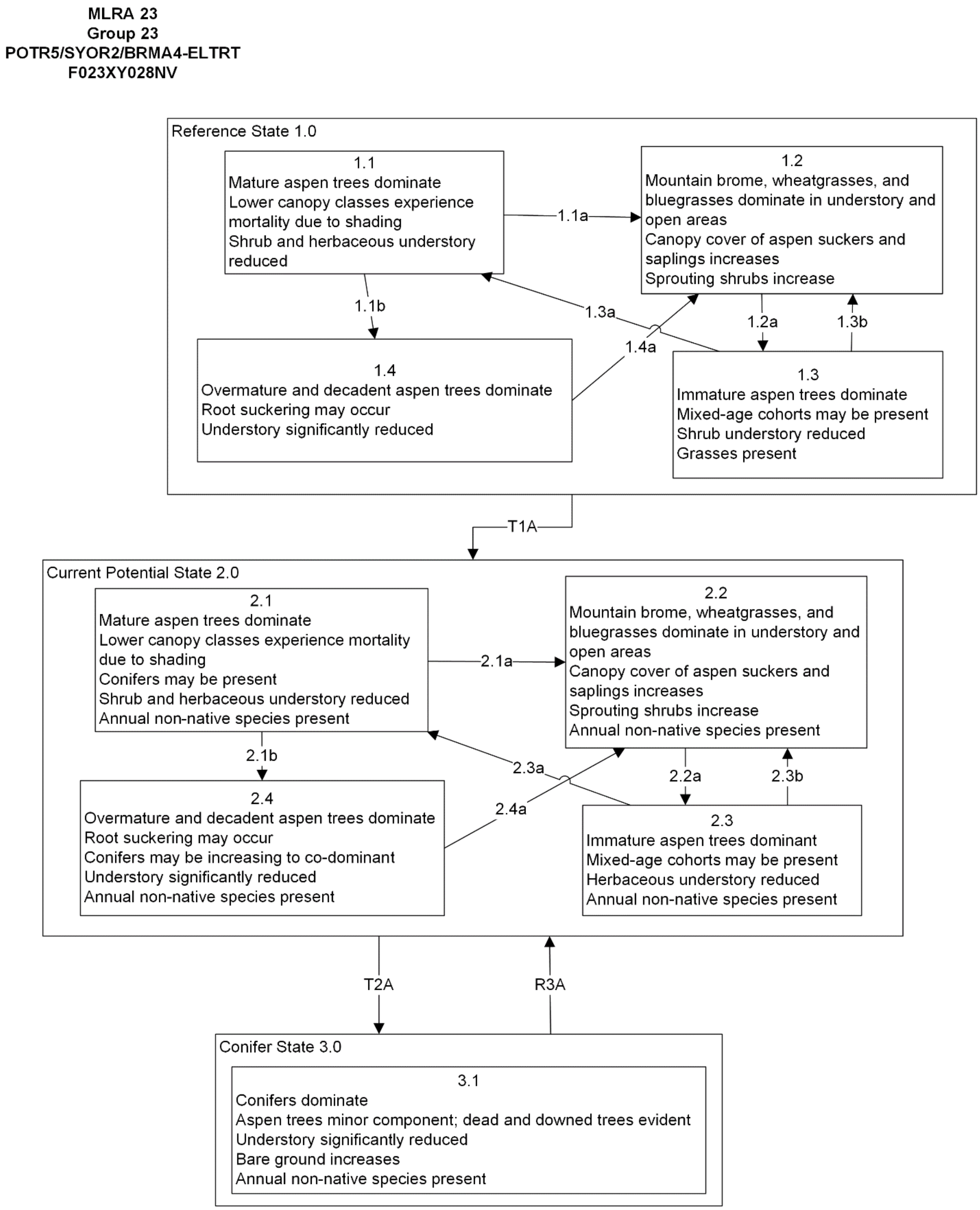
Prescribed fire or mechanical removal of trees potentially coupled with root ripping to stimulate suckering. This restoration treatment should be completed before all evidence of aspen regeneration is lost. However, it is not known how long an aspen stand can remain dormant in a conifer state before the stand will not return (Strand et al. 2009b).

Potential Resilience Differences with other Ecological Sites:

Aspen Thicket (R023XY027NV):

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). Visually it is quite different from the modal site in this group, however it will exhibit the same dynamics, just with shorter trees. Each site normally represents a single clone of aspen with a common genetic makeup. 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, mountain brome, 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’s normal understory annual production ranges from 300-800 lb/ac. This site has two stable states.

Modal State and Transition Model for Group 23 in MRLA 23:



MLRA 23
Group 23
POTR5/SYOR2/BRMA4-ELTRT
F023XY028NV
KEY

Reference State 1.0 Community Pathways
1.1a: Fire, insects, disease, 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).

Current Potential State 2.0 Community Pathways
2.1a: Fire, insects, disease, 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.

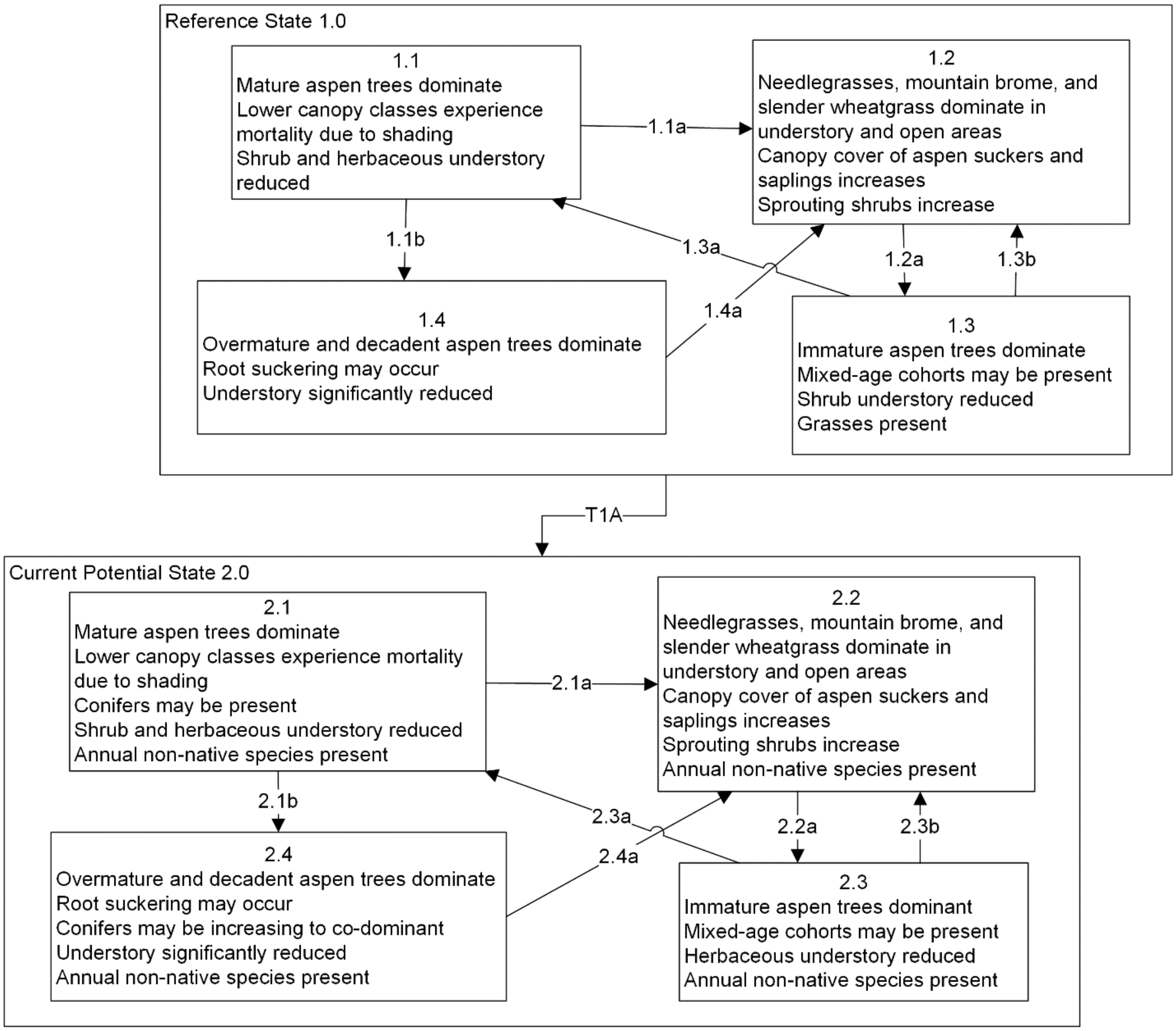
Conifer State 3.0 Community Pathways
None.

R3A: Prescribed fire or other conifer removal via harvesting/cutting, leads to phase 2.2.

Notes: Fire intervals are dependent upon surrounding vegetation communities. Open areas or localized aspen death can occur from disease, insects, heavy snow loading, windfall, etc.

Alternate State and Transition Models for Group 23 in MRLA 23:

MLRA 23
Group 23
Aspen Thicket
R023XY027NV



MLRA 23
Group 23
Aspen Thicket
R023XY027NV
KEY

Reference State 1.0 Community Pathways
1.1a: Fire, insects, disease, 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).

Current Potential State 2.0 Community Pathways
2.1a: Fire, insects, disease, 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.

Notes: Fire intervals are dependent upon surrounding vegetation communities. Open areas or localized aspen death can occur from disease, insects, heavy snow loading, windfall, etc.

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Supplemental Information:

These items will be available at the Major Land Resources (MLRA) Reports page or the UNR Rangeland Ecology Lab page. They will also be available by request from Tamzen Stringham or Devon Snyder.

1. **List of MLRA 23 Disturbance Response Groups**

2. **MLRA 23 field notes organized by DRG**

3. **Site visit list**

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 date and by STM state**

5. **Geospatial data**

These data will include DRG maps and site visit locations.