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The Humboldt River Basin: A Chronology of the Humboldt's Historical Development and Water Resources

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Preface

The Humboldt River Basin is the only river basin wholly contained within the state of Nevada and is central in supporting lives and livelihoods. In 2000, the Nevada Division of Water Planning published the Humboldt River Chronology Series, which chronicled the Basin's historical development and natural resource challenges. Importantly, many of the developments discussed in the Chronology Series have changed in the past 25 years, and climate change further complicates pressing resource management challenges.

This document seeks to provide a timely update to the Chronology Series while expanding on contemporary resource management issues. Moreover, as this document aims to clarify, many of these issues are entangled in the Basin's history of economic expansion, social development, resource extraction, and evolution of water rights and water law. However, the rapidly unfolding changes in the Basin create limitations to this document. Due to the evolving nature of the Basin's numerous resource management challenges, there may be a renewed need for an update. Similar updates may be in order for Nevada's other river systems, and this may prove useful in contextualizing contemporary environmental issues in relation to a basin's historical development while illuminating intersections between past and present challenges in the management of Nevada's natural resources.

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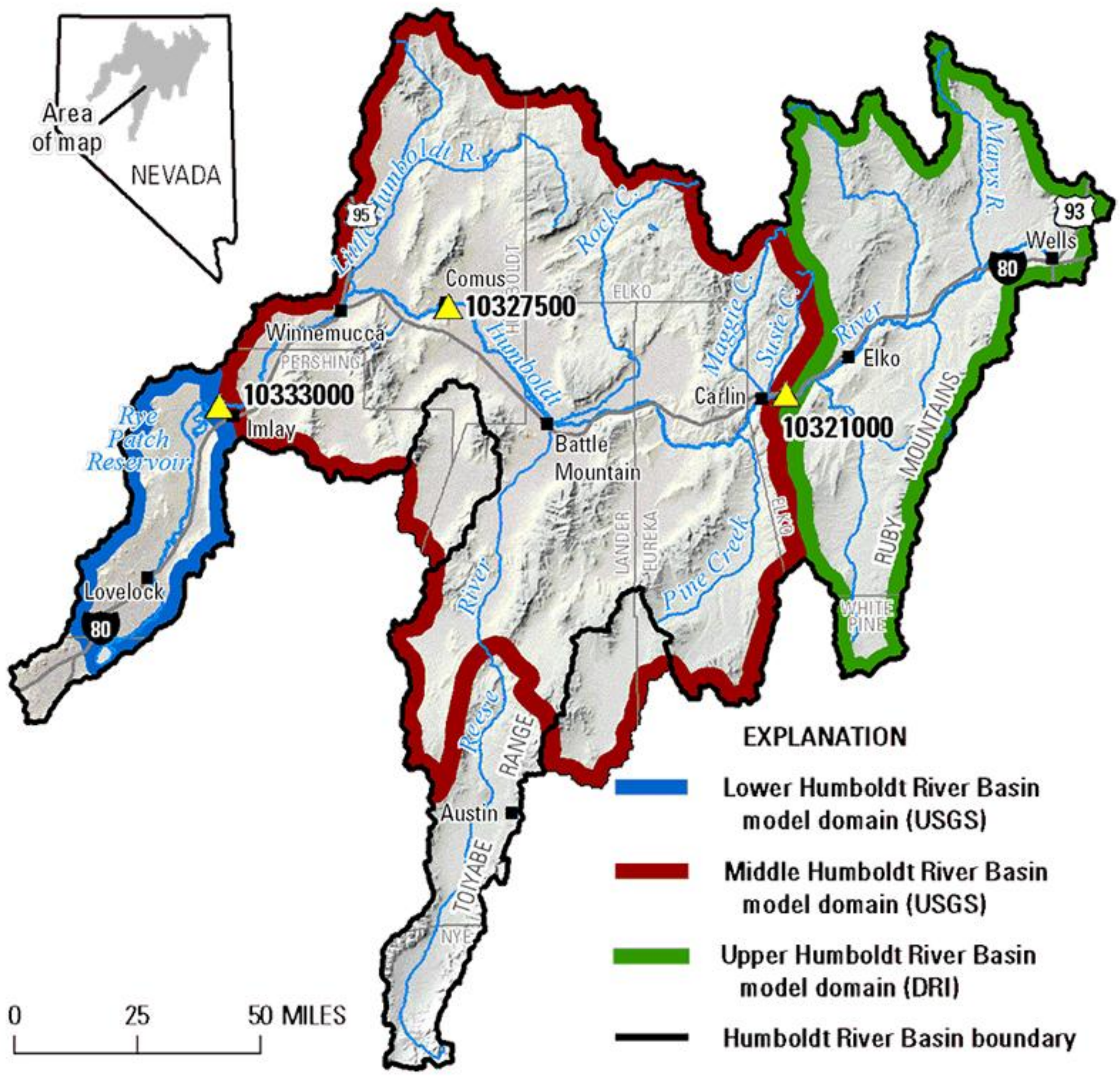
Chapter I: Climate, Terrain, and Streamflow

The Humboldt River Basin, located in north-central Nevada and comprising 33 hydrographic areas and one hydrographic sub-area,[1] is the only river system wholly contained within the state of Nevada. The Basin covers approximately 16,840 square miles, enveloping significant portions of Elko, Eureka, Lander, Humboldt and Pershing counties, and smaller portions of White Pine, Nye, and Churchill counties (NDWP, 2000a; Nadler et al., 2023).[2] The Basin's highest elevations are found in the Ruby Mountains (11,357 feet), with altitude decreasing westward and the lowest elevations occurring in the valley floors (3,900 feet) (Carroll et al., 2023; Nadler et al., 2023). In the east, the Basin is characterized by humid to subhumid continental conditions with cold winters and moderate to heavy precipitation. Moving westward, the climate is that of midlatitude steppe and midlatitude desert with cold winters, hot summers and semi-arid to arid conditions (Prudic et al., 2006; Prudic, 2007). Annual liquid precipitation ranges from an average of 36 inches in the Ruby, Independence and Jarbidge Mountains to a mere 6-8 inches in the valleys. The Basin's precipitation primarily comes from mountain snowpack (Carroll et al., 2023; NDWP, 2000a).

The Humboldt River's headwaters originate as winter snowpack in the Ruby, Independence and Jarbidge Mountains, and spring and summer snowmelt supplies river surface waters that flow westward to the Humboldt Sink, approximately 225 miles away in the desert of Churchill County. During the processes of water rights adjudication in the 1930s, the Palisade gage was identified as an appropriate dividing point between the upper and lower basins due to differences in climate and, hence, growing seasons and corresponding irrigation water requirements (NDWP, 2000a). Historically, the Palisade gage has also been accepted as the point along the Humboldt River where instream flows begin to decrease, and this is largely due to increasing evaporative losses and irrigation diversions (Benke and Cushing, 2005). The U.S. Geological Survey (USGS) topographically and hydrologically defines upper (upstream from Palisade), middle (between Palisade and Emigrant Canyon), and lower (downstream from Emigrant Canyon to the Humboldt Sink) basins based on the Palisade and Emigrant Canyons, which represent key constriction points along the Humboldt River Valley (NDWP, 2000a). The map on the next page shows the upper, middle and lower basins as defined by USGS in addition to the Humboldt River's tributaries. The map also indicates the Imlay, Comus and Carlin streamflow gages (Nevada Water Science Center, 2016). While the Basin is defined in these ways, it is also important to recognize how social, political, economic and environmental processes unfolding near the Basin's periphery may impact communities outside the Basin proper. Examples of such processes may include interbasin flow and the movement of labor.

[1] "Hydrographic area" is defined in Chapter 543, Section 185 of the Nevada Revised Statutes as "the drainage basin of a stream and its tributaries[…]" (Nevada Legislature, 2025b).

[2] Due to a shortage or absence of available Basin-level information, data reported throughout this paper is often at the county level. While this may introduce inaccuracies, discussion surrounding the data remains centered on the Humboldt River Basin. For a map showing how the Basin is spread out among these counties, see Appendix 1. Additionally, it is important to note that social, environment and economic processes occurring within the Basin may impact communities beyond its borders (and vice versa).



Map of the Humboldt River Basin, Nevada (Nevada Water Science Center, 2016).

Spatial and temporal fluctuations in precipitation create variations in the Humboldt River's streamflow and the replenishment of groundwater (Prudic, 2007). USGS streamflow gages tracking streamflow at several points along the Humboldt River make this dynamic clear. Table 1 displays five-year averages for the Humboldt River's streamflow at the Elko, Carlin, Palisade, Comus and Imlay gages for 1950 to 2023 (USGS, 2025). For each gage, the period with the lowest streamflow has been highlighted. The period with the lowest streamflow at each gage (except Comus) was 2000 to 2004. The period from 1990 to 1994 also stands out as a particularly dry period at the Elko, Carlin and Comus gages. Moreover, the periods 2010 to 2014 and 2020 to 2023 also show diminished streamflow compared to earlier periods, although they were not quite as dry as the aforementioned periods.

Table 1: Humboldt River Streamflow (acre-ft/year)

	Elko	Carlin	Palisade	Comus	Imlay
1950-54	166,932	250,333	279,349	218,797	201,479
1955-59	129,213	194,602	222,011	150,947	130,734
1960-64	127,867	198,033	168,742	115,154	123,595
1965-69	159,475	231,017	237,663	186,349	167,844
1970-74	236,809	334,892	408,041	339,004	225,443
1975-79	158,737	254,894	275,527	222,677	189,331
1980-84	386,713	588,670	468,666	445,600	607,450
1985-89	149,035	221,765	465,828	460,572	187,420
1990-94	80,360	127,331	177,994	135,468	79,448
1995-99	261,438	396,313	409,243	413,210	372,900
2000-04	74,525	111,549	165,962	140,189	66,706
2005-09	191,301	299,490	347,358	337,788	270,517
2010-14	105,960	164,543	226,268	149,962	85,438
2015-19	228,773	332,459	284,692	234,680	224,554
2020-23	91,346	151,580	204,448	143,164	74,282

While the upper basin comprises only 25% of the Basin by area, it contributes more than 95% of the Humboldt River's streamflow (Carroll et al., 2023). Over the course of the Humboldt River's flow, a combination of evaporation, irrigation and losses to depleted groundwater aquifers leave very little water to enter the Humboldt Sink (Benke and Cushing, 2005). Moreover, considering the ratio of peak flow to total basin area, the Humboldt River seems less "productive" in comparison to other major river systems in Nevada (e.g. the Truckee, Carson and Walker Rivers). This is attributable, in part, to topographic factors. Since the Humboldt River flows through lowland valleys that partially exist within the Sierra Nevada rain shadow, it has inferior potential for snowpack accumulation and runoff compared to river systems in higher-elevation drainages. Another attributing factor is the extensive irrigation that takes place within the Basin (NDWP, 2000a). As the area was developed and settled over time, increasing irrigation diversions and other human-induced changes would alter the Basin's environment and water resources.

Chapter II: Exploration, Settlement and Development

Native American Groups

The Western Shoshone, known as the Newe people, inhabited a large portion of the Great Basin region.[3] Traditionally, the Newe organized in extended family groups, with each inhabiting a particular place within the region. While they migrated throughout each year, they maintained strong attachments to certain valleys and mountain ranges. This resonance with the land is emblematic of their environmental stewardship: "Long before the coming of the whites, the Newe had developed their own distinctive way of life, characterized by the concept of living in harmony with the natural environment" (Crum, 1994). However, contact with European American explorers and, eventually, settler colonists would radically transform this way of life.

In 1827, Jedediah Smith of the Rocky Mountain Fur Company was likely the first White explorer to encounter the Newe. For this reason, Smith's expedition was significant. The trip was also significant in that Smith's disdain for the Newe established a profoundly negative reputation of the Great Basin tribes (Crum, 1994). Soon after, in 1828, Peter Skene Ogden led a company of trappers into the region, discovering the Humboldt River. In addition to largely clearing the area of beaver and native grasses, resources the Newe depended on, Ogden furthered negative depictions of the Newe (Crum, 1994). From 1827 to 1846, the Newe increasingly encountered White explorers and settlers who claimed the most productive lands and "[...] began the destructive cycle of exploiting natural resources" (Te-Moak Tribe of Western Shoshone, 2022). These explorers and settlers evoked the ethos of Manifest Destiny, making clear their contempt for Native Americans while encouraging public support for westward expansion (Green, 2015).

The westward migration of White explorers and settlers accelerated in the 1840s. The discovery of gold in California in 1848 motivated the influx of approximately 300,000 emigrants, exacerbating the rapid depletion of the region's natural resources (Tiller, 2015). As the Newe and other Native American groups increasingly lost access to resources that had sustained them for generations, White emigrants regarded them as subhuman and treated them with cruelty. The result was a growing tension that sometimes escalated into violence (Green, 2015; Crum, 1994). The rapid transformation of the environment along the Humboldt River during this time drove famine, resulting in extensive loss of Native lives in only a few short years. At the same time, the federal government, which had claimed all Native lands, pressured Native Americans to conform with federal policies and accept government paternalism (Crum, 1994). Ultimately, this period produced a host of changes that irreparably damaged Native ways of life.

The Treaty of Ruby Valley (1863) initiated a new stage in the relationship between the Newe and federal government. The agreement did not cede title to any Newe lands, although it did grant the U.S. rights-of-way to settle, explore and mine the lands. While conflict between White settlers and the Newe persisted, these conflicts were more sporadic. Conflict was primarily fueled by hostilities White settlers directed toward the Newe, who they regarded as "savages" (Crum, 1994; O'Connell, 2002). Despite growing hostility, the Newe honored the Treaty of Ruby Valley. Increasingly, however, the Newe were no longer able to follow their traditional ways of

[3] From southern Idaho to Death Valley, California, and from the Smith Creek Mountains in central Nevada to present-day Ely, Nevada (Crum 1994).

life. The establishment of rangeland fencing, private property rights and permanent settlements, combined with the accelerated depletion of natural resources facilitated by the cattle economy, severely disrupted Native Americans' long-standing traditional subsistence activities, causing widespread physical and economic dislocation (Hanes, 1982; Crum, 1994). The completion of the Transcontinental Railroad in 1869 exacerbated these issues as markets expanded into other parts of the state. As a result, the Newe and other tribal groups increasingly depended on farming and wage labor. However, the collapse of mining in the 1880s and 1890s disrupted the wage labor, produce markets and other systems Native groups had grown dependent on (Hanes, 1982; Crum, 1994).

In the late 19th and early 20th centuries, the federal government initiated greater efforts to assimilate the Newe while attempting to eliminate their culture. In establishing the Duck Valley Reservation in 1877, for example, the federal government sought to assimilate the Newe by eliminating their culture and replacing it with American customs. Moreover, the federal government effectively punished nonreservation Newe through discrimination and institutional neglect; they received little to no federal aid, causing them considerable hardship (Crum, 1994).

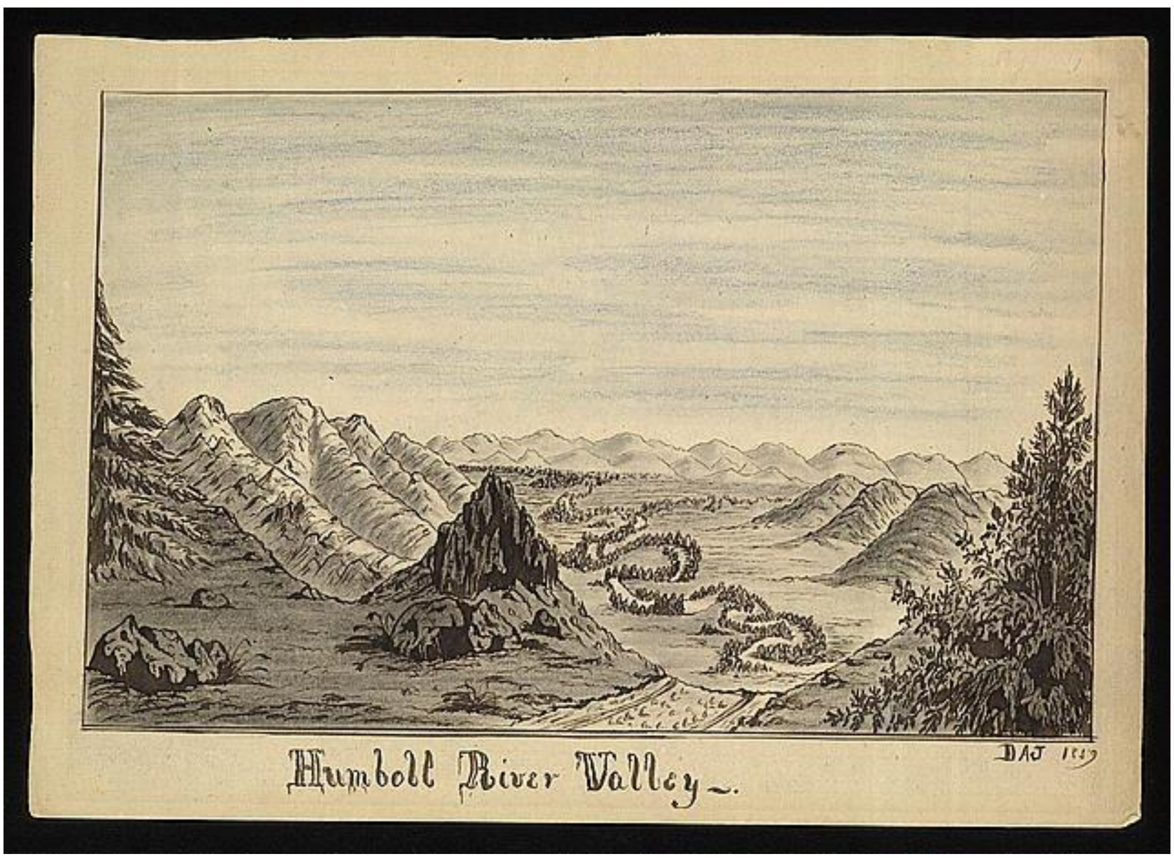
The overall impact of migration and settlement on Nevada's Native American groups was catastrophic. While there were approximately 40,000 Native Americans in Nevada at the beginning of the 19th century, only half remained by 1870 (Green, 2015). This was largely due to malnourishment and the introduction of disease in addition to the abovementioned factors (i.e. rangeland fencing, private property rights, depletion of natural resources and institutional neglect) that irreparably damaged Native ways of life (Hanes, 1982; Crum, 1994).

Over time, the Newe have faced numerous legal battles with the federal government, primarily over land ownership (Te-Moak Tribe of Western Shoshone, 2022). Indeed, Crum (1994) posits that one of the most consequential contemporary issues facing the Newe is that of land claims. Moreover, while the 1908 Winters doctrine (*Winters v. United States*) established that Native American groups have rights to water resources for reservations, its application has been flawed. In addition to there being a dearth of research on tribal water quality and security, insufficient resources have been allocated to address these issues. The fact that no standardized metrics exist for quantifying water security on reservations further complicates the issue, introducing uncertainty into water planning processes (Bandala et al., 2022).

Despite this history of cruelty, discrimination and violence, the Newe and other tribal groups have demonstrated resilience in maintaining key facets of their native cultures (Crum, 1994). Currently, the Te-Moak Tribe of Western Shoshone comprises four Nevada Bands: the Elko Colony, Battle Mountain Colony, Wells Colony and South Fork Reservation (Te-Moak Tribe of Western Shoshone, 2022). The Te-Moak Tribal Council holds jurisdiction over all tribal lands, although each constituent colony has its own governing council, maintaining sovereignty over all other tribal affairs (Tiller, 2015). The Yomba Shoshone Tribe is also proximal to the Humboldt River Basin. Additionally, while this section has largely focused on the Newe, there are other federally recognized tribes within the Basin, namely the Northern Paiute (Numu). Numu tribes within the Basin include the Winnemucca Colony Council and the Lovelock Paiute Tribe (Nevada Department of Native American Affairs, 2024).

Early Exploration

In leading fur trappers of the Hudson's Bay Fur Company into the Humboldt River Basin in 1828, Ogden explored the Humboldt River from its headwaters to its terminus. Fur trapping remained as the Basin's chief economic activity until the late 1830s. As the region was largely cleared of beaver, the fur trade declined. Former fur trappers searching for new ways to generate profits became scouts for emigrant parties traveling westward to Oregon or California (NDWP, 2000b; Green, 2015). The passage of the Bidwell-Bartleson party into the San Joaquin Valley in 1841 marked the beginning of a longer period of emigration and settlement as transportation routes through the Basin were increasingly developed and utilized. Thus, the Humboldt River became critically important in westward migration from the 1840s to the 1870s as a key part of the California Emigrant Trail (NDWP, 2000a).



Drawing of the Humboldt River Valley, 1859 (retrieved from the Library of Congress) (Jenks, 1859).

The arrival of European emigrants and settlers precipitated numerous changes to the Basin. While fur trapping was relatively noninvasive in that resource use and extraction minimally altered the Basin's environmental conditions, later economic activities (e.g. mining, farming and livestock grazing) placed greater stress on the environment, profoundly impacting land, timber, vegetation and water resources. Early farmers, ranchers and miners liberally claimed land and water resources while later settlers vied for remaining resources. Over time, emigration and settlement harmed native grasses, accelerated erosion (thereby intensifying downstream flooding), and exacerbated wildfire frequency and severity as natural fires were increasingly suppressed (Hulse, 2009; NDWP, 2000a).

As the next few sections highlight, the Basin's economic and social development was rapid at times and stagnant at others, following industries' booms and busts. The result was an uneven and discontinuous pattern of development with varied impacts on the environment (NDWP, 2000a). Ultimately, however, the Basin's environment was placed under increasing stress as the region became more populated and developed, thereby producing a host of resource management challenges that have persisted into the present.

Settlement Policies

The Humboldt River served as a primary route for westward migration from the early 1840s to the early 1870s and became a major east-west railroad passage with the completion of the Transcontinental Railroad in 1869 (NDWP, 2000a). Settlers, grazers and miners were active in the Basin during this early period of migration, and many had exploited the area for its land and water resources with little regard for ecological damage or the displacement of Native peoples. During the 1860s and 1870s, the federal government initiated various efforts to "privatize" the West (Hulse, 2009). They sought to motivate rapid settlement by vesting new ownership in settlers, incentivizing them to stay and cultivate the lands through legislation such as the Homestead Act of 1862 and the Desert Land Entry Act of 1877 (Hoffmann, 2015). The Homestead Act allowed citizens to acquire 160 acres of land, receiving title after five years of residency (subsequently reduced to 14 months) and after meeting certain cultivation requirements (Stern and Normand, 2020; NDWP, 2000b). The Desert Land Entry Act effectively expanded on the Homestead Act in that it provided for more land at cheaper prices, again contingent upon the completion of certain reclamation requirements (Stern and Normand, 2020). These reclamation requirements typically involved land leveling, the construction of well water systems and irrigated crop production. Initially, the act allowed citizens to acquire 640 acres of land by diverting water to it, cultivating at least 20% of it (reduced in 1890 to 320 acres with at least 12.5% irrigated) (NDWP, 2000b).

While these acts were integral in the development of the Humboldt River Basin, they were relatively ineffective at empowering individual homesteaders. As it was not economically feasible for individuals to profitably homestead on a few hundred acres of land, the acts effectively consolidated control of land, mineral and water resources for a small number of larger enterprises (Hoffmann, 2015). In this way, while the railroads, livestock barons and mining industry thrived, individual farmers and miners — the intended beneficiaries of these acts — struggled to secure both land and water resources. Additionally, because early settlers abundantly claimed land and water resources, later settlers faced considerable difficulty in obtaining suitable lands and sufficient water supplies (Hulse, 2009; Hoffman, 2015).

The impact of settlement policies is made clear in Table 2 (U.S. Census Bureau, 1872, 1883; Nevada State Library, Archives and Public Records, 1877). Nevada's population grew approximately 680% from 6,857 in 1860 to 53,556 in 1880. While the Humboldt River Basin did not experience growth at this scale, each county's population still expanded considerably. The sole exception was White Pine County, where the population dramatically fell. This was, in part, due to the establishment of Eureka County in 1873 from lands derived from Elko, Lander and White Pine counties (Eureka County, 2023). Additionally, Pershing County is not included because it was not established until 1919, from lands formerly part of Humboldt County (Borden et al. 2021).

Table 2: Population, Real Estate and Personal Property (1860-1880)

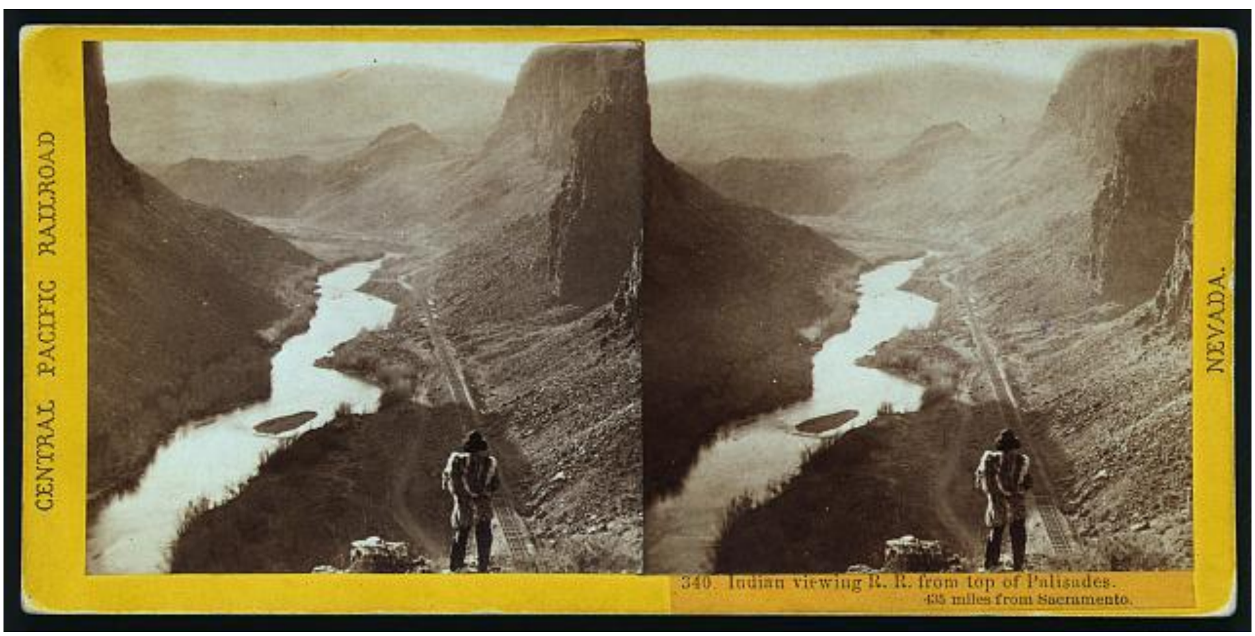
	Nevada	Elko	Eureka	Humboldt
Population (1860)	6,857	-	-	40
Population (1870)	42,491	3,447	-	1,916
Population (1880)	53,556	5,716	7,086	3,471
Real estate value (1875)	$16,011,987	$1,486,725	$1,337,758	$1,289,777
Personal property value (1875)	$13,131,291	$1,480,932	$1,619,422	$1,120,588
	Lander	**White Pine**	**Nye**	**Churchill**
Population (1860)	-	-	-	-
Population (1870)	2,815	7,189	1,087	196
Population (1880)	3,624	2,682	1,875	499
Real estate value (1875)	$436,620	$624,845	$621,820	$260,700
Personal property value (1875)	$1,038,444	$773,403	$706,319	$125,475

The Railroads

The federal government motivated further development in the Basin through the Land Grant Act of 1862 and the Pacific Railway Acts of 1862 and 1864, which provided railroad companies with generous bonds and land subsidies (White, 2011; Green, 2015). The Land Grant Act of 1862 provided railroad companies ownership of every other section (640 acres) of land for 20 miles on each side of a rail line (NDWP, 2000b). Moreover, through the 1862 Pacific Railway Act, two corporations secured rights to build with government aid: Central Pacific and Union Pacific (White, 2011). This act approved land grants, rights-of-way and bonds for Central Pacific to build eastward from Sacramento, while Union Pacific built westward from Omaha. The 1864 Pacific Railway Act expanded on the 1862 act in that it provided $50 million in government bonds for 30 years, while doubling the land subsidy such that, for every mile of railroad built, railroad companies would receive 1,280 acres and any coal or iron those lands contained. Subsequently, the railroad companies sold land to settlers to repay their bonds while simultaneously creating new customers and, thus, revenues (White, 2011; Green, 2015).

The construction of the railroads was central in improving transportation, which stimulated commerce throughout the Basin. In August 1868, Central Pacific reached Lovelock. Soon after, they began the next phase of construction through the Humboldt River Valley from Lovelock to Wells. By September 1868, Central Pacific reached Winnemucca, and the railroad was formally opened for business to that point in October. This enabled greater commerce throughout the Basin. By November 1868, Central Pacific reached Palisade and Pine Creek, initiating a period of greater grass and timber use in Pine Valley. In early 1869, Central Pacific reached Wells, developing the area into a railroad division point and helper terminal. This instigated the development of the upper Basin for expansive ranching and other agricultural uses. Finally, in May 1869, Central Pacific met Union Pacific at Promontory Point, Utah, thereby completing the Transcontinental Railroad (NDWP, 2000b).

The completion of the Transcontinental, which transformed the Basin into a major east-west railroad passage, was integral in fostering population growth while accelerating economic activity. The railroads were also central in building or expanding many towns throughout the Basin as increasing demands for services inspired entrepreneurs to develop trading posts and settlements. Mining and ranching hinterlands were subsequently developed through the valley networks of these railroad towns. Furthermore, larger centers of commerce such as Winnemucca and Elko gained economic traction in servicing the needs of mining districts. Because several of these mining districts were located on the Basin’s periphery, the railroads were critical in enabling this economic activity and growth (Green, 2015; NDWP, 2000a).



A Native American views the Central Pacific Railroad from Palisade, c. 1868-1869 (retrieved from the Library of Congress) (Hart, c. 1868-1869).

The railroads stimulated economic activity with the establishment of communities such as Winnemucca and Elko, and it was the development of these centers of commerce that promoted the growth of mining and ranching hinterlands (Hulse, 2009; Green, 2015). However, it can also be argued that the railroads constrained early commercial opportunities by imposing excessive freight rates, particularly during the last three decades of the 19th century. In this way, railroad investors captured greater value than what flowed to migrants or settlers (Hulse, 2009). Furthermore, since most Western goods needed processing, mills, stockyards and smelters were sited based on freight rates. In setting freight rates, the railroads maintained the power to effectively transform the structure of entire industries: “Railroads had the ability to disrupt existing market networks and determine whether existing towns and businesses prospered or died” (White, 2011). Central to this dynamic is the idea of relational space (the measurement of space through the costs and time of transporting goods), which the railroads controlled through freight rates. As rates changed, the relational space between two places either shrunk or grew. Thus, by manipulating freight rates, the railroads could discriminate against certain individuals, places and goods, effectively allowing them to set the terms of competition (White, 2011).

> “The said railroad company [Central Pacific] exercises over the persons and property of others an almost absolute power, vicious and tyrannical, destructive of the rights of persons and of property, and opposed to common justice, as well as to every principle of civil and constitutional liberty known since the days of Magna Charta [sic]” (Nevada Legislature, 1881).
>
> “Mining and railroad interests almost completely dominated Nevada politics from statehood until well into the twentieth century” (Green, 2015).

In experiencing discrimination in both freight rates and passenger fares, the people of the Humboldt River Basin (and Nevada, overall) urged the State Legislature to prevent further discrimination. One prominent example of discrimination was through back-hauling. Central Pacific required that freights shipped from east of the Missouri River be transported into California before arriving in Nevada. In this way, people were required to pay for hundreds of additional miles of unnecessary transport. This proved inefficient and costly for businesses and towns such as Palisade, Battle Mountain and Elko. This form of discrimination was also prevalent in passenger fares; Central Pacific demanded payment for hundreds of miles passengers would not travel (Nevada Legislature, 1879, 1881). In these ways, the railroads functioned as a double-edged sword: they enabled greater economic activity with the expansion of markets, though they simultaneously impeded growth in setting oppressive freight rates and passenger fares. By the end of the 19th century, however, opponents of the railroads confronted them politically, causing them to lose much of their power in Congress and state legislatures (White, 2011).

Mining and Agriculture

The initial period of migration and settlement created new demands for agricultural products in the Basin. These demands increased with the 1860s mining boom and the resultant influx of migrants and settlers. Consequently, the Basin’s agriculture industry rapidly expanded, initiating a period of land clearing, dam construction, canal building, irrigation diversions, wetland draining, agricultural cultivation and open-range grazing, which have persisted into the present (NDWP, 2000a). Underground mining methods were also developed in the 1860s. As a result, mining interests excavated the Basin's terrain using dynamite while denuding mountain areas of timber for mine shafts (Hulse, 2009). From 1862 to 1873, extensive farming and grazing operations developed across virtually the entire Basin. Then, by 1875, the Basin's agricultural activities had shifted from the production of small grains and produce to raising livestock. Livestock grazing from the 1870s through the 1880s would severely reduce plant cover in upper watershed areas (NDWP, 2000c). At the same time, the discovery of valuable silver ore deposits provoked an explosion of mining activities throughout the Basin. This period emblematizes the Basin's pattern of growth; the region developed sporadically over time in accordance with the booms and busts of industry.

The Mining Law of 1872 provided a significant impetus for the mining industry, as it enabled the prospecting and mining of federal lands in addition to the acquisition of those lands. The law opened federal lands to prospecting, allowing individuals to stake lode and placer claims under a first-in-time, first-in-right basis. In proving a valid mineral discovery in addition to a minimum investment in development of $500, an individual could purchase the land (NDWP, 2000b; Watkins, 2000). To do so would cost applicants $2.50/acre for placer claims and $5/acre for lode claims. To keep their claims valid, mining interests were required to invest at least $100 in labor per year (changed in 1993 to a $100 annual holding fee) (Wolters and Steel, 2020). Additionally, the law does not require mining interests to pay any royalties to the federal government (Watkins, 2000).

The 1860s and 1870s were marked by mining booms, although the depletion of valuable mineral deposits combined with the demonetization of silver would virtually halt mining and prospecting activities throughout the Basin (Green, 2015; NDWP, 2000a, 2000b). Specifically, it was the repeal of the Sherman Silver Purchase Act which demonetized silver, curtailing its use as currency. This reinforced Nevada's Twenty-Year Depression (1881-1900) during which the Basin's population fell by approximately 31.5% (Green, 2015; NDWP, 2000b). Mining, agriculture and livestock grazing were all integral in the early settlement and development of the Basin. However, the boom-to-bust nature of the mining industry fostered a transient culture. Additionally, the capital required to establish a functioning mining economy privileged mining and railroad interests, effectively establishing a small power elite, while workers and the state remained dependent on these industries (Green, 2015).

While mining produced greater economic impacts than agriculture, the latter served as a stabilizing force which, to some extent, counterbalanced the mining industry's volatile boom-to-bust nature. The mining booms that characterized the 1860s and 1870s fueled the growth of towns such as Elko and Winnemucca into hubs for commerce and transportation. Though mining activity was widespread in the Basin, its scale was less than those of the larger booms in other parts of Nevada (e.g. Virginia City and Goldfield). However, the Basin's integral role in the movement of goods and services meant it still benefited from the larger booms occurring beyond its borders (NDWP, 2000a). Agriculture was central in this dynamic. The industry's exports were critical in generating revenue from outside of the Basin. In this way, the agriculture industry would support the mining industry during booms, while conducting business outside the Basin during busts (NDWP, 2000a). Thus, against the backdrop of the mining industry's characteristic volatility, it was in this way that agriculture functioned as a stabilizing economic force.

Rapid population growth during the 19th century escalated competition over increasingly scarce resources throughout the Basin. Much of this competition centered around access to limited surface water sources (Hoffmann, 2015). The 1888-1889 drought put considerable stress on the Basin's already scarce water resources. Following the drought, surface waters were more intensively diverted to irrigate livestock pasture and crop lands (NDWP, 2000a). As upper Basin ranchers increased their water diversions, the amount of water reaching farmers in the lower Basin was severely reduced (Benke and Cushing, 2005). The White Winter (1889-1890) further increased competition as ranchers faced significant livestock losses. At this point, conflict between upper and lower Basin users reached a climax, signaling the clear need for water rights adjudication (NDWP, 2000a).

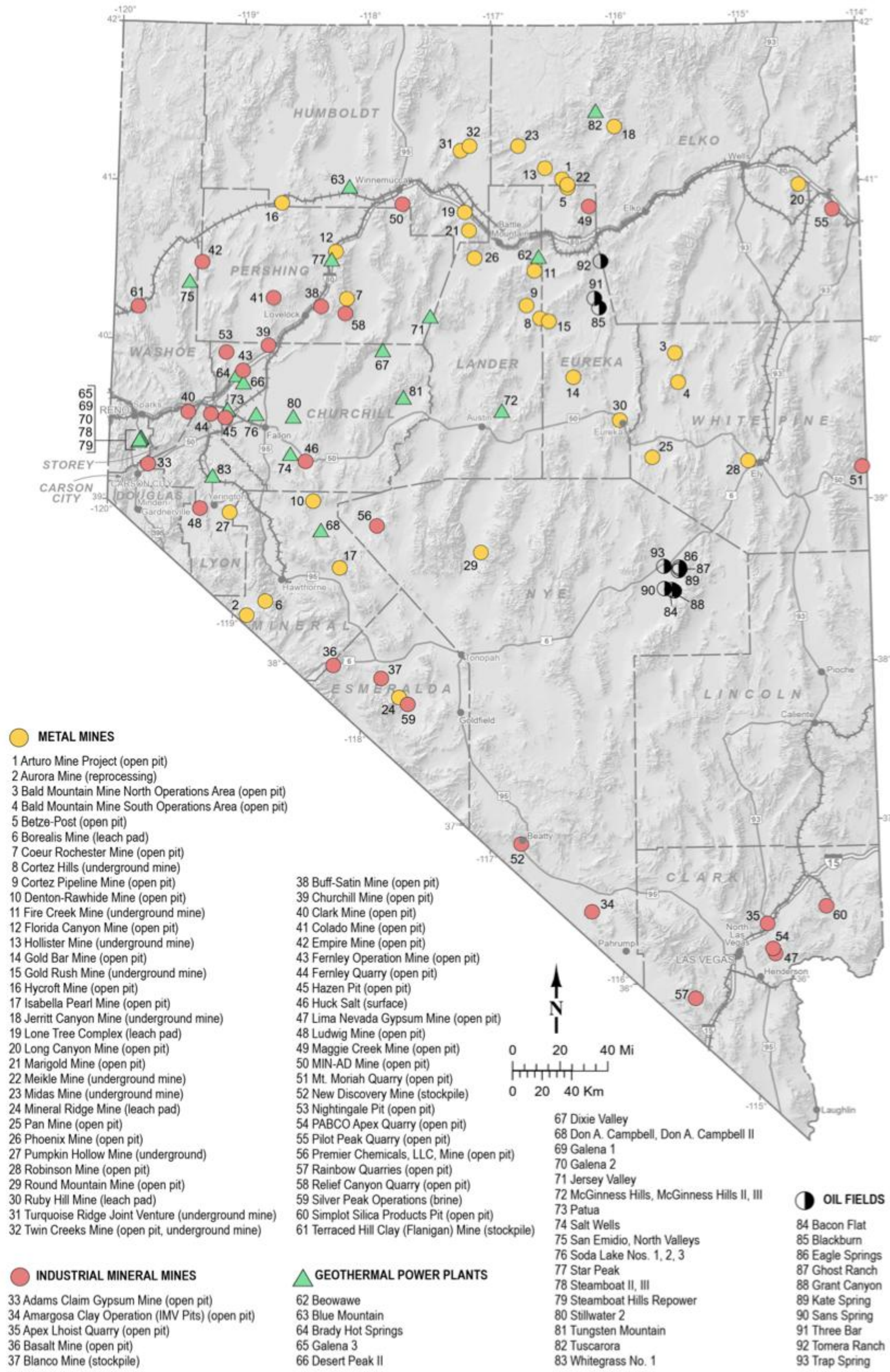
Following the Twenty-Year Depression, the Basin's mining industry was revived by gold and silver discoveries. The discovery of silver in Tonopah in 1900 created other booms and boomtowns, which served as hubs for mining and ranching hinterlands (Green, 2015). With the resurgence of prospecting throughout Nevada, gold was discovered north of Carlin in 1907 (NDWP, 2000a). The Basin's mining and agriculture industries further benefited from increased global wartime production demands, although the former's boom-to-bust nature would persist throughout much of the 20^{th} and 21^{st} centuries. The Basin's economy benefited from World War I, as higher prices for agricultural commodities boosted profits for farmers and ranchers. The mining industry also flourished, as copper production boomed and the Pittman Act of 1918 initiated federal silver purchases. Following WWI, however, mining and agriculture revenues declined (Green, 2015). The Great Depression further impacted mining and agriculture productivity, plunging revenues. However, agriculture rebounded in the 1930s with the New Deal. Additionally, the 1934 Silver Purchase Act provided a valuable impetus to the mining industry, significantly increasing both mining production and employment. As the U.S. economy cooled down in 1937 and 1938, however, so did the mining industry (Green, 2015).

Main Street, Winnemucca, c. 1940 (retrieved from the Library of Congress) (Rothstein, 1940).

Like WWI, World War II provided an important stimulus for mining and agriculture with both industries increasing production. In 1934, the Riley and Getchell Mines were developed in Humboldt County for tungsten and gold (NDWP, 2000a). However, these booms would also eventually bust. Later, the Korean War and Vietnam War sparked mining booms with increasing copper prices and production. This boosted mining operations in White Pine County. Uranium mining near Austin and mercury mining in Humboldt County also flourished during this time. Subsequently, mining activities slowed with the end of the Vietnam War, curbing demand. However, there remained some successful gold and silver mining operations along the Carlin Trend, at Round Mountain and in White Pine County (Green, 2015). It was also during the 1960s that groundwater pumping began in the upper Basin. Pumping increased in the following decades, reaching a peak in the 1990s with the proliferation of large gold mines. This has created concerns over the Basin's water resources, as the increased demand for groundwater combined with dewatering activities threaten to deplete downstream water supplies (Carroll et al., 2023; Prudic et al., 2006).

As the mining industry faced considerable volatility throughout much of the 20th century, agriculture and transportation would be central to the Basin's economy until the 1980s (NDWP, 2000a). The mining industry was then resurrected in the 1980s with abundant gold discoveries combined with favorable macroeconomic conditions. Rising gold prices plus advancements in metallurgy and mining technologies produced a gold rush in the Basin. This fueled the extensive development of gold mining in western Elko and northern Eureka counties (Hulse, 2009; NDWP, 2000a).

The newfound prosperity of the mining industry slowed in the 1990s. In 1992, European nations signed the Maastricht Treaty, which underpinned the foundation of the European Monetary Union (EMU) and creation of the euro. As a result, from 1992 to 1999, EMU banks sold millions of ounces of gold, drastically impacting global gold demands. This significantly reduced gold prices. In the Humboldt River Basin, this severely reduced gold mine production and employment (NDWP, 2000c). Despite this downward economic trend, mining interests remained hopeful, as gold prices increased from 2000 to 2012. The mining industry then rebounded, producing considerable revenues and job growth from 2009 to 2012. After the market slowed in 2013, however, ore exploration plummeted in the Basin (Green, 2015). Even though the Basin's mining industry has faced extreme volatility since its initial booms in the 1860s, it has maintained considerable political and economic power. Nevada produced 74% of the nation's gold and was the fifth-largest world gold producer in 2021 (Berry et al., 2024). Moreover, the map on the next page highlights the abundance of (primarily metal) mines along the Humboldt River and proximal to it as of 2023, indicating the industry's continued importance throughout the Basin (Ghiglieri and Patterson, 2024). Moving forward, Thacker Pass (located approximately 60 miles northwest of Winnemucca) will play an integral role in meeting the U.S.' lithium demand (Lithium Americas, 2024).



Major mines of Nevada, 2023 (Ghiglieri and Patterson, 2024).

Role of Federal Government

Federal public lands in the Humboldt River Basin (and in Nevada, overall) are abundant and serve an important role for people, businesses and the environment. These lands are managed by a variety of federal agencies — the Bureau of Land Management (BLM), U.S. Forest Service, U.S. Fish and Wildlife Service, National Parks Service (NPS) and the Department of Defense (DOD) — and various other agencies at the state and local levels. These agencies administer public lands to serve multiple, sustained uses to optimize and promote commercial, recreational and conservation activities such as energy development, livestock grazing, mining, recreation and ecosystem conservation (e.g. the protection of watershed areas and fish and wildlife habitat) (Payne, 2016; U.S. BLM, 2016b). A central goal of management is the promotion of healthy and productive public lands to ensure continued access for future generations. This includes the conservation of natural, historical and cultural resources, all of which are important components of sustainable resource management (Segerblom, 2024; U.S. BLM, 2016c).

"One of the ironies of the American West is that despite its place in American mythology as a place of unlimited bounty, opportunity, and success for any rugged individual willing to move there, its growth in the nineteenth and early twentieth centuries actually spawned an economy where only a relatively small number of Americans harvested the region's rich natural resources" (Bakken, 2011).

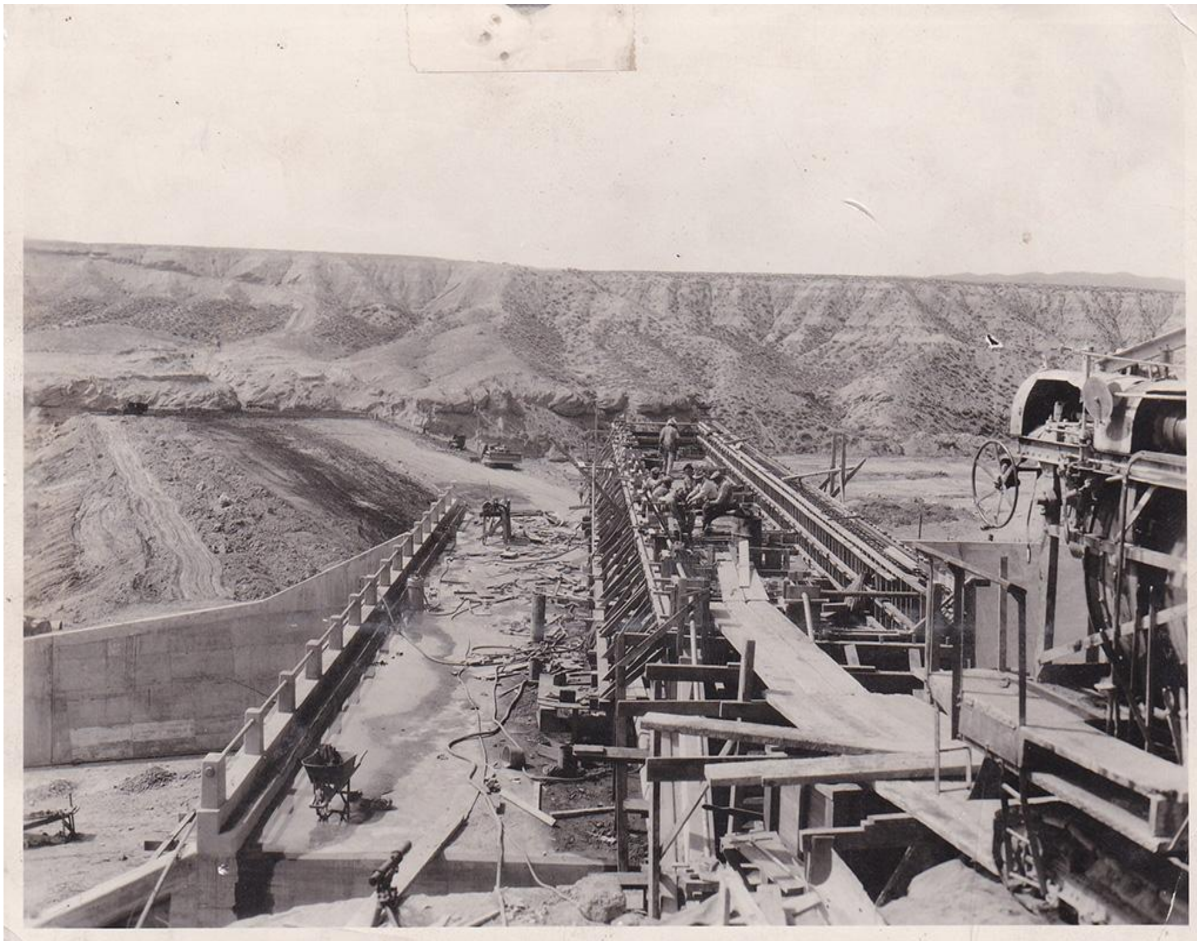
While mining, farming and livestock grazing generated considerable economic activity, a lot of the Basin's development was enabled by the federal government. As the Basin expanded and its population grew, the need for large water diversions and storage infrastructure became abundantly clear. Thus, federal involvement increasingly became needed to support development. The Reclamation Act of 1902 enabled the federal government to develop large water projects, and its establishment of the Bureau of Reclamation (BOR) was instrumental in fueling the development of water resources (Freemuth and Smith, 2016). The Humboldt Project, which provided for the acquisition of upstream lands and water rights for storage at Rye Patch Reservoir, was critical in addressing the growing demands for water storage. Another element of the project was initiated in the 1950s when the Army Corps of Engineers alongside the Bureau of Reclamation channelized a large section of the Argenta Marsh (near Argenta and Battle Mountain) to drain the area's floodplain, transferring the acquired water rights for storage at Rye Patch Reservoir (U.S. Bureau of Reclamation, 2024; NDWP, 2000c). The Basin's agriculture industry in Lovelock Valley has been and remains highly dependent on the Rye Patch Reservoir. As the sole storage facility on the Humboldt River's main stem, it plays an integral role in the lower Basin's agricultural development (NDWP, 2000a). Table 3 displays some of the Basin's major water storage facilities, including the Rye Patch Reservoir (National Inventory of Dams, 2024).

Table 3: Humboldt River Basin Water Storage Facilities

Name	Completion Date	Location	Purpose	Max. Storage Capacity (acre-ft)	Normal Storage Capacity (acre-ft)	Condition, Hazard Potential
Bishop Creek Dam	1912	Metropolis, Elko County	Irrigation, recreation, flood risk mitigation	28,250	230	Unsatisfactory, High
South Fork Dam	1989	Palisade, Elko County	Recreation, fish/wildlife, flood risk mitigation	52,500	41,250	Fair, High
Maggie Creek Dam	1992	Carlin, Elko County	Flood risk mitigation, irrigation, recreation, water supply	9,500	3,500	Fair, High
T-S Ranch Dam	1990	Dunphy, Eureka County	Irrigation	1,900	40	Not rated, Significant
Willow Creek Dam	1986	Tuscarora, Elko County	Irrigation, fish/wildlife, recreation, flood risk mitigation	8,000	5,000	Not rated, Low
Chimney Dam	1974	Winnemucca, Humboldt County	Recreation, irrigation	66,000	35,000	Poor, Significant
Lone Tree Section 23 Tails Dam	1996	Golconda, Humboldt County	Flood risk mitigation, tailings	20,040	17,760	Fair, Significant
Upper Pitt-Taylor Dam	1907-1911	Lovelock, Pershing County	Irrigation	24,000	20,000	Unsatisfactory, Low
Lower Pitt-Taylor Dam	1907-1911	Lovelock, Pershing County	Irrigation	20,200	20,000	Poor, Low
Rye Patch Dam	1936	Lovelock, Pershing County	Irrigation, recreation	201,600	194,300	Fair, High

While the role of the federal government was instrumental in the development of the Humboldt River Basin, a sense of alienation has existed among communities who felt disadvantaged in decision-making processes unfolding outside of the Basin, and outside of the West altogether. Decision-making concerning natural resources (i.e. developing water supplies, grazing fees, timber roads and access to minerals) have historically been concentrated at the federal level, limiting the agency of Western communities, such as those in the Humboldt River Basin

(Freemuth and Smith, 2016). Moreover, the Reclamation Act of 1902 has been criticized for fostering an environment where large bureaucracies and corporate farmers (speculators and non-resident landowners) could prosper as the main beneficiaries of reclamation projects, while settlers — small farmers and landowners the act sought to help — struggled (Cannon, 2002).



Rye Patch Dam and Reservoir construction, 1935 (Nevada Division of State Parks, 1935).

The high degree of federal land ownership is another major point of contention. Currently, approximately 84.4% of land in Nevada (59.6 million acres out of 70.6 million acres) is owned and administered by the federal government, and federal ownership is greater than 90% in some rural counties, including the Humboldt River Basin's Nye and White Pine counties (Solano-Patricio et al., 2020). Table 4 shows the distribution of land ownership across each of the Basin's constituent counties (Solano-Patricio et al., 2020). State lands comprise very small shares (less than 0.5%) of the total land area in each county. Additionally, while private lands represent a much larger share across each county, it still pales in comparison to the amount of land federally owned.

Table 4: Land Ownership in the Humboldt River Basin (acres)

	Total Land Area	Federal Lands	State Lands	Private Lands	Tribal Lands
Elko County	11,009,486	7,982,731 (72.5%)	22,413 (0.2%)	2,844,111 (25.8%)	160,231 (1.5%)
Eureka County	2,675,173	2,110,168 (78.9%)	0 (0%)	565,004 (21.1%)	0 (0%)
Lander County	3,532,482	2,991,340 (84.7%)	3,476 (0.1%)	537,034 (15.2%)	630 (0.018%)
Humboldt County	6,181,029	5,054,762 (81.8%)	0 (0%)	1,096,813 (17.7%)	29,453 (0.5%)
Pershing County	3,883,169	2,923,252 (75.3%)	7,431 (0.2%)	946,467 (24.4%)	6,018 (0.2%)
White Pine County	5,693,255	5,369,792 (94.3%)	7,831 (0.1%)	245,145 (4.3%)	70,488 (1.2%)
Nye County	11,647,102	11,322,575 (97.2%)	10,263 (0.1%)	305,785 (2.6%)	8,479 (0.1%)
Churchill County	3,215,467	2,364,081 (73.5%)	7,823 (0.2%)	791,160 (24.6%)	52,401 (1.6%)
Nevada	70,664,589	59,661,755 (84.4%)	166,321 (0.2%)	9,576,613 (13.6%)	1,243,958 (1.8%)

Federal public lands are not subject to taxation, depriving Nevada of considerable revenues. Although rural counties receive payments in lieu of taxes (PILT), some argue that the abundance of federal land ownership constrains the state's ability to motivate economic development. And, since the PILT formula is partially population-dependent, counties with high percentages of federal land ownership and small populations do not always receive the greatest payments (Nevada Legislative Counsel Bureau, 2016a; Ruedy, 2016). Although Nevada had the second largest amount of entitlement acreage in 2024, it ranked 10th highest in PILT payments at $32,886,305 ($0.58 per entitlement acre). PILT payments are important to rural counties such as those in the Humboldt River Basin because they enable local governments to execute vital services (e.g. emergency services, education and infrastructure development) (Harris, 2024).

Due to the federal government's dominant presence in the Basin, federal laws and regulations are critical in natural resource management, significantly influencing local policy and individual behaviors (Nevada Legislative Counsel Bureau, 2016a). The federal government's control in the Basin and across the state generally increased through the late 20th century, exercising greater authority in enforcing air and water quality standards while also committing to maintaining ownership over and management of public lands. In the 1950s, the BLM reduced the number of livestock permitted to graze by roughly one-third. Grazing allotments were then fenced for the first time in the 1960s. In 1974, the National Resource Defense Council successfully argued in a lawsuit against the Secretary of the Interior that public lands were being overgrazed. As most Nevadan ranchers, including those in the Basin, leased public grazing lands from the BLM and the U.S. Forest Service, this series of developments had major implications for the livestock industry (Library of Congress, 2014).

The Federal Land Policy Management Act (FLPMA) of 1976 established that most public domain land would permanently remain under federal control. The act ultimately provoked the "Sagebrush Rebellion," which originated in Elko County and sought to transfer federal lands to state and local interests. While proponents of the movement contested that they were resisting oppressive federal control and encroachment, others argued the movement was fueled by government hatred (Las Vegas Sun, 1999).

The Sagebrush Rebellion ultimately reflected a deep discontent with the degree of federal control throughout Nevada. While the movement's momentum has stagnated over time, traces of resistance remain. For example, in 1994, Nye County Commissioner Dick Carver forcibly reopened a road the federal government had closed. Similarly, in Elko County in 2000, the Jarbidge Shovel Brigade reopened a road the U.S. Forest Service had closed (Green, 2014). More recently, in April 2014, a standoff with hundreds of backers of the Clark County cattle rancher Cliven Bundy resulted in the BLM ceasing the enforcement of court orders to remove Bundy cattle from public lands surrounding his ranch (Ritter, 2024).

Overall, the great extent of federal land ownership has created a simultaneous reliance on and resentment of federal control (Freemuth and Smith, 2016; Green, 2015; Hulse, 2009). Notably, participants of the Western Governors' Drought Forum emphasized that there exists a clear need for greater transparency and collaboration among federal, state and local stakeholders in decision-making processes surrounding the management of natural resources (Western Governors' Association, 2015).

The Contemporary Humboldt River Basin

The Humboldt River Basin has considerably expanded over time with respect to its population and economy. Table 5 shows the changes in population among the Basin's counties (Nevada Legislative Counsel Bureau, 2021). Of the Basin's five principal counties, only Lander's population has decreased since 1990. White Pine's population also fell, but by only 2% compared to Lander's 8%. In contrast, Elko and Nye have experienced substantial growth. The enormous growth observed in Nye County, however, is likely attributable to growth outside of the Basin in communities such as Pahrump.

Table 5: Humboldt River Basin Population Over Time

	Nevada	Elko	Eureka	Humboldt	Lander	Pershing	White Pine	Nye	Churchill
1990 Census	1,201,833	33,530	1,547	12,844	6,266	4,336	9,264	17,781	17,938
2000 Census	1,998,257	45,291	1,651	16,106	5,794	6,693	9,181	32,485	23,892
2010 Census	2,700,551	48,818	1,987	16,528	5,775	6,753	10,030	43,946	24,877
2020 Census	3,104,614	53,702	1,855	17,285	5,734	6,650	9,080	51,591	25,516
Change, 1990-2020	158%	60%	20%	35%	-8%	53%	-2%	190%	42%

Although a variety of industries have developed and grown throughout the Basin over time, mining and agriculture remain central to the Basin's economy. Table 6 outlines the distribution of labor by industry among the Basin's constituent counties (U.S. Census Bureau, 2025).[4] Of each industry that plays a role in the Basin's economy, agriculture, forestry and mining comprise the largest share of employment. The exceptions to this include White Pine, Nye and Churchill counties. While White Pine and Nye see their greatest shares of employment from arts, entertainment, recreation and food services, the largest employer in Churchill is educational services, health care and social assistance.[5]

[4] These numbers come from the 2023 American Community Survey (U.S. Census Bureau, 2025).
[5] Appendix 2 provides additional social and economic characteristics (i.e. employment, poverty, income and education) for the counties comprising the Humboldt River Basin.

Table 6: Industry for the Civilian Employed Population (16 Years and Over)

	Elko	Eureka	Humboldt	Lander	Pershing	White Pine	Nye	Churchill
Agriculture, forestry and mining	22%	38%	25%	30%	25%	16%	9%	4%
Construction	8%	6%	8%	1%	10%	5%	9%	10%
Manufacturing	4%	4%	4%	4%	2%	2%	7%	12%
Retail and wholesale trade	8%	9%	7%	6%	15%	10%	12%	11%
Transportation, warehousing and utilities	5%	10%	5%	10%	-	9%	7%	8%
Professional, scientific and management services	6%	4%	6%	10%	3%	-	9%	7%
Educational services, health care and social assistance	17%	24%	19%	13%	23%	16%	14%	19%
Arts, entertainment, recreation and food services	16%	3%	10%	4%	6%	22%	18%	10%
Public administration	4%	-	7%	17%	9%	12%	6%	8%
Finance, insurance and real estate	4%	-	4%	1%	-	-	4%	-
Other	-	1%	-	-	5%	5%	-	6%

In addition to comprising the largest share of the Basin's employment, mining and agriculture each generate important economic impacts. The figure on the next page shows mining wages and economic output per capita for each of the Basin's counties (NVMA, 2024). Additionally, Table 7 displays the employment, wages and total economic output for agriculture in each of the same counties (Schulz and Davidson, 2024; Nevada Department of Agriculture, 2023).

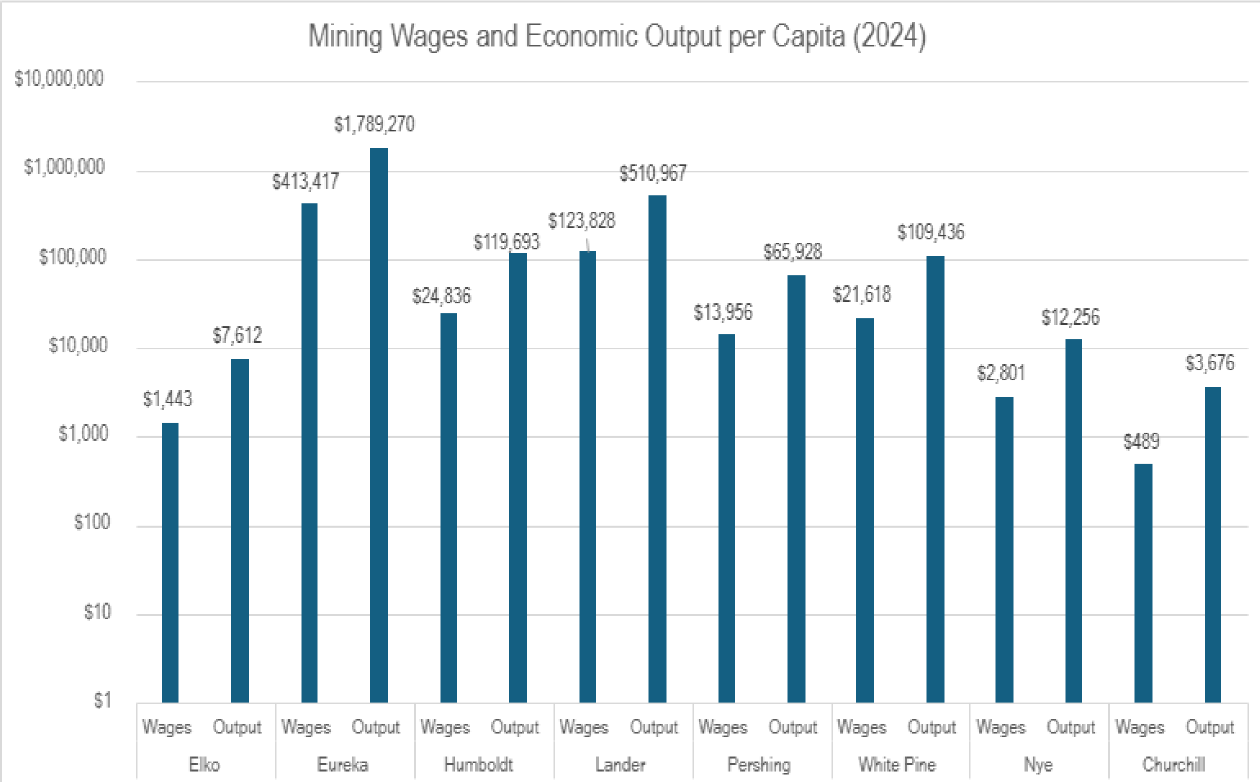


Table 7: Economic Impact of Agriculture (2022)

	Elko	Eureka	Humboldt	Lander	Pershing	White Pine	Nye	Churchill
Total employment in agriculture	575	158	571	182	239	204	166	678
Total employment in food and beverage manufacturing	85	4	26	9	4	23	54	193
Average wage	$49,552	$39,253	$45,791	$35,177	$70,226	$54,174	$51,652	$84,514
Number of farms	437	110	266	87	138	140	173	540
Average farm size (acres)	4,764	5,481	3,556	4,300	2,130	1,542	287	315
Total economic output	$174 M	$69 M	$200 M	$55 M	$54 M	$57 M	$78 M	$347 M
Change in output since 2020	26%	39%	37%	33%	41%	34%	-1%	19%

With respect to mining, the greatest wages and economic outputs per capita are observed in Eureka County. A few companies operate mines in the county, most notably Nevada Gold Mines' Betze-Post Mine and their Carlin Operations. Collectively, these operations produced nearly 1.2 million ounces of gold and more than 70,000 ounces of silver in 2023. A considerable economic impact is also generated in Lander County, where Nevada Gold Mines operates three mines that collectively produced more than one million ounces of gold and approximately 1.08 million ounces of silver in 2023 (Ghiglieri and Patterson, 2024).

Like mining, agriculture drives considerable economic activity throughout the Basin. According to the Nevada Department of Agriculture, the largest economic outputs are generated in Churchill, Humboldt and Elko counties. In Churchill County, the industry is split between farming and ranching (48%) and food and beverage manufacturing (52%). In contrast, farming and ranching comprise much larger shares of the agriculture industries in Humboldt and Elko counties at 98% and 87%, respectively (Schulz and Davidson, 2024). Moreover, agriculture has grown considerably throughout much of the Basin, with only Nye County's output levels falling since 2020. Pershing and Eureka counties experienced the most rapid growth since 2020 at rates of 41% and 39%, respectively. While the growth in recent years has been considerable, drought and other climate conditions (e.g. rising temperatures, soil moisture deficits and flooding) pose a threat to the industry, highlighting the crucial importance of sustainable water management (Schulz and Davidson, 2024; Nevada Department of Agriculture, 2023).

Chapter III: The Evolution of Water Rights and Water Law

Nevada Water Law

Water law in Nevada is governed by the doctrine of prior appropriation, which consists of the priority rule, diversionary requirement and beneficial use requirement. The priority rule states that the first person to divert water from a stream has the priority right to that water. Junior water right holders must therefore curtail or cease water usage during times of scarcity. The diversionary requirement asserts that a "valid" water use entails the physical removal of water from its source. Mining and agriculture, the earliest economic uses of water in the state, were diversionary activities. Finally, the beneficial use requirement states that appropriated water resources must be put to a "beneficial use" within a certain time parameter. Historically, "beneficial use" was equated with economic use. If a water right holder did not continuously use their allocated water for a defined beneficial purpose, the water right may be considered abandoned or forfeited (Wilds, 2014). The doctrine of prior appropriation was and remains important in that it recognized and sought to address one of the defining characteristics of water in the state: its scarcity.

> "The scarcity of Nevada's water is the defining circumstance of its water laws" (Harrison, 2001).

Prior appropriation in Nevada was born from legislation that addressed the growing water needs of mining and agriculture interests (Nevada Legislative Counsel Bureau, 2019). The Mining Law of 1866 emphasized the "priority of possession," which recognized the prior appropriation of water resources for mining, agriculture and other economic uses. However, Nevada had not yet formally adopted the doctrine of prior appropriation and would struggle to clarify its water law for decades (Harrison, 2001). In 1875, the doctrine of riparian ownership gained legal support with the Nevada Supreme Court's decision in *Barnes v. Sabron*. In 1885, however, the Nevada Supreme Court rejected the doctrine of riparian ownership, formally adopting the doctrine of prior appropriation with their decision in *Jones v. Adams* (NDWP, 2000b). Prior appropriation is critical to the Humboldt River Basin and to the state due to the scarcity of water, which has fueled competition and, at times, animosity over access and use. However, the formal adoption of the doctrine of prior appropriation was still far from resolving conflict and controversy.

Without a comprehensive water law or system of water rights adjudication, tensions between competing users escalated, especially between upper and lower Basin users. As previously discussed, these tensions were amplified by the 1888-1889 drought and White Winter (1889-1890), which both placed immense stress on the Basin's already scarce water resources. Lower Basin users found themselves unable to access sufficient water resources due to increased upstream diversions. This had the effect of furthering the schism between the upper and lower Basin users (NDWP, 2000a).

Escalating conflict signaled the dire need for the adjudication of water rights, initiating decades of evolving legislation (Benke and Cushing, 2005). Nevada's 1889 Water Act was enacted in response to ongoing water rights conflicts, although it was imperfect. Likely fearing potential restrictions created by the act, individual water users' claims were typically exaggerated. As a result, the combination of individual water rights claims far exceeded the capacity of most stream systems for which they were filed (NDWP, 2000a). Nevada's Irrigation Act of 1903 (and its amendment in 1905) expanded on the 1889 Water Act in that it established the Office of the State Engineer and provided a quick, relatively inexpensive way of adjudicating water rights. However, it did not provide any provisions to control new appropriations for water, nor did it address groundwater resources. In 1907, the Nevada Legislature repealed the Irrigation Act of 1903 in favor of a statutory method for determining existing water rights, although the act did not fundamentally differ from the 1903 law (NDWP, 2000a, 2000c). The adjudication of water rights was still effectively incomplete, giving way to continued conflict. Nevada's 1913 General Water Law sought to resolve some of these shortcomings in that it addressed groundwater, including it under the doctrine of prior appropriation. This law became the foundation for Nevada's current water law. Despite this, lower Basin users still endured water shortages, and they lacked reliable storage infrastructure. At the same time, upper Basin users, concerned for their own water rights, opposed plans to build a reservoir. It was this continued conflict between upper and lower Basin interests that eventually brought adjudication to the Basin in the 1930s (NDWP, 2000c).

Humboldt River Basin Water Rights Adjudication

After compiling a list of existing water rights in the Basin, the Nevada State Engineer submitted the "Final Order of Determination" on Jan. 17, 1923. Users could then file exceptions to the diversion rights and appropriation dates. This resulted in a hearing in which Nevada Judge George A. Bartlett took evidence and testimony over a period of six years, ultimately issuing the Bartlett Decree on Jan. 2, 1931. The Bartlett Decree adjudicated water rights along the Humboldt River and its tributaries, recognizing that surface waters were already fully appropriated. For this reason, new water users would increasingly turn to unappropriated groundwater or to changes in existing water rights to promote new agricultural, commercial, industrial, mining and/or residential growth. The Bartlett Decree additionally divided the Basin into two districts (with Palisade as the cutoff) in recognition of the differences between upper and lower Basin growing seasons (NDWP, 2000a; Nevada Legislative Counsel Bureau, 2019).

The Bartlett Decree was quickly faced with numerous protests. For this reason, beginning on Dec. 16, 1931, Nevada Judge H.W. Edwards made several rulings to amend the Bartlett Decree (NDWP, 2000a). Based on these amendments, the Edwards Decree was issued on Oct. 8, 1935. Since many of its modifications pertained to the lands above Palisade, the Edwards Decree would apply to those lands, while the Bartlett Decree would apply to lands below Palisade. Moreover, the E.P. Carville Decree was issued on Jan. 24, 1935, to adjudicate water rights along the Little Humboldt River. Each Decree established three classes of land (Class A – harvest crops, Class B – meadow pasture, and Class C – diversified pasture), each with specific dates of irrigation and flow rates. The Bartlett Decree provides for 0.81 cubic feet per second (cfs) per 100 acres of decreed land, the Edwards Decree provides for 1.23 cfs per 100 acres of decreed land, and the E.P. Carville Decree provides for 1.0 cfs per 100 acres of decreed land. Finally, nearly all water rights in the Reese River area are vested rights, meaning they are water rights that were established and put to beneficial use before the enactment of Nevada water law (NDWP, 2000a, 2000c).

Table 8 displays the 2023 distribution of water rights and their total maximum flow allocations in the Humboldt River Basin. The data was derived from a larger database of water rights from 11 Western states compiled by Lisk et al. (2023).[6] However, Table 8 focuses solely on the Humboldt River Basin. Each water use category corresponds to the type of water use, not the type of water right holder. For example, this means that dewatered mine water exported to another basin and used for crop irrigation would be counted as an irrigation use, effectively obfuscating the fact that the water originated from a mining use and is owned by a mining company (Berry et al., 2024). Thus, the water rights shown in Table 8 indicate the distribution of use, not the distribution of ownership.

Table 8: Distribution of Water Rights by Use and Maximum Flow (2023)

Water Use Category	Water Right Count	% Total Water Rights	Maximum Flow of Allocations (ac-ft/year)	% Total Maximum Flow
Commercial	128	2.93%	17,551	0.21%
Construction	13	0.30%	4,418	0.05%
Domestic	61	1.40%	1,178	0.01%
Environmental	55	1.26%	14,841	0.17%
Industrial	112	2.56%	111,827	1.31%
Irrigation	1,344	30.77%	2,782,484	32.62%
Mining, milling and dewatering	612	14.01%	665,626	7.80%
Municipal and quasi-municipal	295	6.75%	134,253	1.57%
Other	76	1.74%	383,447	4.50%
Power	20	0.46%	194,400	2.28%
Recreation	26	0.60%	12,142	0.14%
Stock-watering	1,605	36.75%	30,082	0.35%
Storage	7	0.16%	8,111	0.10%
Wildlife	14	0.32%	4,169,146	48.88%
Sum	**4,368**	**100%**	**8,529,505**	**100%**

In total, as of 2023, there are 4,368 water rights in the Humboldt River Basin that provide for a total maximum flow of allocations of 8,529,505 acre-feet per year. Stock-watering and irrigation comprise the highest proportions of water rights by use at approximately 37% and 31%,

[6] Lisk et al. (2023) do not describe total combined duties (TCDs) in the dataset.

respectively. Mining, milling and dewatering represent 14% of water rights.[7] This is unsurprising given the economic importance of farming, ranching and mining throughout the Basin. Although stock-watering represents a large amount of the Basin's total water rights, the maximum flow of allocations for these rights sums to less than 0.5%. In contrast, water rights for wildlife uses represent less than 0.5% of the Basin's total water rights, but they can be attributed to about 49% of the maximum flow of allocations. Irrigation and mining also make up relatively large shares of the maximum flow of allocations at approximately 33% and 8%, respectively.

[7] Mine water use is defined as mining (i.e. water used during excavation), milling (i.e. ore processing) and dewatering (i.e. groundwater pumped from a mining operation) (Berry et al., 2024).

Chapter IV: Contemporary Water Management Issues

Overappropriation

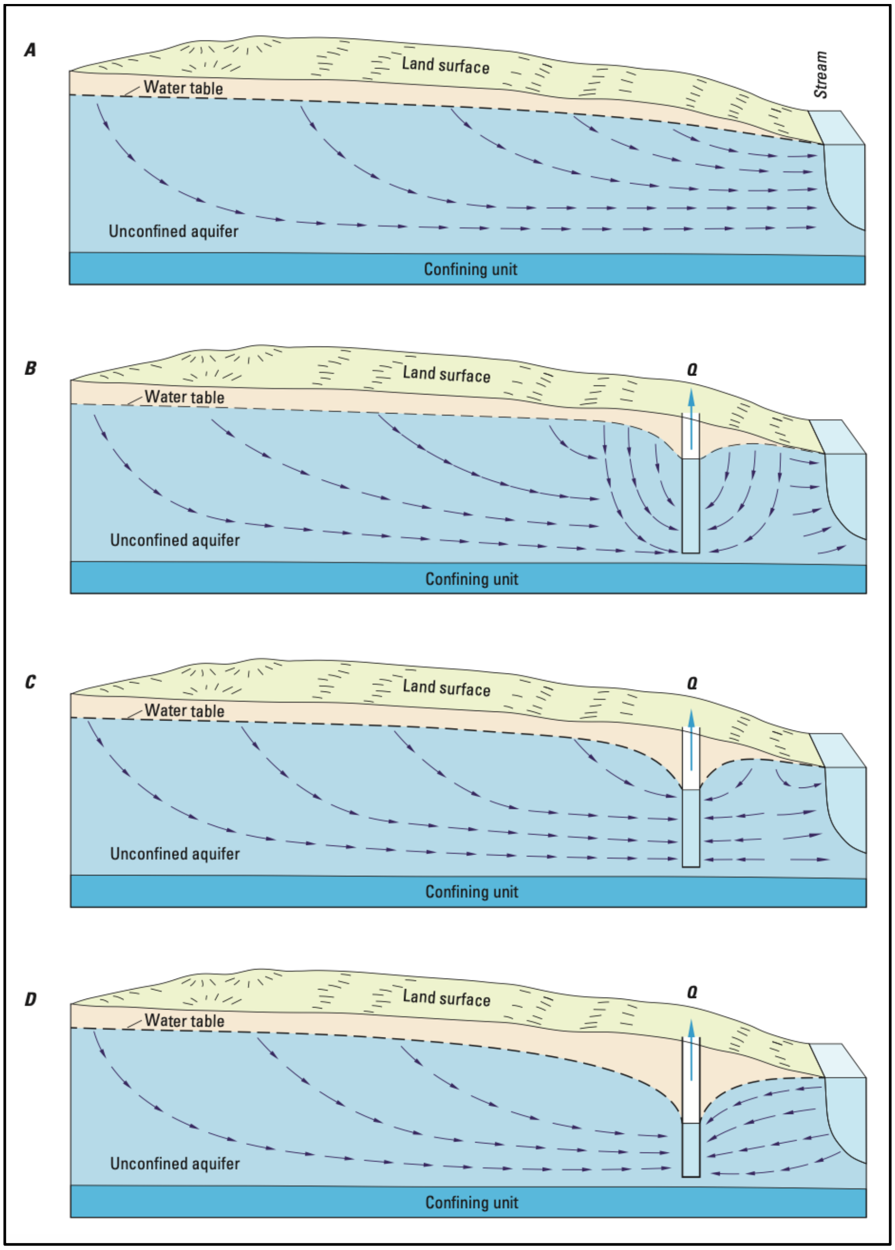
While the Basin's water rights adjudication process was completed through the Bartlett, Edwards and E.P. Carville Decrees, not all water rights conflicts were resolved (NDWP, 2000c). Presently, the central issue facing the Basin is that the legal rights to water use exceed the amount of water available (Fontaine, 2024). As a result, of the Basin's 33 hydrographic areas (and one hydrographic subarea),[8] 20 are overappropriated when comparing groundwater commitments to perennial yield. Of these basins, 11 are overappropriated by more than 250% of the perennial yield. Additionally, 17 of the Basin's hydrographic areas face some level of potential capture of surface water rights by groundwater pumping (NDWR, 2023).[9] While there are approximately 757,758 acre-feet of committed groundwater rights in the Basin, there is only 469,900 acre-feet of perennial groundwater yield. This results in a total overappropriation of 287,858 acre-feet of groundwater (Meyers and PCWCD, 2022).

"The United States is a nation of two mind-sets, constantly juxtaposing the individual against the group. This is especially true in the West, where the frontier mentality and 'rugged individualism' have deep historical roots. Westerners tend to focus on the rights of the individual, often at the expense of the common good. This orientation is perhaps most greatly reflected in efforts to determine how best to allocate and use our water" (Wilds, 2014).

While surface water and groundwater are often hydraulically connected (meaning that groundwater pumping may deplete surface flows), Nevada has historically administered water rights to each source separately. Historically and presently, this has led to conflict between surface water and groundwater right holders (Nadler et al., 2023). The connection between surface water and groundwater has been known since the 19th century. However, this hydrologic fact was not recognized from a legal standpoint. For example, in *Mosier v. Strait* (1872), the first Nevada court decision addressing the right to appropriate groundwater, the respondent dug wells on their property that dried up the appellant's spring. While the court understood the connection between the respondent's well and the appellant's spring, it refused to acknowledge that connection legally. In this way, decisions such as *Mosier v. Strait* evince a disconnect between hydrologic and legal principles (Harrison, 2001). Understanding interbasin flow and how surface water and groundwater interact are critical in establishing and improving water budgets. Currently, the Nevada Division of Water Resources is developing a database of existing interbasin flow estimates and documented locations of interbasin connections (NDWR, 2024).

[8] Hydrographic areas 42 through 74 (including the hydrographic subarea 73A) define the Humboldt River Basin (NDWP, 2000a).

[9] Data relating to surface water capture includes the total combined duties (TCDs) for groundwater sites that have them, and these TCDs were divided equally among the points of diversion within each TCD group (NDWR, 2023).

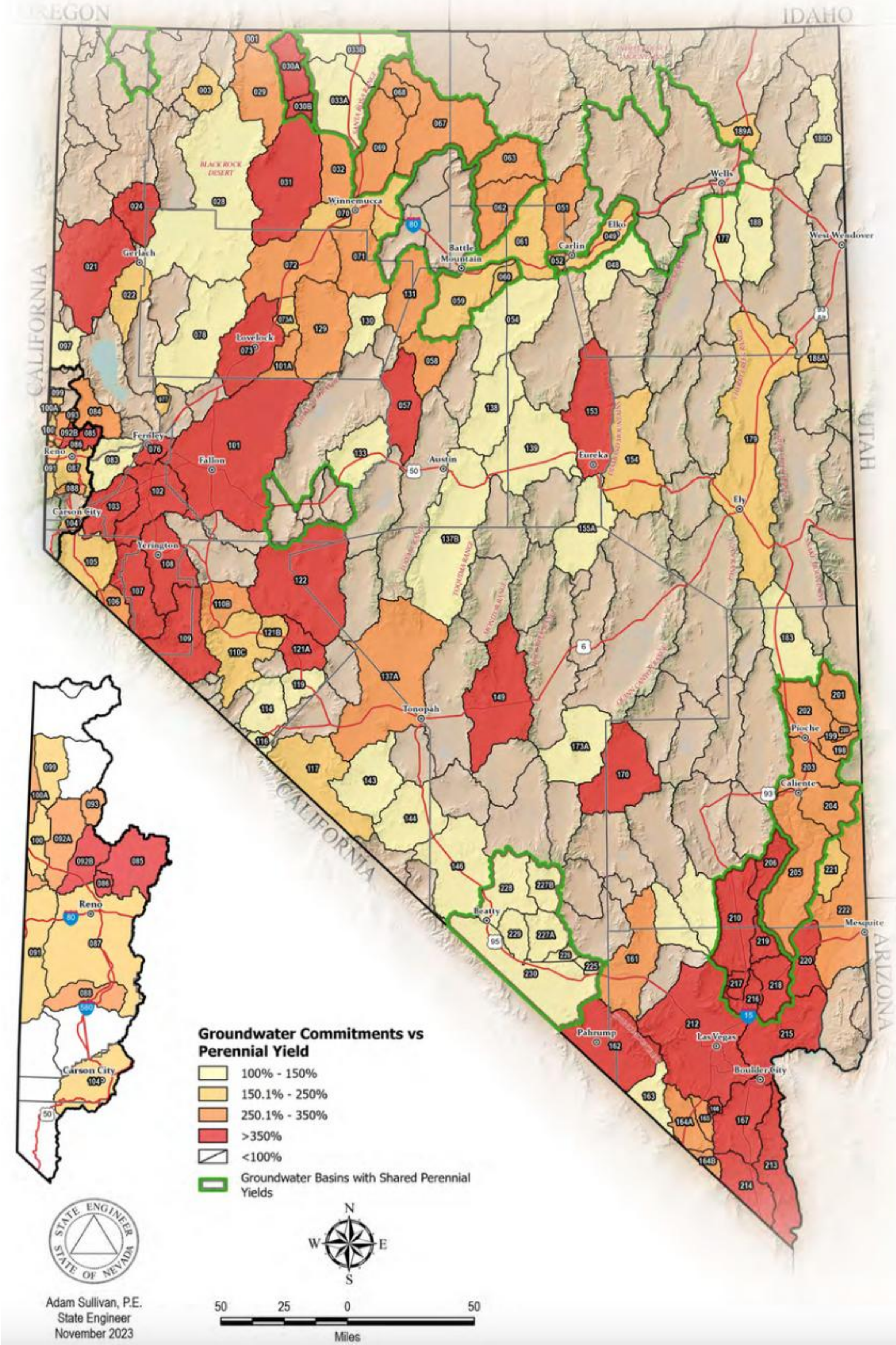


Streamflow depletion by groundwater pumping (Barlow and Leake, 2012).

The issue of overappropriation is further complicated by the fact that estimates of perennial yield are based on studies that are 50 to 70 years old, thereby introducing uncertainty and/or inaccuracies into resulting water budget estimates. Perennial yield estimates also often include groundwater discharges which, in many basins, feed springs, streams and wetlands. The result is that they inadvertently include surface waters that have already been appropriated (Carson River Watershed, 2022). The map on the next page shows the overappropriation of groundwater versus perennial yield. It compares the maximum amount of groundwater pumping possible under existing water rights to each basin's perennial yield, with the shading indicating the severity of overappropriation (NDWR, 2023).

GROUNDWATER COMMITMENTS VS. PERENNIAL YIELD

NEVADA DIVISION OF WATER RESOURCES - 2023 BASIN STATUS ASSESSMENT



These issues are made abundantly clear in the lower Basin, Lovelock Valley, where farmers have endured repeated water shortages despite holding senior water rights (Rothberg, 2023; Meyers and PCWCD, 2022). In comparing groundwater commitments to perennial yield in Lovelock, the area is overappropriated by more than 350% (NDWR, 2023). Overappropriation is additionally caused, in part, by periodic drought. Additionally, however, upper basin irrigators and mines have pumped increasing amounts of groundwater from aquifers that feed the Humboldt River over the past 50 to 70 years. This has reduced the amount of groundwater that reaches the Humboldt River in Lovelock Valley where farmers rely on surface flows to fulfill their righted water allotments (Fontaine, 2024). Moreover, while Rye Patch Reservoir is integral in providing water storage for the lower Basin, it faces numerous issues. Seepage through the reservoir banks and/or bed reaches the water table, causing losses to groundwater (Nadler et al., 2023). Losses are also driven by evaporation and sedimentation, the latter of which has reduced the reservoir's capacity by at least 10% since its construction in 1936 (Rice and Rice, 1972; Seiler et al., 1993). The culmination of these factors compromises the lower Basin's access to their righted water allotments. For the period 2002-2022, water right holders in Lovelock faced nine years with only 50% of their water allotment or less and three years with zero allotment (Meyers and PCWCD, 2022). This can potentially impact local economies and livelihoods, as unanticipated reductions in water supplies may reduce farm and ranch profitability (Taylor et al., 2021).

Agriculture

Numerous additional water-related issues face the Humboldt River Basin. During the late 19th century, widespread open-range livestock grazing throughout the Basin severely reduced plant cover in upper watershed areas. Overgrazing combined with extensive timber cutting during this time exposed these upper watersheds to severe sheet and gully erosion, thereby exacerbating the impacts of flooding (NDWP, 2000c). This trend continued into the 20th century, as the BLM cleared large tracts of piñon-juniper forestland to increase pasturage for cattle (Miller, 2024).[10] Furthermore, the denudation of upper watershed areas and the overgrazing of both the Basin's upper watersheds and lowland meadows has driven soil and channel erosion. These processes not only accelerated drastic changes to the Basin's vegetation composition but also increased its susceptibility to both flooding and wildfire (NDWP, 2000a). By the early 1900s, the great extent of vegetation destruction and erosion caused by overgrazing prompted the federal government to include several mountain headwater areas in the National Forest system (Benke and Cushing, 2005). However, this would not resolve the many issues, historic and forthcoming, brought on by overgrazing.

Overgrazing also had the effect of depleting native perennial grasses throughout the Basin, enabling the expansion of cheatgrass, an invasive species (Benke and Cushing, 2005). Due to the ability of cheatgrass to germinate early and rapidly grow, it tends to crowd out other, more desirable forage grasses, thereby converting a landscape into a cheatgrass monoculture (NDWP, 2000a). This has the effect of rendering the landscape vulnerable to repeated wildfire. Furthermore, since cheatgrass seeds possess strong post-burn recuperative abilities, the

[10] Cutting, chaining and burning have persisted in recent years. Historically and presently, deforestation has harmed the Western Shoshone, who rely on pine nuts as a source of food (Miller, 2024; Crum, 1994).

density of cheatgrass tends to increase over time, as fewer native grasses survive each burn. Thus, there exists a powerful feedback loop between cheatgrass and wildfire, wherein the former increases the frequency and severity of the latter while expanding its own coverage (NDWP, 2000a; Hoffman, 2015; Molvar et al., 2024).

Recognizing the destructive impacts of overgrazing on public lands, the federal government passed the Taylor Grazing Act in 1934. The act established grazing districts and a permitting system with the goal of protecting public lands from further grazing-induced degradation. The act also created the Grazing Service (now the BLM) to administer public domain lands (NDWP, 2000c). Since 2019, the BLM has charged a livestock grazing fee of $1.35 per animal unit month, and this remains as the grazing fee for the 2025 Grazing Fee Year (effective March 1, 2025) (U.S. BLM, 2025).

Cattle grazing on cheatgrass (Wolterbeek, 2022).

Overgrazing in the Humboldt River Basin may interact with climate change to compound many of the abovementioned environmental harms. Climate change has driven alterations in temperatures, precipitation, snowpack, tree mortality and runoff patterns, and these changes can reduce ecosystem health. Continued overgrazing can accelerate declines in ecosystem health, thereby rendering the land less productive. The decreasing availability of suitable land, water and forage resources is now a major source of conflict. This cycle of resource use and scarcity creates new uncertainties from a management perspective, while amplifying historical and contemporary challenges faced by communities across the Basin and throughout the Great Basin region more broadly (Hoffmann, 2015; Wolters and Steel, 2020).

Invasive Species

Invasive species can spread in multifarious ways and may produce adverse environmental consequences. As previously described, cheatgrass outcompetes native grasses, expanding its coverage while perpetuating a feedback loop with wildfire (NDWP, 2000a; Hoffman, 2015; Molvar et al., 2024). Other invasive plants and animals can create further harms to people, local economies and the environment (Knight et al., 2023).

Invasive pests, once established in an environment, may produce drastic alterations, introduce diseases and outcompete native species for resources. This can negatively impact the environment and its natural resources, but it can also harm food systems and local economies (Knight et al., 2023).[11] Invasive weeds pose further management challenges, with the potential to harm both environmental and human systems. Invasive weeds are those that the state identifies as harmful to agriculture, the public and the environment. They can rapidly spread and outcompete native plants for light, nutrients and water. Once established, their ability to rapidly reproduce enables them to persist in an area for several years. Impacts on the environment may include increased soil erosion, decreased water quality, displacement of plant and wildlife, and increased flood and wildfire risk. Other impacts may include diminished forage and crop yield, reduced recreational value, and potential injury to humans (Creech et al., 2020). In addition to cheatgrass, tall whitetop (perennial pepperweed) poses numerous problems for the Humboldt River Basin. Tall whitetop can decrease biodiversity, destabilize riverbanks through erosion and harm agriculture operations, with the potential to drive significant economic losses. Since tall whitetop is incredibly productive, it threatens to invade hay and alfalfa croplands, jeopardizing the agriculture industry's export potential. Moreover, due to its ability to rapidly spread, complete eradication would be expensive and unlikely to succeed (NDWP, 2000a).

Feral equids pose yet another challenge in resource management. Feral equids threaten to degrade wildlife habitat and rangeland health by reducing available forage and seed banks, while increasing bare ground cover and the spread of invasive species. Feral equids also impact plant and animal life near water resources, in that grazing and trampling reduce vegetative cover, and their presence may affect the behaviors of subordinate species (e.g. sheep). The Wild Free-Roaming Horses and Burros Act of 1971 protects feral horses and burros on public lands, stipulating that the BLM and U.S. Forest Service have the authority to conduct management actions to maintain an ecological balance between feral equid populations and the capacity of public lands to sustain other ecosystem services. Thus, it is the BLM and U.S. Forest Service that decide which population control methods are most appropriate for managing feral equid populations that exceed the appropriate management levels. However, feral equid grazing on public lands is far less regulated than livestock grazing (McNew et al., 2023). This is largely due to two key impediments to management abilities. First, financial constraints limit the abilities of federal agencies to effectively manage feral equid populations. Second, the prevalence of litigation surrounding feral equid population management has sparked periods of

[11] Two examples in the Humboldt River include New Zealand mudsnails (found near Carlin) and Northern Pike. Both species disrupt native fish, threatening the loss of biodiversity (Nevada Department of Wildlife, 2017, 2022; NAISMA, 2025).

management stasis during which feral equid populations and associated resource management challenges have both grown (McNew et al., 2023).

Mining

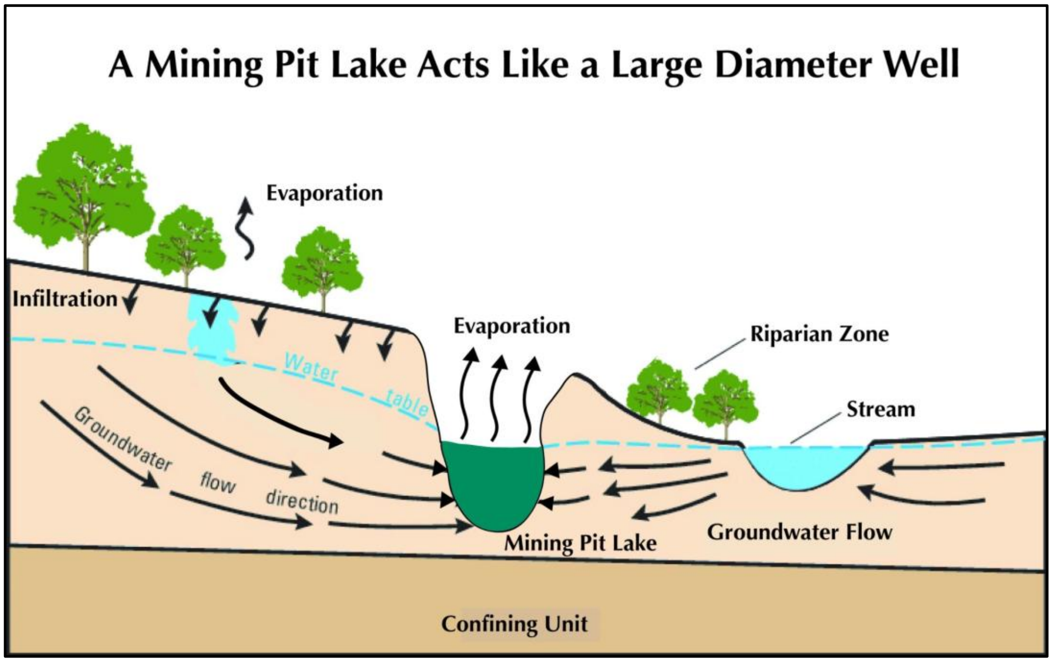
Mine dewatering and pit lake formation pose another management challenge for the Basin's water resources. To access a mineral deposit below the water table, open pit mining requires groundwater to be pumped in a process of mine dewatering. Groundwater is then disposed of through reuse, reinjection or infiltration, or as surface water discharge (NDWP, 2000a). Mine dewatering creates a cone of depression that draws down the groundwater table. This lowering of the groundwater table may impact the flow of nearby springs and streams. Continued pumping may expand the cone of depression into other regions, capturing nearby spring and stream flows. Deep, extensive open pit mining operations create pit lakes that may impact local groundwater and surface water conditions once dewatering ceases and the pits begin to fill (Carroll et al., 2023; NDWP, 2000a; Blair et al., 2024). In this way, dewatering may regionally reduce groundwater levels, altering access and availability for other water users and the environment. Moreover, since groundwater moves slowly compared to surface water, the full effects of pumping may not be realized for decades. Even when dewatering ceases, water levels continue to decline as groundwater flows into dewatered regions to form pit lakes (Berry et al., 2024). As previously described, the capture of surface water rights by groundwater pumping is already an issue across the Basin, as 17 of its hydrographic areas are affected. The issue is especially salient in areas surrounding Winnemucca and Carlin (NDWR, 2023).

> "Nevada will have more precious metals pit lakes than any other state in the union, and they will consume a considerable portion of Nevada's scarce water" (Hadder, 2012).

The formation of pit lakes poses another challenge: water quality. Since it may take 100 years or more for a pit lake to reach its final level and chemical composition, long-term water quality is uncertain (Hadder, 2012). Furthermore, while the Nevada Code stipulates that pit lakes must not cause harm to human, terrestrial and/or avian life, no quantitative pit lake water quality standards exist. Instead, pit lake water standards are based on ecological risk assessments, which develop "hazard quotients" for wildlife. Ultimately, these are based on assumptions of how contaminants might affect an environment and its wildlife. In this way, resulting standards are variable (Great Basin Resource Watch, 2023). For these reasons, under current regulations, groundwater flowing into a pit lake may become degraded to a point where it is not only undrinkable but also unusable for irrigation or stock-watering. Moreover, since pit lakes represent "new" surface waters, Nevada's reclamation requirements specify no post-mining uses for them. While the Nevada Department of Environmental Protection (NDEP) has the authority to designate beneficial uses for pit lakes, no beneficial use has been established for them (Hadder, 2012). Together, these factors create considerable risk for present and future damage to senior water users (Schroeder Law Offices, 2024).

Considering its abundance of mining operations, the challenges associated with pit lake formation are pertinent to the Humboldt River Basin. Along the Carlin Trend, for example, is the

Betze-Post Mine. Once this open pit fills, it will contain an estimated 580,000 acre-feet of groundwater (NDWP, 2000a). The Lone Tree Mine near Battle Mountain is another example. The pit lake, which is only 1 mile from the Humboldt River, began to fill in 2006. By 2007, the acidity of the pit lake had reached a hazardous point, requiring corrective action. The pit lake remains a threat to the Humboldt River and the surrounding water table (Hadder, 2012).



Pit lake formation (Great Basin Resource Watch, 2023).

Despite the heavy water usage involved in mining, mining water rights are considered both temporary and nonconsumptive. Each category of mine water use (mining, milling and dewatering) is considered temporary, despite producing considerable impacts (Berry et al., 2024). Dewatering, as previously discussed, may affect both surface water and groundwater conditions through the formation of pit lakes (Carroll et al., 2023; NDWP, 2000a). This temporary designation exists primarily for the mining industry, as it is not readily available for other types of water use. Furthermore, while mining and milling are generally considered consumptive water uses, most groundwater from dewatering is considered nonconsumptive. For this reason, mining and milling are counted as water rights within a groundwater basin and are included when assessing allocated water rights versus perennial yield, but dewatering is not accounted for in the same way. Even when dewatered groundwater is reinjected or infiltrated back into the ground, the process often takes place in a different groundwater basin, and there may be considerable losses during the process. Additionally, as previously described, dewatered mine water put to another use is counted in that water use category, despite the water coming from a mining operation. In these ways, it can be argued that the mining industry maintains a unique privilege in how their water rights are accounted for (Berry et al., 2024).

Lithium mining is becoming increasingly important in fueling the development of green technologies and renewable energy, and Nevada is positioned to become a key lithium producer. As of 2023, approximately 85% of known U.S. lithium deposits were in the state. This primarily includes deposits in Thacker Pass and Clayton Valley. According to Saftner et al. (2023), direct lithium extraction may represent an “ideal” lithium extraction scenario with respect to hydrologic impacts, though it depends on the environmental context and the specific methods used. Under direct lithium extraction, brine is pumped from an aquifer disconnected from other nearby aquifers and surface waters. Brine is then reinjected into the original aquifer with the goal of causing minimal change to original groundwater and surface water levels and quality. However, this process has the potential to impact both the quantity and quality of groundwater and connected surface waters. Additionally, because direct lithium extraction technologies are still being developed and have not yet been commercially proven at a large scale across different environmental and social contexts, it is still unclear whether direct lithium extraction uses less freshwater than other extraction methods. [12] Remaining uncertainties signal a need to quantify not only the consumptive use of freshwater, especially in arid, water-scarce regions like the Humboldt River Basin, but also other risks associated with direct lithium extraction processes (e.g. possible water depletion and contamination) (Saftner et al., 2023; Blair et al., 2024).

Besides water depletion and pollution, other risks of lithium mining include toxicity impacts on plant and animal life, waste generation and disposal, and land subsidence (Kaunda, 2020). These issues are pertinent to the Humboldt River Basin, as numerous lithium claims exist within Nevada, and some are in the Basin or are proximal to it (Donnelly, 2024). Notably, Thacker Pass, an open-pit lithium mine located approximately 60 miles northwest of Winnemucca, began construction in March 2023. Once completed, Thacker Pass is projected to meet most, and possibly all, of the U.S.' lithium demand (Lithium Americas, 2024). Although Thacker Pass is located outside of the Basin, it will generate economic benefits for Humboldt County and the state (e.g. short-term capital investment for construction, long-term annual investments in operations, and taxes collected at the state and local levels). Winnemucca, a key outsourcing center, also stands to benefit from the mine (Borden and Harris, 2023). There are several additional lithium claims in the Basin and close to it (Donnelly, 2024). Some include the Daisy Creek (GMV Minerals, 2023), Edwards Creek Valley (Ameriwest Lithium, 2022), North Big Smoky (Lithium Corporation, 2022), ELi (Little Smoky Valley) (Chatterton, 2022), Grass Valley (Iconic Materials, 2023) and Smith Creek projects (Iconic Materials, 2018).

Water Transfers

As Nevada's growing urban and exurban population and increasing development drive water demand, climate variability (i.e. drought) renders water supplies increasingly uncertain. Moreover, many of the state's water resources are distant from its rapidly expanding urban centers. For these reasons, cities, industries and energy developers increasingly turn toward water transfers, through market transactions, to satisfy current and future water needs (Doherty and Smith, 2012; NDWP, 2000a). The Western Governors' Association (WGA) and Western States Water Council (WSWC) define a water transfer as “[...] a voluntary agreement that results in a temporary or permanent change in the type, time, or place of use of water and/or a

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[12] For example, Blair et al. (2024) point to various instances where direct lithium extraction may consume more freshwater than other extraction methods.

water right" (Doherty and Smith, 2012). Water transfers create an opportunity for greater efficiency in the conservation and reallocation of water resources, providing an important mechanism for adaptive management. However, water transfers have been and remain highly controversial, as the loss of water in rural areas may adversely affect both local economies and the environment. Thus, the Association and Council recognize that it is important for decision-makers to strike a balance between economic development and the wellbeing of rural communities, especially if rural-to-urban water transfers constrain the future development opportunities of the basin-of-origin (Doherty and Smith, 2012; Nevada Legislative Counsel Bureau, 2016b).

The Association and Council outline several benefits to water transfers. First, they are both voluntary and decentralized, meaning that buyers and sellers can directly negotiate to satisfy local needs and conditions. Second, water transfers provide considerable flexibility, allowing for the accommodation of new and emerging uses over time. Water transfers enable adaptation to changing values and priorities as water is flexibly reallocated. Finally, water prices increase with water demand, thereby incentivizing investment in agricultural water conservation measures (i.e. lower water-intensive crops, improved irrigation technologies, improved on-farm conveyance infrastructure, improved soil health and similar conservation measures), enhanced land and water management, and new and/or updated water storage and conveyance infrastructure (Doherty and Smith, 2012). In Nevada, Libecap (2010) estimated a net welfare gain of 91% (of the average annual water market value for all transfer types and sectors) that would be generated from all proposed agricultural-to-urban transfers at that time (Libecap, 2010).

"In light of possible climate change and growing scarcity of water, the social losses of inefficient water management and allocation could be high" (Libecap, 2010).

While water transfers provide an efficient mechanism for meeting evolving water needs, there are various risks involved. Because water transfers may involve entities such as mutual ditch companies and irrigation districts, decision-making processes may not be restricted to the individual level. Therefore, transfers may impact other water users and stakeholders. For example, in rural areas where agricultural water use underpins the local economy, water transfers from agricultural to nonagricultural uses may disrupt local economies (Doherty and Smith, 2012). Concerns to this effect have been voiced in the Humboldt River Basin in recent years (Rothberg, 2020; Roerink, 2021). Local economic stagnation from decreased agricultural activity may impact small businesses that depend on farm productivity. Decreased agricultural activity may also reduce local demand for farm labor, potentially diminishing wholesale and retail trade within rural communities, and ultimately the local tax base, which can lead to reduced public services. Additionally, senior water rights transfers that change place and purpose of use affect the amount of water released and subsequently consumed as return flows downstream available to junior water right holders. Increasing ag-to-urban and ag-to-environmental water transfers may therefore harm junior water right holders reliant on those return flows (Doherty and Smith, 2012; Libecap, 2010).

Water transfers may also have unintended consequences for the environment. While water transfers can potentially improve a river system, redirecting water to new uses may also dry up streams and wetlands, while allowing for invasive species to spread (Doherty and Smith, 2012). As observed in the Humboldt River Basin, increased water diversions can render water supplies uncertain. For example, growing upstream irrigation diversions have historically resulted in diminished flows downstream (NDWP, 2000a). Instream flows may be further impacted by water transfers. Moreover, since irrigation waters not consumed by crops help in replenishing underground water tables, transferring water away from agricultural uses may adversely impact groundwater recharge. Finally, water transfers may inadvertently enable the spread of invasive species due to changes in soil and vegetative conditions from the transition of farmland to dry pasture (Doherty and Smith, 2012). Notably, the Nevada Revised Statutes stipulates that a proposed use or change of water must not conflict with existing rights or threaten the public interest (Nevada Legislature, 2025a).

The issue of water transfers has been and remains critical to the Humboldt River Basin. Numerous proposed projects have sought to transfer water away from the Basin's rural communities, largely for urban use. While some of these projects were rejected, others have succeeded in acquiring water rights in the Basin. In 1995, for example, the State Engineer rejected applications by Eco-Vision Inc. to pump and move 387,300 acre-feet of groundwater per year from Elko, Eureka, Humboldt, Lander and Pershing counties for municipal use. More than 1,300 protests were filed, citing concerns such as overappropriation and potential ecological damage. The applications were ultimately rejected (Office of the State Engineer of Nevada, 1995). In more recent years, however, efforts to acquire water rights within the Basin have succeeded. After being established in 2009 as an investment vehicle for the New York-based hedge fund Water Asset Management, U.S. Water and Land, LLC acquired Winnemucca Farms, including its 36,621 acre-feet of water rights. In 2017, the company additionally applied for up to 300,000 acre-feet of floodwater from the Humboldt River. U.S. Water and Land intends to sell their acquired water rights, anticipating growing demands from growing urban centers. These moves have sparked concern among communities in the Basin dependent on the water for sustaining their livelihoods. Environmental activists have also voiced concerns over potential ecological damage (Rothberg, 2020). Others in recent years have expressed more general concerns that water transfers could enable those with the most economic and political capital to buy, sell and export water resources with minimal oversight to the detriment of rural stakeholders (Roerink, 2021).

Climate Change

Climate change further compromises our ability to meet growing water demands while threatening to exacerbate many of the aforementioned water resource challenges. Population growth and increasing development pressures have increased consumption and demand for water. At the same time, water supplies are increasingly uncertain due to the exacerbation of drought risks (Libecap, 2010). The Humboldt River Basin has faced periods of extreme drought, and rising temperatures, decreasing precipitation and earlier snowmelt can exacerbate water management challenges by reducing runoff into streams such as the Humboldt River. The issue is compounded by the fact that water rights allocations for the Humboldt River were made in the 1930s, and surface waters were fully appropriated (NDWP, 2000a; NIDIS, 2025b). Water management decisions, including the design of water storage and conveyance infrastructure, for the Humboldt River and other rivers across the West were completed under assumptions of a stationary climate. Overappropriation and the potential capture of surface waters by groundwater pumping stand as both historical and current threats to the Basin's scarce water resources. Further changes in water supply (i.e. increasing scarcity) will likely increase tension and competition among different users (NDWR, 2023; Wolters and Steel, 2020; Bandala et al., 2022; Siirila-Woodburn et al., 2021).

> "Public lands are already facing a host of threats, including invasive species, wildlife disease, and habitat loss and fragmentation. Climate change is expected to amplify these impacts and add a host of additional threats, including higher temperatures and drought" (Wolters and Steel, 2020).

As seasonal mountain snowpack contributes greatly to the Humboldt River's headwaters, climate change poses a threat to water supplies through declining snowpack. Siirila-Woodburn et al. (2021), for example, anticipate declines of approximately 25% in snow water equivalent throughout the West by 2050. Diminished snowpacks will alter groundwater and streamflow dynamics, and the issue is further complicated by other climate change factors such as increasing evaporation and evapotranspiration, altered vegetation composition, drought, and wildfire. The changes these are expected to produce in groundwater recharge and stream discharge will impact the overall supply of water, creating additional resource challenges for both industry and the environment (Siirila-Woodburn et al., 2021).

The below figures show snow water equivalent (inches) and precipitation accumulation (inches) for the Lamoille (#570) and Golconda (#1195) SNOTEL stations for the period 1990 to 2025 (NRCS, 2025).[13] While the Lamoille station has collected data for a longer period of time, the Golconda station started in 2011. Observations from both stations show fluctuations in snow water equivalent and precipitation over time. However, a more substantial decline is observed in the early 2010s due to severe drought (NIDIS, 2025a). Although drought is intermittent, the Humboldt River Basin has faced periods of extreme drought lasting several years (NDWP, 2000a). In recent years, a combination of high temperatures and decreased precipitation has contributed to rapid snowmelt. As a result, the Humboldt River Basin observed snow water equivalent levels within 0% to 50% of the 1991-2020 median. As previously stated, this can cause flooding and disrupt water supplies, soil conditions, and ecosystem health (NIDIS, 2025b).

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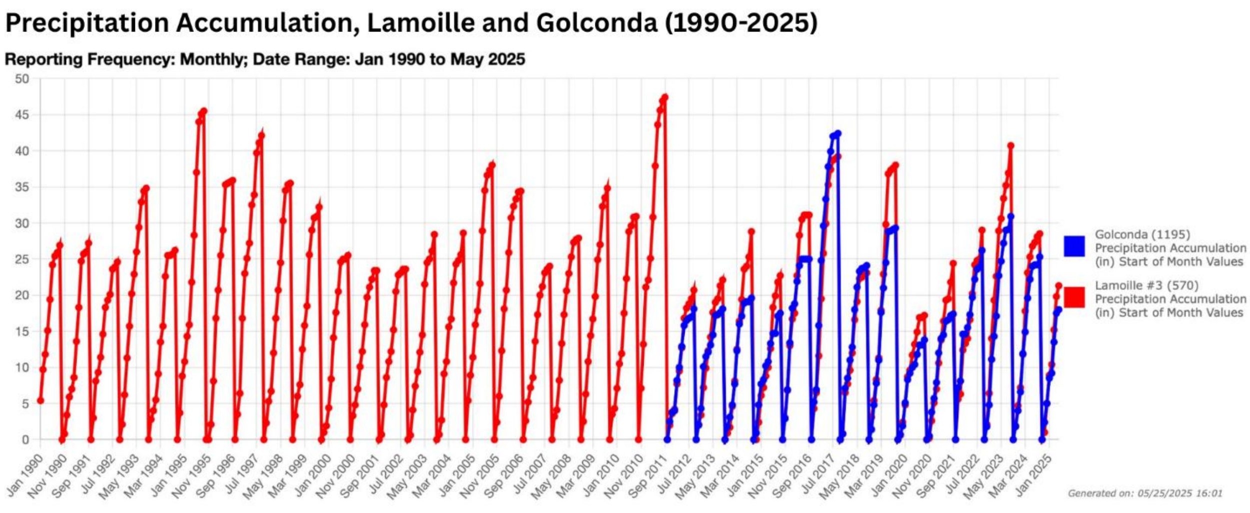
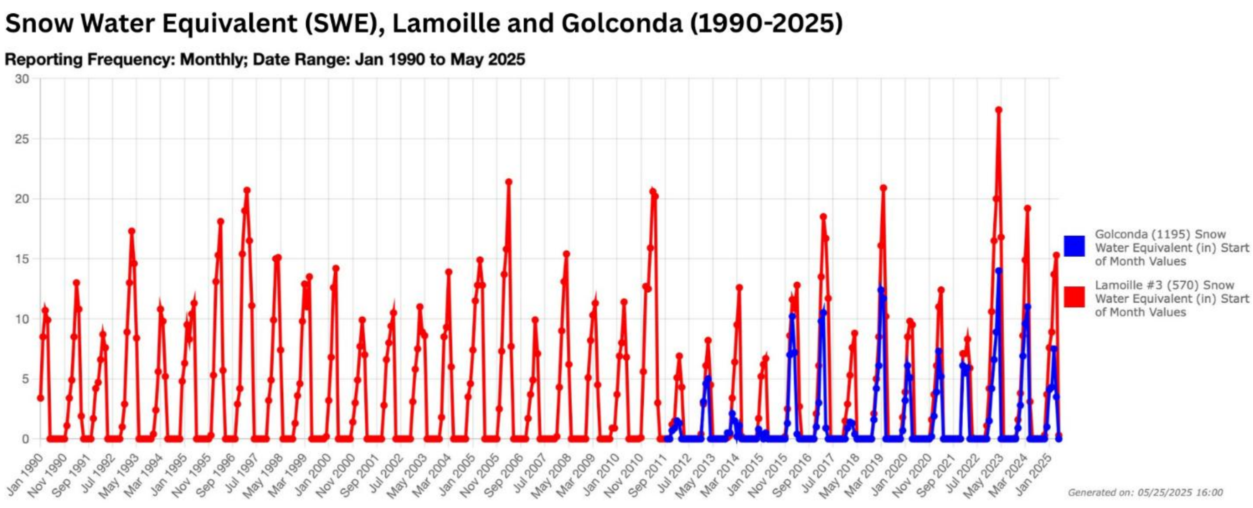
[13] The Natural Resources Conservation Service defines snow water equivalent as the "depth of water that would theoretically result if the entire snowpack were melted instantaneously" (NRCS, 2025a).





Increasing temperatures, changes in vegetation and decreased summer precipitation are expected to exacerbate the Basin's risk of wildfire. Specifically, climate change may increase wildfire frequency and lengthen the fire season, placing additional stress on water supplies (Hoffmann, 2015). At the same time, average annual suppression costs across the U.S. increased from $453,498,600 in the 1990s to $1.3 billion in the 2000s (Wolters and Steel, 2020). The long-term intensification of wildfire activity is made clear by the 1999 fire season, which burned approximately 1.6 million acres in Nevada. Nearly 87% of burnt acreage was concentrated in Elko, Eureka, Humboldt, Lander and Pershing counties — the Humboldt River Basin's five principal counties (NDWP, 2000a). Wildfire also threatens one of the Basin's key industries, agriculture. In addition to directly damaging crops and livestock, wildfire may affect water quality and quantity in streams, reservoirs and irrigation supplies. These jeopardize farm productivity and profitability in both the short and long term (Kabeshita et al., 2023).

Mining and agriculture, two of the Basin's chief economic activities, are further threatened by climate change in various ways. For mining, climate change may have both direct effects on operations and indirect effects on supply chains and energy costs. Furthermore, mining is a water-intensive industry. Water usage has increased over time, while precipitation falls and temperatures rise. This signals that the future of mining is unsustainable should these trends continue (Wolters and Steel, 2020). Regarding agriculture, drought has harmed rangeland forage, livestock herds and agricultural production overall. Moreover, changes in precipitation and temperature can adversely affect the suitability of growing conditions, while exacerbating susceptibility to pests and disease (Wolters and Steel, 2020). Finally, reductions in water supplies leave farmers with fewer resources to sustain farm productivity (Stephen et al., 2023). Growing challenges in water availability and quality may also inflict social harms on affected communities, exacerbating socioeconomic vulnerabilities in historically marginalized communities (Siirila-Woodburn et al., 2021).

Conjunctive Management: A Path Forward?

In recent years, the increasingly severe challenges in water management have called the doctrine of prior appropriation into question (Freemuth and Smith, 2016). The doctrine of prior appropriation has fueled the development of a consumptive approach to water management, "[...] which historically perpetuated the notions that water not used is wasted or lost; only economic, diversionary uses are beneficial; and individuals have the right[...] to use the allotted amount of water no matter what conditions prevail — even to the detriment of other users or the surrounding environment" (Wilds, 2014). Furthermore, the doctrine of prior appropriation has been criticized, as it fails to accommodate new uses and users of water, and its beneficial use ("use-it-or-lose-it") requirement effectively discourages water conservation. For these reasons, there has been an increase in conjunctive water management in some Western states, including Nevada (Wilds, 2014; Freemuth and Smith, 2016).

Historically, surface water and groundwater were administered separately despite being hydraulically connected. Conjunctive management recognizes this connection, allowing for the management of both surface water and groundwater across basins. Given the current challenges of overappropriation and increasing water scarcity, conjunctive management is becoming increasingly important in sustainable water management. Additionally, it has already been made clear that a failure to conjunctively manage scarce water resources creates problems for senior surface water right holders who face continuous water shortages, and this issue is especially pronounced for irrigators in Lovelock Valley (Schroeder Law Offices, 2024). In response to these longstanding issues, the Nevada Supreme Court ruled in January 2024 that the State Engineer has the authority to conjunctively manage surface water and groundwater and to jointly administer multiple basins. This will be critical moving forward as it empowers Nevadan water managers to more firmly address overappropriation and the depletion of groundwater resources (Rothberg, 2024).

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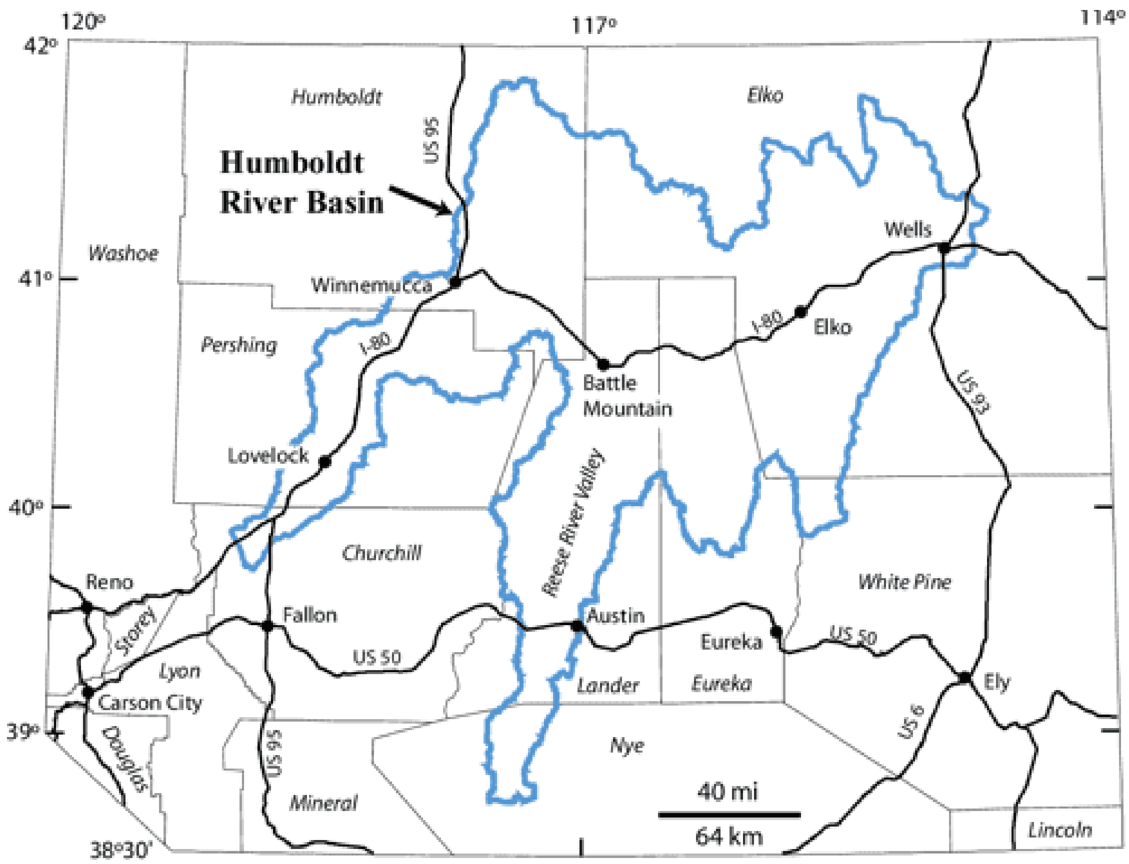
Appendix 1



The Humboldt River Basin is primarily contained within Elko, Eureka, Lander, Humboldt and Pershing counties with smaller portions in White Pine, Nye and Churchill counties (Wallace et al., 2004).

Appendix 2

Table 9 displays additional social and economic characteristics for the counties comprising the Humboldt River Basin (U.S. Census Bureau, 2025). Data is derived from the 2023 American Community Survey and the 2020 Decennial Census. Employment (defined as full- and part-time work) ranges from 37% in Nye County to 65% in Elko County. Median household income in Nye County is also low compared to other Basin counties at $55,975. The highest median household income is observed in Lander County at $84,474. Poverty, which is based on income thresholds that vary by family size and composition, ranges from 8% in Pershing and White Pine counties to 22% in Eureka County. Finally, the proportion of the population (25 years and older) with a bachelor's degree or higher is at or below 20% throughout the Basin, ranging from 9% in Pershing County to 20% in Humboldt County.

Table 9: Selected Social and Economic Characteristics

	Elko	Eureka	Humboldt	Lander	Pershing	White Pine	Nye	Churchill
Total Population	53,702	1,855	17,285	5,734	6,650	9,080	51,591	25,516
Employment	65%	42%	60%	56%	38%	48%	37%	53%
Poverty	11%	22%	12%	11%	8%	8%	16%	9%
Median Household Income	$83,427	$73,095	$79,946	$84,474	$72,007	$72,294	$55,975	$73,268
Bachelor's Degree or Higher	18%	18%	20%	17%	9%	14%	13%	19%