Steptoe Valley Units B & C Watershed Analysis

Landscape Conservation Forecasting™

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Summary

The Implementation Strategy for Steptoe Valley watersheds is the last phase of a four-part watershed analysis process. Using updated LANDFIRE vegetation data to predict needed implementation rates for ecological system restoration, we forecasted the future ecological condition of 16 ecological systems of the Bureau of Land Management (BLM) Ely District's Steptoe Valley Units B and C. For 11 ecological systems in need of restoration or predicted to further degrade, we simulated the effects of 20 years of management actions on ecological condition and calculated cumulative costs and Return-on-Investment under two active management scenarios. For several ecological systems at middle and high elevations, restoration was relatively affordable; however, restoration of sub-xeric shrublands at lower elevations, restoration was expensive and success limited, resulting in thousands of acres of seeded areas that will require decades of recovery before resembling more natural vegetation classes.

Introduction

The Ely District manages approximately 598,298 acres of the combined Units B & C of Steptoe Valley watersheds (**Fig. 1**), located within Northeastern Great Basin Resource Advisory Council jurisdiction. Steptoe Valley is perhaps rare among Great Basin valleys because Duck Creek in the valley bottom is an extensive slough and a high concentration of thermal and cold springs supports globally rare and endemic aquatic species in the lower valley (Nachlinger et al. 2001).

Extension of the Fire Regime Condition Class (FRCC) methodology (Rollins 2009) was used to assess the watersheds' ecological condition as part of the Implementation Strategy for Steptoe Valley watersheds. Implementation is the last phase of a four-part watershed analysis. Although called "fire regime condition," FRCC is an integrated, landscape-level estimate of the ecological condition of terrestrial and riparian ecological systems that incorporates all significant disturbances, not just fire. FRCC incorporates species composition, vegetation structure, and disturbance regimes to estimate an ecological system's departure from a Desired Range of Conditions (DRC). Ecological departure is measured using the Fire Regime Condition (FRC) metric, on a scale of 0 to 100, where higher numbers indicate higher departure from DRC. A separate designation and calculation of "high-risk" vegetation classes (e.g., cheatgrass invaded) was also applied because it is possible to improve ecological departure while some especially undesirable uncharacteristic classes increase in area; indeed, the cost and management urgency to address different uncharacteristic vegetation classes can vary greatly (Low et al. 2010). The methodology for enhancing the original LANDFIRE geodata with other geodata is presented in **Appendix I**. Initial conditions, DRC, and forecasted results of vegetation classes by ecological systems are also found in **Table I-2** in the appendix. Descriptions of each ecological system's vegetation classes are found in Appendix II.

Management strategies were explored to achieve the objectives for 11 focal ecological systems in the watershed. Predictive state-and-transition computer models were used to simulate conditions under alternative future management scenarios (methodology explained in Low et al. 2011). Using computer-based models, the likely future condition of 11 focal ecological systems was assessed after 20 years under three scenarios:

(1)   Minimum management – e.g., no treatment of invasive species, no thinning while maintaining fire-suppression activities and livestock grazing;

(2)   Maximum management – management treatments to restore ecological condition to the greatest possible degree, regardless of budget; and

(3)   Streamlined management – management strategies to improve ecological condition at reduced cost or relatively low investment.

Return on investment (ROI) was calculated to compare ecological benefits to costs, both *within* and *across* ecological systems. Land managers may select final strategies based upon a variety of additional factors, such as availability of financial resources, policy constraints, and non-ecological objectives.

Key Findings

- **The majority of the watersheds' ecological systems are highly or moderately departed from their Desired Range of Condition (DRC).** Of the area's 16 ecological systems, only three (pinyon-juniper woodland, curl-leaf mountain mahogany woodland, and limber-bristlecone pine) were currently not departed from DRC (**Table 1**). Most ecological systems were currently at least moderately departed, including the two largest systems (Wyoming big sagebrush and black sagebrush) that collectively comprise almost 54% of the area and were highly departed from DRC (**Table 1**).

- **Based on current condition, future ecological departure, and high-risk vegetation predicted by minimum management simulations, 11 focal systems require special attention, including four sagebrush systems, mountain shrub, two aspen systems, montane riparian, valley bottom riparian, greasewood, and mixed salt desert (Table 1).** These 11 include seven highly departed systems and five moderately departed (below). With the exceptions of mountain shrub and aspen woodland, which were at low levels of high-risk vegetation classes, nine focal systems had at least moderately high percentages of high-risk vegetation classes (**Table 1**).

Wyoming big sagebrush	169,085 acres	69% departure (FRCC 3)
Black sagebrush	151,847 acres	85% departure (FRCC 3)
Greasewood	62,609 acres	79% departure (FRCC 3)
Mountain big sagebrush	36,648 acres	68% departure (FRCC 3)
Mixed Salt Desert	34,430 acres	75% departure (FRCC 3)
Valley Bottom Riparian	13,101 acres	65% departure (FRCC 2)
Montane riparian	7,398 acres	55% departure (FRCC 2)
Aspen-mixed conifer	4,723 acres	70% departure (FRCC 3)
Aspen Woodland	3,865 acres	44% departure (FRCC 2)
Low sagebrush steppe	1,777 acres	75% departure (FRCC 3)
Mountain Shrub	268 acres	47% departure (FRCC 2)

- *Low and middle elevation sagebrush systems* have primarily experienced increasing cover of cheatgrass within shrublands, although pinyon-juniper encroachment is a marginal problem in black sagebrush. Both Black sagebrush and Wyoming big sagebrush have cheatgrass present in over 65% of their areas.

- *Greasewood and mixed salt desert* have more than 74% of their area invaded by cheatgrass.

- *Montane sagebrush steppe* is more than 45% invaded by trees, whereas cheatgrass is present in about 25% of the system.

o *Valley bottom riparian* primarily suffers from exotic weed invasion in about 29% of its area.
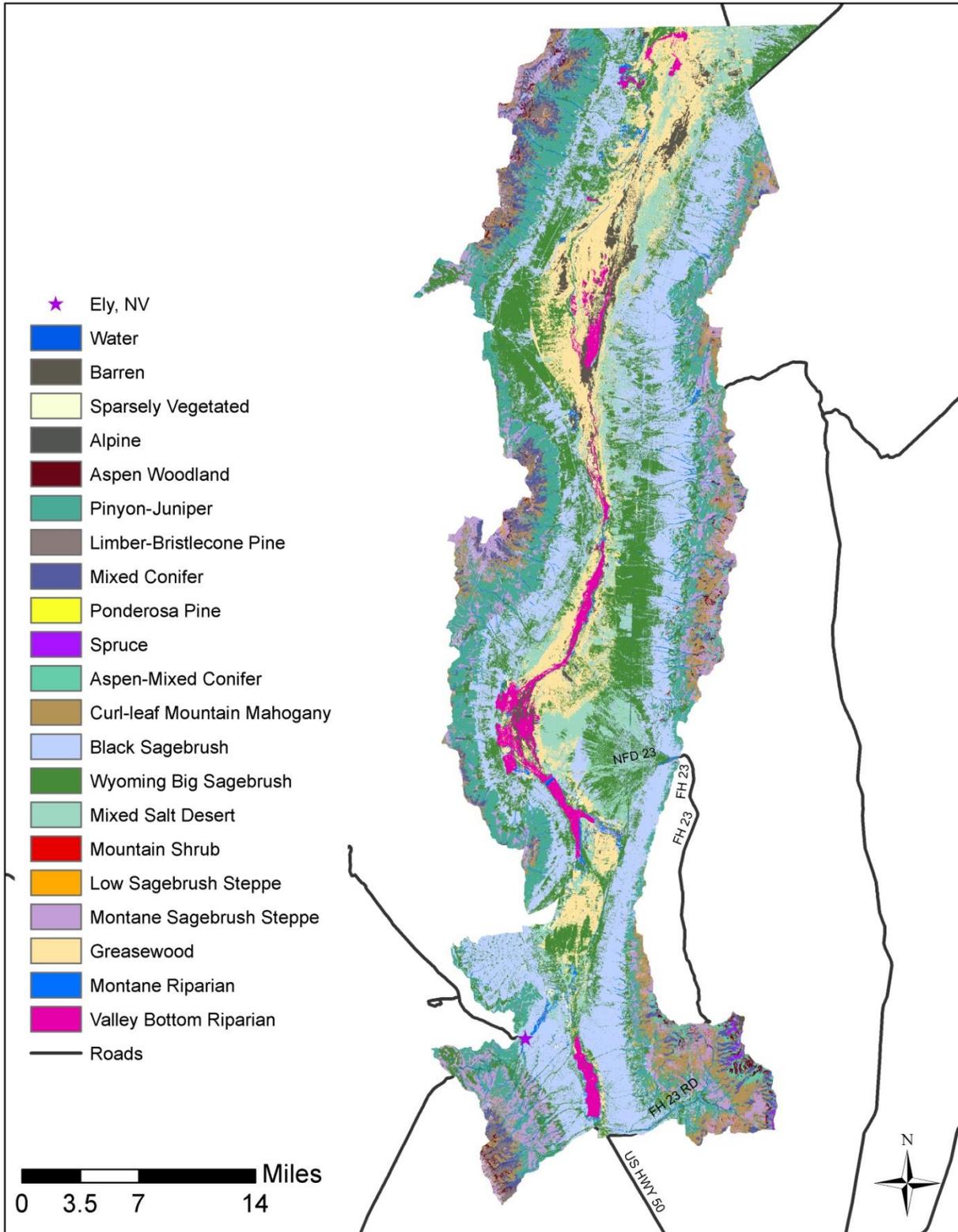

Figure 1. Ecological systems (aka, biophysical settings) of Units B and C of Steptoe Valley.

Aspen-mixed conifer woodland has 80% in the late succession class (versus a DRC of 10%), and is thereby facing a potential large loss of aspen clones.

- *Aspen woodland* is 25% depleted and, therefore, threatened by significant clone loss.

- *Montane riparian* has experienced exotic weed encroachment in 15% of its area and entrenchment of streams on over 40% of its acreage.

- *Low sagebrush steppe* is highly departed with more than 50% encroached by trees and 15% lacking understory herbaceous vegetation.

- *Mountain shrub* is a small system with 15% of its area invaded by cheatgrass.

- **Over the next 20 years, 6 of the 16 focal systems are predicted to become increasingly departed (>5% change) from DRC and/or have increases in high-risk vegetation, without thoughtful active management (Table 1): low sagebrush steppe, mixed salt desert, montane sagebrush steppe, mountain shrub, and Wyoming big sagebrush**. Conversely, ecological departure or the percentage of high-risk vegetation classes decreased in 10 ecological systems without active management, but with wildfire activity.

- **Various management strategies were explored for each targeted ecosystem, using computer simulations to test their effectiveness and adjust the scale of application. Multiple strategies are required for most ecological systems (Table 2):**

  - *Sagebrush* and *mountain shrub* strategies tested include: restoring sagebrush with mixed annual and perennial grasses through mowing and herbicide application, sometimes with supplemental seeding; restoring tree-encroached sagebrush through thinning (chaining or mastication), herbicide and seeding; restoring depleted sagebrush with mowing and seeding of native herbaceous species; annual grass control followed by seeding with native and introduced plant species; chainsaw lopping and thinning of encroaching conifer trees; chaining of late-succession classes with trees; and prescribed fire.

  - *Greasewood* and *mixed salt desert* strategies tested include: annual grass control followed by seeding with native and introduced plant species; and restoring shrublands with both annual and perennial grasses through mowing, herbicide application, and seeding with primarily salt-tolerant introduced species.

  - *Montane riparian* and *valley bottom riparian* strategies tested include weed inventory and spot application of herbicides; and fencing.

  - *Aspen* strategies tested include prescribed fire; chainsaw thinning of late-successional classes; and fencing.

- **With the exception of the small mountain shrub system, the maximum management scenarios largely eliminated or substantially reduced high-risk vegetation classes for all 11 focal ecological systems, except mixed salt desert, and moved three systems to low departure (FRCC 1) and four to moderate departure (FRCC 2); however, this scenario achieved these results at a very high**

dollar cost (Table 1). This scenario also produced sizable areas of seeding at lower elevations. While seedings are not high-risk vegetation, they are considered uncharacteristic vegetation that directly increases ecological departure. For example, the total 20-year cost for maximum management on the four sagebrush systems was >$100 million, over two times higher than the combined streamlined management cost of approximately $45 million for these systems.

- **The streamlined management scenarios improved FRC results as compared to minimum management for all ecological systems, reducing ecological departure from high (FRCC 3) to low (FRCC 1) for one system, achieving moderate departure (FRCC 2) from high departure for four other systems, reducing moderate departure (FRCC 2) to low departure (FRCC 1) for two systems, and reducing departure, although not Fire Regime Condition Class, within moderate and low classes for one system each (Table 1).** Using computer models, varied management strategies were tested to improve ecological condition at reduced cost or relatively low investment. Streamlined management also reduced high-risk vegetation as compared to minimum management for all systems, except for valley bottom riparian.

- **Across the 11 focal systems, the streamlined management scenarios produced the highest area-weighted ROI for four systems: aspen-mixed conifer, low sagebrush steppe, mountain shrub, and valley bottom riparian (Table 1).** Greasewood achieved a higher ROI in the maximum management scenario (**Table 1**). ROIs were comparable (i.e., within 0.5 unit of ROI, which we found to be comparable based on replicate runs) between the maximum and streamlined management scenarios for aspen woodland, black sagebrush, mixed salt desert, montane riparian, montane sagebrush steppe, and Wyoming big sagebrush. However, the absolute cost of restoration was clearly less expensive for the streamlined management scenario, sometimes by $20-$30 million for each of black sagebrush and Wyoming big sagebrush. Overall, the recommended management actions were selected from the streamlined management scenario based on higher performance or lower cost when ROIs were comparable between scenarios, with the exception to select the maximum management scenario for greasewood (see bolded ROIs in **Table 1** showing the selection).

Recommended Strategies, Annual Application Rates and Costs

The strategies recommended for the 11 focal systems are presented in **Table 2**. The average annual cost for managing all 11 systems (~485,752 acres) with the recommended strategies is approximately $3.74 million *per year*, over 20 years, if BLM chooses to include mixed salt desert and greasewood that are usually not actively restored. The maximum management scenario would cost $6.2 million *per* year. Some strategies have higher application rates during the first five years, so the average annual cost in these earlier years is higher. Black sagebrush and Wyoming big sagebrush account about equally for 75% of the total cost for the recommended strategies (77% for the maximum management scenario) and their restoration costs are high because of their inherently high failure rates at those elevations, seeding is required in most operations, and prevalence of a cheatgrass seed bank.

Based on ROI alone (a combination of ecological improvements, cost, and size of the ecological system) and not regulatory or policy constraints, a few ecological systems might be given higher priority by the BLM. In decreasing order of ROI, these ecological systems are: greasewood, valley bottom riparian, aspen-mixed conifer (aka, seral aspen), low sagebrush steppe (i.e., upper montane and subalpine low sagebrush), montane riparian, aspen woodland (aka, stable aspen), black sagebrush, montane sagebrush

steppe, mixed salt desert, Wyoming big sagebrush, and mountain shrub. Greasewood is an unexpected result, but only possible with the use of salt-tolerant introduced grass species (e.g., Russian wheatgrass) and the rapid ability of greasewood to reestablished in sodic soils. We realize, however, that greasewood might not be a priority for BLM.

Maps for all potential areas where treatments could currently be applied are shown in **Figs. 2-17**. Some modeled treatments are mostly forecasted, and therefore only small areas are associated with them today (e.g., restoration of annual grassland created by future fires in uncharacteristic vegetation). Prescribed fire polygons applied to reference classes (i.e., classes of succession retaining native herbaceous and shrub cover) are shown in **Fig. 2**. Some polygons were situated on slopes >15%, including >30% slope. Prescribed fire on steeper slopes would likely require helicopter burning.

Chaining reference classes on slopes less that 15% in black sagebrush are presented in **Fig. 3**. Two types of chaining (two-way smooth chaining to avoid soil disturbance, which could favor cheatgrass) were used to remove pinyon pine and juniper. Of all mechanical treatments, chaining is clearly the least expensive. Chaining only was deployed in the reference late-succession class (D) because it was assumed that herbicide and seeding were not necessary. In tree-encroached (TE) black sagebrush, which theoretically lacks native understory vegetation and cheatgrass, two-way chaining followed by seeding of native and/or introduced (e.g., crested wheatgrass) species was recommended (see also the alternative, more expensive mastication followed by seeding treatment; **Fig. 4**).

A series of operations used chainsaws to cut trees. Although the majority of chainsaw operations apply to various reference classes, chainsaw lopping of young trees in uncharacteristic classes also apply. Chainsaws can also be deployed on steep slopes where other mechanical equipment cannot operate. Mechanical thinning with chainsaw in more heavily wooded reference classes was used in both aspen types (classes D and E) and in montane sagebrush steppe (classes D and E) (**Fig. 5**). In aspen-mixed conifer, only conifers are proposed for cutting in the late succession D and E classes, whereas all trees are cut in the late-succession class D of aspen woodlands to stimulate heavy suckering. Pinyon and juniper are removed in late-succession classes D and E in montane sagebrush steppe. Chainsaw-thinning was also used in low sagebrush steppe to remove trees in the uncharacteristic tree-encroached class (TE), which could include limber pine, pinyon pine, or juniper growing on clay soils (**Fig. 6**). The final use of chainsaws was for lopping young trees invading reference and uncharacteristic shrublands (the "Christmas tree" phase; **Fig. 7**). This method was used because it is much cheaper to cut young and dispersed trees than remove developed woodlands decades later.

A series of mechanical treatments coupled with herbicide and seeding were used on slopes usually less than 10%. Mowing shrubs followed by herbicide application to control cheatgrass and seeding was simulated on 1000's of acres (**Fig. 8**). At lower elevations, introduced and native seed might be used in black sagebrush, whereas BLM should be successful with pure native seed at the higher elevation of montane sagebrush steppe. (Note that the shrub with mixed annual and perennial grasses class $-$ SAP $-$ in montane sagebrush steppe includes the vegetation class without any perennial class $-$ SA; thus the need for seeding.) A very similar method without seeding applied at very high rates is used in black sagebrush's shrub with mixed annual and perennial grasses class (SAP) where native herbaceous cover is present, but cheatgrass needs to be controlled (**Fig. 9**). Similar to mowing, thinning is proposed as a general method to reduce shrub cover, but a mower or a rugged rangeland drill can be used to accomplish this action is less woody or more open vegetation. In mixed salt desert, thinning (perhaps with a rugged rangeland drill) followed by herbicide application to control cheatgrass and seeding with mostly introduced salt tolerant species is used in the depleted (DP), shrub with mixed annual and

perennial grasses class (SAP), and the annual grassland (AG) classes was simulated at a rate of 1,000 acres per year for 20 years in the maximum management scenario only (**Fig. 10**). The same treatment was applied in Wyoming big sagebrush as a more typical mowing operation and at very large scale (**Fig. 10**). Thinning followed by seeding of native species without herbicide is applied in subalpine low sagebrush steppe in the depleted shrub class, however slope constraints for machinery limited application to very small few and small areas (**Fig. 11**). The restoration of annual grasslands (AG) was perhaps the most intensively used treatment in all simulations, but the action applied to future restoration caused by wildfires and restoration failures in classes with cheatgrass. Only a few areas qualify today for spraying herbicide and seeding because annual grasslands are still relatively uncommon in Steptoe Valley and the constraints of deploying machinery on slopes of <10% (**Fig. 12**).

Among less mechanically intensive actions, fencing of depleted patches of aspen woodland to reduce domestic and wild ungulate herbivory, while clones recover by suckering, was proposed for very dispersed patches at the eastern and western upper elevation boundaries of the watershed (**Fig. 13**). Fencing was proposed primarily because clones are considered too brittle to even receive prescribed burning; therefore, clones require an accumulation of root reserves and foliage before receiving other treatments.

The last group of management actions was focused on riparian systems and greatly differed from those above. The use of cowboys to temporarily and periodically push livestock away from creeks (in lieu of permanent fences and water gaps) serves the purpose of reducing or reversing bank erosion and overgrazing of montane riparian vegetation (**Fig. 14**). This action was only proposed for the maximum management scenario (i.e., it was not retained for the recommended scenario) and would entirely depend on voluntary action by livestock operators. In other parts of Nevada and eastern California where TNC has worked, some ranchers successfully use this approach. A fundamental action for maintaining the ecological integrity of montane and valley bottom riparian systems is weed inventory (**Fig. 15**), which includes both periodic surveys to detect exotic forbs and salt cedar, and immediate spot-spraying if possible. If detection and spot-spraying failed, riparian vegetation enters the exotic forb class (EF) where the exotic control action is deployed (**Fig. 16**). In the LANDFIRE derived map in **Fig. 16**, the current area supporting exotic forbs and tress, especially in the valley bottom riparian, is surprisingly large and may have been over-mapped. The last riparian action proposed is the use of low-technology rock riffles and rock dams to slow down water velocity and elevate water surface and tables in stream reaches with incised banks and desertified floodplains (DE; **Fig. 17**). Although BLM has no history with this action, a few ranchers have successfully used it in the southwest USA by creating hand-made rock weirs in small ephemeral and perennial waterways. These ranchers were inspired by the use of this common practice in northern Mexico. Moreover, the action does not require equipment, although using mechanical bobcats can greatly accelerate work in areas where the creeks are accessible. Increasing the elevation of the water table and residence time of water in creeks might also be considered important with increasing drought levels as predicted by many climate models (Dettinger et al. 2004).

Table 1. Ecological departure, high-risk classes, cumulative cost, and Return-On-Investment (ROI) for ecological systems of Steptoe Valley Units B and C. Ecological systems without costs and ROI did not receive management. Legend: Min = Minimum Management Scenario, Max = Maximum Management Scenario, Stream = Streamlined Management Scenario. ROIs in bold identified the scenario chosen for recommended management.

Stratum	Area (acres)	Ecological Departure Summary				High-Risk Vegetation Classes				20-year Cumulative Cost		ROI-Max	ROI-Stream
		Initial	Min	Max	Stream	Initial	Min	Max	Stream	Max Scenario	Stream		
Aspen Woodland	3,865	44%	30%	17%	20%	25%	10%	1%	6%	$202,225	$125,643	4.3	**4.4**
Aspen-Mixed Conifer	4,723	70%	53%	42%	28%	na	na	na	na	$429,578	$179,091	1.2	**6.5**
Black Sagebrush	151,847	85%	87%	49%	64%	70%	58%	2%	45%	$47,367,572	$21,067,748	3.0	**2.6**
Curl-leaf Mountain Mahogany	27,859	28%	25%			0%	1%						
Greasewood	62,609	79%	75%	12%	39%	79%	62%	4%	35%	$9,365,757	$7,813,134	**8.0**	5.0
Limber-Bristlecone	5,239	23%	21%			na	na	na	na				
Low Sagebrush Steppe	1,777	75%	85%	16%	17%	75%	70%	0%	3%	$522,668	$466,011	4.3	**4.8**
Mixed Conifer	15,290	62%	33%			0%	0%						
Mixed Salt Desert	34,430	75%	80%	77%	79%	75%	63%	31%	52%	$8,816,998	$2,630,996	2.5	**2.4**
Montane Riparian	7,398	55%	58%	26%	24%	55%	45%	3%	1%	$1,267,658	$1,203,616	4.5	**4.1**
Montane Sagebrush Steppe	36,648	68%	59%	32%	38%	2%	23%	2%	12%	$7,128,761	$4,802,737	2.5	**2.4**
Mountain Shrub	268	47%	45%	53%	41%	1%	8%	0%	3%	$37,094	$23,533	0	**1.0**
Pinyon-Juniper	59,591	8%	7%			0%	2%						
Spruce	641	36%	28%			na	na	na	na				
Valley Bottom Riparian	13,101	35%	65%	12%	21%	16%	29%	1%	14%	$1,602,003	$975,545	1.86	**1.82**
Wyoming Big Sagebrush Upland	169,085	69%	71%	51%	58%	34%	39%	1%	14%	$47,416,313	$34,128,194	2.1	**1.9**

Table 2. Implementation rates of management actions for 11 ecological systems of Steptoe Valley Units B and C. Implementation rates are proposed <u>average</u> rates; PATH might have simulated higher or lower rates, although usually lower rates were selected when a vegetation class decreases in area. Implementation rates also reflect current and forecasted restoration needs based on the Minimum Management scenario 20-year results.

Ecological System	Management Action	Description	Unit Cost ($/acre)	Maximum Management Scenario Years of Implementation (acres/year)			Streamlined Management Scenario Years of Implementation (acres/year)	
				1-5	6-20		1-5	6-20
Aspen-Mixed Conifer	Mechanical Thinning	• Chainsaw thinning of conifers in late-succession classes D and E.	150	500	0		100	0
	RxFire	• Prescribed burning of late-succession classes D and E.	50	400	0		450	0
Aspen Woodland	Fence	• Temporary fencing of depleted aspen patches.	150	50	50		100	0
	Mechanical Thinning	• Chainsaw thinning of older aspen patches in late-succession class D.	150	40	40		0	0
	RxFire	• Prescribed burning of older aspen patches in late-succession class D.	50	0	0		100	0
Black Sagebrush	Chaining	• Two-way smooth chaining of late-succession class D.	85	0	0		800	0
	Chaining+Seed	• Two-way smooth chaining of the tree-encroached class (TE) followed by seeding native and/or introduced species.	130	0	0		1,000	0
	Chainsaw-Lopping	• Chainsaw lopping young trees in the depleted (DP) and shrub with annual grass (SA) classes.	100	0	0		0	500
	Herbicide+Seed	• Herbicide control of annual grasses followed by seeding native and/or introduced species in the annual grassland class (AG).	130	7,000	7,000		1,500	1,500
	Mastication+Herbicide+Seed	• Mastication of the tree with annual grass class (TA) followed by herbicide spraying to control annual grass and seeding native and/or introduced species.	350	0	500		500	500
	Mastication+Seed	• Mastication of trees in the tree-encroached class (TE) followed by seeding native and/or	310	500	550		0	0

Vegetation Type	Treatment	Description						
		introduced species.						
	Mow+Herbicide+Seed	• Mow shrubs in the shrub with annual grass (SA) and depleted shrubland (DP) classes followed by herbicide spraying to control annual grass and seeding native and/or introduced species.	300	5,000	5,000		2,000	2,000
	Mow+Herbicide	• Mow shrubs in the shrub with perennial and annual grass (SAP) class followed by herbicide spraying to control annual grass.	50	2,000	2,000		3,500	1,000
Greasewood	Herbicide+Seed	• Herbicide control of annual grasses followed by seeding native and/or introduced species in the annual grassland class (AG).	90	5,000	5,500		3,000	3,000
Low Sagebrush Steppe	Chainsaw-Lopping	• Chainsaw lopping of trees in the late-succession class (C) and shrub with perennial and annual grass (SAP) classes.	70	50	50		25	25
	Chainsaw-Thinning	• Chainsaw thinning of trees in the tree-encroached class (TE) class.	100	80	80		40	80
	RxFire	• Prescribed burning in the late-succession class (C) to control tree invasion.	50	10	0		0	0
	Thin+Seed	• Thin (mow or with rangeland drill) shrub cover followed by seeding of native species in the depleted shrub (DP) class.	180	400	400		100	100
Mixed Salt Desert	Herbicide+Seed	• Herbicide control of either annual grasses or exotic forbs (mostly halogeton) followed by seeding native and/or introduced species in the annual grassland (AG) and exotic forbs (EXF) classes.	90	1,000	2,000		200	2,000
	Thin+Herbicide+Seed	• Mow (mower or rangeland drill) shrubs in the shrub with perennial and annual grass (SAP) and depleted shrub (DP) classes followed by herbicide spraying to control annual grasses followed by seeding native and/or introduced species in the annual grassland class (AG).	300	1,000	1,000		0	0
Montane Riparian	Cowboying	• Livestock operators actively and periodically move livestock away from streams as they aggregate there (in lieu of fencing streams and creating water gaps).	3	1,000	1,000		0	0
	Exotic-Control	• Herbicide application of exotic forbs in the exotic-invaded class (EXF).	260	210	250		210	250
	Rockfill-Riffle	• Inexpensive creation of rock riffles to elevate the	100	200	200		200	2,000

	Weed-Inventory	water surface and water table, and slow down water velocity along incised banks (DES). • Periodic survey of streams to detect exotic forbs and spot-application of herbicide to control them.	50	100	100		100	100
Montane Sagebrush Steppe-upland	Herbicide+Seed	• Herbicide control of annual grasses followed by seeding native and/or introduced species in the annual grassland class (AG).	90	0	125		0	65
	Mastication+Herbicide+Seed	• Mastication of the tree-encroached class (TE; which also includes cheatgrass-invaded patches) followed by herbicide spraying to control annual grasses and seeding native and/or introduced species.	350	375	375		150	150
	Mechanical Thinning	• Chainsaw thinning of trees in late-succession classes D and E.	300	600	600		300	300
	Mow+Herbicide+Seed	• Mow shrubs in the shrub with perennial and annual grass (SAP) class followed by herbicide spraying to control annual grasses and seeding native and/or introduced species.	300	500	500		250	250
	RxFire	• Prescribed burning of late-succession classes D and E.	50	600	600		400	400
Mountain Shrub	Mastication+Herbicide+Seed	• Mastication of the tree-encroached class (TE; which also includes cheatgrass-invaded patches) and the shrub with perennial and annual grass class (SAP; after 80 years) followed by herbicide spraying to control annual grasses and seeding native and/or introduced species.	350	20	15		10	5
	RxFire	• Prescribed burning of late-succession classes C and D.	50	20	10		0	10
Valley Riparian	Exotic-Control	• Herbicide application of exotic forbs in the exotic-invaded class (EXF).	260	370	370		150	150
	Weed-Inventory	• Periodic survey of streams to detect exotic forbs and use spot-application of herbicide to control them.	50	220	220		200	200
	Floodplain-Restoration	• Hydro-geomorphic restoration of incised or straightened river reaches	1,000	5	5		0	0
Wyoming Big Sagebrush-upland	Chainsaw-Lopping	• Chainsaw lopping trees in the tree with annual grass class (TA).	70	0	0		1,000	1,000

	Herbicide+Seed	• Herbicide control of annual grasses followed by seeding native and/or introduced species in the annual grassland class (AG).	90	500	10,000	500	8,000
	Mastication+Herbicide+Seed	• Mastication of trees in the tree with annual grass class (TA) followed by herbicide spraying to control annual grasses and seeding native and/or introduced species.	350	1,000	1,200	500	600
	Thin+Herbicide+Seed	• Mow shrubs in the shrub with perennial and annual grass (SAP), shrub with annual grass (SA), depleted shrub (DP) classes followed by herbicide spraying to control annual grasses and seeding native and/or introduced species.	300	10,000	8,000	5,000	4,000

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Potential Prescribed Fire Treatment Areas

Roads
Steptoe Valley Boundary
★ Ely, NV

Ecological Systems

- Aspen Woodland x D
- Aspen-Mixed Conifer x D
- Aspen-Mixed Conifer x E
- Mountain Shrub x C
- Low Sagebrush Steppe x C
- Montane Sagebrush Steppe x D
- Montane Sagebrush Steppe x E

Miles
0   3.5   7   14

NFD 23
FH 23
FH 23
FH 23 RD
US HWY 50

N

Fig. 2. Map of potential vegetation classes where prescribed burning could be used today. Vegetation classes are represented by the ecological system combined with the succession class. Only late-succession reference classes (C, D, and E) from higher elevations were chosen.

Fig. 3. Map of potential vegetation classes where chaining and chaining followed by seeding could be used today. Vegetation classes are represented by the ecological system combined with the succession class. Chaining is only used in the late-succession D class of black sagebrush, whereas chaining followed by seeding is only used in the uncharacteristic tree-encroached sagebrush class (TE).

Fig. 4. Map of potential vegetation classes where mastication followed by seeding could be used today. Vegetation classes are represented by the ecological system combined with the succession class. Mastication followed by seeding is only used in the uncharacteristic tree-encroached sagebrush class (TE).
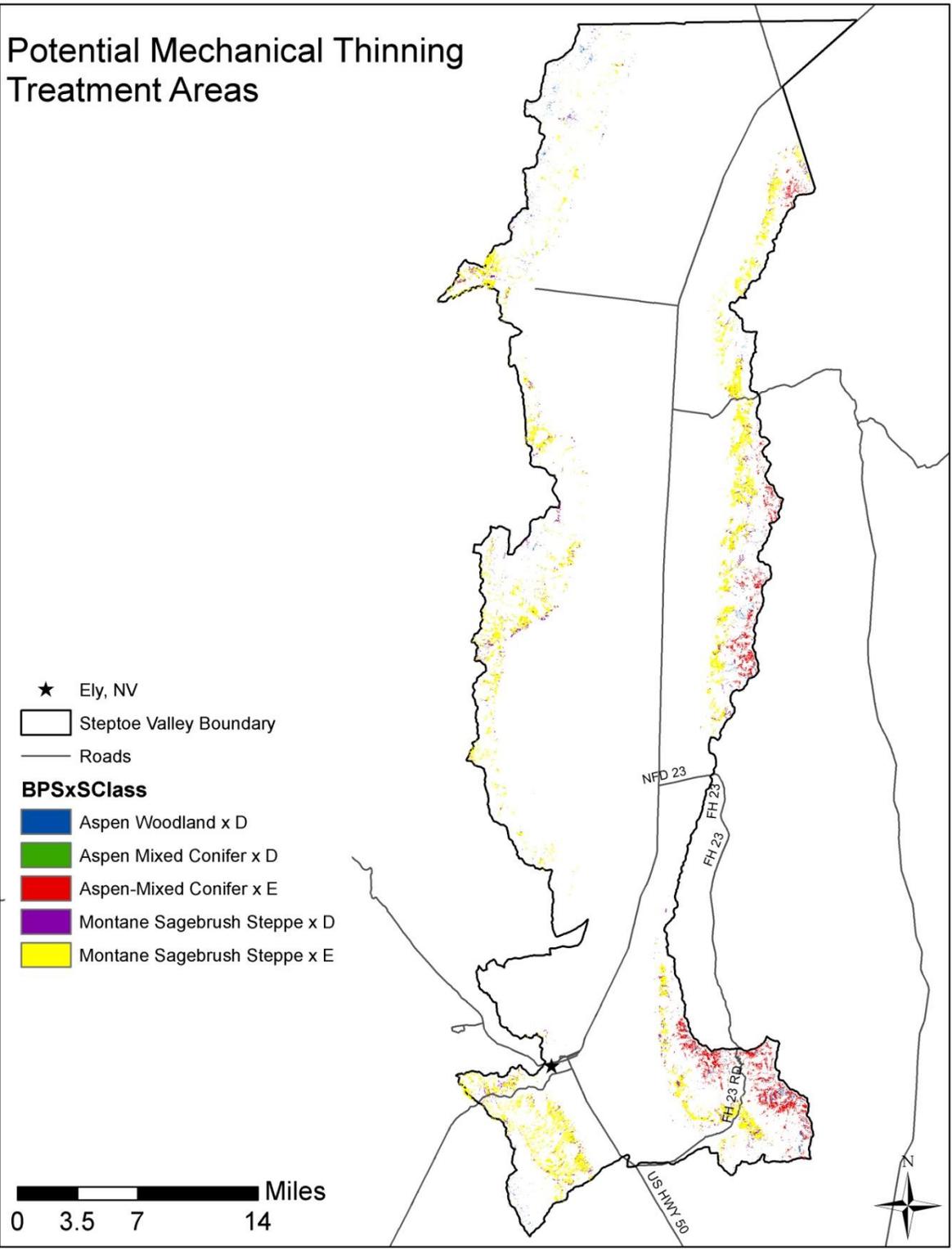
Fig. 5. Map of potential vegetation classes where mechanical thinning with chainsaws could be used today. Vegetation classes are represented by the ecological system combined with the succession class. Only reference classes are targeted.
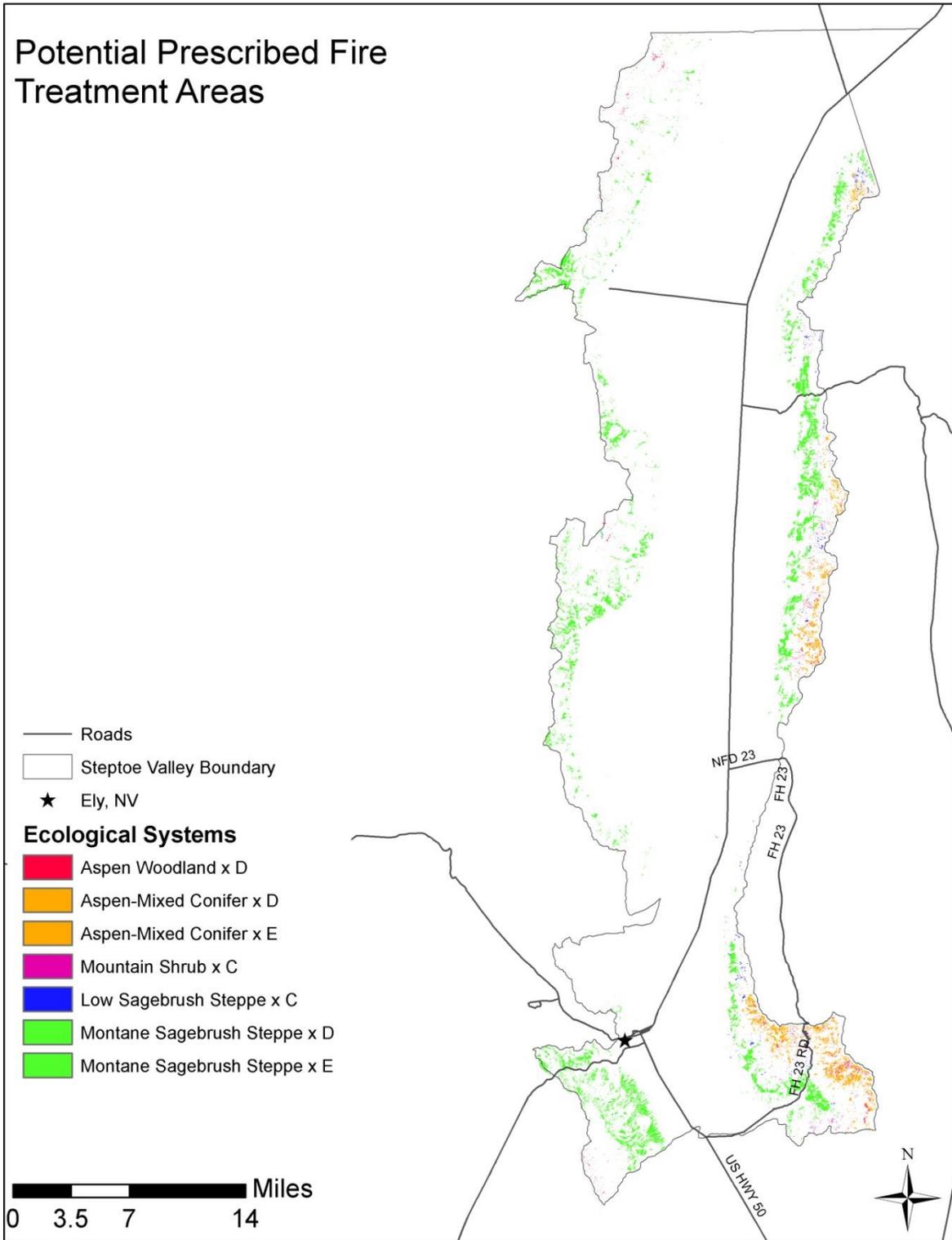
Fig. 6. Map of potential vegetation classes where chainsaw thinning could be used today. Vegetation classes are represented by the ecological system combined with the succession class.
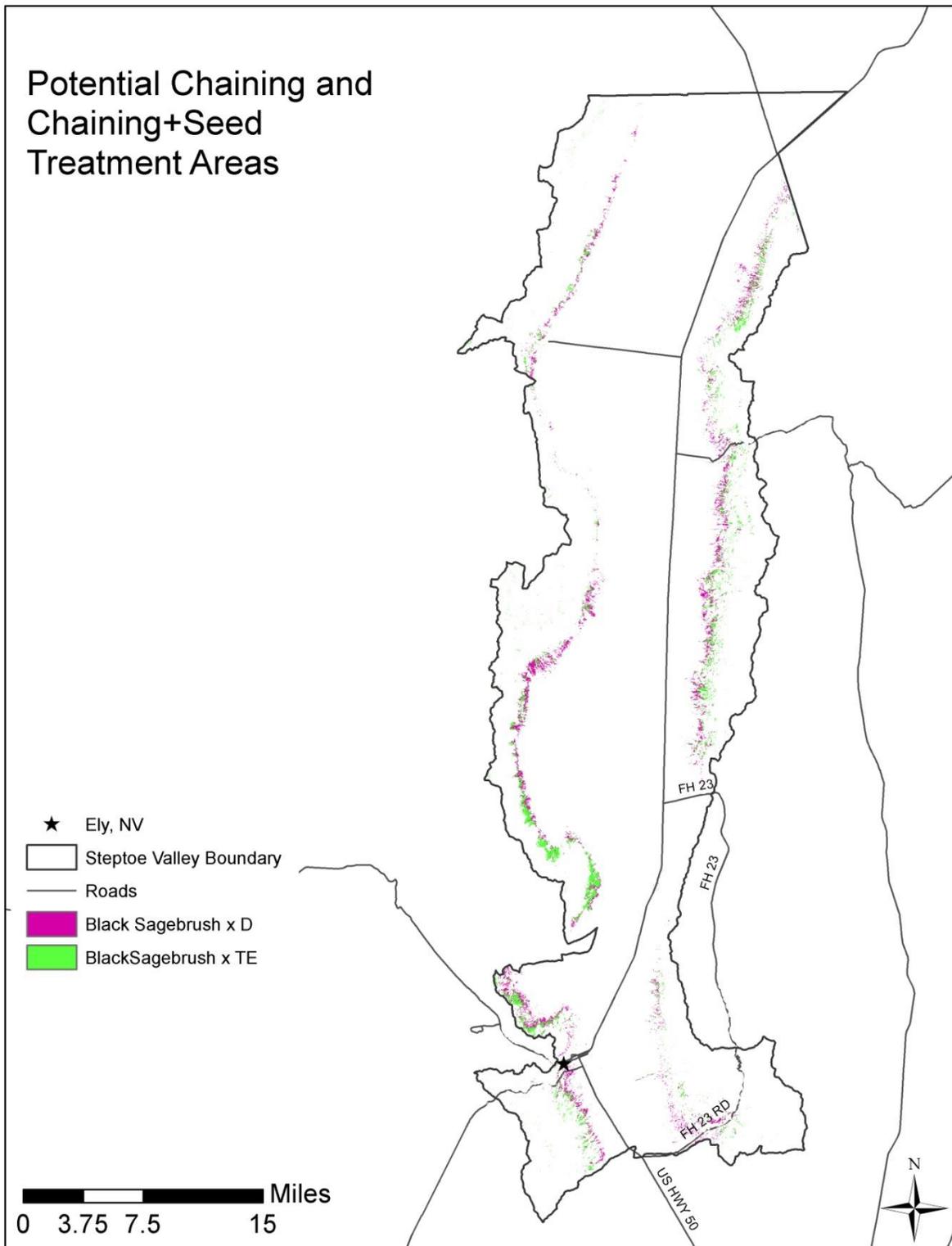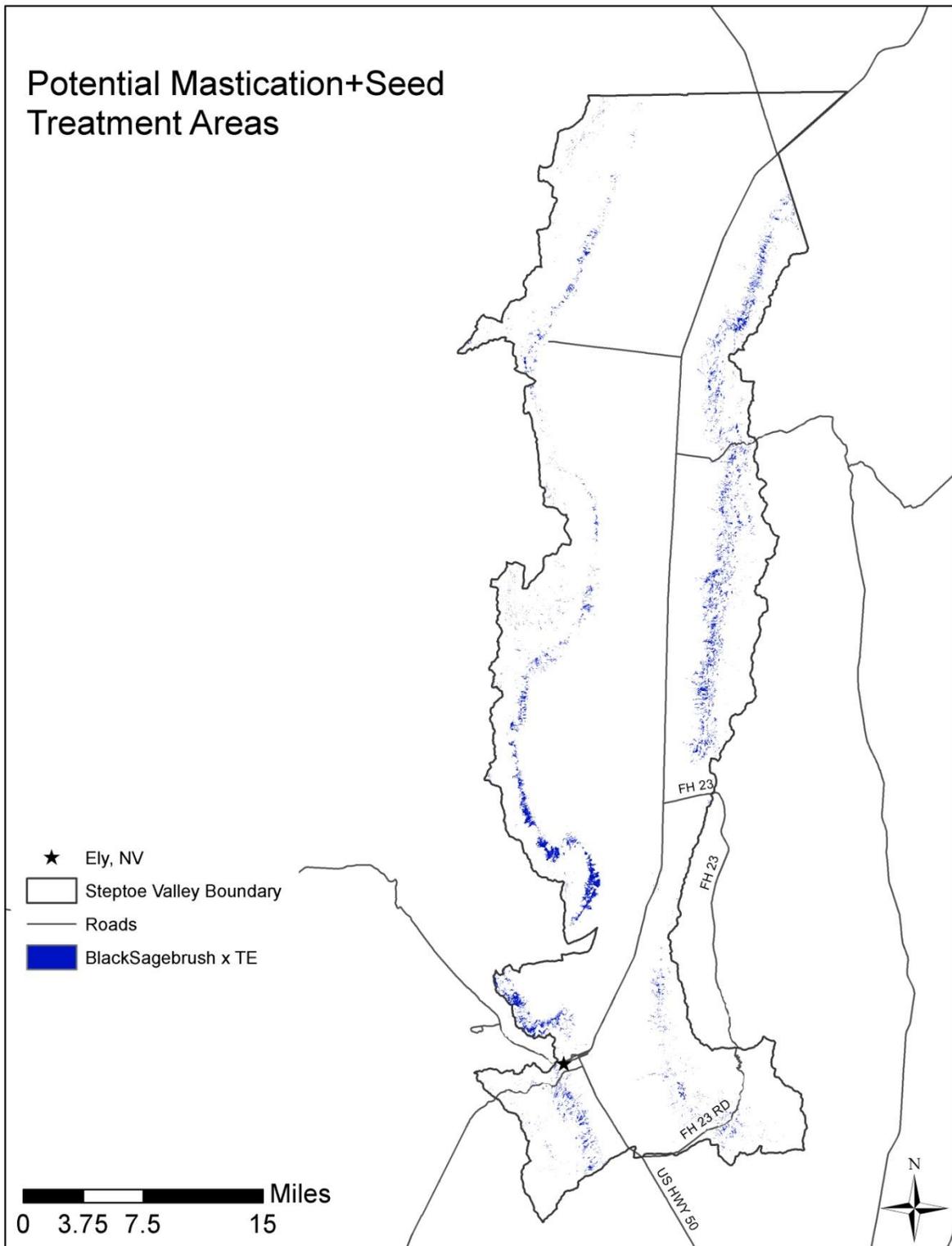
Fig. 7. Map of potential vegetation classes where chainsaw lopping could be used today. Vegetation classes are represented by the ecological system combined with the succession class. Both reference (low sagebrush steppe class C) and uncharacteristic classes are targeted for thinning young trees.
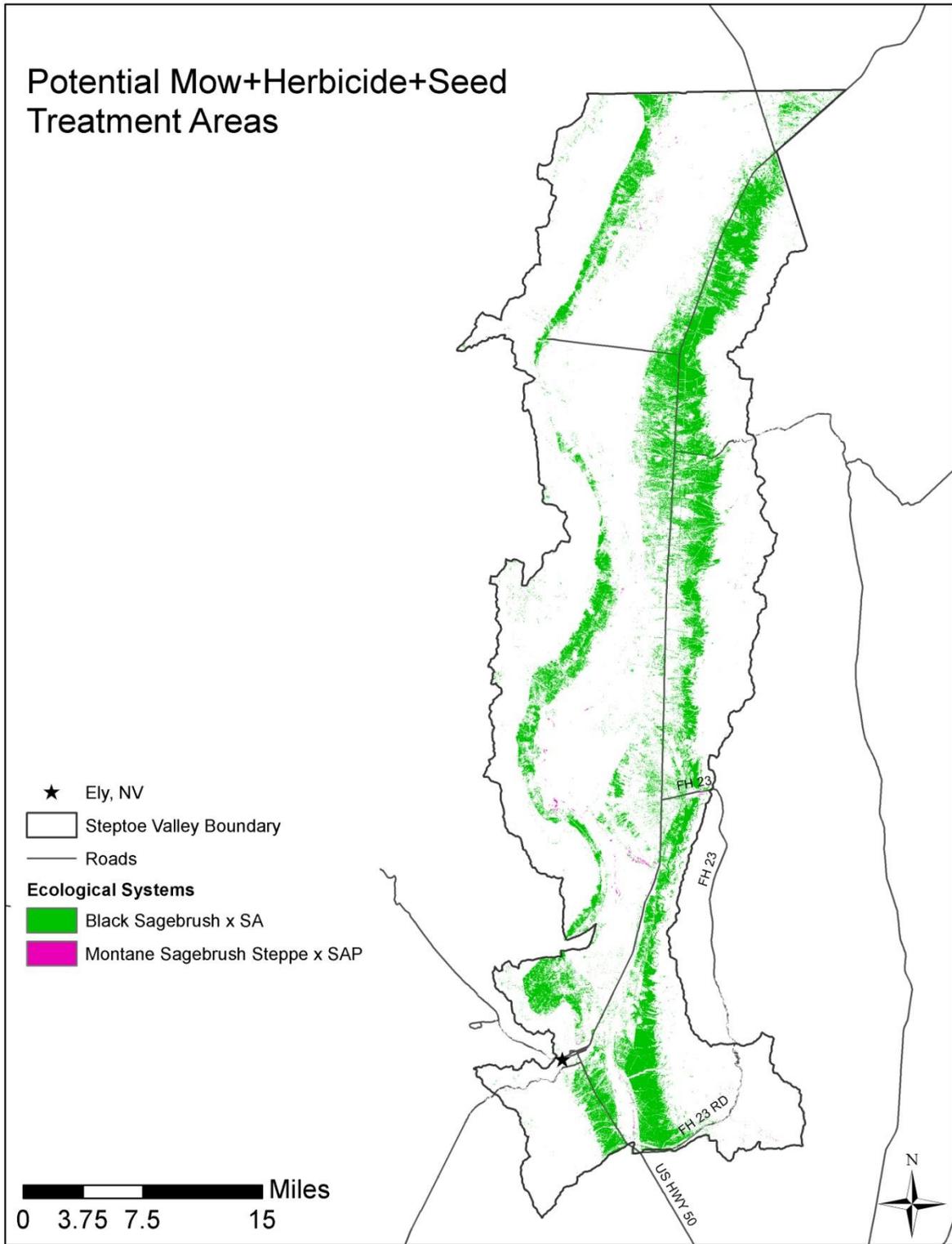
Fig. 8. Map of potential vegetation classes where mowing uncharacteristic shrublands followed by herbicide spraying to control cheatgrass and seeding could be used today. Vegetation classes are represented by the ecological system combined with the succession class.
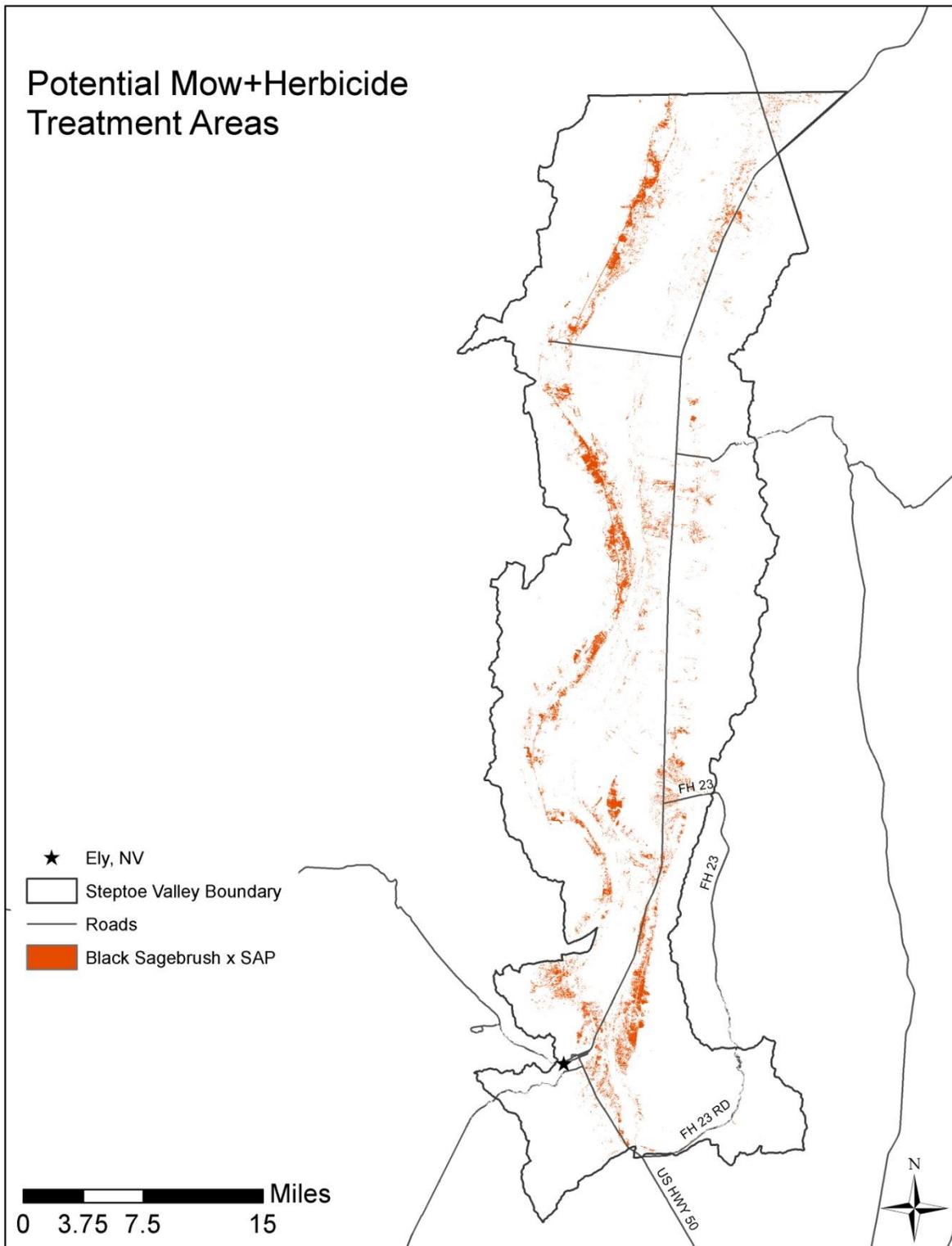
Fig. 9. Map of potential vegetation classes where mowing uncharacteristic shrublands followed by herbicide spraying to control cheatgrass could be used today. Vegetation classes are represented by the ecological system combined with the succession class.
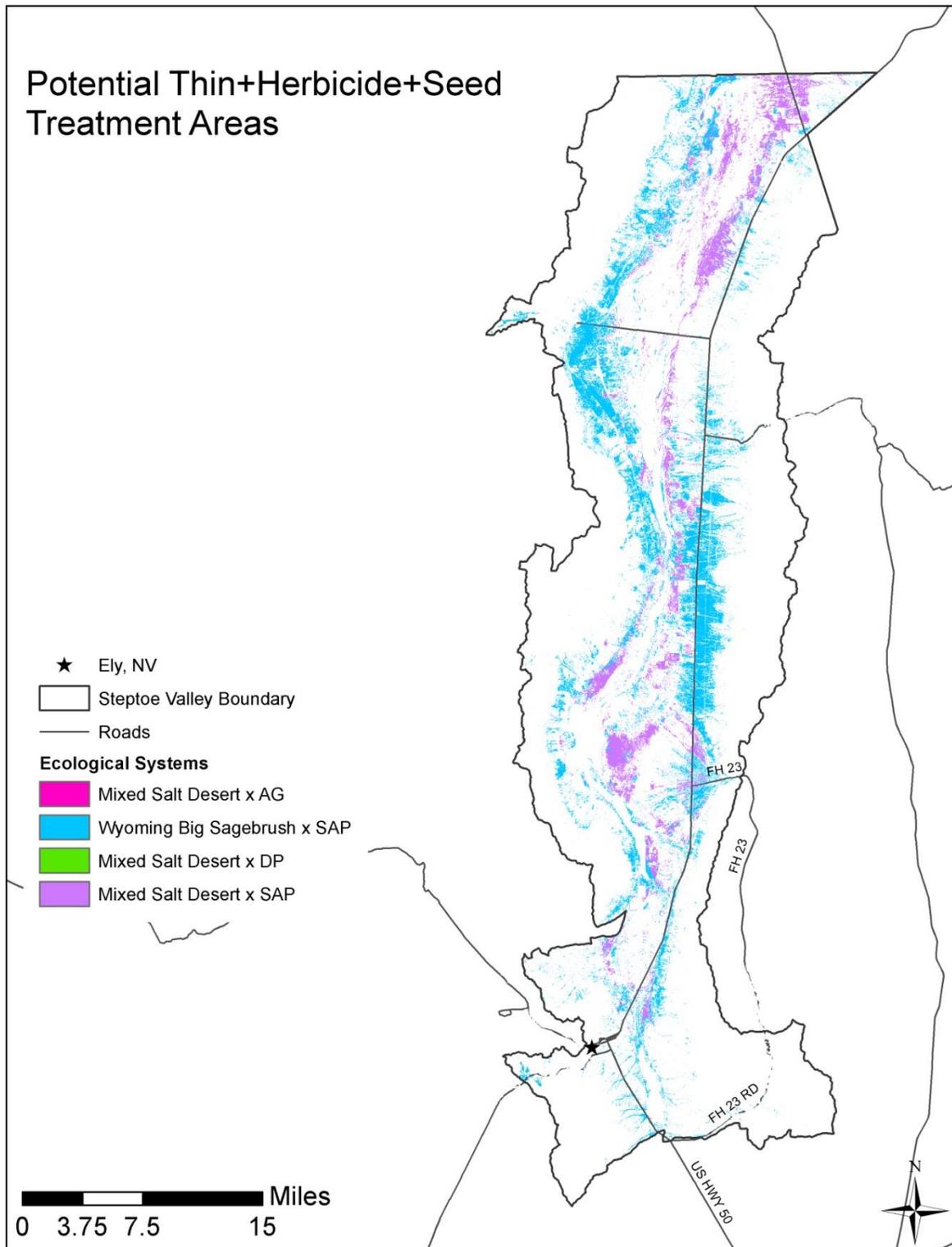
Fig. 10. Map of potential vegetation classes where thinning uncharacteristic shrublands followed by herbicide spraying to control cheatgrass and seeding could be used today. Vegetation classes are represented by the ecological system combined with the succession class.
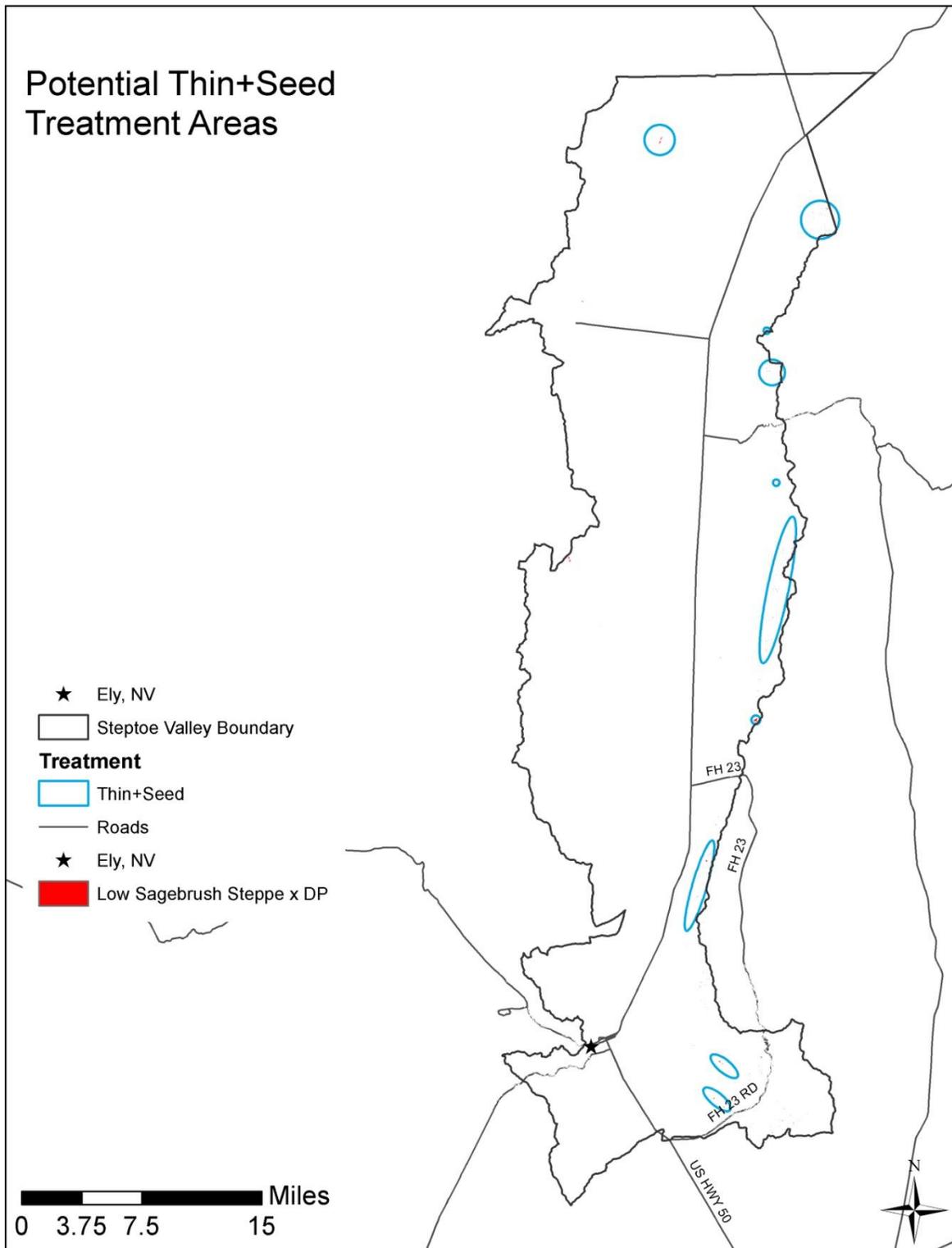
Fig. 11. Map of potential vegetation classes where thinning uncharacteristic shrublands followed by herbicide spraying to control cheatgrass and seeding could be used today. Vegetation classes are represented by the ecological system combined with the succession class.
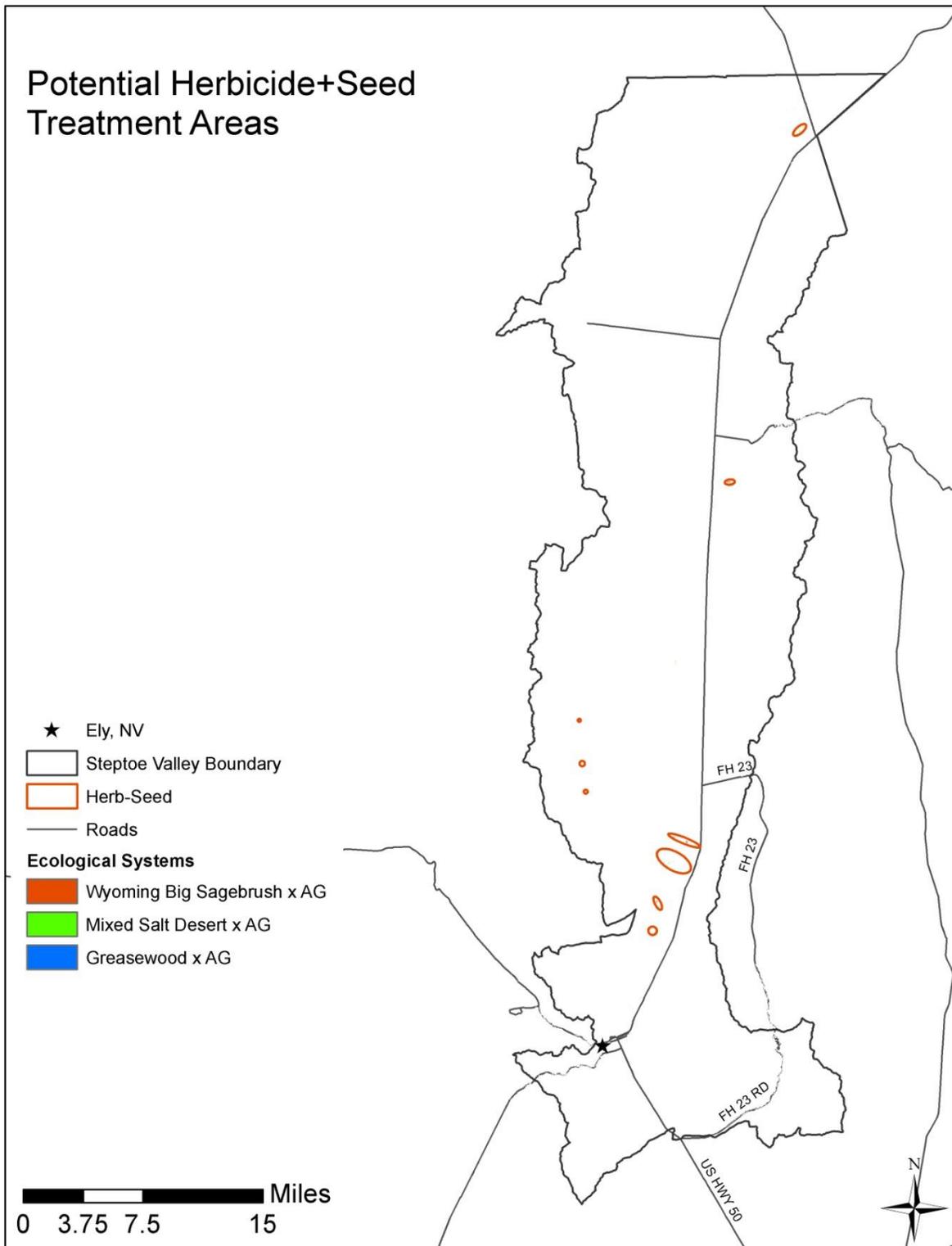
Fig. 12. Map of potential vegetation classes where herbicide spraying to control cheatgrass followed by seeding could be used today to restore annual grassland. Vegetation classes are represented by the ecological system combined with the succession class.
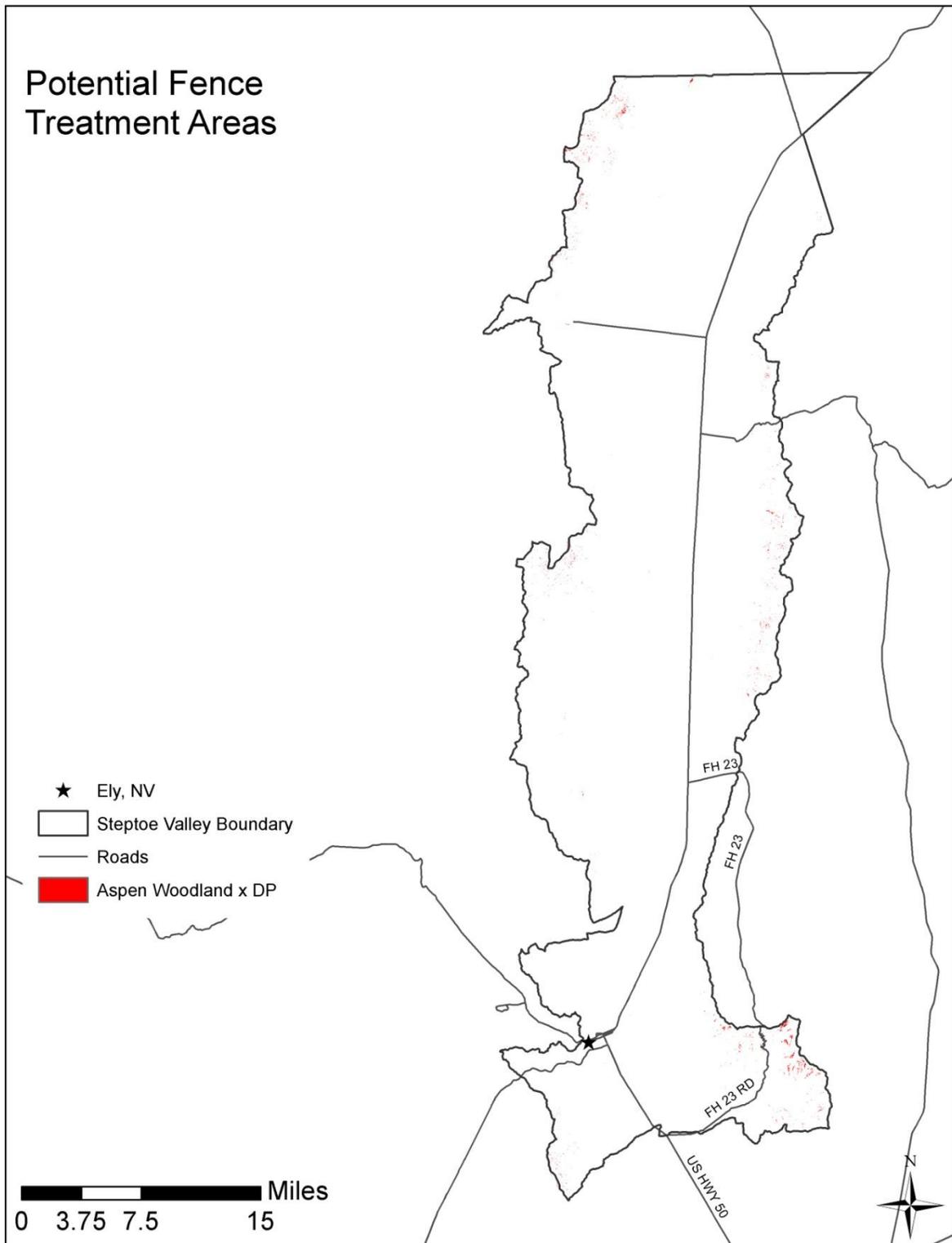
Fig. 13. Map of potential vegetation classes where temporary fencing of depleted (DP) aspen woodlands could be used today. Vegetation classes are represented by the ecological system combined with the succession class.
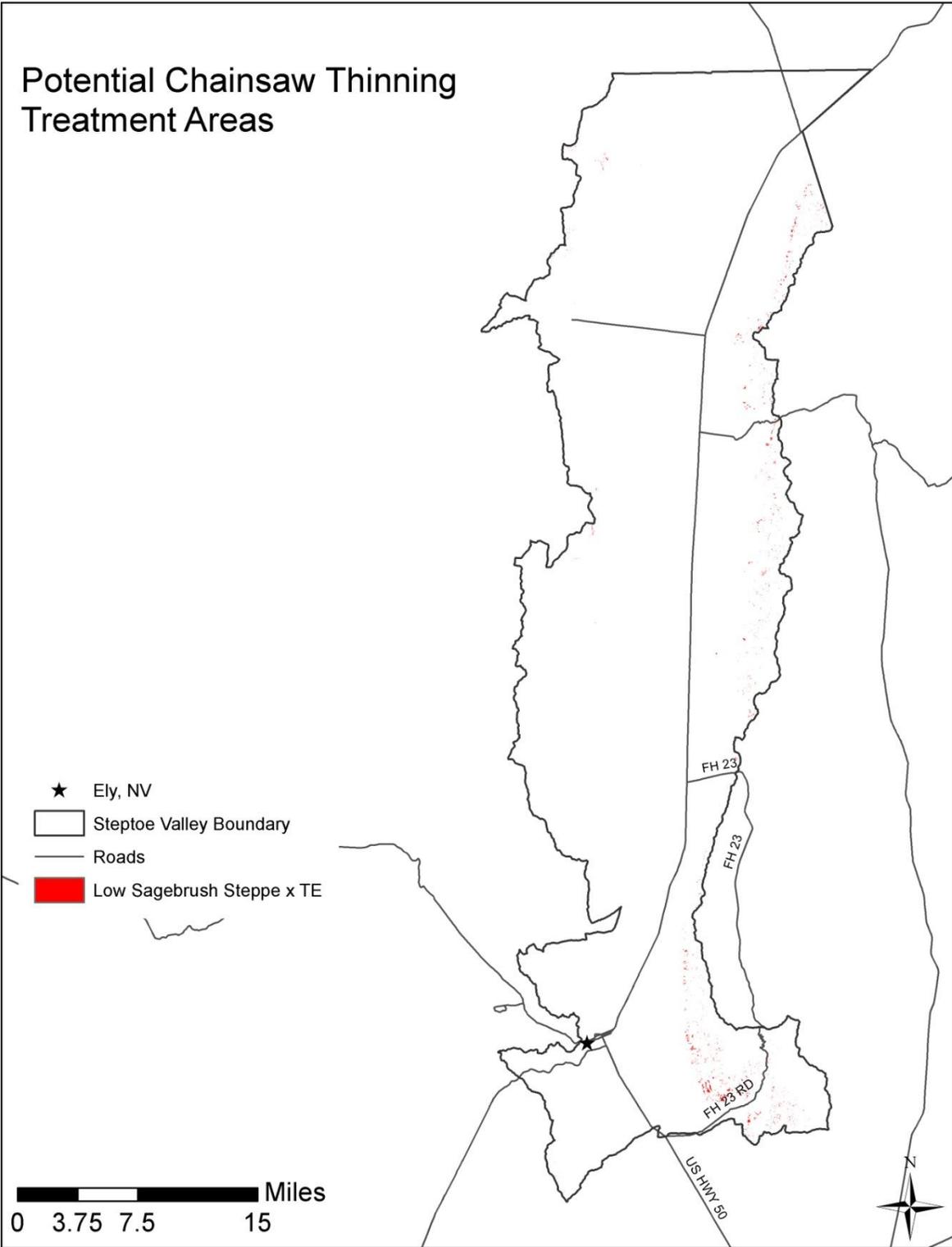
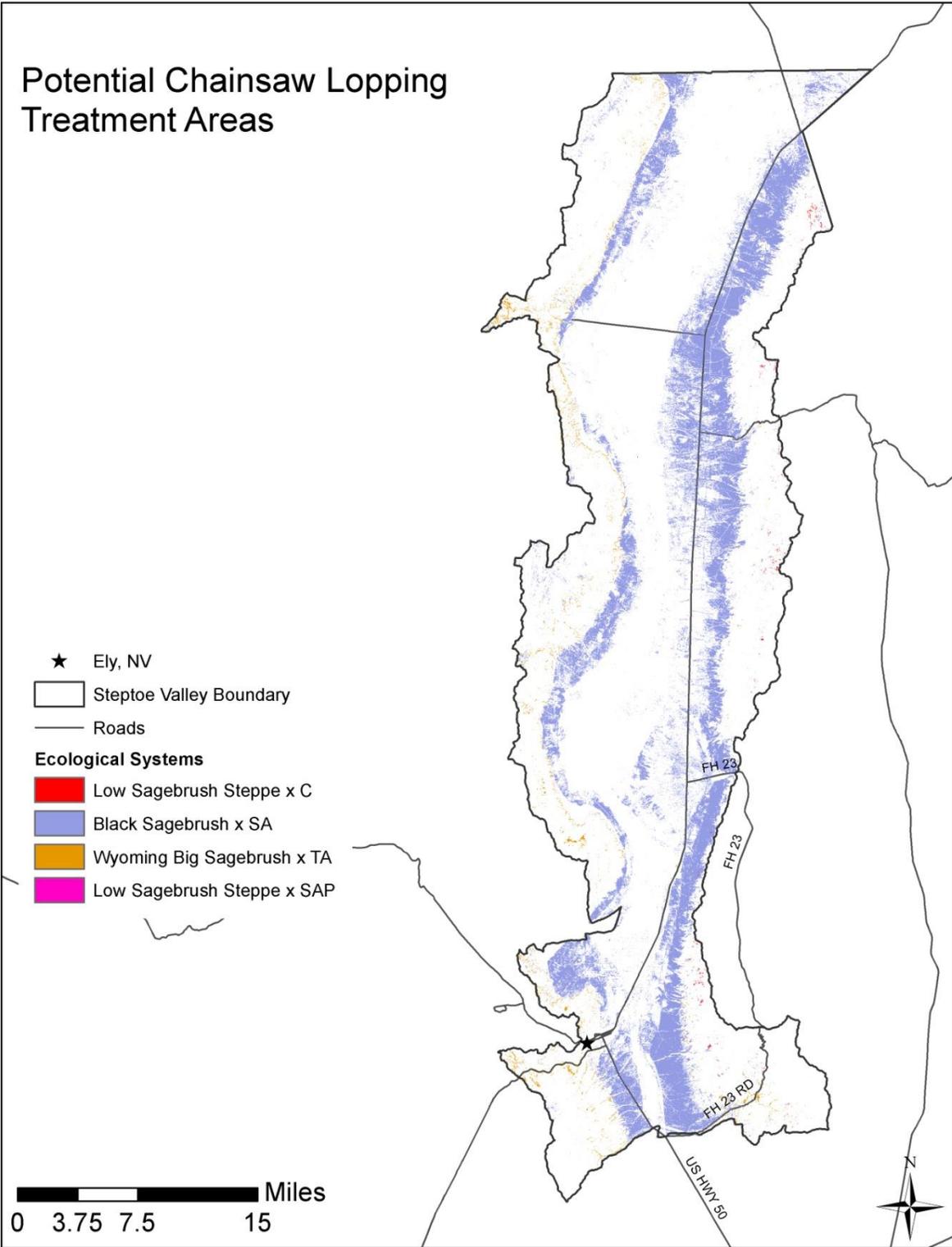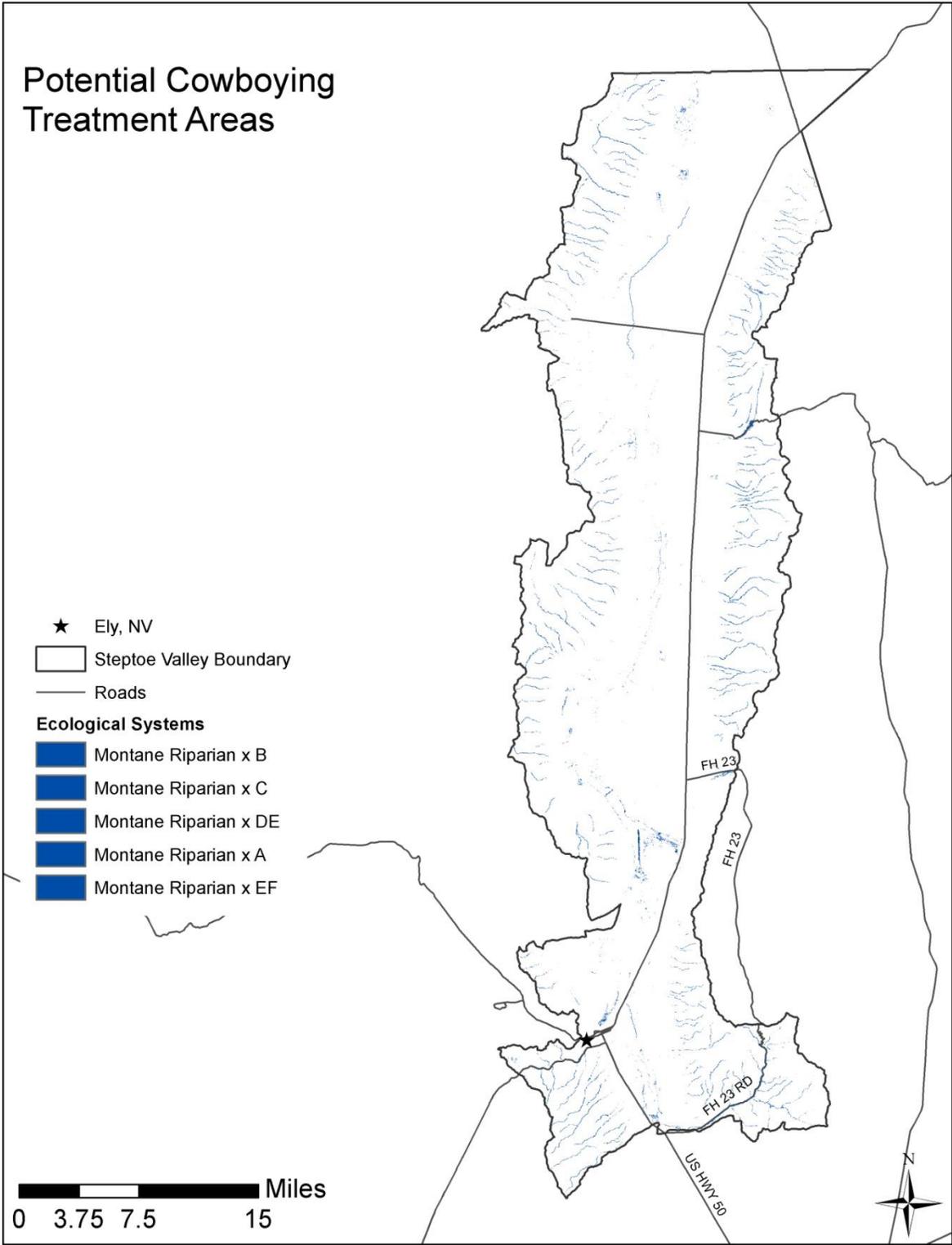**Fig. 14. Map of potential vegetation classes where cowboying could be used today to periodically push livestock away from montane riparian areas. The area of implementation is all riparian classes. Vegetation classes are represented by the ecological system combined with the succession class.**
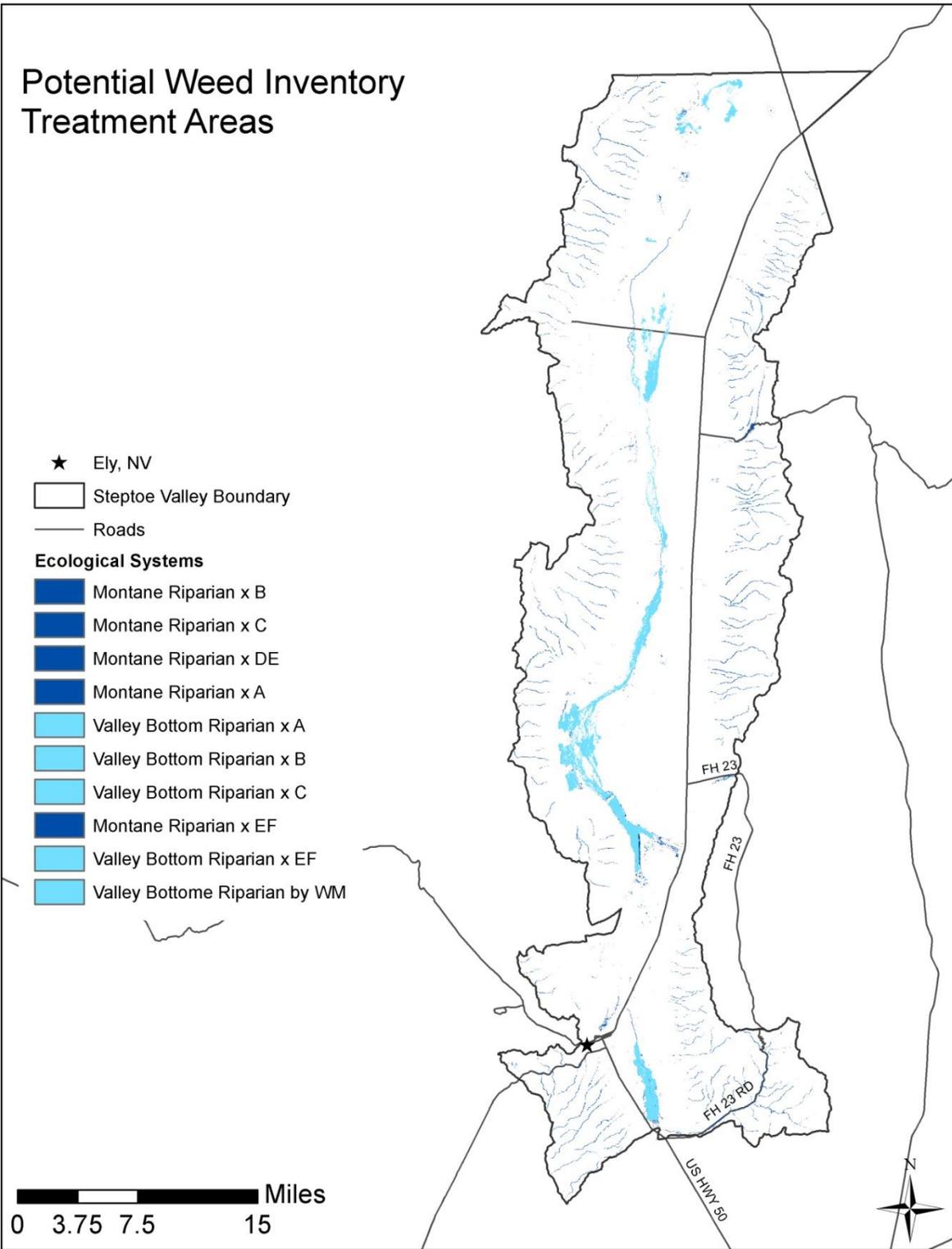
Fig. 15. Map of potential vegetation classes where weed inventory in montane and valley bottom riparian systems could be used today. The area of implementation is all riparian classes. Vegetation classes are represented by the ecological system combined with the succession class.
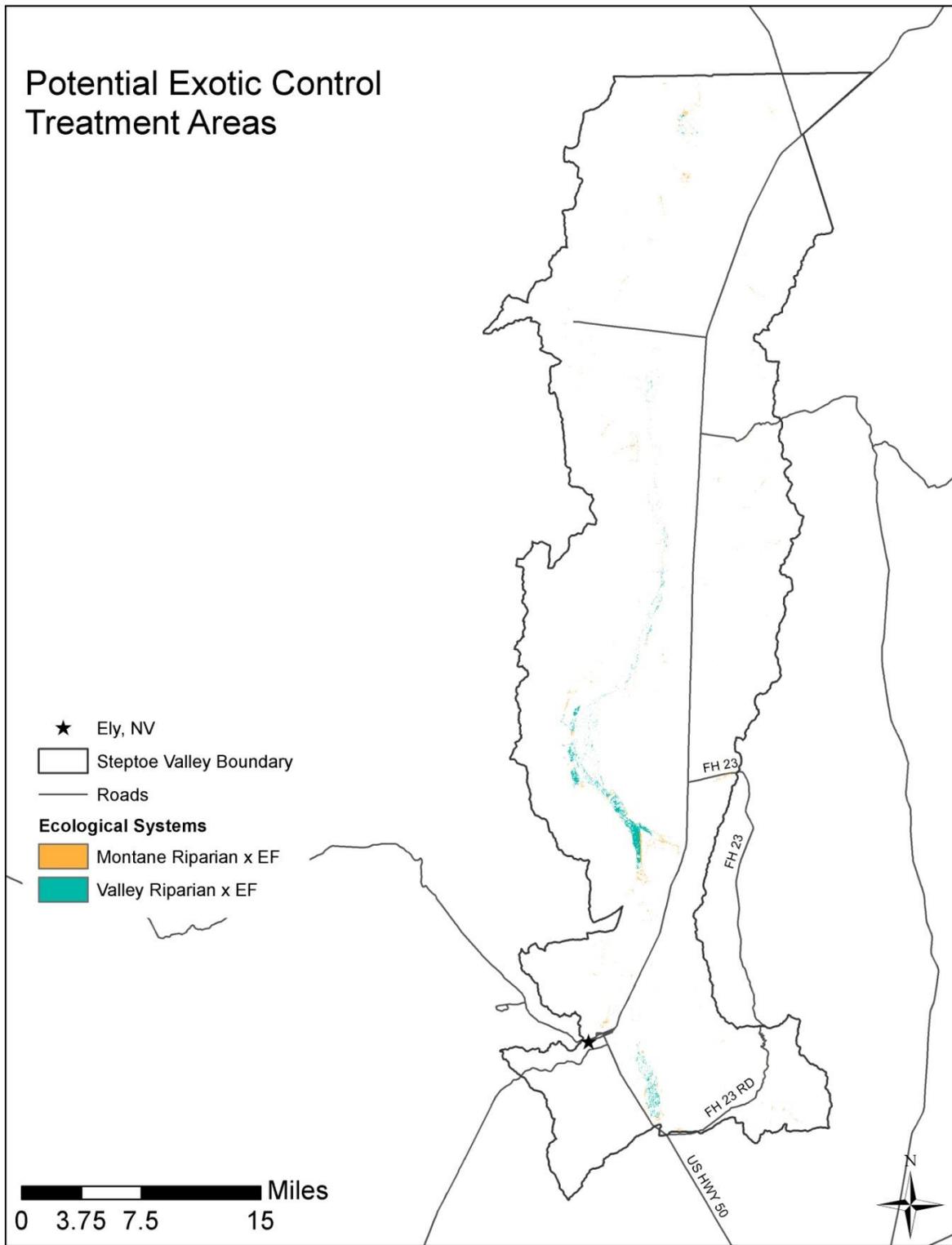
Fig. 16. Map of potential vegetation classes where control of exotic forbs and trees in montane and valley bottom riparian systems could be used today. The area of implementation is riparian classes with exotic forbs (EF). Vegetation classes are represented by the ecological system combined with the succession class.

Fig. 17. Map of potential vegetation classes where rock riffles and dams could be built today in montane riparian systems. The area of implementation is riparian classes with desertified floodplains (incised banks, DE). Vegetation classes are represented by the ecological system combined with the succession class.

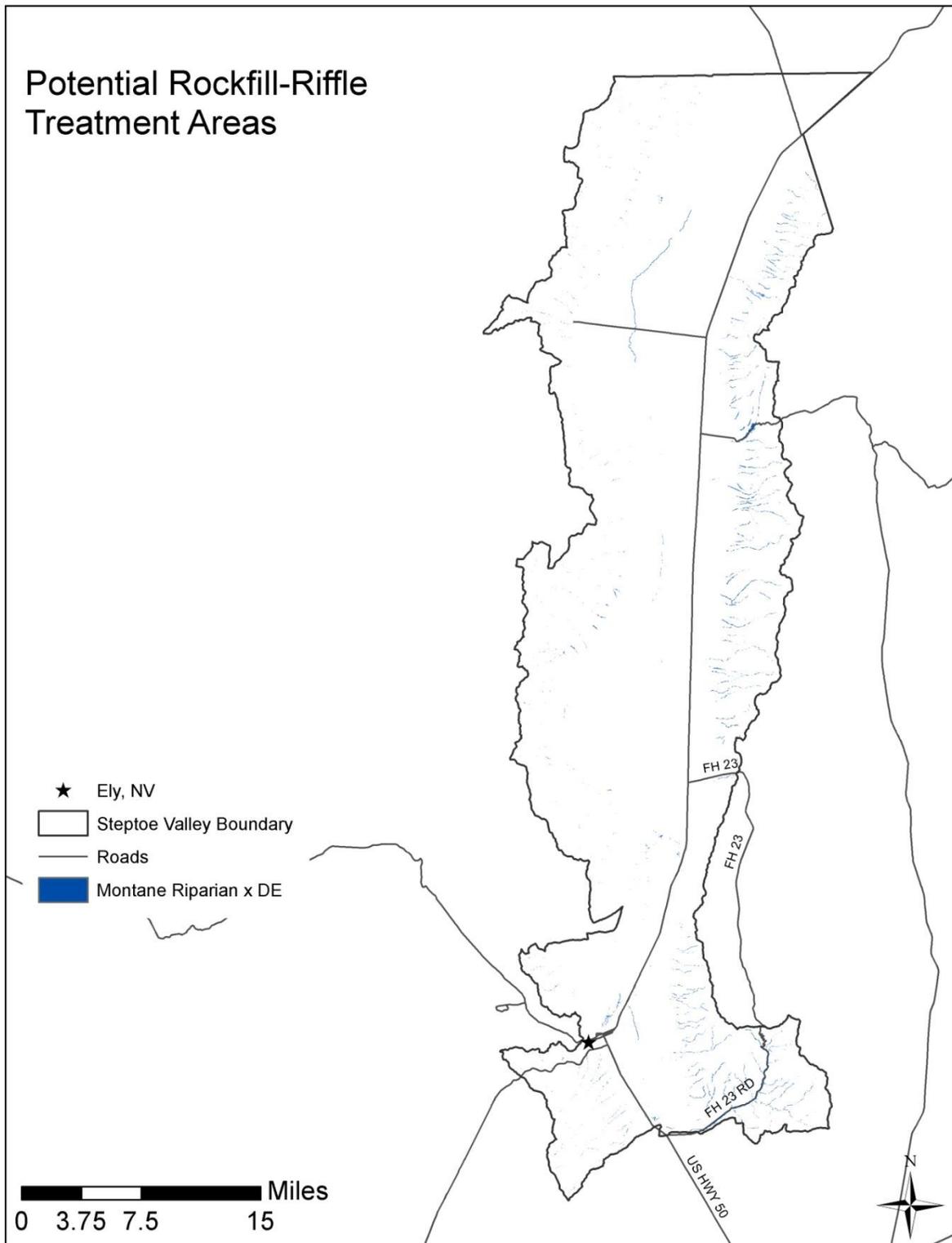**Appendix I. Description of the methodology to update the LANDFIRE geodata with other geodata.**

Mapping Biophysical Settings (aka, ecological systems) and S-Classes

The foundation of the mapping component of this project is the stratification of the landscape into biophysical settings (BpS), which represent potential vegetation types. More specifically, the BpS is represented by the "type" of dominant vegetation that is expected in the physical environment under natural ecological conditions and disturbance regimes. Biophysical settings can be interpreted as single or grouped ecological sites from Natural Resource Conservation Service (NRCS) soil surveys. The NRCS defines ecological site as "a distinctive kind of land with specific physical characteristics that differs from other kinds on land in its ability to produce a distinctive kind and amount of vegetation." (*National Forestry Manual*, ww.nrcs.usda.gov/technical/ECS/forest/2002_nfm_complete.pdf). Biophysical settings are composed of one or more ecological sites sharing the same dominant upper-layer species.

This project was primarily based on LANDFIRE geodata (Rollins 2009), which we enhanced with other geodata and cross-walks. Therefore, spatial data of vegetation-type distributions from several different sources were integrated or merged to generate one final vegetation map product. The five input sources were:

1. LANDFIRE is interpreted satellite imagery, which for each grid cell (30-meter pixel) includes: (1) the biophysical setting type; and (2) the succession class or "S-Class" of the BpS that currently occupies the grid cell. These LANDFIRE geodata were primary in the sense that all other products had to adopt their structure, because only these LANDFIRE spatial layers provided the critical S-Class (more intuitively, vegetation class) layer used to measure ecological departure.

2. The Nevada Natural Heritage Program developed the Annual Grass Index layer, which is interpreted satellite imagery which through statistical modeling attempted to estimate percent ground cover (Nevada Natural Heritage Program 2004; Peterson 2005).

3. Dr. Don Major with the Bureau of Land Management interpreted shrub and tree cover from NAIP (National Agricultural Imagery Program) panchromatic satellite imagery of natural and semi-natural vegetation for a few watersheds of the Ely District, including Steptoe Valley. This layer was especially valuable to tease from LANDFIRE's general uncharacteristic class more refined classes used in state-and-transition models, such as depleted and tree-encroached shrubland classes. We were not capable of splitting LANDFIRE's uncharacteristic classes in previous watershed assessments. Unfortunately, no documentation was available; therefore, TNC used its high resolution (GeoEye 65-cm multi-spectral satellite imagery) mapping geodata from Ward Mountain in Steptoe Valley to benchmark shrub and tree cover to groups found in BLM's geodata.

4. U.S. Fish and Wildlife's National Wetland Inventory is the interpretation of aerial imagery to detect approximate locations of wetlands and deep water habitats. The original imagery occurs as a shapefile. This layer was used to update the riparian areas in the Steptoe Valley, especially for the valley bottom portion of Steptoe Creek and Duck Creek. LANDFIRE did not consider the large expanse of wet meadows in the valley bottom as riparian and does not classify wet meadow as a distinct BpS or vegetation class. Therefore, a large area of the Duck Creek Slough known as wetland in the NWI was either mapped as greasewood, pasture, or mixed salt desert

by LANDFIRE.

5. The BLM's "perennial stream" shape files mapping every perennial stream in the district. LANDFIRE is not typically accurate at mapping riparian systems. In eastern Nevada, LANDFIRE often maps as montane riparian dry washes occupied by Wyoming big sagebrush, basin big sagebrush, and, even, winterfat. We assumed BLM's shape file was accurate and corrected LANDFIRE pixels that are truly not riparian with complicated cross-walks.

The integration of these sources in the following order was accomplished by a two-step process:

1. After a review of all LANDFIRE biophysical settings (BpS), TNC merged minor with larger ones (e.g., Great Basin Semi-Desert Grassland was nested in Wyoming Big Sagebrush), combined ecologically-compatible BpS for simplicity (e.g., dry-mesic mixed conifer with mesic mixed conifer), or converted implausible BpSs into more probable ones (e.g., chaparral was converted to mountain shrub); and

2. TNC wrote a lengthy set of queries or decision rules as to how those input data were to be depicted, pixel by pixel, on the output of the single merged map (**Table I-1**; **Fig. 1** for the BpS only layer; the BpS and vegetation class combined layer is difficult to decipher but **Table I-2** shows percentages of classes by BpS under **Initial** conditions). These queries were designed primarily to reclassify the uncharacteristic classes using the most current on-the-ground spatial information available. The queries also were used to rectify implausible vegetation classes. The full set of queries for the Steptoe Valley, appears in Table I-1.

For each BpS pixel in the raster data, it was next necessary to assign the correct vegetation class for any changed BpS (as a result of queries). Different BpS that were merged may have the same code of vegetation classes; however, the codes could correspond to distinct succession or uncharacteristic classes. This re-assignment of the vegetation class attributes was done according to field-informed knowledge of Nevada ecological systems by one of the project's principals (L. Provencher). A short description of each vegetation class by BpS used in the analyses is presented in Appendix 2.

Table I-1. Queries to reclassify the LANDFIRE BpSs and uncharacteristic classes using the most current on-the-ground spatial information available.

A. BpS codes

BPS ID	BPS Name
11	Water
31	Barren
1001	Sparsely Vegetated
1006	Alpine
1011	Aspen Woodland
1019	Pinyon-Juniper
1020	Limber-Bristlecone Pine Woodland
1052	Mixed Conifer
1054	Ponderosa Pine

1055	Spruce
1060	Pacific Oak-Pine Woodland
1061	Aspen-Mixed Conifer
1062	Curl-leaf Mountain Mahogany
1079	Low-Black Sagebrush
1080	Wyoming Sagebrush
1081	Mixed Salt Desert
1086	Mountain Shrub
1124	Low Sagebrush Steppe
1153	Greasewood
1154	Montane Riparian
11541	Valley Riparian

B. Vegetation class codes

S class ID	S Class name
1	A
2	B
3	C
4	D
5	E
6	UN – Uncharacteristic Natives
7	UE – Uncharacteristic Exotics
8	AG – Annual Grass
9	DE – Desertified
10	DP – Depleted
11	EF – Exotic Forbs
12	SA – Shrubs mixed with annual grass
13	SAP – Shrubs mixed with annual and perennial grass
14	SFE – Shrub-Forb-Encroached
15	TE – Tree Encroached
16	TA –Tree Annual Grass
17	Wet Meadow
111	Water
112	Snow/Ice
120	Urban
131	Barren
180	Agriculture
0	No Data

B. Queries

Number	Model ID	S class existing	Sclass new	Rule
	1051			Merge 1051 with 1052 (Keep 1052)
	1057			Merge 1057 with 1020 (Keep 1020)
	1033			Merge 1033 with 1020 (Keep 1020)
	1012	B &C	B	Merge B & C into B
	1012			Merge 1012 with 1154 (keep 1154)
	1107			Merge 1107 with 1086 (keep 1086)
	1081			Merge 1082 with 1081 (keep 1081)
	1103	B & C	B	Merge 1103 with 1086 (keep 1086)
	1135			Merge C and B into B
	1135			Merge 1135 into 1080 (keep 1080)
	1127			Merge 1127 with 1080 (keep 1080)
1	1019	UE	TA	if annual grass index (angrin)*** is > 0, AND existing veg tree cover (EVC) > or equal to 10%, then TRAG
2	1019	UE	AG	if index is > 10, then AG OR index 1-10 AND existing veg shrub cover (LF) is < 10%
3	1019	UN	E	
4	1019	UE	TA	
5	1020	UN	C	Convert all UN to class C
6	1020	UE	AG	Convert all to AG
7	1052	UE	AG	Convert all to AG
8	1061	UN	E	Convert all UN to E
9	1062	UE	TA	if annual grass index is > 0, AND existing veg tree cover (EVC) > or equal to 10%, then TRAG angrin = >0, EVC = 101 or 102 or 103 or 104 or 105 or 106 or 107 or 108 or 109
10	1062	UE	AG	if index is > 10, then AG OR index 1-10 AND existing veg shrub cover (EVC) is < 10% angrin = >10,
11	1062	UE	TA	
12	1062	UN	E	
13	1079	UN & UE	TA	Tree cover >2 & annual grass index >5 %, then TA
14	1079	UN & UE	TE	If annual grass index ≤5%, then TE
15	1079	UN & UE	TE	If tree cover > 2, and Angrin ≤ 5% TE
16	1079	UN & UE	AG	if tree cover < 2 & shrub cover <2 & annual grass index > 10%, then AG
17	1079	UN & UE	SAP	if shrub cover >2 & annual grass >5%, then SAP
18	1079	UN & UE	SA	if not, then rest gets converted to SA

19	1080	UN & UE	TA	If tree cover ≥ 2, then TA
20	1080	UN & UE	AG	if shrub cover <2 & Annual grass index > 10%, then Annual Grass
21	1080	UN & UE	SAP	Everything else converts to SAP
22	1081	UN & UE	AG	If shrub cover >1 & annual grass index >10%, then AG
23	1081	UN & UE	SAP	Everything else converts to SAP
24	1086	UN	TE	Tree cover ≥ 2, then TE
25	1086	UN	DP	Tree cover <2 & annual grass index < 5%, then DPL
26	1086	UN	SAP	Everything else converts to SAP
27	1086	UE	SAP	Everything converts to SAP
28	1124	UN	TE	If tree cover ≥ 2, then TE
29	1124	UN	DP	If tree cover <2, then DP
30	1124	UE	SAP	Everything converts to SAP
31	1126	UN & UE	AG	If tree cover <3 & shrub cover <2 and annual grass > 10%, then AG
32	1126	UN & UE	SAP	if shrub cover >2 & annual grass >5%, then SAP
33	1126	UN & UE	SA	Everything else converts to SA
34	1153	UN & UE	AG	If shrub cover < 1 and annual grass index >10, then AG
35	1153	UN & UE	SAP	Everything else converts to SAP
36	1154	UN	DE	First must update with perennial water layer, If tree cover < 2 & shrub cover >3, then DE
37	1154	UN	DE	Tree cover >3, then DE
38	1154	UN	SFE	Tree cover < 3 & shrub cover > 3, SFENC
39	1154	UN	DE	Tree cover <3 & shrub cover <3, DE
40	1011	UE	DP	If UE, then DPL
41	1154	UE	DE	Annual grass index > 5%, then DE
42	1154	UE	EF	Everything else converts to EF
43	1154			Where BPs = 1154 or 1160 and river = 0, change values to Majority of Nearest neighbors
44	1011	UN/ UE	DP	Convert all UN/UE to DPL
45	1052	UN	TA	Convert all UN to TA
46	1154	UN & UE	DE	Convert all UN/UE to DE
47	1154		Wm	Any, but exotic wet meadow if Freshwater emergent, and 1154 any class, but exotic, then 1154vb sclass wet meadow
48	1154			Any, but exotic If forest and shrub, new bps=1154vb, but class remains unchanged

49	1153 &1081		WM	any, but exotic wetmeadow if freshwater emergent a 1153 any class, then 1154vb sclass wet meadow
50	1153 & 1081		A	if forest and shrub wetland and 1153, then 1154vb, sclass then A class
51	1062	Any class	B	if freshwater emergent or forest and shrub wetland and 1062, then 1154vb, sclass then B Class
52	1086	Any class	B	if freshwater emergent or forest and shrub wetland and 1086, then 1154vb, sclass then B Class
53	1079	Any class	WM	Wet Meadow if freshwater emergent and 1079 then 1154vb and sclass Wet meadow
54	1079	Any class	B	if forest and shrub wetland and 1079, then 1154vb and sclass B
55	1080	Any class	WM	wet meadow if freshwater emergent and 1080 then 1154vb and sclass Wet meadow
56	1080	Any Class	B	if forest and shrub wetland and 1080, then 1154vb and sclass B
57	1126	Any Class	WM	if freshwater emergent and 1126 then 1154vb and sclass Wet meadow
58	1126	Any Class	B	if forest and shrub wetland and 1126, then 1154vb and sclass B
59	1011	Any Class	C	if forest and shrub wetland or freshwater emergent then 1154 vb then sclass C
60	1081	UN	DPL	
61	1126	UN	TE	
62	1154	UN	DE	
63	1062	UE	AG	
64	1126	UE	SAP	
65	1154	UE	EF	
66	1154, 1159, 1160	UE	EF	Combine ALL 1154, 1159, 1160. Combine as Montane riparian
67	1103			Convert chaparral to mountain shrub from 1103 converts to 1086
66	1154, 1159, 1160	UE	EF	Combine all 1154, 1159, 1160
67	1103			Combine all 1154, 1159, 1160 as montane riparian.

Table I-2. Distribution of vegetation classes by ecological system for the Initial condition and the Minimum and recommended management scenarios. The recommended scenario is the Streamlined Management scenario for all ecological systems, except for greasewood where the Maximum Management scenario is used.

Ecological System	Vegetation Class	DRC	Initial	Minimum	Recommended
Aspen Woodland	A-Early1:CLS	19	27	21	17
	A-Fenced:ALL	0	0	0	0
	B-Mid1:CLS	42	21	37	48
	C-Late1:CLS	29	7	13	18
	D-Late1:OPN	10	21	17	9
	DPL:OPN	0	25	12	6
	DPL-Fence:OPN	0	0	0	2
Ecological Departure			**44**	**30**	**20**
High-Risk Vegetation			**25**	**10**	**6**
Aspen-Mixed Conifer	A-Early1:ALL	15	9	16	16
	A-Fenced:ALL	0	0	0	0
	B-Mid1:CLS	39	7	15	54
	C-Mid2:CLS	28	4	4	4
	D-Late1:OPN	7	0	8	6
	E-Late1:CLS	10	80	56	20
Ecological Departure			**70**	**53**	**28**
High-Risk Vegetation			**na**	**na**	**na**
Black Sagebrush	A-Early1:ALL	15	0	2	11
	B-Mid1:OPN	49	3	2	8
	C-Late1:OPN	25	5	5	15
	D-Late1:CLS	11	6	4	2
	AG:OPN	0	0	4	15
	DPL:CLS	0	0	0	0
	ESH:CLS	0	0	2	4
	EXF:CLS	0	0	0	0
	SA:OPN	0	63	57	26
	SAP:CLS	0	15	15	1
	SD:ALL	0	0	1	16
	TA:CLS	0	0	2	0
	TE:CLS	0	7	5	0
Ecological Departure			**85**	**87**	**64**
High-Risk Vegetation			**70**	**58**	**45**
Curl-leaf Mountain Mahogany	A-Early1:ALL	8	32	10	
	B-Mid1:OPN	11	15	33	
	C-Late1:CLS	14	6	11	
	D-Late1:OPN	24	18	16	
	E-Late2:CLS	43	29	29	
	AG:OPN	0	0	0	

	TA:CLS	0	0	1	
Ecological Departure			**28**	**25**	
High-Risk Vegetation			**0**	**1**	
Greasewood	A-Early1:ALL	3	2	0	2
	B-Late1:CLS	97	19	25	87
	AG:OPN	0	0	7	1
	SAP:ALL	0	79	68	2
	SD:ALL	0	0	0	9
Ecological Departure			**79**	**75**	**12**
High-Risk Vegetation			**79**	**75**	**4**
Limber-Bristlecone	A-Early1:ALL	10	21	20	
	B-Mid1:OPN	12	24	23	
	C-Late1:OPN	78	55	57	
Ecological Departure			**23**	**21**	
High-Risk Vegetation			**na**	**na**	
Low Sagebrush Steppe	A-Early1:ALL	17	0	1	5
	B-Mid1:OPN	48	0	1	43
	C-Late1:OPN	34	25	14	32
	DPL:CLS	0	17	23	17
	ESH:ALL	0	0	0	0
	SAP:ALL	0	0	1	3
	TE:CLS	0	57	61	1
Ecological Departure			**75**	**85**	**17**
High-Risk Vegetation			**75**	**70**	**3**
Mixed Conifer	A-Early1:ALL	8	18	10	
	B-Mid1:CLS	16	67	35	
	C-Mid1:OPN	16	15	24	
	D-Late1:CLS	28	0	23	
	E-Late1:OPN	32	0	9	
	AG:ALL	0	0	0	
	TA:ALL	0	0	0	
Ecological Departure			**62**	**33**	
High-Risk Vegetation			**0**	**0**	
Mixed Salt Desert	A-Early1:ALL	4	0	1	1
	B-Mid1:OPN	72	5	9	10
	C-Late1:OPN	23	20	10	11
	AG:OPN	0	0	39	18
	DPL:CLS	0	2	6	4
	EXF:CLS	0	0	1	2
	SAP:ALL	0	74	30	38
	SD:ALL	0	0	4	16
Ecological Departure			**75**	**80**	**79**

High-Risk Vegetation			**75**	**63**	**52**
Montane Riparian	A-Early1:ALL	22	0	9	23
	B-Mid1:OPN	36	12	13	45
	C-Late1:CLS	41	33	20	27
	DES:ALL	0	39	33	0
	EXF:OPN	0	15	21	1
	PAS:OPN	0	0	0	0
	SFE:ALL	0	0	4	3
Ecological Departure			**55**	**58**	**24**
High-Risk Vegetation			**55**	**45**	**1**
Montane Sagebrush Steppe	A-Early1:ALL	21	0	12	24
	B-Mid1:OPN	44	0	8	22
	C-Late1:CLS	23	26	15	16
	D-Late2:OPN	9	6	5	2
	E-Late2:CLS	3	42	31	7
	AG:ALL	0	0	4	3
	DPL:CLS	0	0	1	1
	ESH:CLS	0	0	2	4
	EXF:CLS	0	0	0	0
	SAP:CLS	0	24	14	8
	SD:ALL	0	0	0	13
	TE:CLS	0	2	9	1
Ecological Departure			**68**	**59**	**38**
High-Risk Vegetation			**2**	**23**	**12**
Mountain Shrub	A-Early1:ALL	8	12	2	13
	B-Mid1:CLS	25	0	20	58
	C-Late1:CLS	45	70	22	10
	D-Late1:OPN	22	0	24	17
	DPL:ALL	0	0	4	0
	ESH:CLS	0	0	0	0
	SAP:ALL	0	15	22	3
	TE:CLS	0	1	7	0
Ecological Departure			**47**	**45**	**41**
High-Risk Vegetation			**1**	**8**	**3**
Pinyon-Juniper	A-Early1:ALL	2	0	2	
	B-Mid1:OPN	6	0	2	
	C-Late1:OPN	20	28	18	
	D-Late2:OPN	71	71	75	
	AG:OPN	0	0	0	
	TA:CLS	0	0	2	
Ecological Departure			**8**	**7**	
High-Risk Vegetation			**0**	**2**	

Spruce	A-Early1:ALL	19	3	14	
	B-Mid1:CLS	38	27	34	
	C-Late1:CLS	41	32	33	
	D-Late1:OPN	2	38	19	
Ecological Departure			**36**	**28**	
High-Risk Vegetation			**na**	**na**	
Valley Bottom Riparian	A-Early1:ALL	4	7	4	5
	B-Mid1:OPN	8	3	3	4
	C-Late1:CLS	29	1	3	14
	DES:ALL	0	0	0	0.3
	EXF:ALL	0	16	29	14
	PAS:OPN	0	0	0	0
	SA:ALL	0	0	0	0
	SFE:ALL	0	0	5	3
	WL:CLS	2	0	0	0
	WM:OPN	57	74	57	57
Ecological Departure			**35**	**65**	**21**
High-Risk Vegetation			**16**	**29**	**14**
Wyoming Big Sagebrush	A-Early1:ALL	15	0	5	7
	B-Mid1:OPN	43	1	5	16
	C-Late1:CLS	27	21	12	14
	D-Late2:OPN	7	2	2	0
	E-Late2:CLS	7	9	4	5
	AG:OPN	0	0	7	3
	DPL:CLS	0	0	1	0
	ESH:CLS	0	0	1	1
	SA:CLS	0	34	27	8
	SAP:CLS	0	32	21	3
	SD:ALL	0	0	2	40
	TE:CLS	0	0	12	2
Ecological Departure			**69**	**71**	**58**
High-Risk Vegetation			**34**	**39**	**14**

Appendix II: Descriptions of biophysical settings' vegetation classes as presented in the Nevada Wildlife Action Plan. Biophysical settings not present in Steptoe Valley were deleted. Some classes will differ for Steptoe Valley because they were merged, added, deleted, or relabeled. The valley bottom riparian is not included, although it would be similar to the montane riparian with the difference that cottonwood may have been rare and wet meadows abundant.

Class Code	Class abbreviation and brief description
Aspen-Mixed Conifer	
1061	
A	*Early*; 0-100% cover aspen <5m; mountain snowberry and *ribes* common; 0-19 yrs
B	*Mid1-closed*: 40-99% cover aspen <5-10m; mountain snowberry and *ribes* common; 11-39 yrs
C	*Mid2-closed*: 40-99% cover aspen 10-24m; conifer saplings visible in mid-story; mountain snowberry and *ribes* common; 40-79 yrs
D	*Late-open*: 0-39% cover aspen 10-25 m; 0-25% montane and subalpine conifer cover 5-10 m; mountain snowberry and *ribes* common; >80 yrs
E	*Late-closed*: 40-80% cover of mixed conifer 10-50m; <40% cover of aspen 10-25m; mountain snowberry and *ribes* present; >100 yrs
Aspen Woodland	
1011	
A	*Early*: 0-100% cover of aspen <5m tall; 0-9 yrs
B	*Mid-closed*: 40-99% cover of aspen <5-10m; 10-39 yrs
C	*Late-closed*: 40-99% cover of aspen 10-25m; few conifers in mid-story; >39 yrs
D	*Late-open*: 0-39% cover of aspen 10-25 m; 0-25% conifer cover 10-25 m; >99 yrs
U-DP	*Depleted*: 10-50% cover of older aspen 10-25m; no or little aspen regeneration; few conifers in mid-story
Black Sagebrush	
1079	
A	*Early*: <10% cover rabbitbrush; 10-40% cover of grass; 50-80% cover mineral soil; 0-25 yrs
B	*Mid-open*: 10-20% cover of black sagebrush and rabbitbrush; 10-30% grass cover; <40% cover of mineral soil; 25-119 yrs
C	*Late-Open*: 20-30% cover of black sagebrush; 10-30% cover of grasses; 1-10% pinyon-juniper sapling cover; 120-194 yrs
D	*Late-Closed:* 10-30% cover of mature pinyon or juniper on black sagebrush sites; <10% black sagebrush or 5-20% cover of low sagebrush; <10% grass cover; >195 yrs
U-AG	*Annual-Grass*: 10-30% cover of cheatgrass but reduced shrub cover
U-DP	*Depleted*: 20-50% cover of black sagebrush; <5% herbaceous cover; <10% pinyon or juniper sapling cover
U-ES	*Early-Shrub*: 10-40% cover rabbitbrush species
U-SAP	*Shrub-Annual-Grass-Perennial-Grass*: 20-50% cover of black sagebrush; >5% cover of native grass; 5-20% cheatgrass cover; <10% pinyon or juniper sapling cover
U-SA	*Shrub-Annual-Grass*: 20-50% cover of black sagebrush; <5% cover of native grass; 5-20% cheatgrass cover; <10% pinyon or juniper sapling cover
U-SD	*Seeded*: 5-20% cover of native or non-native (crested wheatgrass, forage koshia) seed mix; ≤5% cover of annual grass

Class Code	Class abbreviation and brief description
U-TA	**Tree-Annual-Grass**: >20% pinyon or juniper cover on black sagebrush sites 10m; >5% cover of annual grass; <5% shrub cover; <5% herbaceous cover
U-TE	**Tree-Encroached**: >20% pinyon or juniper cover on black sagebrush sites; <5% shrub cover; <5% native herbaceous cover; ≤5% cover of annual grass

Curl-leaf Mountain Mahogany
1062

Class Code	Class abbreviation and brief description
A	**Early**: 10-55% cover mountain mahogany seedlings and saplings, 0-2m; mineral soil abundant; grasses and shrubs present but not abundant; 0-19 yrs
B	**Mid-Open**: 0-30% cover mountain mahogany 2-5m; mineral soil abundant; grasses and mountain sagebrush, snowberry, and mountain snowberry common; 20-59 yrs
C	**Late1-Closed**: 30-45% cover of mountain mahogany, mountain sagebrush, snowberry, and mountain snowberry 2-5m high; 60-59 yrs
D	**Late1-Open**: 0-30% cover of large diameter mountain mahogany 5-25m; grasses and mountain sagebrush, snowberry, and mountain snowberry common; >60 yrs
E	**Late2-Closed**: 30-55% cover of mature mountain mahogany, 5-25m; >49 yrs;
U-AG	**Annual-Grass**: 5-30% cheatgrass cover; <10% shrub cover
U-TA	**Tree-Annual-Grass**: 10-55% cover of mountain mahogany; 5-20% cheatgrass cover

Greasewood
1153

Class Code	Class abbreviation and brief description
A	**Early**: 0-20% herbaceous (inland saltgrass, bottlebrush squirreltail, and alkali sacaton) cover; <5% cover rabbitbrush and resprouting greasewood; 0-5 yrs
B	**Late-closed**: 15-25% greasewood cover; <10% cover other shrubs (rabbitbrush, saltbushes, and budsage); <10% cover of grass (inland saltgrass, bottlebrush squirreltail, and alkali sacaton); >5 yrs
U-*AG*	**Annual-Grass**: 5-30% non-native annual grass cover; <10% shrub cover
U-*SAP*	**Shrub-Annual-Perennial-Grass**: 5-25% cover of greasewood; 5-20% non-native annual grass cover; native grass cover may be absent to abundant
U-*SD*	**Seeded**: 5-20% seeded native or introduced species cover

Limber-Bristlecone Pine Woodland
1020

Class Code	Class abbreviation and brief description
A	**Early**: 0-10% limber and bristlecone pine cover 0-5m high; abundant mineral soil or talus cover; sparse ground cover; 0-99 yrs
B	**Mid-Open**: 11-30% limber and bristlecone pine cover 5-10m high; abundant mineral soil or talus cover; sparse ground cover; 100-249 yrs
C	**Late-Open**: very old trees; 11-30% limber and bristlecone pine cover 5-25m high; abundant mineral soil or talus cover; sparse ground cover; >250 yrs

Low Sagebrush Steppe (>14 inch precipitation zone)
1124

Class Code	Class abbreviation and brief description
A	**Early**: 15-25% herbaceous cover (bluebunch wheatgrass, Thurber's needlegrass); 0-10% cover of rabbitbrush; 0-25 yrs
B	**Mid-open**: 11-20% cover of low sagebrush and mountain snowberry; 15-25% herbaceous cover (bluebunch wheatgrass, Thurber's needlegrass); 25-99 yrs
C	**Late-Closed**: 21-30% cover of low sagebrush and Utah serviceberry; 10-15% herbaceous cover (bluebunch wheatgrass); >100 yrs
U-DP	**Depleted**: 10-30% cover of low sagebrush; <5% herbaceous cover; <10% pinyon or juniper sapling cover

Class Code	Class abbreviation and brief description
U-ES	**Early-Shrub**: 10-40% cover rabbitbrush species
U-SAP	**Shrub-Annual-Grass-Perennial-Grass**: 21-30% cover of low sagebrush; >5% cover of native grass; 5-20% cheatgrass cover; <10% pinyon or juniper sapling cover
U-TE	**Tree-Encroached**: ≥10% pinyon, juniper cover, or montane-subalpine conifer; <5% shrub cover; <5% native herbaceous cover; annual grass usually absent

Mixed Conifer
1052

Class Code	Class abbreviation and brief description
A	**Early**: 0-15% cover of tree/shrub/grass; <5m; 0-29 yrs
B	**Mid-closed**: 35-100% cover of white fir and other conifers <24m; 30-99 yrs
C	**Mid-open**: 0-35% cover of white fir and other conifers <24m; 30-99 yrs
D	**Late-open**: 0-35% cover of white fir and other conifers 25-49m; >100 yrs
E	**Late-closed**: 35-100% cover of white fir and other conifers 25-49m; >100 yrs
U-AG	**Annual-Grass**: >10% cheatgrass cover; <10% shrub cover; trees largely absent; charred logs or standing dead trees often present; native grasses and forbs present to abundant
U-TA	**Tree-Annual-Grass**: 10-80% cover of young and older white fir and other conifers; >5% cheatgrass cover; native grass and shrubs present to abundant

Mixed Salt Desert Scrub
1081

Class Code	Class abbreviation and brief description
A	**Early**: 0-5% cover of young *Atriplex* spp. or other shrubs, Indian ricegrass and squirreltail common; 0-5 yrs
B	**Mid-open**: 5-20% cover *Atriplex* spp. or other shrubs; >6 yrs
C	**Late-open**: 5-20% cover budsage <0.25m; >7 years
U-AG	**Annual-Grass**: 5-30% cheatgrass cover; <10% shrub cover
U-SAP	**Shrub-Annual-Perennial-Grass**: 5-20% cover of *Atriplex* spp. or other shrubs; 5-20% cheatgrass cover; native herbaceous cover may be absent to common
U-DP	**Depleted:** 5-20% cover of *Atriplex* spp. or other shrubs; <5% cheatgrass cover; <5% native herbaceous cover
U-EF	**Exotic-Forb**: >5% cover of halogeton, non-native mustards, or other forbs; <10% cheatgrass cover
U-SD	**Seeded**: native or non-native (crested wheatgrass, forage koshia) seed mix cover 5-20%

Montane Riparian
1154

Class Code	Class abbreviation and brief description
A	**Early**: 0-50% cover of cottonwood, willow, Wood's rose <3m; carex present; 0-5 yrs
B	**Mid-open**: 31-100% cover of cottonwood, aspen, willow, Wood's rose <10m; 5-20 yrs;
C	**Late-closed**: 31-100% cover of cottonwood, alder, aspen, willow 10-24m; >20 yrs
U-EF	**Exotic-Forb**: 5-100% cover of exotic forbs (knapweed, tall whitetop, purple loosestrife, thistle), salt cedar, or Russian olive
U-DE	**Desertification**: Entrenched river/creek with 10-50% cover of upland shrubs (e.g., big sage); cheatgrass absent to common
U-PA	**Pasture**: agricultural pasture
U-SFE	**Shrub-Forb-Encroached**: 10-50% cover of unpalatable shrub and forb species (*Rosa woodsii* and *Rhus trilobata*) in open areas or under tree canopy

Montane Sagebrush Steppe
1126

Class Code	Class abbreviation and brief description
A	*Early*: 10-80% grass/forb cover; 0-10% cover of mountain big sagebrush/mountain brush; 0-12 yrs
B	*Mid-open*: 11-30% cover of mountain big sagebrush /mountain shrub/low sagebrush; >50% herbaceous cover; 13-38 yrs
C	*Mid-closed*: 31-50% cover of mountain big sagebrush /mountain brush/low sagebrush; 25-50% herbaceous cover, <10% conifer sapling cover; 38+ yrs
D	*Late-open*: 10-30% cover conifer <5m for pinyon pine or juniper and <10m for mixed conifers; 25-40% cover of mountain big sagebrush/mountain brush/low sagebrush; <30% herbaceous cover; 80-129 yrs
E	*Late-closed*: 31-80% conifer cover (lower for pinyon pine and juniper, greater for mixed conifers) 10-25m; 6-20% shrub cover; <20% herbaceous cover; 130+ yrs
U-AG	*Annual-Grass*: 10-30% cover of cheatgrass; <10% shrub cover
U-DP	*Depleted*: 20-50% cover of big sagebrush (Wyoming and sometimes mountain))/mountain brush; <5% herbaceous cover; <5% cheatgrass cover; <10% conifer sapling cover; >50 yrs
U-ES	*Early-Shrub*: 20-50% cover rabbitbrush species
U-SAP	*Shrub-Annual-Grass-Perennial-Grass*: 21-50% cover of mountain big sagebrush /mountain brush/low sagebrush; ≥5% cover of native grass AND 5-10% cheatgrass cover OR <5% cover of native grass AND 5-10% cheatgrass cover; <10% conifer sapling cover; >50 yrs
U-SD	*Seeded*: >10% cover of seeded herbaceous and/or shrub species, either native, introduced, and mixed native and introduced; <5% cheatgrass cover
U-TE	*Tree-Encroached*: 31-80% conifer cover 10-25m; <5% shrub cover; <5% herbaceous cover and <5% cheatgrass cover OR ≥5% cheatgrass regardless of native herbaceous cover; >140 yrs
	Mountain Shrub **1086**
A	*Early*: 0-10% canopy of Utah snowberry/antelope bitterbrush; 10-80% grass/forb cover; 0-4 yrs
B	*Mid-open*: 11-30% cover of Utah snowberry/antelope bitterbrush; >50% herbaceous cover; 5-19 yrs
C	*Mid-closed*: 31-50% cover of Utah snowberry/antelope bitterbrush/mountain big sagebrush; 25-50% herbaceous cover, <10% conifer sapling cover;20-79 yrs
D	*Late-open*: 10-20% pinyon pine-white fir cover <5m; 25-40% cover of Utah snowberry/antelope bitterbrush/mountain big sagebrush; <30% herbaceous cover; >80 yrs
U-DP	*Depleted*: 20-50% cover of Utah snowberry/antelope bitterbrush/mountain big sagebrush; <5% herbaceous cover; <10% pinyon sapling cover
U-ES	*Early-Shrub*: 20-50% cover rabbitbrush species
U-SAP	*Shrub-Annual-Grass-Perennial-Grass*: 20-50% cover of Utah snowberry/antelope bitterbrush/mountain big sagebrush; >5% cover of native grass; 5-10% cheatgrass cover; <10% pinyon sapling cover
U-TE	*Tree-Encroached*: >21% pinyon pine-white fir cover 10-25m; <5% shrub cover; <5% herbaceous cover
	Pinyon-Juniper **1019**
A	*Early*: 5-20% herbaceous cover; 0-9 yrs

Class Code	Class abbreviation and brief description
B	***Mid1-open***: 11-20% cover big sage or black sage <1.0m; 10-40% herbaceous cover; 10-29 yrs
C	***Mid2-open***: 11-30% cover of pinyon and/or juniper <5m; 10-40% shrub cover; <20% herbaceous cover; 30-99 yrs
D	***Late-open***: old growth, 31-50% cover of pinyon and/or juniper <5m-9m; 10-40% shrub cover; <20% herbaceous cover; >99 yrs
U-AG	***Annual-Grass***: 5-30% cheatgrass cover; <10% shrub cover
U-TA	***Tree-Annual-Grass***: 31-50% cover of pinyon and/or juniper <5m-9m; 10-40% shrub cover; <20% cheatgrass cover

Spruce **1056**	
A	***Early***: 0-100% cover of Engelman spruce seedling/shrub/grass <5m; 0-39 yrs
B	***Mid-closed***: 40-100% cover of Engelman spruce and aspen 5-24m; 40-129yrs
C	***Mid-open***: 0-40% cover of Engelman spruce 5-24m pole size; ; 40-129yrs
D	***Late-closed***: 40-100% cover of Engelman spruce 25-49m; >129 yrs

Valley Bottom Riparian **11541**	
A	***Early***: immediate floodplain; 20-59% cover of basin wildrye, sedges, and tufted grasses distributed in large patches; 0-50% willow scattered in clumps along generally herbaceous vegetation; 20-50% exposed organic soil; cottonwood uncommon; 0-2 yrs
B	***Mid-open***: immediate floodplain; 60-100% cover of basin wildrye, sedges, and tufted grasses; willow locally abundant in clumps; 0-19% exposed organic soil; occasional young cottonwood trees; 3-22 yrs
C	***Late-closed***: immediate floodplain; 5-10% shrub (willow, Wood's rose, greasewood, sagebrush) cover; 60-80% graminoid cover; occasional large cottonwood clumps; exposed organic soil uncommon; >22 yrs
WL	***Wetland***: usually far from main stream channel where only 100-year events cause inondation; perennial or seasonally dry water-filled pools with emergent aquatic vegetation such as rushes, cattails, and, sometimes, willow at the periphery of pools.
WM	***Wet-Meadow:*** usually far from main stream channel where only 100-year events cause inondation; 60-100% herbaceous cover – mostly graminoids; 0-10% shrub (willow, Wood's rose, greasewood, sagebrush) cover; mineral soil often present in drier wet meadows; >22 yrs
U-DES	***Desertified:*** : Entrenched river/creek with 10-50% cover of upland shrubs (e.g., greasewood, big sage); cheatgrass absent to common
U-EF	***Exotic-Forbs***: >5% of thistle or other exotic forbs (tall whitetop, Russian knapweed, purple loosestrife); native woody shrubs and trees absent to abundant; graminoids dominated patches may be common
U-PA	***Pasture***: agricultural pasture
U-SA	***Shrub-Annual-Grass***: >5% cover of greasewood, big sagebrush, and salt desert shrub species; >5% cheatgrass cover; native grass species may be absent to common

Wyoming Big Sagebrush **1080**	
A	***Early***: 10-80% grass/forb cover; 0-10% cover of big sagebrush (Wyoming and sometimes mountain)/mountain brush; 0-12 yrs
B	***Mid-open***: 11-30% cover of big sagebrush (Wyoming and sometimes mountain)/mountain shrub; >50% herbaceous cover; 13-38 yrs

Class Code	Class abbreviation and brief description
C	**Mid-closed**: 31-50% cover of big sagebrush (Wyoming and sometimes mountain)/mountain brush; 25-50% herbaceous cover, <10% conifer sapling cover; 38+ yrs
D	**Late-open**: 10-30% cover conifer <5m for pinyon pine and juniper; 25-40% cover of big sagebrush (Wyoming and sometimes mountain)/mountain brush; <30% herbaceous cover; 80-129 yrs
E	**Late-closed**: 31-80% conifer cover (lower for PJ, greater for mixed conifers) 10-25m; 6-20% shrub cover; <20% herbaceous cover; 130+ yrs
U-AG	**Annual-Grass**: 10-30% cover of cheatgrass; <10% shrub cover
U-DP	**Depleted**: 20-50% cover of big sagebrush (Wyoming and sometimes mountain)/mountain brush; <5% herbaceous cover; <5% cheatgrass cover; <10% conifer sapling cover; >50 yrs
U-ES	**Early-Shrub**: 20-50% cover rabbitbrush species
U-SAP	**Shrub-Annual-Grass-Perennial-Grass**: 21-50% cover of big sagebrush (Wyoming and sometimes mountain)/mountain brush; ≥5% cover of native grass; 5-10% cheatgrass cover; <10% conifer sapling cover; >50 yrs
U-SA	**Shrub-Annual-Grass**: 21-50% cover of big sagebrush (Wyoming and sometimes mountain)/mountain brush; <5% cover of native grass; 5-10% cheatgrass cover; <10% conifer sapling cover; >50 yrs
U-SD	**Seeded**: >10% cover of seeded herbaceous and/or shrub species, either native, introduced, and mixed native and introduced; <5% cheatgrass cover
U-TE	**Tree-Encroached**: 31-80% conifer cover 10-25m; <5% shrub cover; <5% herbaceous cover and <5% cheatgrass cover OR ≥5% cheatgrass regardless of native herbaceous cover; >140 yrs