Ward Mountain Restoration Project: An ecological assessment and landscape strategy for native ecosystems in the Ward Mountain landscape

Report to the Bureau of Land Management and U.S. Forest Service

Ely, Nevada

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Photo: Louis Provencher, 2009

By

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Executive Summary

Introduction

The Bureau of Land Management's Ely District Office (BLM) and U.S. Forest Service (USFS) entered into a cooperative agreement in August 2009 with The Nature Conservancy (TNC) to complete an ecological assessment for approximately 120,000 acres at and around Ward Mountain southwest of Ely, Nevada. The Ward Mountain project area is a largely unfragmented landscape that includes a diversity of Great Basin ecosystems in the Egan Range and adjoining valleys. The 120,000 acre project area includes lands managed by BLM and the USFS, as well as Ely Shoshone Tribal Lands. Private inholdings are scattered throughout the project area.

Due to its close proximity to Ely, the Ward Mountain area is used for varied recreation activities and its northwestern corner serves as the main municipal watershed for the city of Ely. Moreover, there are concerns about the potential for wildfire spread from Ward Mountain to Ely. The fire regime in many of the Ward Mountain systems is outside the natural range of variability due to past land management practices and the invasion of non-native annual grasses at lower elevations. Several vegetation communities are in need of restoration to improve or maintain watershed health.

The assessment's primary purpose was to inform and guide the formulation of future site-specific, cost-effective vegetation management projects to protect, enhance and restore the ecological integrity of the area. The assessment was developed using satellite imagery, remote sensing, predictive ecological models, and cost-benefit assessments. Three workshops were held (one advance session via WebEx conference and two multi-day workshops in Ely) with agency natural resource managers to review and refine ecological models, review findings, and identify and explore potential vegetation management scenarios. The cooperative agreement reflects the mutual desire of BLM, USFS, TNC and other stakeholders to conserve and restore the Ward Mountain area.

Objectives for Ward Mountain Ecological Assessment

- ✓ Assess current ecological condition using the ecological departure metric (a.k.a., Fire Regime Condition).
- ✓ Develop maps of ecological systems and vegetation succession classes using high-resolution satellite imagery verified by field surveys.
- ✓ Refine and use ecological models for the varied vegetation types to evaluate future trends and alternative management scenarios.
- ✓ Use return-on-investment analysis to assess which strategies for which ecological systems yield the most advantageous results.
- ✓ Use GIS analysis to help determine and map alternative treatment areas

Process and Methodologies

TNC used Ecological Departure (also known as Fire Regime Condition by federal agencies) methodology developed under the national LANDFIRE program to assess the project area's ecological condition. Ecological Departure is an integrated, landscape-level estimate of the ecological condition of terrestrial, riparian and wetland ecological systems. Ecological Departure incorporates species composition, vegetation structure, and disturbance regimes to estimate an ecological system's departure from its natural range of variability (NRV). NRV is the percentage of each vegetation succession class that would be expected under a natural disturbance regime. Ecological Departure is then measured using a scale of 0 to 100 where higher numbers indicate higher departure from NRV. In addition, since the cost and management urgency to address different uncharacteristic vegetation classes vary greatly, a separate designation and calculation of "high-risk" vegetation classes (e.g. cheatgrass invaded) was also applied.

TNC completed the following tasks that were reviewed at the workshops with the natural resource managers:

- Worked with Spatial Solutions, Inc. to obtain high-resolution satellite imagery, ground-truth the imagery via field surveys, and conduct remote sensing to interpret and map current ecological systems and their succession classes across the project area.
- Refined ecological models for each major ecological system, using reference and management models developed by staff from Great Basin National Park, BLM, Utah Partners for Conservation and Development, and TNC. These models incorporated vegetation composition, structural classes and disturbance regimes to predict the natural range of succession classes.
- Mapped the project area's biophysical settings (the dominant vegetation types expected in the physical environment under a natural disturbance regime).
- For each ecological system, compared current vegetation class distributions with the biophysical setting and calculated each system's departure from its NRV. Each ecological system was assigned an Ecological Departure score (0% to 100% departure from NRV) and an associated Fire Regime Condition Class (1, 2 or 3) rating.
- Identified which ecological systems are likely to suffer future impairment over the next 20 years, based on computer simulations using the predictive ecological models.

At the February 2010 workshop, agency natural resources managers confirmed a set of key conservation and restoration objectives for the Ward Mountain project area, as follows:

Conservation and Restoration Objectives

- Maintain overall condition and prevent deterioration of Ward Mountain's native ecological systems.
- Restore degraded ecological systems to their natural range of variability or an "acceptable" range if NRV is not feasible.
- Reduce and prevent expansion of High-Risk Vegetation Classes (e.g. exotic species).
- Manage Murray municipal watershed to prevent high severity events and restore ecological stability.
- Treat Wildland-Urban Interface (WUI) areas and reduce fuel loads to help protect human settlements and cultural resources in and around the project area from wildfire.
- Develop a collaborative restoration plan with shared vision and action among BLM, Forest Service, Ely Shoshone tribe, partners and stakeholders.
- Help BLM and USFS meet objectives specified in management plans.
- Help make the project area competitive for potential funding resources.

Ten focal ecological systems were selected for treatment, based upon their high departure from NRV, likelihood of high future departure and/or presence of High-Risk Vegetation Classes. These systems included:

Black sagebrush	46,700 acres
Montane sagebrush steppe (≤9500 ft)	25,600 acres
Wyoming big sagebrush	8,300 acres
Montane sagebrush steppe (>9500 ft)	2,600 acres
Aspen-mixed conifer	2,200 acres
Basin wildrye	1,700 acres
Aspen woodland	600 acres
Winterfat	600 acres
Montane-subalpine riparian	200 acres
Mountain shrub	30 acres

At and between workshops, management strategies were explored to achieve the objectives for these focal systems. Predictive state-and-transition computer models were used to simulate conditions under alternative future management scenarios. Using computer-based models, the likely future condition of the ten focal systems was assessed after 20 years under three primary scenarios:

(1) MINIMUM MANAGEMENT – e.g., no treatment of invasive species, no thinning.
(2) MAXIMUM MANAGEMENT – management treatments to restore ecological condition to the greatest possible degree, regardless of budget.
(3) PREFERRED MANAGEMENT – management strategies identified by workshop participants, often streamlined to improve ecological condition at reduced cost or relatively low investment.

Return on investment was calculated to compare ecological benefits to costs, both *within* and *across* ecological systems. Maps were developed to show potential treatment areas for each recommended strategy for each focal system. Land managers may select final strategies or treatment areas based upon a variety of additional factors, such as availability of financial resources, policy constraints, and non-ecological objectives.

Key Findings

The primary findings of the ecological assessment are summarized as follows:

1. **The approximately 120,000-acre Ward Mountain project area is a largely unfragmented landscape that includes a diversity of Great Basin ecological systems, ranging from desert shrublands to ancient bristlecone pines.** Recent major fires and invasive species such as cheatgrass have not yet overtaken and highly altered most of the area, as they have done elsewhere in the Great Basin. Cheatgrass invasion has occurred at Lower elevations on the western slopes.
2. **The current condition of the Ward Mountain ecological systems varies in terms of departure from their NRV.** Of the area's 21 ecological systems, five are slightly departed from their natural range of variability, ten are moderately departed, and four are highly departed. (Note: Ecological Departure not calculated for two incidental systems)
3. **The primary cause of high departure is that the sagebrush systems are significantly lacking the earliest succession classes.** For example, black sagebrush comprises almost 47,000 acres, almost 40% of the project area. There is virtually no presence of the early succession classes and is dominated by late-succession classes. In addition, a large portion is depleted of native grasses and forbs and conifer tree species have encroached upon the native sagebrush and herbaceous community.
4. **Ten ecological systems require special attention.** Four of the targeted systems are highly departed from NRV and six are moderately departed. Eight of the targeted systems have, or are projected to have, an undesirable percentage of High-Risk Vegetation Classes. Key ecological management issues includes:
   - ***Sagebrush systems*** – lack of early succession classes, diminished herbaceous cover, pinyon-juniper encroachment, and increasing cover of cheatgrass within shrublands.
   - ***Aspen systems*** -- high percentage of vegetation on a pathway of conversion to conifers or loss of aspen clones.
   - ***Riparian*** -- entrenched streams or dominance by associated uncharacteristic species (e.g. Wood's rose or sagebrush).

5. **Varied 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 ecosystems;**
   - ***Sagebrush*** strategies include: prescribed fire; chainsaw lopping of encroached conifer trees; mechanical thinning of late succession classes or tree-encroached sagebrush, combined with seeding of native species; restoration of depleted sagebrush through mowing/Dixie harrow and seeding of native species; mowing and herbicide application in shrublands with both perennial and annual grasses; herbicide application combined with seeding to treat annual grasses
   - ***Aspen*** strategies include: prescribed fire and mechanical thinning to prevent transition to no-aspen class.
   - ***Riparian*** strategies include: continued weed inventory and spot application of herbicides, as well as temporary exclosure fencing.
6. **The PREFERRED MANAGEMENT scenarios <u>significantly reduced Ecological Departure for all ten focal systems</u> -- as compared to current condition and/or minimum management scenarios, and achieved low Ecological Departure for five systems. Moreover, the preferred management strategies reduced or contained High-Risk Vegetation Classes for all ten systems.**
7. **The PREFERRED MANAGEMENT scenarios accrued the highest "return on investment" for all systems, as compared to the MAXIMUM MANAGEMENT scenario.** However, in many cases the MAXIMUM MANAGEMENT scenario would achieve even greater ecological benefits if additional management funds were to become available. TNC's area-weighted return on investment analysis showed that across the ten ecological systems, the greatest predicted ecological benefits per dollar invested would accrue to aspen-mixed conifer and the sagebrush systems.

Introduction

The Bureau of Land Management's Ely District Office (BLM) and U.S. Forest Service (USFS) entered into a cooperative agreement in August 2009 with The Nature Conservancy (TNC) to complete an ecological assessment for approximately 120,000 acres at and around Ward Mountain southwest of Ely, Nevada. The Ward Mountain project area is a largely unfragmented landscape that includes a diversity of Great Basin ecosystems in the Egan Range and adjoining valleys. The 120,000 acre project area includes lands managed by BLM and the USFS, as well as Ely Shoshone Tribal Lands.

Due to its close proximity to Ely, the Ward Mountain area is used for varied recreation activities and serves as the main municipal watershed for the city of Ely. Moreover, there are concerns about the potential for wildfire spread from Ward Mountain to Ely. The fire regime in many of the Ward Mountain systems is outside the natural range of variability due to past land management practices and the invasion of non-native annual grasses at lower elevations. Several vegetation communities are in need of restoration to improve or maintain watershed health.

The assessment's primary purpose was to inform and guide the formulation of future site-specific, cost-effective vegetation management projects to protect, enhance and restore the ecological integrity of the area. The assessment was developed using satellite imagery, remote sensing, predictive ecological models, and cost-benefit assessments. Three workshops were held (one advance session via WebEx conference and two multi-day workshops in Ely) with agency natural resource managers to review and refine ecological models, review findings, and identify and explore potential vegetation management scenarios. The cooperative agreement reflects the mutual desire of BLM, USFS, TNC and other stakeholders to conserve and restore the Ward Mountain area.

Background

In the Intermountain West, rangelands have undergone unprecedented change over the last 150 years (Blackburn and Tueller, 1970; Tausch *et al*., 1993; National Research Council, 1994; Tausch and Nowak, 1999; McPherson and Weltzin, 2000; Anderson and Inouye, 2001; Young and Sparks, 2002). Prior to settlement, the grasslands and shrublands of the arid West were structured primarily by fire, precipitation cycles, and insects, with grazing ungulates playing a role whose importance varied regionally. However, these roles have changed; domestic livestock now graze a large majority of both private and public lands in western North America, and wildfire occurs at times, frequencies, and intensities that are outside of pre-settlement ranges (Blackburn and Tueller, 1970; Brown and McDonald, 1995; Schmidt *et al*., 2002). Longer fire-free intervals, the long-term historic consumption of fine fuels by livestock, and aggressive policies of fire-suppression starting in the 1920s (Pyne, 2004) have favored the expansion of woody species throughout grasslands and shrublands that historically supported few trees, even in areas that have had livestock use removed for decades (Miller and Rose, 1999; Tausch and Nowak, 1999; Curtin and Brown, 2001; Pyne, 2004).

While longer fire-free intervals have favored woody species, the regional invasion of cheatgrass (*Bromus tectorum* L.) has shortened fire-free intervals. Cheatgrass, a non-native annual grass, increased dramatically after historic livestock use reduced native bunchgrasses and forbs (Young et al., 1987; Young and Sparks, 2002). Because native plant species do not survive the frequent fires facilitated by cheatgrass (Young et al., 1987), do not compete successfully against cheatgrass for soil moisture (Melgoza et al., 1990), and some do not disperse as effectively, systems can move toward a cheatgrass monoculture nearly devoid of biodiversity, habitat, and economic values. Cheatgrass control, even for the purpose of restoring native species, may face obstacles because it is best achieved by the application of herbicides.

Public agencies responsible for range management have responded to the major ecological changes of the Intermountain West and, accordingly, stakeholders have strongly supported or opposed traditional land management practice and proposed restoration actions (Fleischner, 1994; Brown and McDonald 1995, Brussard et al., 1994; Wuerthner and Matteson, 2002; Freilich et al., 2003). Stakeholders may disagree with public rangeland management because they share different values about land uses or because there is historic distrust of public land management. Therefore, bringing stakeholders together and in-depth examination of land management values has been described as a first step towards effectively managing and conserving natural resources through community-based conservation (Margoluis and Salafsky, 1998; Groves and The Nature Conservancy, 2003). Adaptive management theory proposes that stakeholders may quantify and partially resolve their beliefs about land management by comparing the effects of alternative management actions on whole ecosystems using simple, yet robust experimental design procedures (Walters and Holling, 1990; Wilhere, 2002). Because the space, investment, and time frame required to carry out an experiment can be large, modeling of alternative management actions is often recommended prior to experimentation, if only to discard ineffective actions and document beliefs about system function (Hilborn et al., 1995; Hardesty et al., 2000; Forbis et al. 2006). Managers also may not have the time or funding to wait several years for experimental results, therefore, modeling provides more immediate recommendations. One type of modeling, the state-and-transition models (Horn, 1975; Westoby *et al*., 1989; McIver and Starr, 2001; Bestelmeyer *et al*., 2004) are increasingly popular in natural resource management because their discrete representations of vegetation dynamics simplify ecological complexity and can be developed in cooperation with specialists and lay-people.

Project Area

The 120,000-acre Ward Mountain project area is a representative Great Basin landscape with diverse topography and a mosaic of ecological systems. The area contains multiple terrestrial ecological systems, three rare plants, and an endemic reptile species (Nachlinger et al. 2001). In addition, the project area contains nesting and core breeding habitat for Greater sage-grouse. While major fires and invasive species have not yet overtaken the area, both woody species encroachment and cheatgrass invasion have occurred. The area is under mixed land management jurisdictions shared by the BLM, Forest Service, Ely Shoshone Tribe, and private landowners (Figure 1).

Objectives

Key objectives for the Ward Mountain Restoration Project identified by workshop participants were:

- Maintain overall condition and prevent deterioration of Ward Mountain's native ecological systems.

- Restore degraded ecological systems to their natural range of variability or an "acceptable" range if NRV is not feasible.
- Reduce and prevent expansion of High-Risk Vegetation Classes (e.g. exotic species).
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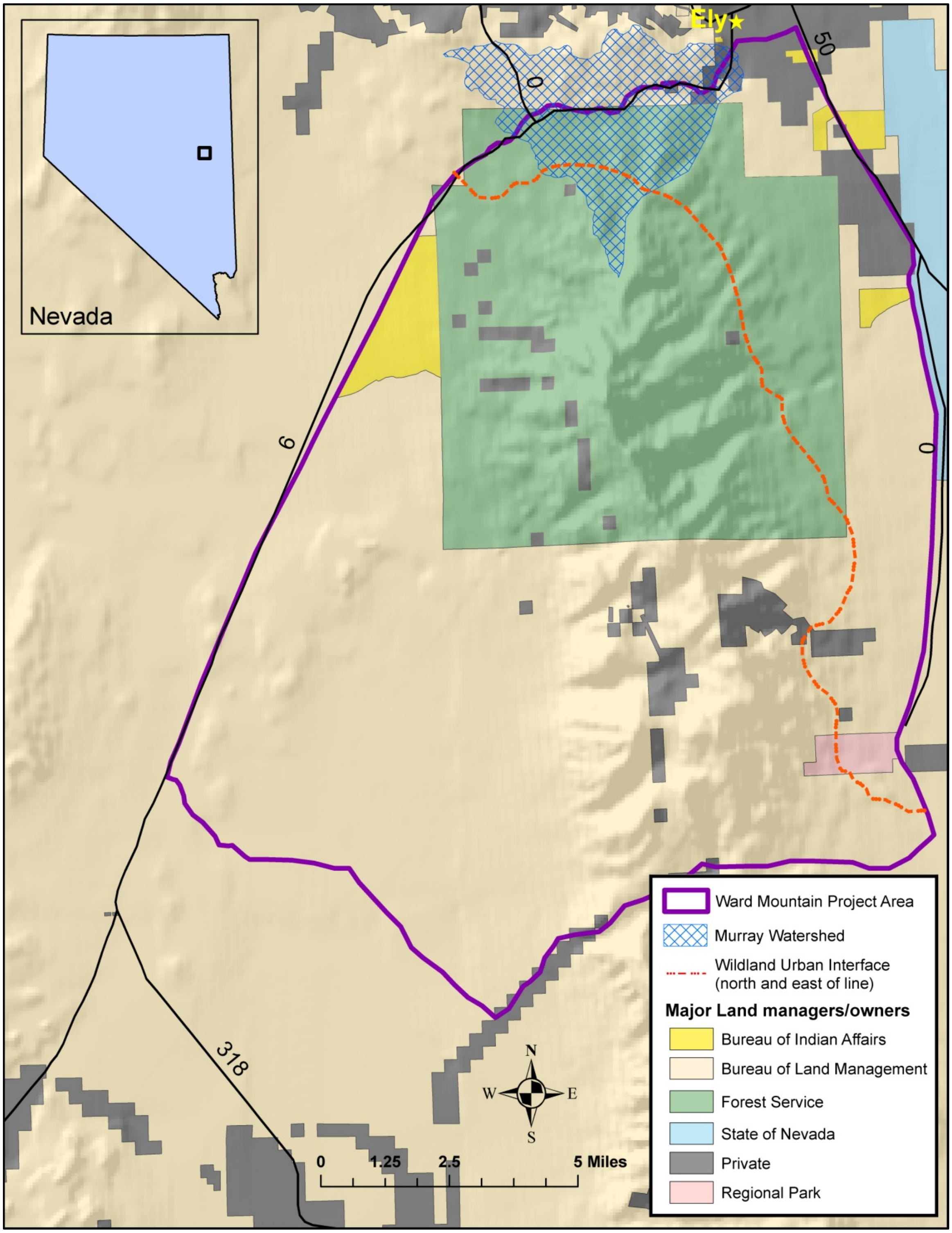


Figure 1. Ward Mountain Restoration Project ecological assessment area. The Wildland Urban Interface boundary was delineated by Forest Service and BLM staff at the February 2010 workshop. The areas north and east of the boundary are considered WUI.

Process and Methodologies

The ecological assessment was iteratively implemented in three steps during the project:1) assessment of current ecological condition of Ward Mountain native ecosystems; 2) assessment of predicted future ecological condition; and 3) development and testing of management strategies and scenarios to improve ecological condition.

Assessment of Ecological Condition

Prior to the first workshop, TNC used Ecological Departure (a.k.a., Fire Regime Condition) methodology developed under the national LANDFIRE program to assess the project area's ecological condition. Ecological Departure is an integrated, landscape-level estimate of the ecological condition of terrestrial, riparian, and wetland ecological systems. Ecological Departure incorporates species composition, vegetation structure, and disturbance regimes to estimate an ecological system's departure from its natural range of variability (NRV). NRV is the percentage of each vegetation succession class that would be expected under a natural disturbance regime.

The fundamental elements of Ecological Departure analysis include: 1) mapping the distribution of biophysical settings (ecological system) – i.e., the dominant vegetation types expected in the physical environment under a natural disturbance regime; 2) mapping current vegetation succession classes of each ecological system; and 3) for each ecological system, comparing the current vegetation class distribution with the expected "natural" distribution and calculating each system's departure from its NRV. Ecological Departure mapping with remote sensing of the Ward Mountain project area started during June 2009.

Remote Sensing Analysis of Biophysical Settings and Current Vegetation Classes

Spatial Solutions was contracted by TNC to conduct remote sensing analysis of the project area. TNC provided Spatial Solutions with a description of biophysical settings and assisted in remote sensing field surveys. Spatial Solutions used the software Imagine® from Leica Geosystems to conduct the unsupervised classification of GeoEye1 imagery (pixels are 65cm multispectral imagery on the side) captured from July 5, 2009. Imagery was cloud free. The imagery was clipped to the project area.

The unsupervised classification of the satellite imagery is described in Provencher *et al*. (2008, 2009) and Low et al. (2010). To support interpretation of spectral classes (Lilles and Kiefer 2000), TNC and Spatial Solutions conducted an initial field trip to establish training plots and rapid observations from July 12-18, 2009. Spatial Solutions collected formal training plots and 1,000+ geo-referenced road and hiking observations. A large proportion of the project area was visited.

The field and geo-referenced road data were combined, when necessary, with the U.S. Geological Survey's Digital Elevation Model and BLM's fire history map, vegetation plot data, and drainage map to create draft maps of biophysical settings and current vegetation classes. Vegetation classes could only be defined after the biophysical setting was assigned to a group of pixels. The short description of each vegetation class by biophysical setting used for remote sensing is presented in Appendix 1. The penultimate draft of biophysical settings and vegetation classes were verified and improved during a second field trip from 12-15 October, 2009. At each pre-selected field location, TNC verified the mapped biophysical setting and current vegetation class. The same verification process was conducted for "road and hiking observations." This final field trip allowed Spatial Solutions to complete the biophysical setting map and the current vegetation class map. The last iteration in the final draft map of current vegetation classes was used to calculate the Ecological Departure.

Mapping Biophysical Settings

The foundation of Ecological Departure mapping is the stratification of a landscape via biophysical settings, which represent potential vegetation. Preferably, biophysical settings are mapped by interpreting ecological sites from Natural Resource Conservation Service (NRCS) soil surveys to major vegetation types. 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*, www.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. The older Western White Pine County and draft of the new USFS Ward Mountain soil surveys were used to first approximate associations of biophysical settings. In combination with the soil surveys, TNC used current, high-resolution satellite imagery to map 21 vegetation types from the soil associations that were subsequently modified to reflect the influence of landforms, as done in the creation of soil surveys, and ecological processes (for example, fire, flooding, insect outbreaks) (Table 1).

Table 1. Biophysical settings of the Ward Mountain project area.

BpS	Acres	% of project area
Alpine	35	<1%
Aspen Woodland	591	<1%
Aspen-Mixed Conifer Woodland	2,235	2%
Basin Wildrye (loamy bottom)	1,646	1%
Black Sagebrush	46,660	39%
Curl-leaf Mountain Mahogany Woodland	10,841	9%
Limber-Bristlecone Pine Woodland	174	<1%
Limber-Bristlecone Pine Woodland - mesic	395	<1%
Low Sagebrush – semi-desert	2	<1%
Low Sagebrush Steppe	113	<1%
Mixed Conifer Woodland	2,691	2%
Montane Sagebrush Steppe – mountain	2,575	2%
Montane Sagebrush Steppe – upland	25,611	22%
Montane Wet Meadow	12	<1%
Montane-Subalpine Riparian	171	<1%
Mountain Shrub	33	<1%
Pinyon-Juniper Woodland	15,561	13%
Pygmy Sagebrush	2	<1%
Subalpine Spruce Forest	65	<1%
Winterfat	615	<1%
Wyoming Big Sagebrush	8,333	7%

Current vegetation detected from satellite imagery was used to map biophysical settings. During remote sensing, it was immediately apparent that soil association polygons a) were too large to be useful, b) contained biophysical settings that were hard to separate because of the spectral characteristics of similar current vegetation classes, c) did not contain biophysical settings they were supposed to have, or d) contained large examples of biophysical settings that were not in the soil association polygon. Therefore, to facilitate a more refined mapping of biophysical settings, a two-step process was used. First, those biophysical settings whose dominant upper-layer species were not prone to moderately rapid expansion or contraction due to limiting soil characteristics were mapped as representative of pre-settlement vegetation. Rules were then applied to map those biophysical settings whose dominant upper-layer species were prone to moderately rapid expansion or contraction.

Group 1: Readily mapped biophysical settings

Biophysical settings that were edaphically controlled and not prone to decadal area change were winterfat, low sagebrush (*Artemisia arbuscula*), curl-leaf mountain mahogany (*Cercocarpus ledifolius* var. *intermontanus*), limber-bristlecone pines (dry and moist), and subalpine spruce. Both Engelmann spruce and bristlecone pine were undetected by the draft USFS soil survey.

- Winterfat is uniquely found on silty or coarse silty soils at low elevations, usually associated with shallow washes and flat areas of fine soil accumulation. Mapping of winterfat was straightforward.
- Low sagebrush is the only sagebrush that survives on a claypan that perches the water table for extended periods during the spring (USDA-NRCS 2003). Therefore, the presence of sagebrush today was an excellent predictor of this species' dominance during the long process of soil formation. This criterion made the separation of low and mountain big sagebrush relatively easy. However, low sagebrush steppe on the upper terrace of Ward Mountain, as predicted by the soil survey, was difficult to distinguish from the surrounding black sagebrush. Field verification of species in every candidate patch was the only way to separate the two dwarf sagebrushes.
- Curl-leaf mountain mahogany woodland is similarly dependent on a few soil types (USDA-NRCS 2003). Because this species is slow-growing and long-lived (>500 years lifespan), it could be reliably mapped as potential vegetation wherever found.
- Ancient limber and bristlecone pines were only found in very small areas on the crest of the project area on very rocky or steep soils and on wind-swept slopes. These areas were clearly mapped, whereas the rest of the highest elevations was either alpine or sagebrush (black or mountain big).
- Engelmann spruce was found in small and thick patches on very steep north to north-east facing slopes that were obvious cold snow pocket below the crest. Patches were localized and soils appeared deep.

Group 2: Rule-based mapping

Other biophysical settings mapped with current, high-resolution imagery using a set of rules were:

- Aspen woodland *may appear smaller than its potential* due to historic and current ungulate grazing.
- Aspen-mixed conifer woodland *may appear smaller than its potential* due to white fir dominance and historic and current ungulate grazing.
- Basin wildrye, black sagebrush, montane sagebrush steppe (mountain and upland), mountain shrub, and Wyoming big sagebrush *that may appear smaller than their potential* because of pinyon and juniper expansion precipitated by fire exclusion.
- Pinyon-juniper woodland *that may appear larger than its potential* due to the same expansion process.
- Montane-subalpine riparian and montane wet meadow *that may appear smaller than their potential* because of hydrologic changes including entrenchment precipitated by road proximity, water diversion, and historic livestock use.

Among this list, the mountain shrub community was very distinctive in the infra-red spectrum of satellite imagery and easy to detect in localized patches. Pinyon-juniper cover was not a problem for detection.

Decadent, open clones of aspen woodland or stable aspen (*Populus tremuloides*) with an uncharacteristic understory encroached by mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana*), had the same spectral classes as montane sagebrush steppe. Aspen clones are known to decrease under grazing pressure (Bartos and Campbell, 1998; Debyle et al., 1987; Kay 1997, 2001a-b; Mueggler 1988); therefore clones are likely smaller than they were before European settlement since the Ward Mountain project area has been grazed for at least a century. Therefore, all visible patches of aspen were "generously" mapped (i.e., if aspen was detected, all pixels with appropriate spectral classes in the immediate area were labeled as aspen) and field observations confirmed new pixels and patches. It is highly conceivable that soils that formerly supported aspen were mapped as montane sagebrush steppe.

Aspen-mixed conifer (seral aspen) was frequently in proximity to stable aspen patches. Any substantial evidence of white fir from saplings to larger trees revealed the aspen-mixed conifer status. The greatest difficulty was to distinguish late-succession aspen-mixed conifer from true mixed conifer. As a rule, any evidence of aspen stems dead or alive caused us to classify a pixel as aspen-mixed conifer; however, an aspen-mixed conifer pixel that had loss all aspen was technically modeled as mixed conifer (the uncharacteristic class of aspen-mixed conifer). Ground-truthing was required to distinguish both cases, which were both confirmed.

Montane wet meadows, including variations from dry to wet, were highly visible in the infra-red spectrum. Small meadows that were remnants of either entrenchment or water diversion had converted into subxeric shrublands were more difficult to map if they were adjacent to uncharacteristic basin wildrye vegetation classes containing subxeric shrubland or adjacent to entrenched creeks or washes. Mapping these entrenched meadows was validated by field verification. Basin wildrye soils are usually fine to silty and deep, whereas wet meadows are more organic and often located on shallow to flat slopes. Entrenched creeks of Ward Mountain have coarser fragments in their soil and slopes are significant.

Montane-subalpine riparian corridors that harbored perennial water where distinct are relatively easy to map; however, pipes were observed diverting water on many creeks.

Several dry creek beds were observed below diversion points and, in some cases, sagebrush, pinyon and juniper had completely covered the original bed. The riparian vegetation was completely absent. In such cases, the riparian classification was restricted to the wetted area unless the dry wash clearly retained a dry stream character (as in intermittent washes, which were common in canyons).

Other biophysical settings with a potential for tree invasion into shrublands were generally resolved by examination of landforms, slope, and elevation (using USGS Digital Elevation Models), and field visits. The following rules were used for pinyon-juniper:

(a) Tree-encroached shrublands. The following delineations were used to describe tree-encroached shrublands: a) trees were conical, therefore less than 150 years old; b) the understory contained several skeletons of dead sagebrush; and c) the herbaceous understory was absent or very reduced; and

(b) Pinyon-juniper woodlands. True pinyon-juniper woodlands occurred on rocky, thin, clearly unproductive soils, or on slopes >30%. Old trees with large trunk diameters were generally common. An exception to the rule was the occasional case where montane sagebrush steppe was found on slopes between 30-35%. Another exception was the occasional case where old trees were found growing on very rocky soils on <20% slopes.

A last list of decision rules applied to the remaining biophysical settings:

(a) Basin wildrye was strictly associated with deep fine soils in loamy bottoms, which are dry and level sub-irrigated wash or creek bottoms. Although basin wildrye (*Leymus cinereus*) was frequently absent from valley bottoms, basin big sagebrush (*Artemisia tridentata* spp. *tridentata*) and rabbitbrush (*Chrysothamnus nauseosus*, *Chrysothamnus viscidiflorus*) dominated these sites with obvious fine soil. Pinyon and juniper encroachment was present in some locations along valley slopes, but the contact point between the slope and the bottom was an adequate boundary to map loamy bottoms; and

(b) Montane sagebrush steppe upland was separated from Wyoming big sagebrush at 7,500 feet on the east facing slopes but at 6,500 feet on the western slopes. The transition zone between the two sagebrush types on both sides of Ward Mountain was visited to confirm this large difference. It is noteworthy that an elevation of 6,500 feet, which was used to separate montane sagebrush steppe and Wyoming big sagebrush on the west side, is below the project's eastern boundary. On the east side, black sagebrush and Wyoming big sagebrush are observed from the boundary at about 6,800 feet to far up on the mountain side. USGS Digital Elevation Models were used to draw the boundary, which was adjusted with local observations

Biophysical Setting Descriptions and Natural Range of Variability (NRV)

To determine the Natural Range of Variability (NRV) original LANDFIRE descriptions and vegetation dynamics models (www.LANDFIRE.gov, accessed February 2008) were modified for projects from northwestern Utah, eastern Nevada and California using standard LANDFIRE methodology (Hann and Bunnell, 2001). Occasional modifications were applied to reflect local conditions of Ward Mountain. New biophysical settings not required in previous projects were split from existing ones or were newly created, such as winterfat. The NRV was calculated with the state-and-transition modeling software Vegetation Dynamics Development Tool (VDDT, ESSA Technologies; Forbis *et al*. 2006, Provencher *et al*. 2007; Provencher *et al*. 2008). Descriptions of biophysical settings, including the natural range of variability, are found in Appendix 7. The natural range of variability for each biophysical setting is listed below (Table 2).

Table 2. The natural range of variability for biophysical settings of the Ward Mountain project area.

Biophysical Setting	Natural Range of Variability (%)					
Name	**A@**	**B**	**C**	**D**	**E**	**U**
Alpine	5	95	0	0	0	0
Aspen Woodland	14	40	45	1	0	0
Aspen Mixed Conifer Woodland	14	40	35	10	1	0
Basin Wildrye	20	70	10	0	0	0
Black Sagebrush	15	50	25	10	0	0
Curl-leaf Mountain Mahogany	10	10	15	20	45	0
Limber-Bristlecone Pine Woodland	20	20	60	0	0	0
Limber-Bristlecone Pine Woodland - mesic	15	35	50	0	0	0
Low Sagebrush Semi-desert	10	40	50	0	0	0
Low Sagebrush Steppe	10	50	40	0	0	0
Mixed Conifer Woodland	10	30	30	20	10	0
Mixed Salt Desert Scrub	5	50	45	0	0	0
Montane Sagebrush Steppe – mountain	20	50	15	10	5	0
Montane Sagebrush Steppe – upland	20	50	15	10	5	0
Montane Wet Meadow	5	45	50	0	0	0
Montane-Subalpine Riparian	20	35	45	0	0	0
Mountain Shrub	10	40	45	5	0	0
Pinyon-Juniper Woodland	5	10	30	55	0	0
Pygmy Sagebrush	0	0	0	0	0	0
Subalpine Mesic Spruce-Fir Forest	20	25	10	45	0	0
Winterfat	10	50	40	0	0	0
Wyoming Big Sagebrush - upland	15	50	25	5	5	0

@ The Standard LANDFIRE coding for the 5-box vegetation model is: A = early-development; B = mid-development, open; C = mid-development, closed; D = late-development, open; E = late-development, closed; and U = uncharacteristic. This terminology was modified for several biophysical settings (Appendix 2).

Calculating Ecological Departure

TNC calculated the Ecological Departure of each ecological system from NRV using the grid data obtained from remote sensing. Ecological Departure is scored on a scale of 0% to 100% departure from NRV: Zero percent represents NRV while 100% represents total departure. Fire Regime Condition Class (FRCC) is a coarser-scale metric used by federal agencies that groups Ecological Departure scores into three classes: FRCC 1 represents ecological systems with low (≤33%) departure; FRCC 2 indicates ecological systems with moderate (34 to 66%) departure; and FRCC 3 indicates ecological systems with high (>66%) departure (Hann et al. 2004). An example of Ecological Departure and FRCC calculation is shown in Table 3.

Table 3. Example of calculation of Ecological Departure (a.k.a., FRC) and FRCC.

	Current Vegetation Class						
	A[&]	B	C	D	E	U	Total
Natural range of variability (%)	20	50	15	10	5	0	100
Current acres by class in project area from remote sensing	182	7,950	58,718	6,659	264	46,123	119,894
Current percentage of classes	0.2	6.6	49.0	5.6	0.2	37.4	
Fire Regime Condition[@] (%)	0.2	6.6	15	5.6	0.2	0	72.4
Fire Regime Condition Class[#]							3

[&] Legend modified from LANDFIRE standard: A = early-development; B = mid-development, open; C = mid-development, closed; D = late-development, open; E = late-development, closed; and U = uncharacteristic.

[@] Ecological Departure (ED) = $100\% - \sum_{i=1}^{n} \min\{Current_i, NRV_i\}$

[#] FRCC: 1 for 0% ≤ ED ≤ 33%; 2 for 34% ≤ ED ≤ 66%; 3 for 67% ≤ ED ≤ 100%.

During the first two workshops, participants completed the following:

Workshop I (WebEx, December 2009) and Workshop II (February 2010)

- Reviewed and refined the 21 ecological systems (i.e., biophysical settings) for Ward Mountain
- Reviewed and refined state-and-transition predictive ecological models for the ecological systems, including their natural succession classes as well as major uncharacteristic classes (such as cheatgrass invasion), with special attention to the dominant montane sagebrush steppe ecosystem.
- Reviewed maps of the ecological systems and their current classes.
- Reviewed each ecosystem's current condition using the FRCC methodology.

Assessment of Future Condition

Ecological Departure provides a robust measure of current ecological condition, which informs land managers of their restoration needs. In addition, managers need to assess which ecological systems are likely to become more altered in the future in the absence of proactive management. Predictive state-and-transition computer models (Bestelmeyer et al., 2004) are a key tool in assessing future condition because they process the remote sensing-based information of vegetation classes and simulate management scenarios. Using computer-based models, TNC assessed the likely future condition of each ecological system after 20 years, assuming minimum management (e.g., no treatment of exotic forbs, no prescribed fire, and no active management of livestock).

State-and-Transition Predictive Ecological Models

A state-and-transition model is a discrete, box and arrow representation of the continuous variation in vegetation composition and structure of an ecological system (Bestelmeyer et al., 2004). An example of a state-and-transition model for mountain big sagebrush from eastern Nevada (Forbis et al. 2006) is shown in Figure 2. Different boxes either belong to different *phases* within a state or different *states*. States are formally defined in rangeland literature (Bestelmeyer et al., 2004) as: persistent vegetation and soil changes per potential ecological sites that can be represented in a diagram with two or more boxes (phases of the same state). Different states are separated by “thresholds.” A threshold implies that substantial management action would be required to restore ecosystem structure and function. Relatively reversible changes (e.g., fire, flooding, drought, insect outbreaks, and others), unlike thresholds, operate between phases within a state. For example, the boxes showing vegetation classes A-E in Figure 2 belong to one state but are different phases of vegetation succession.

Core Reference Models and Descriptions

State-and-transition models were used to represent vegetation classes and dynamics of each Ward Mountain ecological system. Most of the ecological systems at Ward Mountain were common in the Great Basin ecoregion. The state-and-transition models for these ecological systems were modified by workshop participants to reflect local ecological dynamics and management constraints. All models contained a reference component and, with a few exceptions, a management component. A general description of model dynamics is presented in Appendix 2.

All models had at their core, the LANDFIRE reference condition represented by some variation around the A-B-C-D-E succession classes (Table 2). The A-E class models typically represented succession, usually from herbaceous vegetation to increasing woody species dominance where the dominant woody vegetation might be shrubs or trees. The vegetation classes of pre-settlement vegetation classes described in the natural range of variability (Table 2) were considered to be each ecological system’s core reference condition. As such, the reference condition does not describe vegetation condition caused by post-settlement management or unintentional actions (e.g., release of cheatgrass). State-and-transition models were simulated non-spatially with VDDT software as described in Forbis et al. (2006).

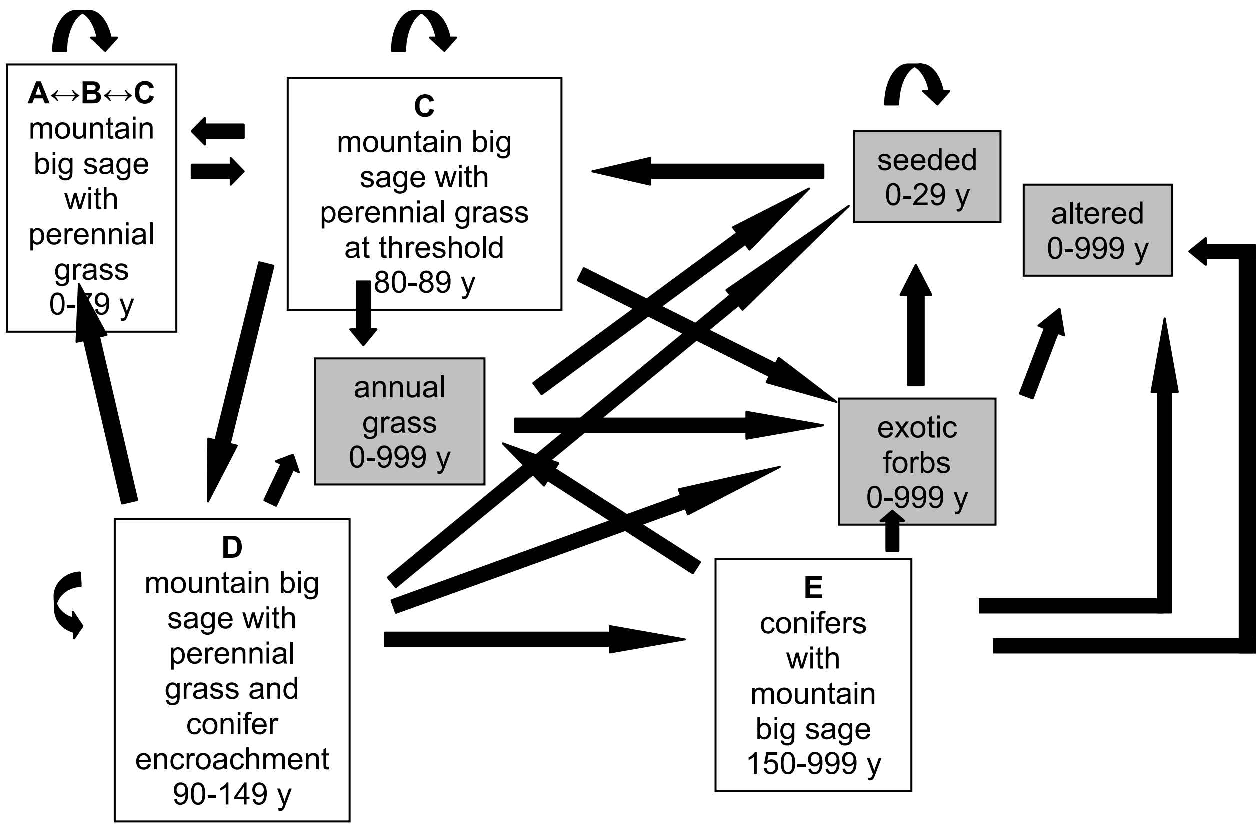


Figure 2. Example of state-and-transition models for mountain big sagebrush based on a VDDT model used for the revision of the Bureau of Land Management Ely Field Office's Resource Management Plan from Forbis et al. (2006).

Management Models

In addition to modeling reference conditions, the predictive models included a management component to allow managers to simulate future conditions under alternative management strategies and scenarios. State-and-transition management models were developed for each focal ecological system during and between the three workshops from December 2009 – May 2010. The vegetation classes of all ecological systems are briefly defined in Appendix 1. A complete description of the models is found in Appendix 2 (model discussion) and parameter values are shown in Appendix 5.

High-Risk Vegetation Classes

The models for most ecological systems included "uncharacteristic" (U) classes. Uncharacteristic classes are classes outside of reference conditions, such as invasion by annual grasses or weeds, tree-encroached shrublands, and entrenched riparian areas. Ecological Departure calculations do not differentiate among the uncharacteristic classes – i.e. all U-classes are treated as equally outside of NRV. However, the cost and management urgency to restore different uncharacteristic classes varies greatly. TNC therefore recommended that Ecological Departure should not be the only metric used to assess future conditions. TNC developed a separate designation and calculation of "high-risk" vegetation classes in consultation with partners. A high-risk class was defined as an uncharacteristic vegetation class that met at least one of three criteria: 1) ≥5% cover of invasive non-native species, 2) very expensive to restore, or 3) a direct pathway to one of these classes (invaded or very expensive to restore).

Measuring Future Ecological Condition

Workshop participants chose *Ecological Departure* and the percentage of *High-Risk Vegetation Classes* as the two indicators for assessing future condition. Ecological Departure is an integrated measure of composition, structure, and disturbance regime, and was the key metric previously used to assess current condition. The percentage of High-Risk Vegetation Classes was selected as a second key indicator. The importance of including this second indicator was further amplified when some simulations showed that an ecological system's overall Ecological Departure could improve through targeted restoration strategies, while its area of High-Risk Vegetation Classes actually increased.

The cover of High-Risk Vegetation Classes was stratified into four categories:

- Low: 0% of the system's area in High-Risk Vegetation Classes; no future risk posed to ecological system condition;
- Medium: 1-10% of the system's area in High-Risk Vegetation Classes; acceptable future risk posed to ecological system;
- High: 11-30% of the system's area in High-Risk Vegetation Classes; future vegetation classes have the potential to catalyze even greater degradation of ecological system and will require significant resources to contain, let alone restore; and
- Very high: Over 31% of the system's area is in High-Risk Vegetation Classes; the system will be highly degraded, perhaps beyond the ability of managers to restore the ecological system's condition.

Using computer-based models, TNC simulated the likely future condition (Ecological Departure and percentage of High-Risk Vegetation Classes) of each ecological system after 20 years, assuming minimum management (e.g., no inventory or treatment of exotic forbs, no prescribed fire, no active management of livestock). Potential sources of future impairment were explicitly modeled, and included; increased non-native species (cheatgrass and exotic forbs) invasion rates, increased tree encroachment rates, reduced mean fire return intervals, entrenchment of and water diversion from creeks and wet meadows, and excessive herbivory by livestock.

Testing Alternative Management Strategies and Scenarios

Participants at the second workshop identified a set of objectives to guide the development of conservation strategies. Nine ecological systems were selected for strategy development, based upon their current condition, likely future departure from NRV and/or potential for increased high-risk classes, as well as feasibility of management action. Varied management strategies and scenarios were then developed for these ecological systems, and their effectiveness was tested using the predictive ecological models.

Objectives

Workshop participants agreed upon the following objectives to guide the development of conservation and restoration strategies.

Conservation and Restoration Objectives

- Maintain overall condition and prevent deterioration of Ward Mountain's native ecological systems.
- Restore degraded ecological systems to their natural range of variability or an "acceptable" range if NRV is not feasible.
- Reduce and prevent expansion of High-Risk Vegetation Classes (e.g. exotic species).
- Manage Murray municipal watershed to prevent high severity events and restore ecological stability.
- Treat Wildland-Urban Interface (WUI) areas and reduce fuel loads to help protect human settlements and cultural resources in and around the project area from wildfire.
- Develop a collaborative restoration plan with shared vision and action among BLM, Forest Service, Ely Shoshone tribe, partners and stakeholders.
- Help BLM and USFS meet objectives specified in management plans.

The nine focal ecological systems selected by workshop participants were: aspen woodland, aspen-mixed conifer woodland, basin wildrye, black sagebrush, montane sagebrush steppe (mountain and upland), montane-subalpine riparian, winterfat, and Wyoming big sagebrush.

Management Strategies

The Ward Mountain Restoration Project's ecological assessment focused on developing management strategies to achieve the agreed-upon objectives. As such, all strategies were fundamentally designed to: (1) improve the condition of ecological systems that are currently in an undesirable condition and/or (2) abate the most serious future threats to ecological systems or human settlements. Working with BLM, Forest Service, and tribal staff and workshop participants, a comprehensive list of potential management strategies was developed for all of the targeted ecological systems. A cost-per-acre and yearly application rate budget was determined for each management strategy, using various published sources as well as the local experience of managers (more detailed budget information is provided in the following section on Management Scenarios). Various combinations of management strategies were explored for each targeted ecosystem, using VDDT computer simulations to test their effectiveness and adjust the scale of application. The models also included a "failure rate" for many management strategies to reflect that some management actions only partially succeed at restoring a vegetation class. The array of management strategies included the following:

- Sagebrush strategies included: prescribed fire; chainsaw lopping and canopy thinning of encroaching conifer trees; chaining to thin or remove woody vegetation; and restoration of depleted sagebrush through mowing and drill seeding of native herbaceous species. Where annual grasses are present, herbicide application was included in the strategy.
- Montane-subalpine riparian strategies included: continued weed inventory and spot application of herbicides; and temporary exclosure fencing.
- Aspen strategies included: prescribed fire or mechanical treatment.

An initial draft set of management strategies was developed by TNC and workshop participants. TNC then conducted VDDT model runs to test and refine a suite of strategies for each of the targeted ecological systems over a 20-year time horizon. Since VDDT software currently does not have an optimization mechanism, this required testing many different combinations of alternative management strategies and levels of treatment. This trial-and-error process created a robust set of strategies that reduced Ecological Departure and cover of High-Risk Vegetation Classes while minimizing cost.

Management Scenarios

Scenarios for Ward Mountain were developed by participants at the second workshop, February 2010. Three basic scenarios were designed: minimum management (MINIMUM MANAGEMENT); management unrestrained by financial or management plan constraints (MAXIMUM MANAGEMENT); and management identified by workshop attendees that include strategies that were refined based on funding the agencies anticipate for restoration (PREFERRED MANAGEMENT). All scenarios are briefly summarized in Table 4.

Table 4. Brief descriptions of management scenarios for the Ward Mountain Restoration Project.

MANAGEMENT SCENARIOS
MINIMUM MANAGEMENT
A control scenario that only included natural disturbances, unmanaged non-native species invasion, traditional livestock grazing, and fire suppression. Fire suppression by agencies was simulated by reducing natural, reference fire return intervals using time series that reflected current fire events from the immediate and nearby areas. Fire event data were obtained from the Federal Fire Occurrence Website. In essence, this scenario can be considered a no-treatment control, but does not represent current management.
MAXIMUM MANAGEMENT
This scenario allocated restoration funds with the goal of reducing Ecological Departure and High-Risk Vegetation Classes to the greatest extent reasonably feasible. Management strategies were applied only if they significantly reduced Ecological Departure and/or maintained High-Risk Vegetation Classes below 10% of the area of the ecological system. This scenario assumed no financial or other resource constraints on strategy implementation (i.e., annual agency budgets were typically exceeded).
PREFERRED MANAGEMENT
The preferred management scenario was the result of actions identified by workshop participants. It often was 'streamlined' or minimized Ecological Departure and High-Risk Vegetation Classes while recognizing anticipated agency budgets and restoration funding availability. Strategies were sought that produced the highest Return-On-Investment, i.e., the greatest reduction in Ecological Departure compared to MINIMUM MANAGEMENT divide by the total cost for the duration of the simulation (usually 20 years).

Each scenario required budgets for each ecological system, which included costs of all management strategies. Budgets were also expressed as area limits, which was the maximum area that could be treated per year for individual actions. If computer simulations reached a given management strategy's annual area limit, that management strategy was subsequently discontinued in the simulation for that year. Budget information for each management strategy for each ecological system, under the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios, are outlined in Appendix 3 and Appendix 4, respectively.

Accounting for Variability in Disturbances and Climate

The basic VDDT models incorporate stochastic disturbance rates that vary around a mean value for a particular disturbance associated with each succession class for each ecological system. For example, fire is a major disturbance factor for most of Ward Mountain's ecological systems, including replacement fire, mixed severity fire and surface fire. These fire regimes have different rates (i.e., mean fire return interval) that are incorporated into the models for each ecological system where they are relevant. However, in real-world conditions the disturbance rates are likely to vary appreciably over time. To simulate strong yearly variability for fire activity, drought-induced mortality, non-native species invasion rates, tree encroachment rate, loss of herbaceous understory, and flooding, TNC incorporated temporal multipliers in the model run replicates.

A temporal multiplier is a number in a yearly time series that multiplies a base disturbance rate in the VDDT models: for example in a given year, a temporal multiplier of one implies no change in a disturbance rate, whereas a multiplier of zero is a complete suppression of the disturbance rate, and a multiplier of three triples the disturbance rate.

Fire Activity

Data were available for fire activity in the Ward Mountain project area and four nearby areas between 1980 and 2009. Areas were located on either the Egan or Schell Creek Range west-south-west, south-east, north-west, and north-north-east of Ward Mountain. Data from the Federal Fire Occurrence Website were downloaded for the whole western U.S.A. and time series of fire size from 1980 to 2006 were extracted from five "clipped" areas each the same size and shape as Ward Mountain with ARC GIS 9.3. Five time series of fire activity were used as replicates for all scenarios. Time series were 29 years long; time series for 75 years were created by resampling the fire series data and dividing each yearly value of total area burned by the temporal average.

The five time series (i.e., one time series per replicate) were uploaded into VDDT, and yearly probability multiplier values multiplied the average wildfire rate in the models. All replicates had several peaks of fire activity with the second replicate being the most severe (Figure 3).

Upland Variability

Drought-induced mortality, non-native species invasion, tree encroachment, and loss of herbaceous understory are non-fire disturbances that affect upland ecosystems. Accordingly, temporal multipliers were developed to account for variability in these non-fire disturbances. The additional temporal multipliers in Figure 3 were inter-related and dependent on measurements of Snow-Water-Equivalent (SWE) from a NRCS-maintained weather station (Bostetter, ID) close to the intersection of Nevada, Idaho, and Utah. Rates of annual grass and exotic forb invasion were assumed to be greatest in wetter years and least in drier ones. Therefore, these parameters had temporal multipliers equal to the value of SWE for a given year divided by the average SWE (Figure 3). Tree encroachment (Tree-Invasion parameter in the model) similarly responded to SWE, but a much slower process was projected. The temporal multiplier for tree encroachment was, therefore, the square-root of the SWE temporal multipliers when ≥ 1, but simply $0.9 \times$SWE temporal multiplier if it <1. Drought, insect/disease, and understory loss rates were all expressions of stress incurred during dry years. Drought was assumed to be positively correlated to temperature and inversely correlated to SWE. A temperature temporal multiplier was obtained from a resampled temperature time series (1871 to 1999) for the northern Sierra Nevada, as eastern Nevada is strongly influenced by the Pacific Ocean (personal communication, Dr. M. Dettinger, USGS, 2008). The equation for drought was somewhat complicated because the temperature temporal multiplier modified the SWE temporal multiplier and SWE was assumed to have a much greater effect than temperature on drought levels:

$$\text{Yearly drought temporal multiplier} = 1/(TM_{SWE}*EXP^{\{-3.46*(MAX\{1,TM_{temp}\}-1)\}}),$$

where TM_{SWE} and TM_{temp} are the temporal multipliers, respectively, for SWE and temperature (Figure 3). As temperature increases, the TM_{SWE} becomes a smaller number, and drought level increases. For years colder than average ($TM_{temp} < 1$), only SWE has an influence because the exponential function equals one due to the zero value of (MAX – 1) function. The temporal multipliers for insect/disease and loss of understory rates were equal to the drought temporal multiplier.

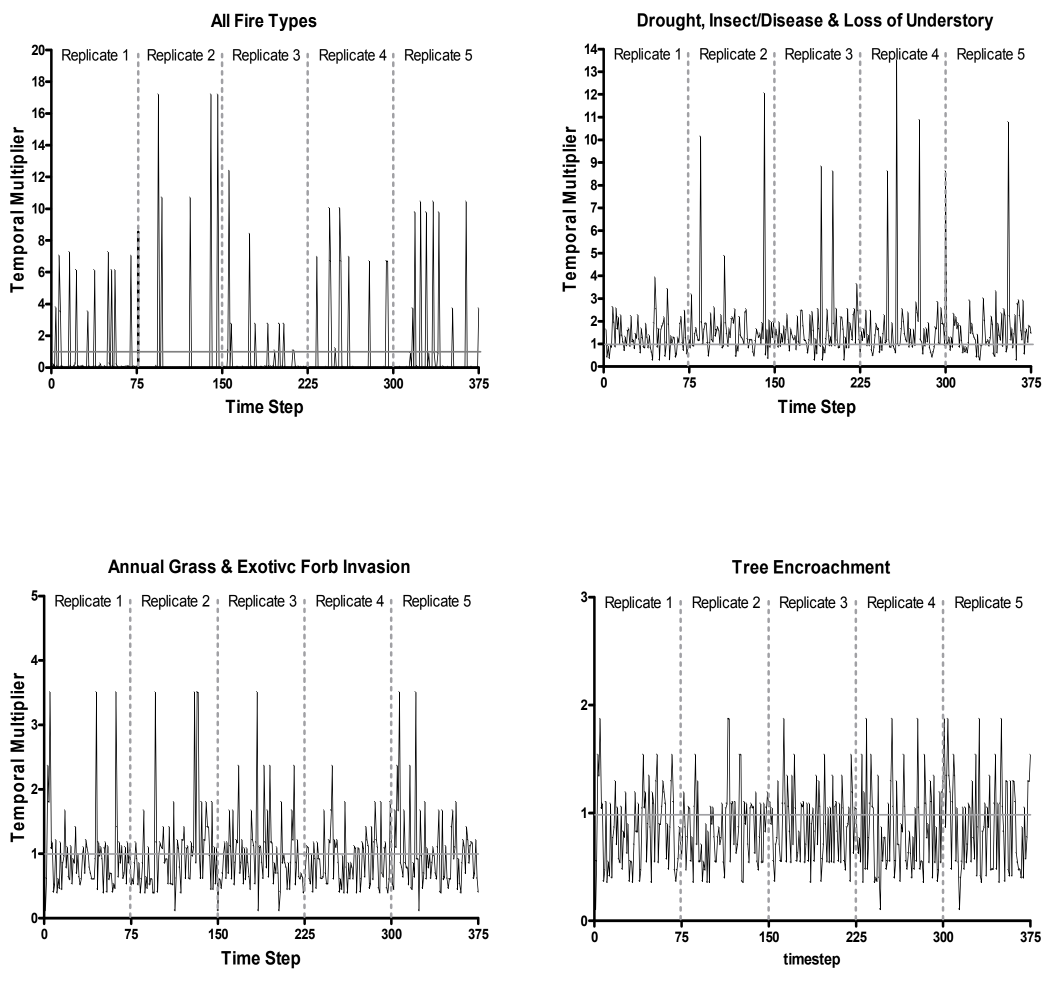


Figure 3. Five replicates of temporal probability multipliers for fire activity; drought, insect/disease and understory loss; annual grass and exotic forb invasion; and tree encroachment rates. Each replicate is numbered and represented by 75-year period.

Riparian Variability

Montane and subalpine riparian were strongly dependent on flow variation for flood events. Gage data was not available from Ward Mountain; however, TNC had recently developed long term flow temporal multipliers for the lower Truckee River (Sparks Truckee River gage) and the snowpack of both the Sierra Nevada and Ward Mountain are completely influenced by the Pacific Ocean. Therefore, these stream flow temporal multipliers were used to introduce strong variability to the systems of Ward Mountain, realizing that actual local gage data would provide a somewhat different pattern of variability. Variability of the 7-year, 20-year, and 100-year flood events are all based on filtering for increasingly higher values of annual peak flow. The 7-year flood events encompass the full time series of peak flow divided by the temporal average. Based on known flood events for the Truckee River, the 20-year and 100-year flood thresholds, respectively, corresponded to 1 and 3.69 of the 7-year flood temporal multiplier (i.e., all values less than the threshold were zero) (Figure 4).

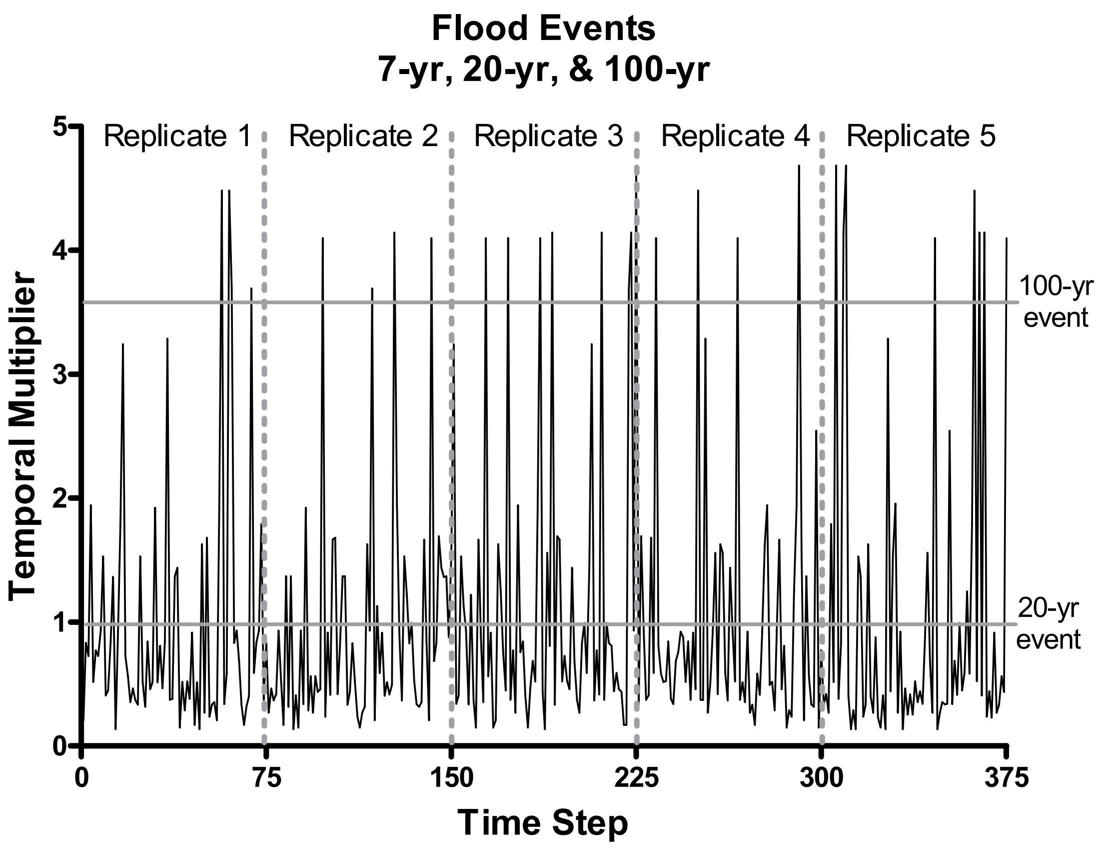


Figure 4. Riparian temporal multipliers for 7-year, 20-year, and 100-year flood events. For the 20-year and 100-year flood events, respectively, all values below their threshold are zero. Data obtained from the Sparks Truckee River U.S. Geological Survey gage.

Computer Simulations, Reporting Variables and Statistical Analysis

Three scenarios were simulated for 20 years using VDDT, including MINIMUM MANAGEMENT, MAXIMUM MANAGEMENT, AND PREFERRED MANAGEMENT. Five replicates were run for each scenario to capture extremes in fire activity and other disturbances.

The two primary reporting variables for simulations – i.e., the key metrics of ecological condition – were Ecological Departure and High-Risk Vegetation Class. The differences in the outcomes for these two factors among the scenarios were compared with a one-way Analysis of Variance (ANOVA; Steel and Torrie 1980). Analysis of variance is a commonly used technique for comparing the means of groups of measurement data. The joint effect of scenarios on both reporting variables was also conducted with Multivariate Analysis of Variance (MANOVA) because these variables are highly correlated and two ANOVAs could overstate the significance of the test (Steel and Torrie 1980).

Cost-Benefit Analysis of Management Scenarios

The last step was the calculation of benefits as compared to costs. TNC developed and employed intra- and inter-system return-on-investment (ROI) metrics to determine which of the scenarios produced the greatest ecological benefits per dollar invested across multiple scenarios within a system and among the ten targeted ecological systems, as compared to minimum management. The two ROI metrics calculated were:

(1) Ecological intra-system ROI. The change of Ecological Departure and High-Risk Vegetation Classes between the MINIMUM MANAGEMENT scenario and other scenarios (MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT) in year 20, divided by total cost over 20 years. Correction factors were used to achieve a common order of magnitude.

(2) Ecological System-wide inter-system ROI. The change of Ecological Departure and High-Risk Vegetation Classes between the MINIMUM MANAGEMENT scenario and PREFERRED MANAGEMENT scenario in year 20, multiplied by total area of the ecological system, divided by total cost over 20 years. Correction factors were used to bring all measures to a common order of magnitude.

Findings

Current Ecological Condition

The Ward Mountain project area is a largely unfragmented landscape that includes 21 Great Basin ecological systems (Figure 5). The current condition of Ward Mountain's ecological systems varies widely in terms of departure from their NRV. Of the 21 ecological systems, five are slightly departed from their natural range of variability, ten are moderately departed, and four are highly departed. Ecological Departure cannot be calculated for two systems that are minimally represented in the landscape. Six ecological systems have an overabundance of High-Risk Vegetation Classes (>10%), whereas 14 systems have no high-risk classes. Major fires and invasive species such as cheatgrass have not yet overtaken the area.

Ecological Systems

Of the 21 ecological systems mapped, black sagebrush was the dominant system, comprising almost 47,000 acres, almost 40% of the project area (Table 1, Figure 5). Other widespread systems included montane sagebrush steppe – upland (~22%), pinyon-juniper woodland (~13%), and Wyoming big sagebrush (7%). Some of the systems were localized. Alpine and subalpine spruce forest occurred in small patches along the crest of Ward Mountain. Small patches occurring on less than a total of 10 acres of pygmy sagebrush were in the southwest corner of the project area. Two acres of low sagebrush steppe occurred on the northern upper terrace of Ward Mountain.

Current Vegetation Classes

Late-development and uncharacteristic vegetation classes dominated the largest ecological system, black sagebrush (Figure 6, Figure 7). The early succession classes were highly underrepresented (1%), and almost 50% of the black sagebrush was depleted (~40%) or encroached by conifers (~10%). The second largest system, montane sagebrush steppe – upland, had 20% in uncharacteristic classes that included depleted sagebrush; degradation of shrublands due to the presence of annual grasses (i.e., cheatgrass); depletion of native grasses and forbs; and conifer encroachment. Pinyon-juniper and curl-leaf mountain mahogany woodlands were in good condition with minimal Ecological Departure and no uncharacteristic classes. Fifty five percent of Wyoming big sagebrush was depleted, and another 11% was invaded by cheatgrass in the shrub understory.

Vegetation classes for all systems are displayed in Figure 6, with a detailed depiction of uncharacteristic classes in Figure 7. Relative amounts of the 21 ecological systems of the Ward Mountain project area are detailed in Appendix 6.

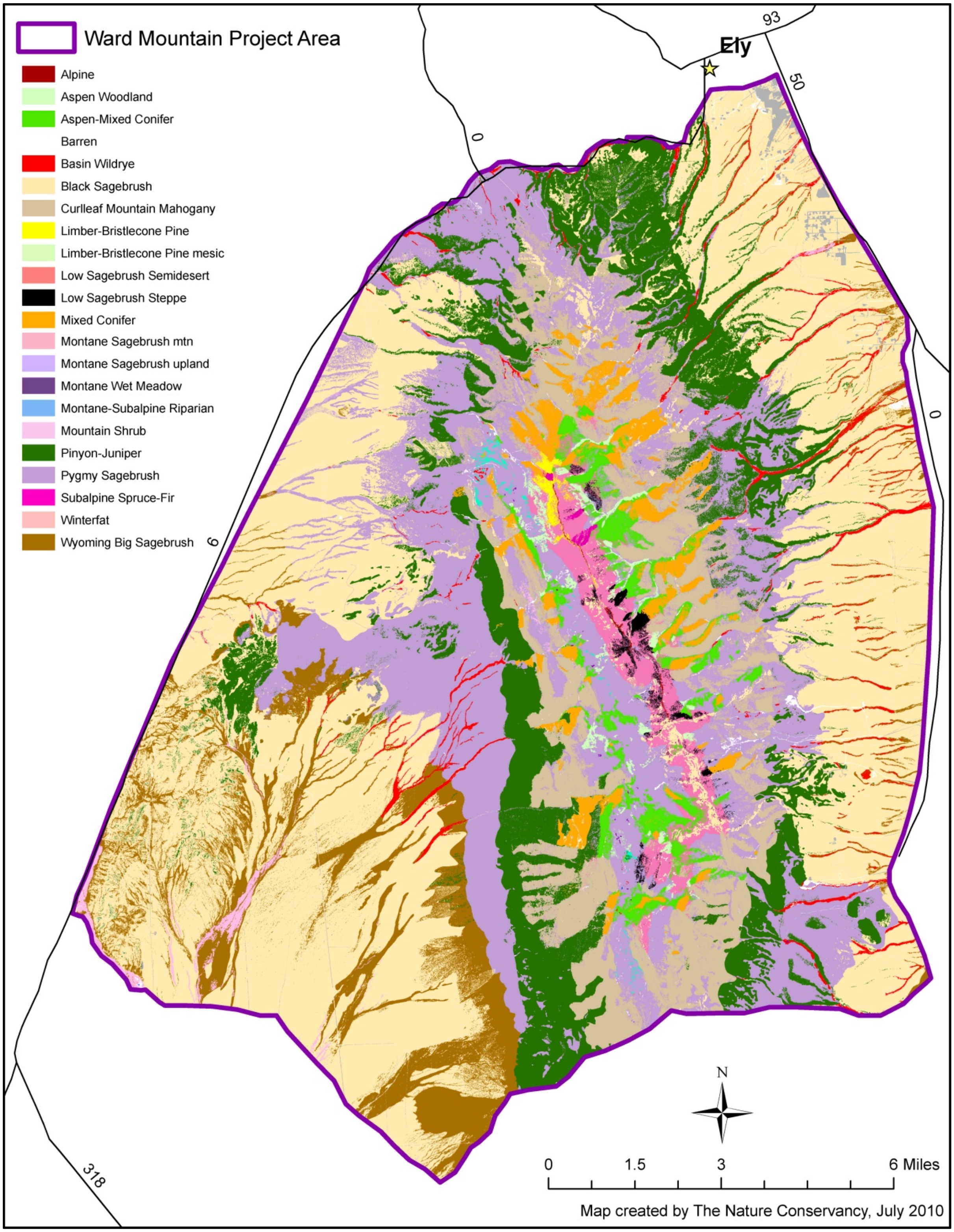


Figure 5. Ecological systems of the Ward Mountain project area based on mapping biophysical settings.

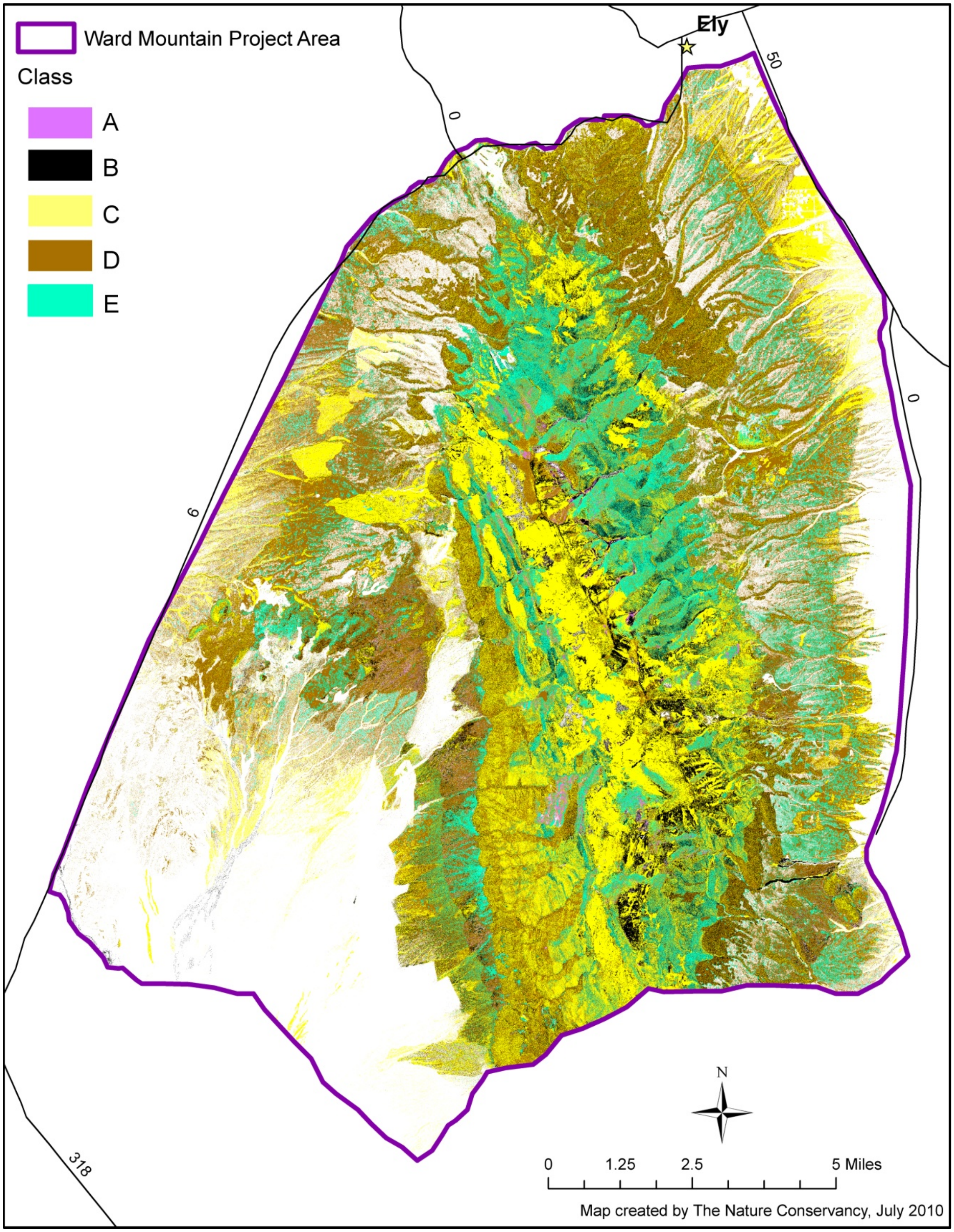


Figure 6. Succession classes of current vegetation in the Ward Mountain project area. Reference classes include Class A – Class E. Uncharacteristic classes would not be expected on the landscape under a natural disturbance regime.

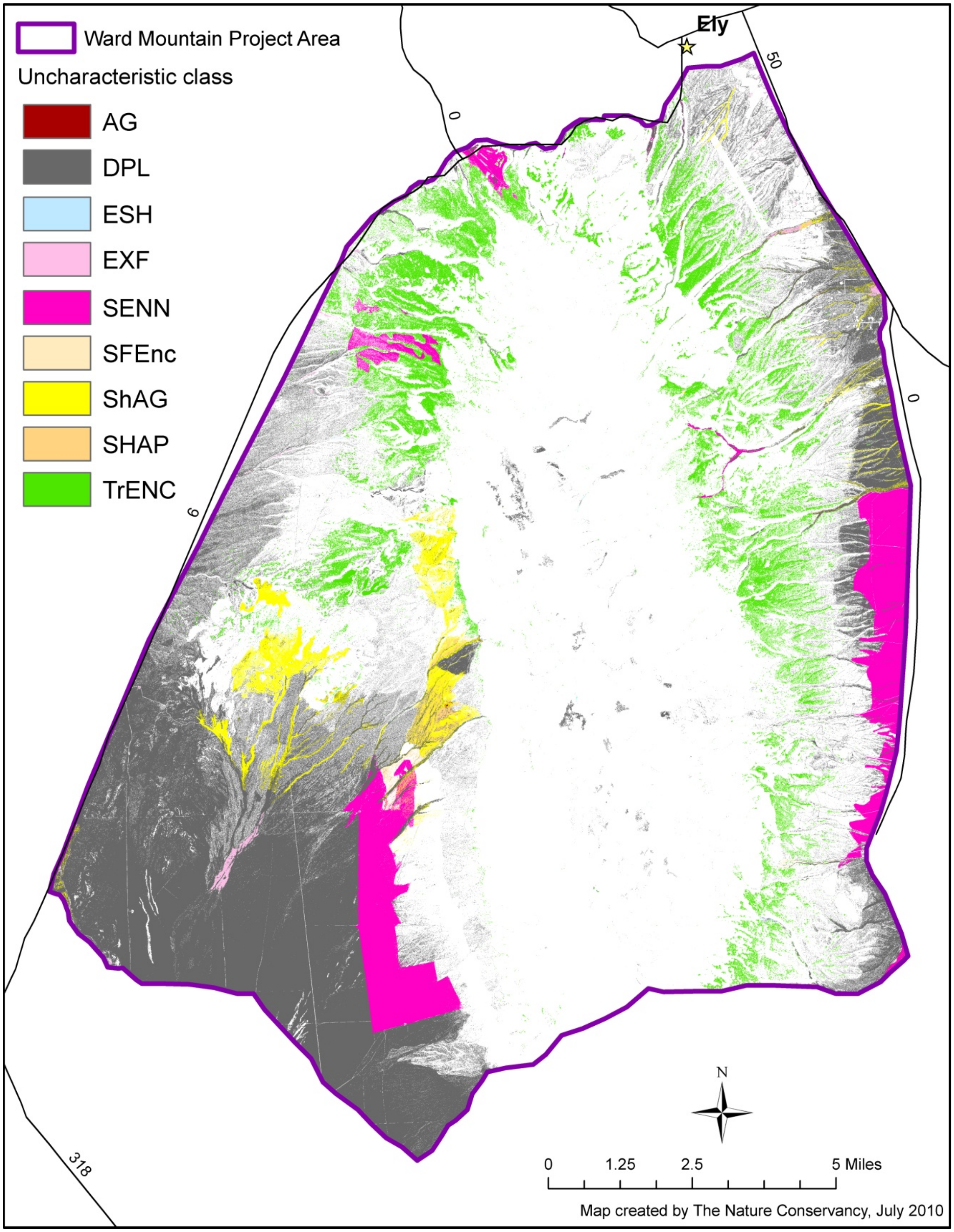


Figure 7. Uncharacteristic vegetation classes of the Ward Mountain project area. Classes include: annual grasses (AG), depleted (DPL), early shrub (ESH), exotic forbs (EXF), crested wheatgrass monoculture (SENN), shrub forb encroached (SFEnc), shrub annual grass (ShAG), shrub annual grass perennial grass (SHAP), and tree encroached (TrENC).

Ecological Departure

The measure of Ecological Departure (i.e., Fire Regime Condition or FRC), is scored on a scale of 0% to 100% departure from NRV: Zero percent represents NRV while 100% represents total departure. Fire Regime Condition Class (FRCC) is a coarser-scale metric that groups FRC scores into three classes: FRCC 1 represents ecological systems with low (≤33%) departure; FRCC 2 indicates ecological systems with moderate (34 to 66%) departure; and FRCC 3 indicates ecological systems with high (>66%) departure.

The current condition of Ward Mountain's ecological systems varies widely in terms of departure from their NRV. Of the 21 ecological systems, five are slightly departed from their natural range of variability and include pinyon-juniper woodland, curl-leaf mountain mahogany woodland, low sagebrush steppe, subalpine spruce forest, and alpine. Four are highly departed and include black sagebrush, Wyoming big sagebrush, basin wildrye, and winterfat. The remaining 10 systems are moderately departed (Table 5). Ecological Departure was not calculated for two systems that are minimally represented in the landscape. Figure 8 displays a map for the project area showing the FRCC classes across the ecological systems.

Table 5. Ecological Departure (FRC) and FRCC of ecological systems of Ward Mountain project area. Ecological Departure equals percent departure. FRCC is color coded: red = FRCC 3, yellow = FRCC 2, and green = FRCC 1. Ecological Departure was not calculated for incidental systems (less than 10 acres in project area).

Ecological System	% Departure	Acres (rounded to next 10)
Alpine	4	40
Aspen Woodland	45	590
Aspen-Mixed Conifer Woodland	53	2,240
Basin Wildrye	86	1,650
Black Sagebrush	79	46,660
Curl-leaf Mountain Mahogany Woodland	17	10,840
Limber-Bristlecone Pine Woodland	37	170
Limber-Bristlecone Pine Woodland-mesic	41	390
Low Sagebrush Steppe	33	110
Low Sagebrush-semi-desert	-	0
Mixed Conifer Woodland	52	2,690
Montane Sagebrush Steppe- mountain	47	2,570
Montane Sagebrush Steppe- Upland	62	25,610
Montane Wet Meadow	52	10
Montane-Subalpine Riparian	59	170
Mountain Shrub	47	30
Pinyon-Juniper Woodland	18	15,560
Pygmy Sagebrush	-	0
Subalpine Spruce Forest	25	60
Winterfat	78	610
Wyoming Big Sagebrush	76	8,330

Ecological Departure analysis works well for large, relatively unfragmented landscapes (i.e., ~100,000 to 1,000,000+ acres). However, the departure scores of ecological systems become increasingly uncertain as landscape size decreases, as well as when system size decreases, especially for systems with longer return intervals of stand replacing disturbances. The approximately 118,000 acre Ward Mountain project area was of adequate size to assess the majority of its ecological systems, including the dominant black sagebrush. However, the departure scores for systems with better representation outside of the project area, including both limber-bristlecone pine systems, low sagebrush steppe, low sagebrush semi-desert, montane sagebrush steppe-mountain, montane wet meadow, mountain shrub, pygmy sagebrush, subalpine spruce forest, and winterfat would have a higher degree of uncertainty.

High-Risk Vegetation Classes

High risk uncharacteristic vegetation classes include annual grass (AG), depleted (DPL), exotic forb (EXF), shrub-annual grass (ShAG), tree annual grass (TrAG), tree encroached (TrEnc), and no aspen (NAS). One exception is worth noting. Depleted classes of aspen woodland were not designated as high risk because the thinning treatment identified in the strategies is not cost prohibitive and positive results were obtained by employing this strategy. Had an action such as fencing been the only strategy option for improving depleted classes of aspen woodland, the class would likely be designated as high risk since large scale fencing projects are not feasibly implemented.

Five ecological systems currently have an overabundance of High-Risk Vegetation Classes (>10%): these include basin wildrye, black sagebrush, montane sagebrush steppe – upland, winterfat, and Wyoming big sagebrush (Table 6). The remaining systems have little to no High-Risk Vegetation Classes. These less impacted systems were typically marginally present within the project area, wetter, or found at higher elevations where ecological processes might be more buffered against unwanted ecological transitions.

Table 6. Percent of ecological system represented by High-Risk Vegetation Classes versus percent of all uncharacteristic classes of Ward Mountain Restoration Project ecological systems. Overabundance, or systems with high risk class representation that can be characterized as fair or poor, are coded yellow and red, respectively. Ecological systems that in good condition relative to the amount of High-Risk Vegetation Classes present are coded green.

Ecological System	% High Risk Classes	% all Uncharacteristic classes
Alpine	0	0
Aspen Woodland	0	33
Aspen-Mixed Conifer Woodland	<0.1	<0.1
Basin Wildrye	81	84
Black Sagebrush	48	57
Curl-leaf Mountain Mahogany Woodland	0	0
Limber-Bristlecone Pine Woodland	0	0
Limber-Bristlecone Pine Woodland-mesic	0	0
Low Sagebrush Steppe	0	0
Low Sagebrush-semi-desert	0	0
Mixed Conifer Woodland	0	0
Montane Sagebrush Steppe- mountain	0	0
Montane Sagebrush Steppe- Upland	18	20
Montane Wet Meadow	5	5
Montane-Subalpine Riparian	0	11
Mountain Shrub	0	0
Pinyon-Juniper Woodland	0	0
Pygmy Sagebrush	0	0
Subalpine Spruce Forest	0	0
Winterfat	79	79
Wyoming Big Sagebrush	66	71

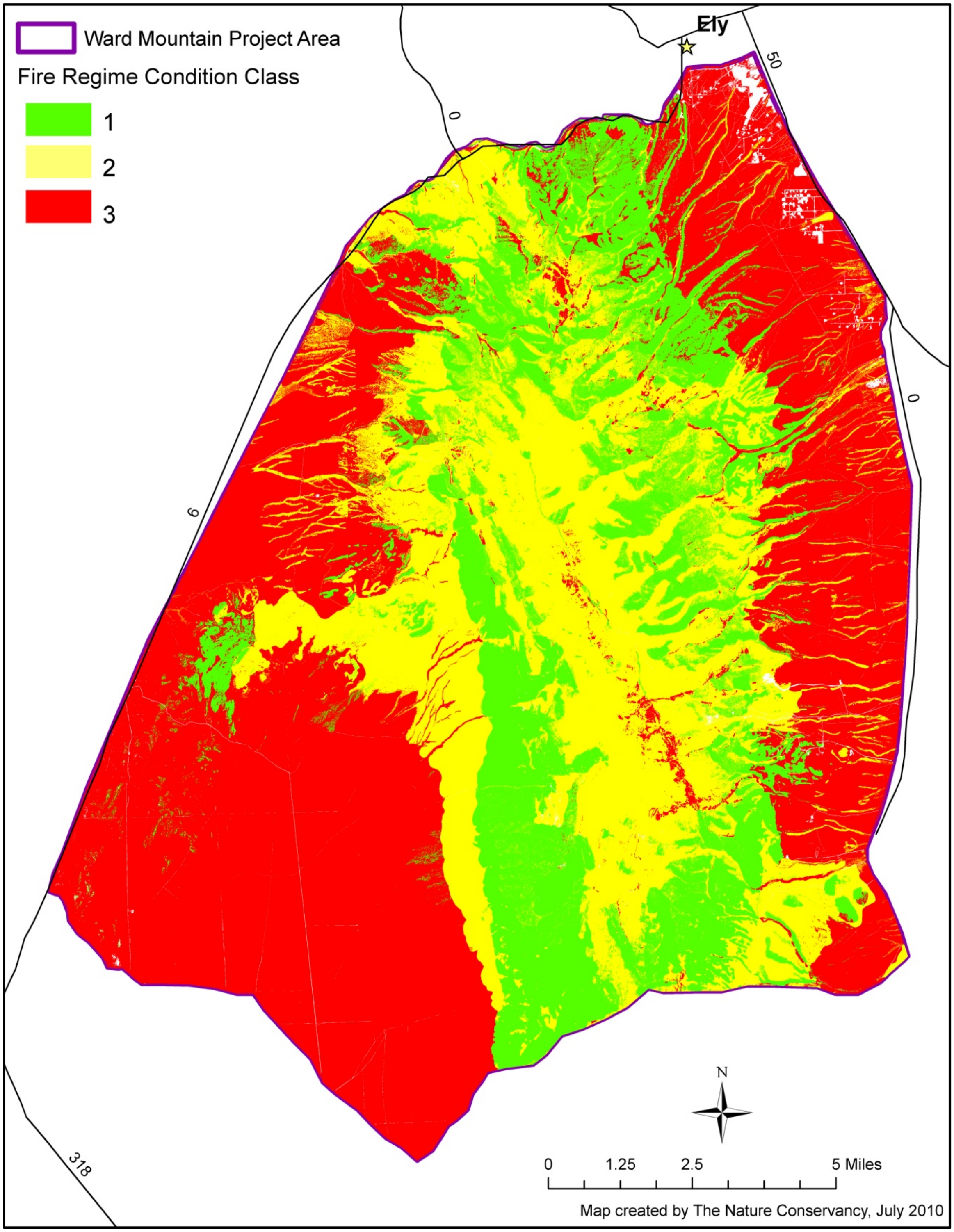


Figure 8. Map of Fire Regime Condition Class (FRCC) of the Ward Mountain project area. Note: While a large portion of the project area is in red (FRCC 3) and yellow (FRCC 2), this does not mean that the entire area must be treated to meaningfully reduce Ecological Departure.

Predicted Future Ecological Condition

Using computer-based models, TNC simulated the likely future condition (Ecological Departure and percentage of High-Risk Vegetation Classes) of ten focal ecological systems identified by workshop participants. Simulations were for 20 years and assumed minimum management (e.g., no inventory or treatment of exotic forbs, no prescribed fire, traditional management of livestock). Systems that require minimal management or were not adequately represented for Ecological Departure calculations were not included in the analysis. For example, because mountain mahogany is not a system that typically receives active management and it was determined to be in good condition (i.e., Ecological Departure of only 17 and no High-Risk Vegetation Classes), it was not included for further analysis.

Ecological Departure

Ten focal systems were analyzed for future conditions (Table 7). For most systems, no significant changes in condition were predicted over the next 20 years with many systems seeing improvements in Ecological Departure. The greatest improvements were observed in the montane sagebrush steppe (mountain and upland) and mountain shrub communities. Montane sagebrush steppe actually improved from FRCC 2 to FRCC 1. Winterfat is the only system that experienced a decline in Ecological Departure due to continued loss of reference classes to uncharacteristic classes.

The primary explanation of the potentially counter-intuitive outcomes was twofold: (1) many ecological systems respond slowly in terms of their change in departure over time, especially if they are dominated by late succession classes which just become older; (2) the "escape" of fires into the ecological systems. The predictive models included a modest failure rate for traditional fire suppression activities, as well as varied fire cycles based upon historical data. The models ran five replicates. One of the replicates included a large fire, which actually served to reduce Ecological Departure for many systems (e.g., montane sagebrush steppe – mountain) by increasing their early succession classes.

Table 7. Current and forecasted Ecological Departure of focal ecological systems. Departure is categorized as good (0-33%, FRCC 1), fair (34-66%, FRCC 2) and poor (>66%, FRCC 3).

Ecological System	Ecological Departure	
	Current Condition	Minimum Mgmt – 20 yrs
Aspen Mixed-Conifer	53	50
Aspen Woodland	45	39
Basin Wildrye	86	86
Black Sagebrush	79	69
Montane Sagebrush Steppe - Mountain	47	31
Montane Sagebrush Steppe - Upland	62	41
Montane-Subalpine Riparian	59	55
Mountain Shrub	47	35
Winterfat	78	87
Wyoming Big Sagebrush	77	74

High-Risk Vegetation Classes

In contrast to the slight changes in Ecological Departure, without thoughtful active management over the next 20 years, seven of the ten focal systems were predicted to have increases of high risk classes. The stress rank for montane-subalpine riparian increased from 'good' (0%) to 'high' (13%). Although a decrease in percent of high risk classes was observed in basin wildrye and black sagebrush, these systems were still predicted to have very high stress ranks in 20 years. The increases in High-Risk Vegetation Classes reflect the critical need to continue good management practices (e.g., prescribed fire in aspen-mixed conifer to prevent loss of aspen to conifer and invasive weed inventory and control in riparian areas to prevent transition to exotic forbs).

Table 8. Current and predicted future percent of High-Risk Vegetation Classes in focal ecological systems of Ward Mountain. Stress to ecological systems is ranked as: low (0%, dark green); medium (1-10%, light green); high (11-30%, yellow), and very high (>30%, red).

Ecological System	High Risk Classes	
	Current %	Minimum Mgmt - 20 yrs*
Aspen Mixed-Conifer	<0.1	6
Aspen Woodland	0	8
Basin Wildrye	82	66
Black Sagebrush	48	46
Montane Sagebrush Steppe - Mountain	0	1
Montane Sagebrush Steppe - Upland	18	19
Montane-Subalpine Riparian	0	13
Mountain Shrub	0	0
Winterfat	79	87
Wyoming Big Sagebrush	66	67

*Assuming minimum management over 20 years (no treatment of exotic forbs, no prescribed fire, traditional management of livestock).

Prioritizing Actions for Implementation: Return-on-Investment

Strategies for the PREFERRED MANAGEMENT scenarios for focal systems of the Ward Mountain project area were identified by workshop participants. The performance of strategies at achieving desired objectives over 20 years was evaluated by TNC using ecological models. Twenty year forecasts from ecological models of the PREFERRED MANAGEMENT scenarios inform a cost benefit analysis developed by TNC (i.e., 'return on investment' or ROI) to assist with prioritization of on-the-ground actions.

Intra-System ROI

The ecological benefits accrued as compared to the costs of securing those benefits *for a given ecological system* represented one element of assessing ROI.

- Ecological ROI. The change of Ecological Departure and High-Risk Vegetation Classes between the MINIMUM MANAGEMENT scenario and other scenarios (i.e., MAXIMUM

MANAGEMENT and PREFERRED MANAGEMENT) in year 20, divided by total cost over 20 years. Correction factors were used to achieve a common order of magnitude.

For all focal ecosystems, the PREFERRED MANAGEMENT scenario produced a higher Ecological ROI compared to MAXIMUM MANAGEMENT (Table 9).

Table 9. Ecological return-on-investment for focal ecological systems of the Ward Mountain project area. The ROI evaluates costs and ecological benefits of strategies for the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios within the focal systems. ROI was not calculated for montane sagebrush steppe – mountain and mountain shrub because strategies had no associated costs (i.e., 'free RxFire' from montane sagebrush – upland).

Ecological System	Intra-system ROI	
	Maximum Management	Preferred Management
Aspen Mixed-Conifer	16.5	26.3
Aspen Woodland	2.5	77.7
Basin Wildrye	15.5	23.8
Black Sagebrush	0.7	1.2
Montane Sagebrush Steppe - Mountain	n/a	n/a
Montane Sagebrush Steppe - Upland	1.3	1.5
Montane-Subalpine Riparian	31.5	35.5
Mountain Shrub	n/a	n/a
Winterfat	23.4	41.3
Wyoming Big Sagebrush	4.0	4.7

Inter-System ROI

- In contrast to applying the intra-system ROI to select the PREFERRED MANAGEMENT scenario for a given system, the inter-system ROI metric is used for assessment *across ecological systems* for the PREFERRED MANAGEMENT scenario. For this element, TNC applied the area weighted, inter-system ROI metric to determine which of the systems produced the greatest ecological benefits per dollar invested *across* the focal ecological systems, as compared to MINIMUM MANAGEMENT (Table 10).
- <u>Ecological System-wide ROI</u>. The change of Ecological Departure and High-Risk Vegetation Classes between the MINIMUM MANAGEMENT scenario and PREFERRED MANAGEMENT scenario in year 20, multiplied by total area of the ecological system, divided by total cost over 20 years. Correction factors were used to bring all measures to a common order of magnitude.

Table 10. Ecological system-wide return-on-investment (ROI) from highest to lowest for focal ecological systems of the Ward Mountain project area. ROI for montane sagebrush – mountain and mountain shrub were not calculated because there were no costs associated with the prescribed fire carrying over into these systems from montane sagebrush – upland (therefore, ROI = n/a).

Ecological System	Preferred Management ROI
Aspen Mixed-Conifer	5.9
Black Sagebrush	5.6
Aspen Woodland	4.6
Basin Wildrye	3.9
Wyoming Big Sagebrush	3.9
Montane Sagebrush Steppe - Upland	3.8
Winterfat	2.5
Montane-Subalpine Riparian	0.6
Montane Sagebrush Steppe - Mountain	n/a
Mountain Shrub	n/a

Ecological system-wide ROI can be used to assist with prioritizing allocation of limited resources across multiple systems in a landscape. If management funding is limited, TNC recommends consideration of this metric for selecting which ecological systems receive priority investments. In the Ward Mountain project area, the systems with the highest intersystem-ROI included aspen-mixed conifer, black sagebrush, and aspen woodland.

Management Strategies and Scenarios

Introduction

For the focal ecosystems, detailed management strategies were developed under the two primary management scenarios: MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT. Two of these systems, montane sagebrush – mountain and mountain shrub, did not require system strategies but benefits of strategies implemented in adjacent systems were analyzed. All strategies were designed to improve the condition of ecological systems that are currently in an undesirable condition and/or to abate serious future threats to ecological systems. Different types of strategies and degrees of application were tested to achieve specific objectives under the two scenarios. Total annual costs for strategy implementation were calculated for each ecological system under each scenario, as well as any one-time costs.

All scenarios for each ecological system were then tested via computer simulations using VDDT to determine whether or not they achieved the desired objectives. Outcomes were calculated and graphed for Ecological Departure and high-risk classes over 20 years. Statistical analysis was conducted to determine the mean outcomes of each management scenario, the degree of variability among the five replicates, and the statistical confidence in the predicted outcomes.

The following descriptions, tables, and graphs are presented for each of the 10 focal ecological systems: aspen-mixed conifer, aspen woodland, basin wildrye, black sagebrush, montane sagebrush steppe – mountain, montane sagebrush steppe – upland, montane-subalpine riparian, mountain shrub, winterfat, and Wyoming big sagebrush.

1. Brief description of the system in the Ward Mountain project area
2. Objectives for the two primary scenarios
3. Management strategies for the two primary scenarios
4. Costs for implementing the two primary scenarios
5. Summary of outcomes and recommendations
6. Tables showing objectives, strategies, acres treated, and costs for the preferred management scenario
7. Graphs showing outcomes for Ecological Departure and high-risk classes for current condition, minimum management and preferred management scenarios after 20 years
    a. Mean (horizontal line the center of box plot)
    b. 1 ± Standard error (edge of box)
    c. 95% confidence interval (error bar of box plot)

Aspen-Mixed Conifer Woodland and Aspen Woodland

Aspen communities have exceedingly high biodiversity, second only to riparian areas on western ranges (Kay 1997). Aspen produce forage for both wildlife and domestic livestock. Healthy aspen communities consist of developed multi-age structure that provides benefits to wildlife dependent upon the diverse nature of these communities. Aspen communities are particularly important to cavity nesting species in Nevada because broad-leaved woodlands in montane areas of the state are scarce. In addition to cavities and peeling bark, mature aspen communities provide larger diameter trees utilized by wildlife as forage substrate or nesting.

Aspen-mixed conifer woodland (seral aspen) represents <2% of the project area (2,235 acres). It was moderately departed from NRV (53%). Although there were no uncharacteristic classes, the system is largely deficient in early and mid succession classes (i.e., classes A and B). After 20 years, departure from NRV slightly decreases to 51% under the Minimum Management scenario. Active management significantly decreases Ecological Departure. In the Preferred Management scenario, Ecological Departure was reduced to 25% in 20 years with only 1% of conversion to the no-aspen class (NAS).

There were 591 acres of aspen woodland (stable aspen) in the Ward Mountain project area, which represented <1% of the total project area. Its current ecological condition was moderately departed from NRV, primarily due to a large percent (33%) being in the depleted class. Twenty year model runs predict an increase in loss of clone (8% to no aspen class). Preferred management actions identified by workshop participants focus on restoration and prevention of future depleted classes of aspen.

Management Objectives

Aspen-Mixed Conifer

Objectives for MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios were to reduce Ecological Departure by increasing early succession classes of aspen-mixed conifer. The main objective of the PREFERRED MANAGEMENT scenario was (Table 11):

- Reduce Ecological Departure from 53% to 25%, mainly by increasing early and mid-succession classes (classes A and B) of aspen-mixed conifer across the landscape
- Apply prescribed fire in first five years over 200 acres a year (i.e., 'front load' treatment) to increase ecological improvement observed in 20 years (i.e., lower Ecological Departure and high-risk classes).

Aspen Woodland

Objectives for the scenarios were similar and included reducing Ecological Departure and lowering presence and threat of uncharacteristic classes. The PREFERRED MANAGEMENT scenario sought to achieve the following (Table 12):

- Reduce Ecological Departure from 45% departure from NRV to ~35%
- Reduce depleted class from 33% to 5%
- Increase presence of early succession class (Class A) across the landscape

Management Strategies

Aspen-Mixed Conifer

Both MAXIMUM and PREFERRED MANAGEMENT scenarios used prescribed fire and manual thinning. The PREFERRED MANAGEMENT scenario 'front-loaded' the application of prescribed fire (Table 11). Specifically, 200 acres of prescribed fire were applied per year for five years. The results of these focused efforts were analyzed at 20 years in the model runs. The average annual cost of the PREFERRED MANAGEMENT scenario was $21,260 per year for 5 years.

Aspen Woodland

Management strategies for the MAXIMUM MANAGEMENT scenario included prescribed fire (RxFire) and grazing systems (i.e., frequently herding cattle away from aspen stands to prevent overutilization). Almost identical results were achieved by the PREFERRED MANAGEMENT scenario which only included manual thinning (Table 12). In this scenario, approximately 10 acres a year would be thinned over 20 years. The cost of the PREFERRED MANAGEMENT scenario is approximately $1,000 per year for 20 years.

Outcomes

Aspen-Mixed Conifer

- The larger scale application of prescribed fire and manual thinning over a shorter time frame in the PREFERRED SCENARIO resulted in greater ecological benefit to aspen-mixed conifer (Figure 9).
- A slower annual rate of application in the MAXIMUM MANAGEMENT scenario resulted in an Ecological Departure of 35%, versus the resulting 25% in the PREFERRED MANAGEMENT scenario where treatments were 'front-loaded' in the first five years.

Aspen Woodland

- The PREFERRED MANAGEMENT scenario reduced Ecological Departure to 35%, compared to MINIMUM MANAGEMENT which resulted in a reduction to 38% (Figure 10)
- All scenarios resulted in an increase in the 'no aspen' class (NAS), defined as a high risk vegetation class by workshop participants.
- The PREFERRED MANAGEMENT scenario ($20,000, 20-year total) reduced the amount of depleted aspen and was less expensive than the MAXIMUM MANAGEMENT scenario ($32,000, 20-year total)

'No aspen' (NAS) is atypical of an uncharacteristic class since there is no recoverable vegetation and the areas have undergone a system conversion. Older classes of aspen that are at risk of system conversion could be considered as the 'high risk' portions of these systems. For the Ward Mountain assessment, the areas lost (NAS) were identified and analyzed as 'high risk'. In Aspen-Mixed Conifer, two acres of NAS were identified by walking through stands of mixed conifer that contained remnant bowls of aspen and no regeneration or live aspen stems.

Table 11. PREFERRED MANAGEMENT scenario for aspen-mixed conifer in the Ward Mountain project area.

Project	Ward Mountain					
Ecological System	Aspen-Mixed Conifer					
Objective	Improve ecological condition of ~2,200 acres of Ward Mountain aspen-mixed conifer from 53% departure from NRV (FRCC 2) to ~25% departure (FRCC 1)... over 20 years					
Ave. Acres Treated/Year						275
Total Ecosystem Acres						2,240
Strategy	Treat 275 acres/year of late succession classes for five years					
Management Actions		One Time Costs	# Years	Acres/Year	Cost/Acre	Cost/Year
	Prescribed fire to increase early succesion class		5	200	$ 50	$ 10,000
	Mechanical thinning (i.e., chainsaw thinning) to increase early succession classes		5	75	$ 150	$ 11,250
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
Average Cost/Year	*including one time costs of*	$ -	over 20 years = $5300/yr			**$ 21,250**
Number of Years						**5**
Total Cost						**$ 106,250**
Notes						

Table 12. PREFERRED MANAGEMENT scenario for aspen woodland in the Ward Mountain project area.

Project	Ward Mountain					
Ecological System	Aspen Woodland					
Objective	Improve ecological condition of ~600 acres of Ward Mountain aspen woodland from 45% departure from NRV (FRCC 2) to ~25% departure (FRCC 1) and contain "high risk" vegetation classes to less than 10%... over 20 years					
Ave. Acres Treated/Year						10
Total Ecosystem Acres						590
Strategy	Treat approximately 10 acres/year of late succession and depleted aspen woodland					
Management Actions		One Time Costs	# Years	Acres/Year	Cost/Acre	Cost/Year
	Mechanically thin (i.e., chainsaw thin) late succession to convert to early succession & contain depleted aspen from conversion		20	10	$ 100	$ 1,000
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
Average Cost/Year	*including one time costs of*	$ -				**$ 1,000**
Number of Years						**20**
Total Cost						**$ 20,000**
Notes						

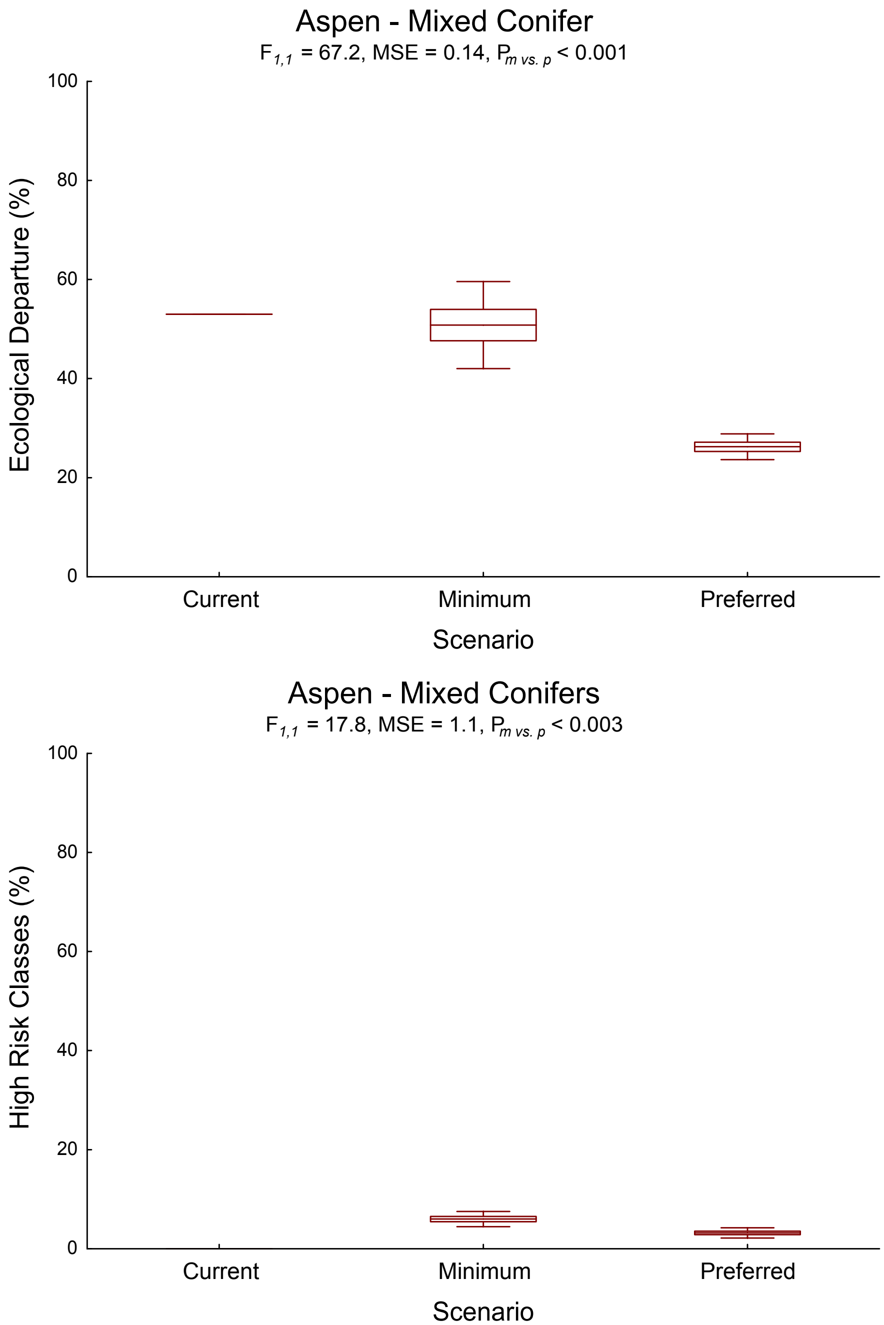


Figure 9. Ecological Departure and high risk classes for aspen-mixed conifer on Ward Mountain, NV. The Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenarios. MANOVA for both variables resulted in Wilk's $\lambda_{2,7}$ = 0.1061, P < 0.001. Sample size = 5 replicates. Simulations were for 20 years. The data for Ecological Departure was square-root transformed to homogenize variances. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

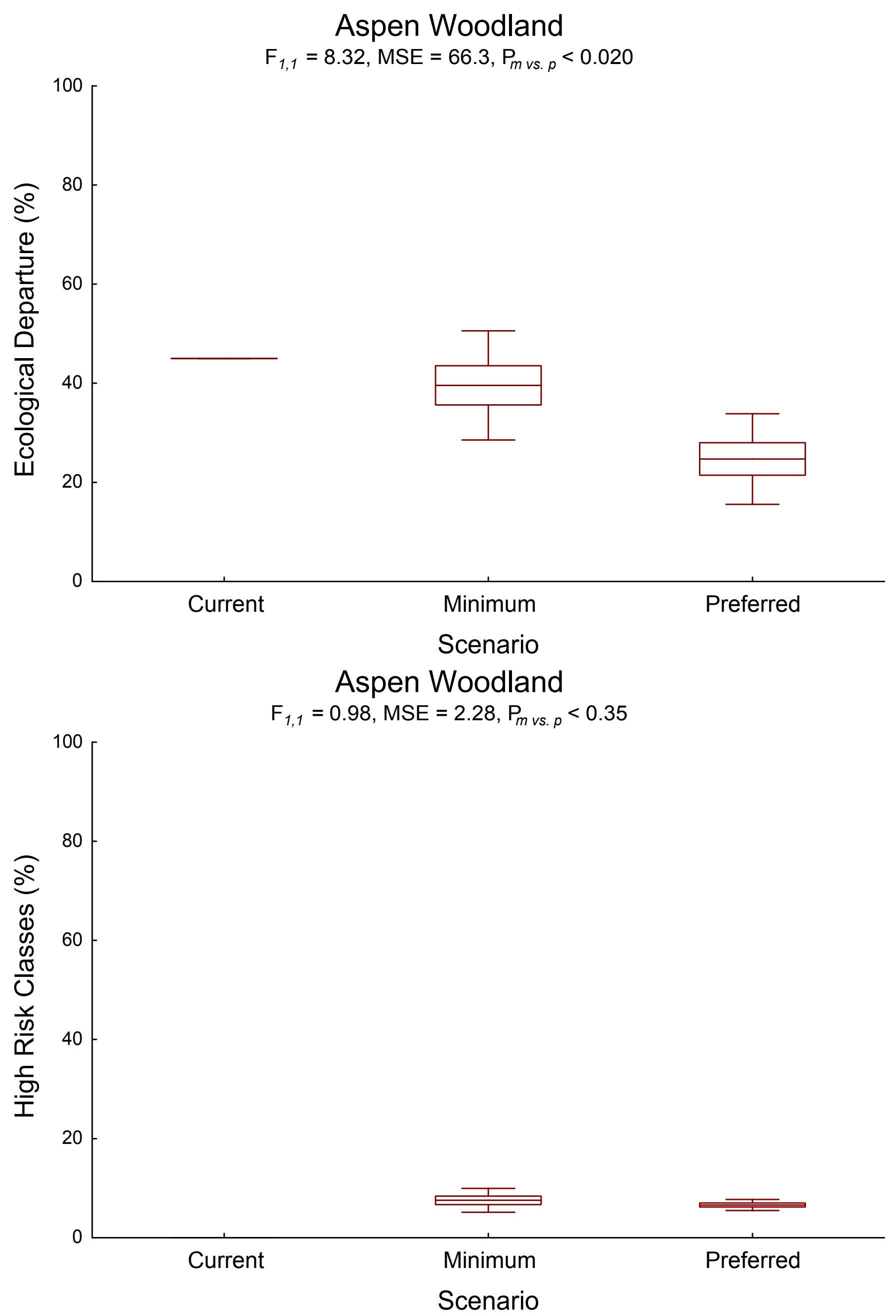


Figure 10. Ecological Departure and high risk classes for aspen woodland on Ward Mountain, NV. The Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenario. MANOVA for both variables resulted in Wilk's $\lambda_{2,7}$ = 0.4832, P = 0.078. Sample size = 5 replicates. Simulations were for 20 years. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

Basin Wildrye

Basin wildrye is another system that represents a small overall proportion of the Ward Mountain project area but has high importance for wildlife, particularly pygmy rabbit (*Brachylagus idahoensis)* where they occur and therefore requires maintaining some shrub cover in areas with burrows. Its current condition is highly departed from NRV (86%), duly to most of it being converted to uncharacteristic classes, 82%, all of which are considered high-risk. MINIMUM MANAGEMENT scenario model runs predict no change in Ecological Departure over 20 years.

Management Objectives

Both the MAXIMUM and PREFERRED MANAGEMENT scenarios sought to reduce the uncharacteristic classes of basin wildrye. The objectives of the PREFERRED MANAGEMENT scenario were the following:

- Reduce Ecological Departure of basin wildrye from 86% departure from NRV to 45% departure
- Reduce 'high-risk' vegetation classes from 82% to ~15% over 20 years

Management Strategies

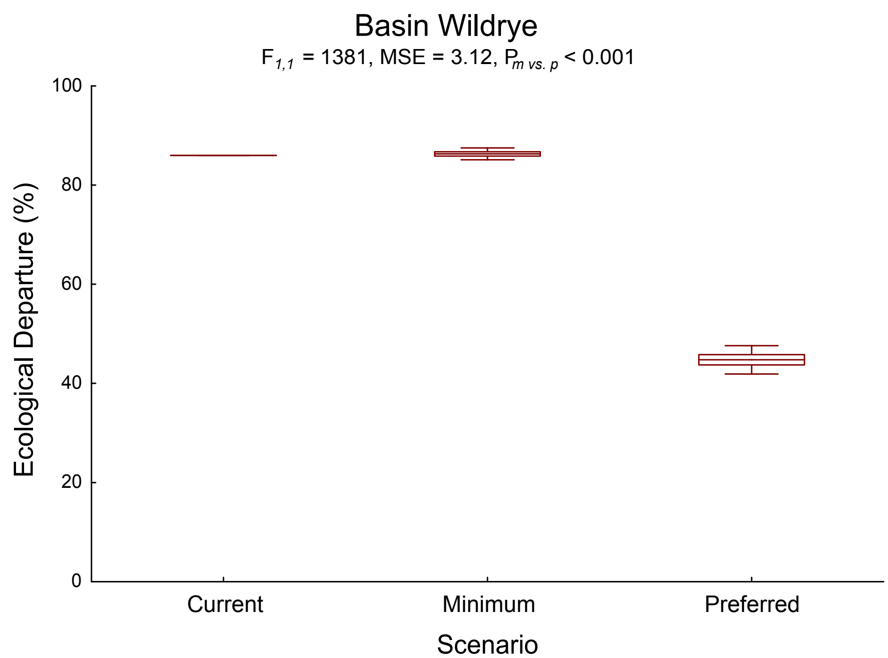
Management strategies focused on treatment of uncharacteristic classes of vegetation and included treating approximately 20 acres a year over twenty years plus conducting annual weed inventory. The PREFERRED MANAGEMENT scenario includes front-loading depleted restoration at 210 acres per year for the first five years (Table 13). This results in a similar benefit for Ecological Departure as the MAXIMUM MANAGEMENT scenario ($33,450 per year) at a lower cost ($20,280 per year).

Outcomes

- The MAXIMUM MANAGEMENT scenario resulted in a slightly larger Ecological Departure (46%) than the PREFERRED MANAGEMENT scenario (43%).
- The MAXIMUM MANAGEMENT scenario reduced high-risk classes to 2% over 20 years, versus 13% reduction observed with the PREFERRED MANAGEMENT scenario.
- The PREFERRED MANAGEMENT scenario demonstrated ecological benefit from front-loading of depleted restoration treatments in basin wildrye which entail treating larger areas over a shorter time frame (Figure 11).

Table 13. PREFERRED MANAGEMENT scenario for basin wildrye in the Ward Mountain project area.

Project	Ward Mountain					
Ecological System	Basin Wildrye					
Objective	Improve ecological condition of ~1,700 acres of Ward Mountain basin wildrye from 86% departure from NRV (FRCC 3) to ~45% departure (FRCC 2) and reduce "high risk" vegetation classes from 82% to ~15%… over 20 years					
Ave. Acres Treated/Year						205
Total Ecosystem Acres						1,650
Strategy	Treat approximately 200 acres/year of late succession, depleted, tree-encroached, and annual-grass-invaded Basin Wildrye, along with spot treatment of exotic weeds					
Management Actions		*One Time Costs*	*# Years*	*Acres/Year*	*Cost/Acre*	*Cost/Year*
	Periodic inventory of invasive weeds		20	130	$ 50	$ 6,500
	Spot treatment of invasive weeds		20	4	$ 150	$ 600
	ShAG Restoration - treat shrubs with annual grass understory via thinning, herbicide and seeding		20	5	$ 300	$ 1,500
	Treat tree-encroached basin wildrye via mechanical thinning and seeding		20	5	$ 350	$ 1,750
	Mechanically thin and seed Depleted sagebrush to restore native grasses		5	210	$ 180	$ 37,800
	Cut "Christmas tree" conifers via chainsaw in late open class		20	8	$ 60	$ 480
						$ -
						$ -
Average Cost/Year	*including one time costs of*	**$ -**				**$ 20,280**
Number of Years						**20**
Total Cost						**$ 405,600**
Notes						



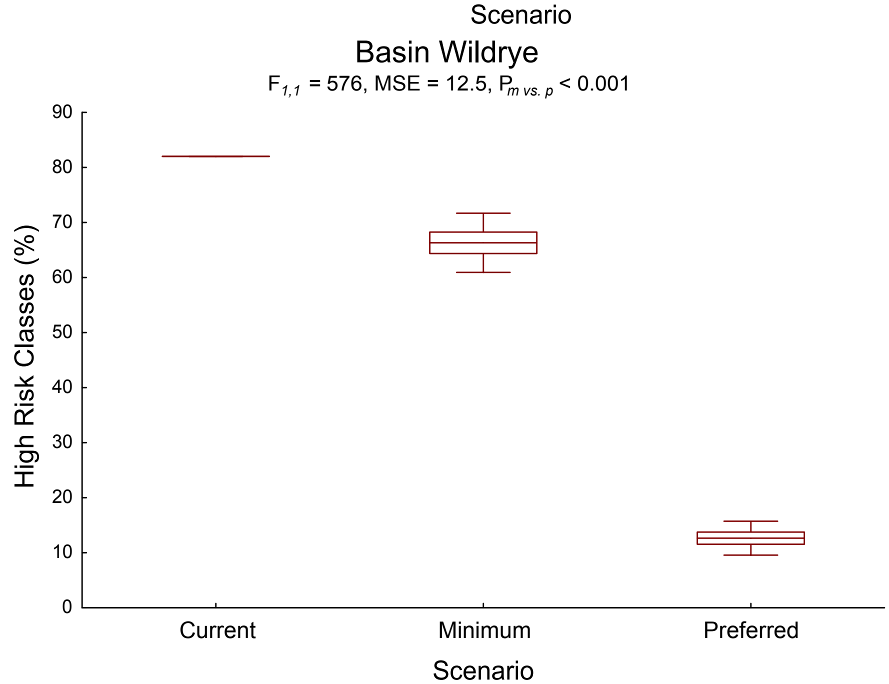


Figure 11. Ecological Departure and high risk classes for basin wildrye on Ward Mountain, NV. The Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenario. MANOVA for both variables resulted in Wilk's $\lambda_{2,7} = 0.0054$, $P < 0.001$. Sample size = 5 replicates. Simulations were for 20 years. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

Black Sagebrush

The dominant ecological system of the Ward Mountain project area is black sagebrush, which comprises almost 40% of the project area (46,660 acres). Grazing by wild ungulates and domestic sheep occurs in black sagebrush due to its high palatability. Black sagebrush was highly departed from NRV (79%) with a lack of early and mid- succession classes (classes A and B) and a high proportion in the depleted class (39%). The MINIMUM MANAGEMENT scenario predicted a slight improvement in Ecological Departure over 20 years with little change in the amount of high-risk uncharacteristic classes.

Management Objectives

Both the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios sought to increase early and mid-succession classes of black sagebrush in the Ward Mountain project area, which would reduce its Ecological Departure from NRV. In addition, strategies were aimed towards reducing High-Risk Vegetation Classes.

The objectives of the PREFERRED MANAGEMENT scenario were to:

- Improve ecological condition of ~47,000 acres of Ward Mountain black sagebrush from 79% departure from NRV to ~35% departure in 20 years
- Reduce 'high-risk' vegetation classes from 48% to 9% over 20 years.

Management Strategies

Management strategies focused on treating late succession classes of black sagebrush (classes C and D) to create more early succession (class A) black sagebrush, remove encroaching conifers and restore tree encroached black sagebrush, and restore depleted classes of black sagebrush. The PREFERRED SCENARIO includes application of prescribed fire on approximately 25 acres per year for 20 years (Table 14). In addition, approximately 1,300 acres a year received manual treatments that included chaining, mastication, and chainsaw thinning for 20 years. The estimated cost of the PREFERRED MANAGEMENT scenario is $257,500 per year over twenty years. The MAXIMUM MANAGEMENT scenario included the same treatments, at higher application rates, and was more than twice the cost per year ($532,000).

Outcomes

- The MAXIMUM MANAGEMENT scenario resulted in a 30% Ecological Departure from NRV and PREFERRED MANAGEMENT in a 36% Ecological Departure. Both were significant improvements over current departure (79%) and departure under the MINIMUM MANAGEMENT scenario (69%) (Figure 12).
- The PREFERRED MANAGEMENT scenario was able to reduce High-Risk Vegetation Classes from 48% to 17%.
- For less than half the annual cost, the PREFERRED MANAGEMENT scenario performed nearly as well as the MAXIMUM MANAGEMENT scenario.

Table 14. PREFERRED MANAGEMENT scenario for black sagebrush in the Ward Mountain project area.

Project	Ward Mountain					
Ecological System	Black Sagebrush					
Objective	Improve ecological condition of ~47,000 acres of Ward Mountain black sagebrush from 79% departure from NRV (FRCC 3) to ~35% departure (FRCC 2) and reduce "high risk" vegetation classes by over 50%… over 20 years					
Ave. Acres Treated/Year						1,325
Total Ecosystem Acres						46,660
Strategy	Treat 1325 acres/year of late succession, depleted, tree-encroached, and annual-grass-invaded black sagebrush					
Management Actions		*One Time Costs*	*# Years*	*Acres/Year*	*Cost/Acre*	*Cost/Year*
	Regular prescribed fire in late succession Class C to convert to early succession classes		20	25	$ 80	$ 2,000
	Chain late succession Class D to remove encroaching conifers and apply some seed		20	200	$ 130	$ 26,000
	Masticate late succession Class D to remove encroaching conifers and apply some seed?		20	100	$ 350	$ 35,000
	Chainsaw to remove conifers in late succesion, depleted, and annual-grass-invaded classes		20	100	$ 70	$ 7,000
	Mechanically thin and seed Depleted sagebrush to restore native grasses		20	750	$ 180	$ 135,000
	Mechanically thin 150 acres/year of tree encroached sagebrush, apply herbicide and seed		20	150	$ 350	$ 52,500
						$ -
						$ -
Average Cost/Year	*including one time costs of*	**$ -**				**$ 257,500**
Number of Years						**20**
Total Cost						**$ 5,150,000**
Notes						

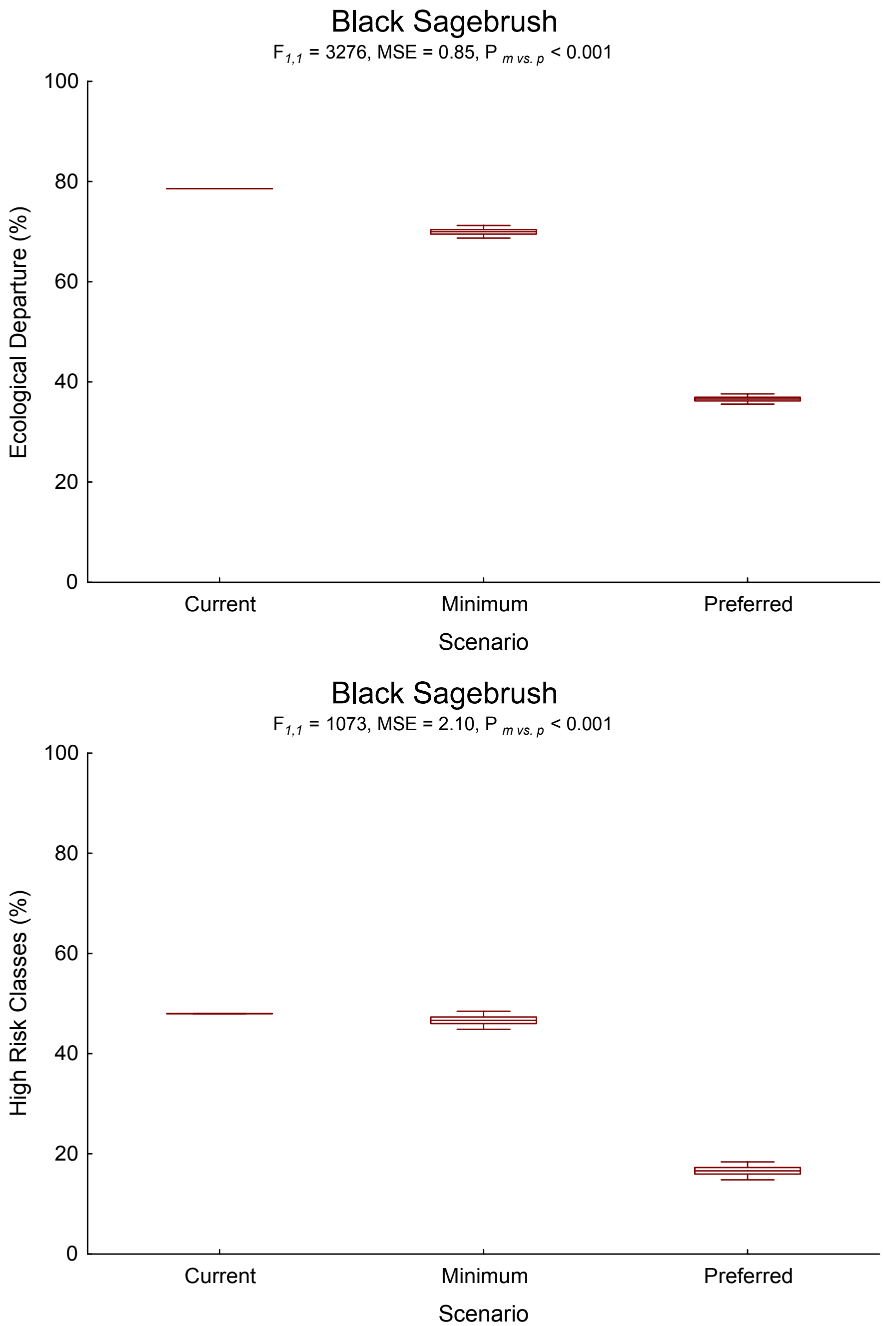


Figure 12. Ecological Departure and high risk classes for black sagebrush on Ward Mountain, NV. The Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenario. MANOVA for both variables resulted in Wilk's $\lambda_{2,7} = 0.0023$, $P < 0.001$. Sample size = 5 replicates. Simulations were for 20 years. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

Montane shrubland ecological systems

Montane shrublands comprised approximately 24% of the Ward Mountain project area and include: montane sagebrush steppe – upland (25,611 acres), montane sagebrush steppe – mountain (2,575 acres), and mountain shrub (30 acres). Montane sagebrush steppe – upland was the second-most dominant system in the Ward Mountain project area and occurred above Wyoming sagebrush up to 9,500 feet.

Montane shrubland communities are important to a variety of wildlife species including Greater sage-grouse and mule deer. All three systems were moderately departed from NRV, with montane sagebrush – upland 62% departed; montane sagebrush steppe – mountain and mountain shrub each 47% departed. Montane sagebrush – upland had 18% in High-Risk Vegetation Classes while 0% of montane sagebrush – mountain and mountain shrub systems were in uncharacteristic classes.

Management Objectives

Management scenarios were not outlined for montane sagebrush – mountain or mountain shrub systems, but it should be noted that a portion of these systems received prescribed fire carrying over from the montane sagebrush – upland treatments (i.e., 'free RxFire') in the PREFERRED MANAGEMENT scenario of montane sagebrush – upland. Beneficial effects of this fire were evaluated in the ecological models with the assumption that the costs were zero since they were accounted for in montane sagebrush – upland strategies.

Objectives of the PREFERRED MANAGEMENT scenario for montane sagebrush – upland included:

- Improve Ecological Departure of ~26,000 acres of Ward Mountain montane sagebrush – upland from 62% departure from NRV to ~30% departure in 20 years.
- Reduce High-Risk Vegetation Classes of montane sagebrush – upland over the next 20 years.

Management Strategies

A variety of management strategies were employed by both the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios for montane sagebrush – upland (Table 15). These included canopy thinning (classes C and D); chaining; chainsaw lopping in uncharacteristic classes; restoration of depleted class; restoration of shrublands with annual grass understory; prescribed fire; and restoration of tree encroached class which included mechanical thinning, herbicide and seeding. The cost of the MAXIMUM MANAGEMENT scenario was approximately $95,000 per year for 20 years versus ~$50,850 per year for 20 years via the PREFERRED MANAGEMENT scenario. As mentioned previously, prescribed fire was assumed to carry over into montane sagebrush – mountain and mountain shrub systems at no additional cost (Table 16).

Outcomes

- The PREFERRED MANAGEMENT scenario resulted in improvement to 29% Ecological Departure from NRV (Figure 13) from 62% which was essentially the same result as the MAXIMUM MANAGEMENT scenario (28% Ecological Departure) after 20 years.

- Application of treatments across larger areas within a shorter amount of time refined and improved the results of strategies.
- Over 20 years, annual prescribed fire from montane sagebrush – upland that carried into montane sagebrush – mountain and mountain shrub systems improved their Ecological Departure to 31% and 27%, respectively (Figure 14 and Figure 15).

Table 15. PREFERRED MANAGEMENT scenario for montane sagebrush – upland in the Ward Mountain project area.

Project	Ward Mountain					
Ecological System	Montane Sagebrush Steppe - upland					
Objective	Improve ecological condition of ~26,000 acres of Ward Mountain montane sagebrush steppe (upland) from 62% departure from NRV (FRCC 2) to ~30% departure (FRCC 1) and contain "high risk" vegetation classes … over 20 years					
Ave. Acres Treated/Year						431
Total Ecosystem Acres						25,610
Strategy	Treat late succession, depleted, tree-encroached, and annual-grass-invaded montane sagebrush-upland -- approximately 900 acres/year for first five years, then approximately 265 acres/year					
Management Actions		One Time Costs	# Years	Average Acres/Year	Cost/Acre	Cost/Year
	Mechanical thinning in late succession classes to increase earlier classes		5	200	$ 100	$ 20,000
	Chain late succession classes to restore earlier classes (300 acres/year for five years, then 50 acres/year)		20	112.5	$ 85	$ 9,563
	Chainsaw to remove conifers in late succesion, depleted, and annual-grass-invaded classes (80 acres/year for five years, then 20 acres/year)		20	35	$ 60	$ 2,100
	Mechanically thin and seed Depleted sagebrush to restore native grasses		5	40	$ 180	$ 7,200
	Mow and apply herbicide to shrubs with annual and perennial grass to convert to early succession classes		5	40	$ 40	$ 1,600
	Regular prescribed fire to convert mid and late succession classes to early succession		20	156	$ 80	$ 12,480
	Restoration of shrubs with annual grass via mechanical thinning, herbicide and seed		5	50	$ 300	$ 15,000
	Mechanically thin tree encroached sagebrush, apply hericide & seed (60 acres/yr for 5 years, then 40 ac/yr)		20	45	$ 350	$ 15,750
Average Cost/Year	*including one time costs of*	$ -				**$ 50,840**
Number of Years						**20**
Total Cost						**$ 1,016,850**
Notes						

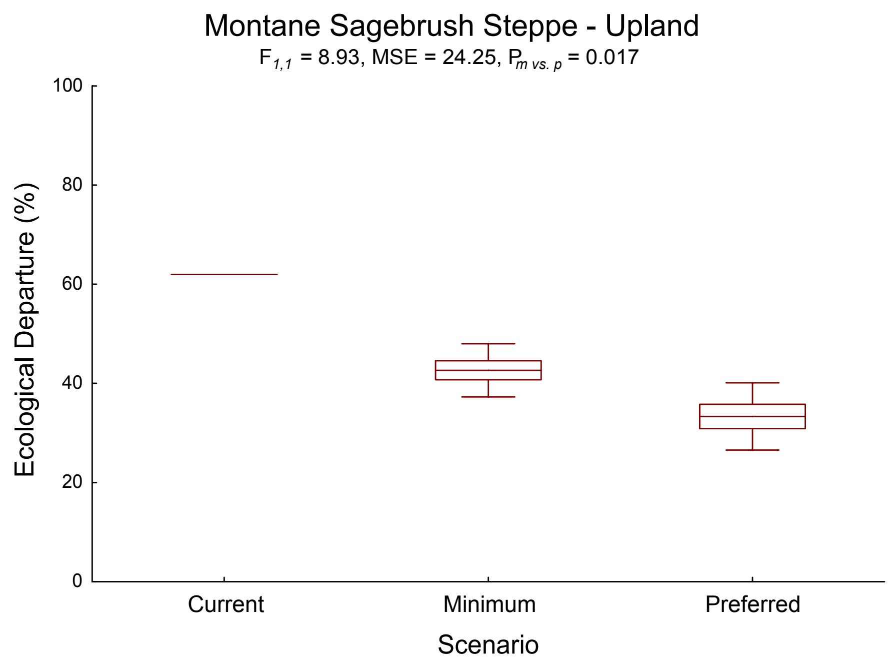
Table 16. Management strategy for a.) montane sagebrush steppe – mountain and b.) mountain shrub for the Ward Mountain project area. Costs for prescribed fire are accounted for in montane sagebrush steppe – upland strategies ('free RxFire for montane sagebrush steppe – mountain and mountain shrub).

a.)

Project	Ward Mountain					
Ecological System	Montane Sagebrush Steppe - mountain					
Objective	Improve ecological condition of ~2,600 acres of Ward Mountain montane sagebrush steppe (mountain) from 47% departure from NRV (FRCC 2) to ~30% departure (FRCC 1)... over 20 years					
Ave. Acres Treated/Year						10
Total Ecosystem Acres						2,570
Strategy	Treat approximately 10 acres/year of late succession classes through carryover of prescribed fire from adjoining ecosystems					
Management Actions		*One Time Costs*	*# Years*	*Acres/Year*	*Cost/Acre*	*Cost/Year*
	Prescribed fire to convert late succession classes to early succession		20	10	$ -	$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
Average Cost/Year	*including one time costs of*	$ -				$ -
Number of Years						20
Total Cost						$ -
Notes						

b.)

Project	Ward Mountain					
Ecological System	Mountain Shrub					
Objective	Improve ecological condition of ~30 acres of Ward Mountain mountain shrub from 47% departure from NRV (FRCC 2) to ~25% departure (FRCC 1)... over 20 years					
Ave. Acres Treated/Year						5
Total Ecosystem Acres						33
Strategy	Treat approximately 5 acres/year of late succession classes through carryover of prescribed fire from adjoining montane sagebrush					
Management Actions		*One Time Costs*	*# Years*	*Acres/Year*	*Cost/Acre*	*Cost/Year*
	Prescribed fire to convert late succession classes to early succession		20	5	$ -	$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
Average Cost/Year	*including one time costs of*	$ -				$ -
Number of Years						20
Total Cost						$ -
Notes						



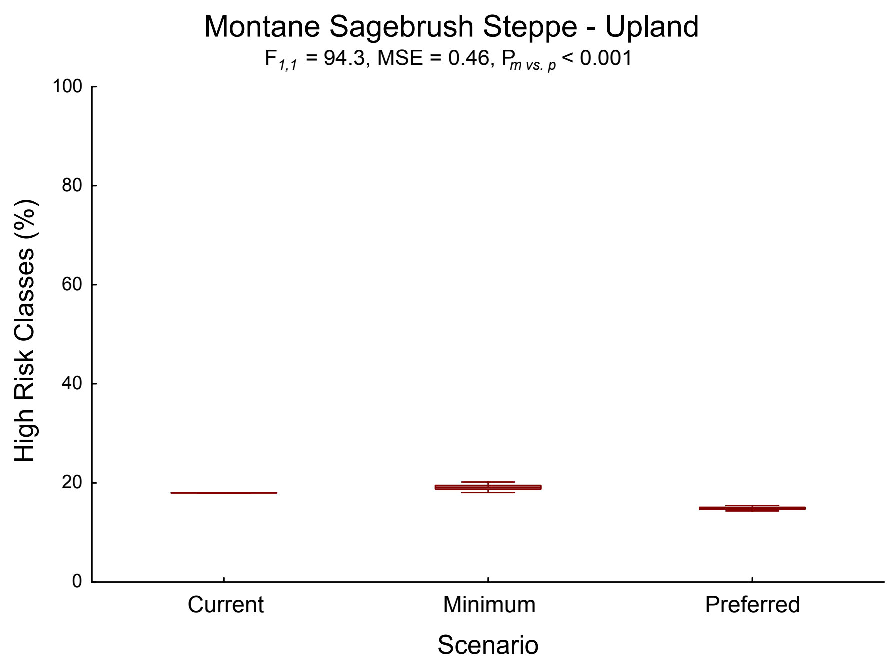


Figure 13. Ecological Departure and high risk classes for montane sagebrush steppe – upland on Ward Mountain, NV. The Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenario. MANOVA for both variables resulted in Wilk's $\lambda_{2,7}$ = 0.0776, P < 0.001. Sample size = 5 replicates. Simulations were for 20 years. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

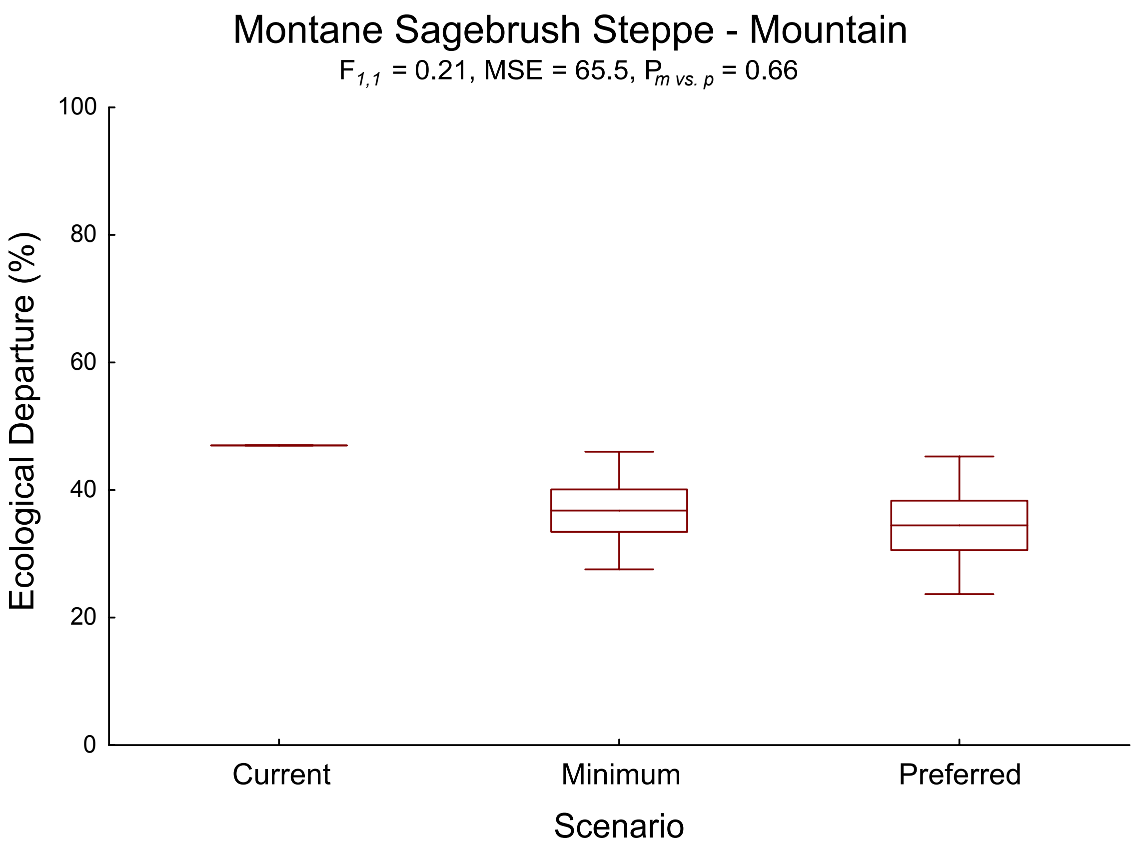


Figure 14. Ecological Departure and high risk classes for montane sagebrush steppe – mountain on Ward Mountain, NV. The Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenario. There are no high risk classes for the mountain site of montane sagebrush steppe. Sample size = 5 replicates. Simulations were for 20 years. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

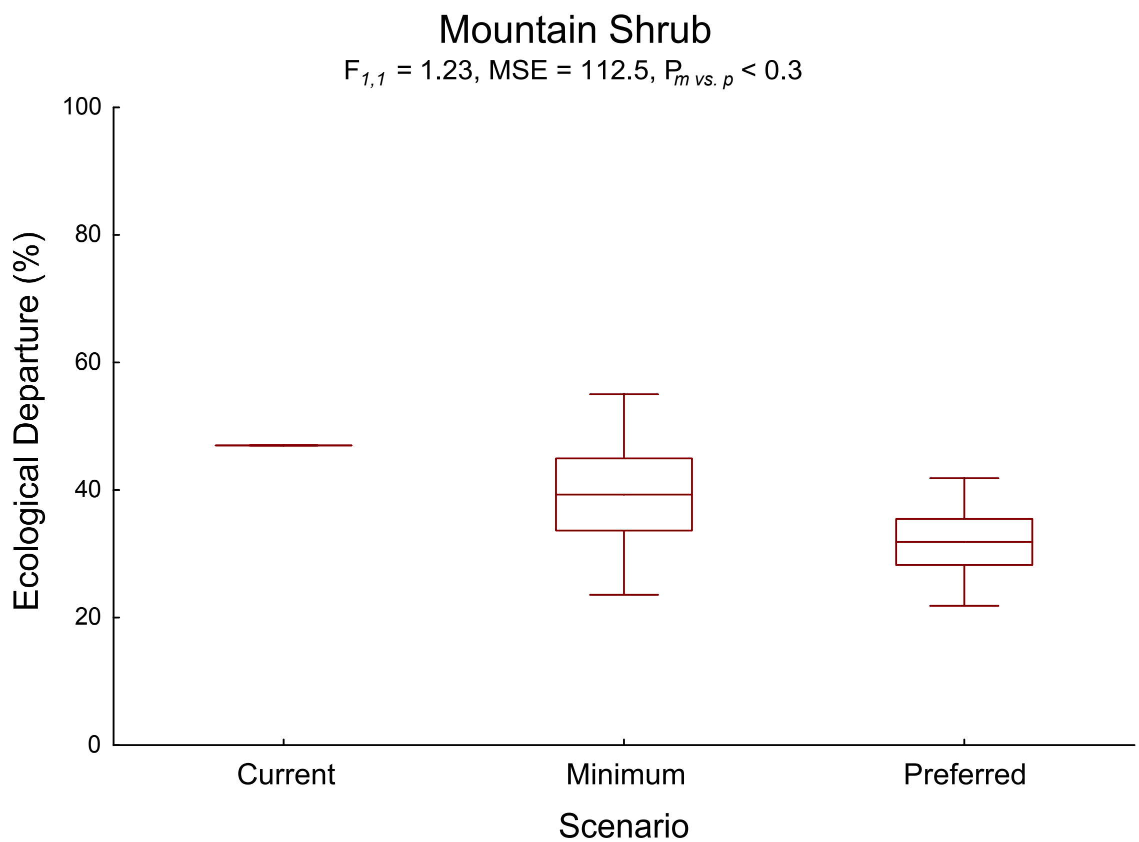


Figure 15. Ecological Departure and high risk classes for mountain shrub on Ward Mountain, NV. The Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenario. There are no high risk classes for mountain shrub. Sample size = 5 replicates. Simulations were for 20 years. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

Montante-Subalpine Riparian

One hundred seventy-one acres of montane-subalpine riparian are within the Ward Mountain project area. Its small extent within the project area (~0.1%) is characteristic of its distribution across the region. Riparian communities of Nevada are critical centers of wildlife diversity (Mac *et al.*, 1988). More than 75 percent of the species in Nevada are strongly associated with riparian vegetation (U.S. General Accounting Office, 1993), including 80 percent of the birds (Dobkin 1998). Montane-subalpine riparian was moderately departed from NRV (59%) mainly due to a large proportion being in the mid-succession class (83%) and 11% within the uncharacteristic vegetation class shrub-forb encroached (i.e., 10-50% cover of Wood's rose in open areas or under tree canopy).

Management Objectives

Because most of the montane-subalpine riparian was in the mid-succession class, management objectives sought to promote more early- and late- classes. In addition, a major objective of both the MAXIMUM and PREFERRED MANAGEMENT scenarios was to prevent High-Risk Vegetation Classes in the future.

The objectives of the PREFERRED MANAGEMENT scenario included:

- Reducing Ecological Departure from 59% departed from NRV to 32%, over 20 years.
- Implement management strategies to prevent future increases in High-Risk Vegetation Classes (desertification and exotic forbs) to 13% (MINIMUM MANAGEMENT scenario).

Management Strategies

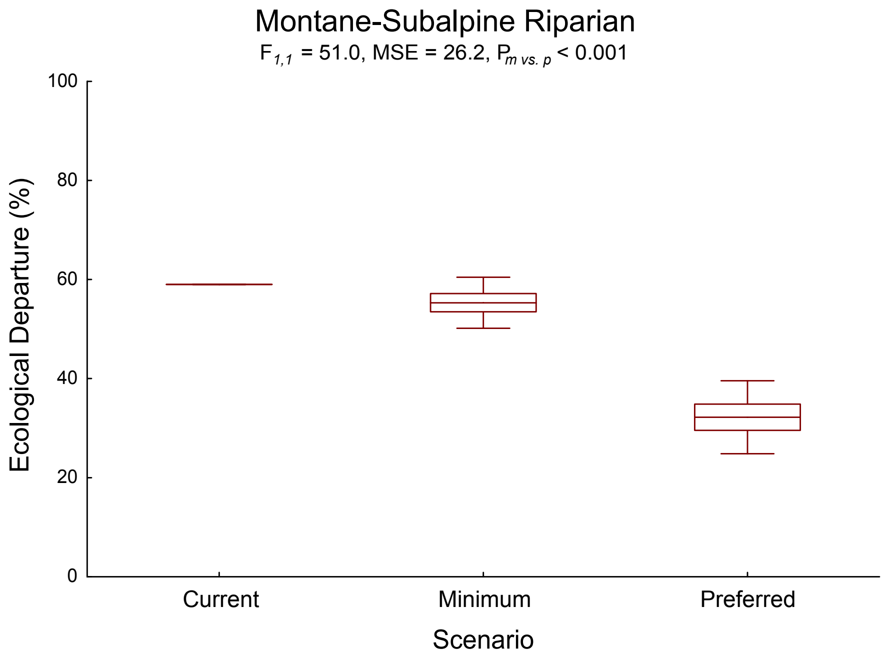
The primary management strategies of both the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios included: weed inventory; exotic control via spot treatment of invasive weeds; and temporary fencing to promote continued succession within reference vegetation classes (i.e., classes A, B and C). The PREFERRED MANAGEMENT scenario employed these three strategies over 20 years at an average cost of $4,510 per year (Table 17).

Outcomes

- Ecological Departure decreased to 32% over 20 years (from 59%) in the MAXIMUM and PREFERRED MANAGEMENT (Figure 16) scenarios.
- With MINIMUM MANAGEMENT, High-Risk Vegetation Classes increased to 13% while only increasing to 4% in MAXIMUM and PREFERRED MANAGEMENT (Figure 16) scenarios.

Table 17. PREFERRED MANAGEMENT scenario for montane-subalpine riparian in the Ward Mountain project area.

Project	Ward Mountain					
Ecological System	Montane-Subalpine Riparian					
Objective	Improve ecological condition of ~200 acres of Ward Mountain montane-subalpine riparian from 59% departure from NRV (FRCC 2) to ~30% departure (FRCC 1) and prevent large increase in "high risk" vegetation classes… over 20 years					
Ave. Acres Treated/Year						26
Total Ecosystem Acres						170
Strategy	Apply approximately 20 acres/year of temporary fencing along riparian areas, along with spot treatment of exotic weeds					
Management Actions		*One Time Costs*	*# Years*	*Acres/Year*	*Cost/Acre*	*Cost/Year*
	Periodic inventory of invasive weeds		20	5	$ 50	$ 250
	Spot treatment of invasive weeds		20	1	$ 260	$ 260
	Temporary fencing		20	20	$ 200	$ 4,000
						$ -
						$ -
						$ -
						$ -
						$ -
Average Cost/Year	*including one time costs of*	$ -				**$ 4,510**
Number of Years						**20**
Total Cost						**$ 90,200**
Notes						



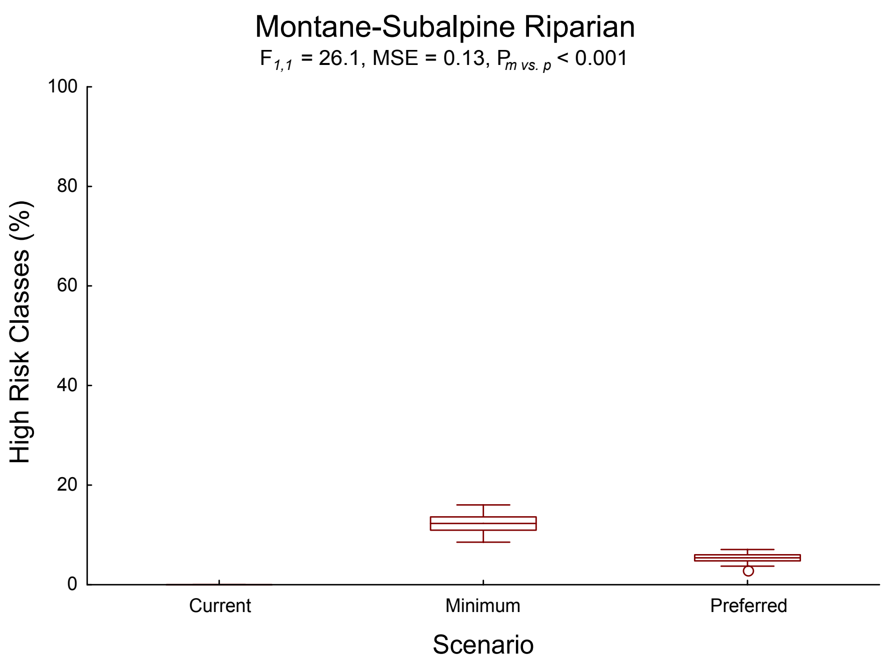


Figure 16. Ecological Departure and high risk classes for montane-subalpine riparian on Ward Mountain, NV. Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenario. MANOVA for both variables resulted in Wilk's $\lambda_{2,7}$ = 0.0933, P < 0.001. Sample size = 5 replicates. Simulations were for 20 years. The data for high risk classes was square-root transformed to homogenize variances. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

Winterfat

Winterfat occurs in salt-desert shrub communities and was 615 acres (0.5%) of the Ward Mountain project area. Associated species of winterfat include green rabbitbrush (*Chrysothamnus viscidiflorus*), Indian ricegrass (*Oryzopsis hymenoides*), galleta (*Hilaria jamesii*), and black sagebrush (*Artemesia nova*). Winterfat is an important forage plant for livestock and wildlife, especially during winter when forage is scarce (Blaisdell et al. 1984; Mozingo 1987). Winterfat is not adapted to fire which can result in total mortality of the species in an affected area.

Management Objectives

A reduction in Ecological Departure was a primary objective of the MAXIMUM and PREFERRED MANAGEMENT scenarios. In addition, both scenarios sought to reduce the percent of high-risk vegetation from 79%. Depleted winterfat dominated the system in the Ward Mountain project area (54%) and reduction of this class was a main focus of the PREFERRED MANAGEMENT scenario.

The objectives of the PREFERRED MANAGEMENT scenario were to:

- Improve Ecological Departure from 78% departed from NRV to 47% over 20 years.
- Reduce High-Risk Vegetation Classes from 79% to 34% over 20 years.

Management Strategies

Depleted winterfat can be improved through seeding efforts although seedling establishment is not consistent (Carey 1995). Aerial broadcasting of winterfat fruits after light chaining of the surface has had demonstrated effectiveness. In Utah, seeding in late fall or winter has been most successful (Herbel 1986).

Management strategies considered by workshop participants included annual grass removal followed by seeding; seeding in depleted winterfat; and an experimental control of exotic forbs (halogeton) followed by seeding. Restoration of areas infested with halogeton have proven challenging because of its prolific seed production, and the best defense against halogeton is a vigorous stand of perennial range plants and variation in grazing patterns (Pavek 1992).

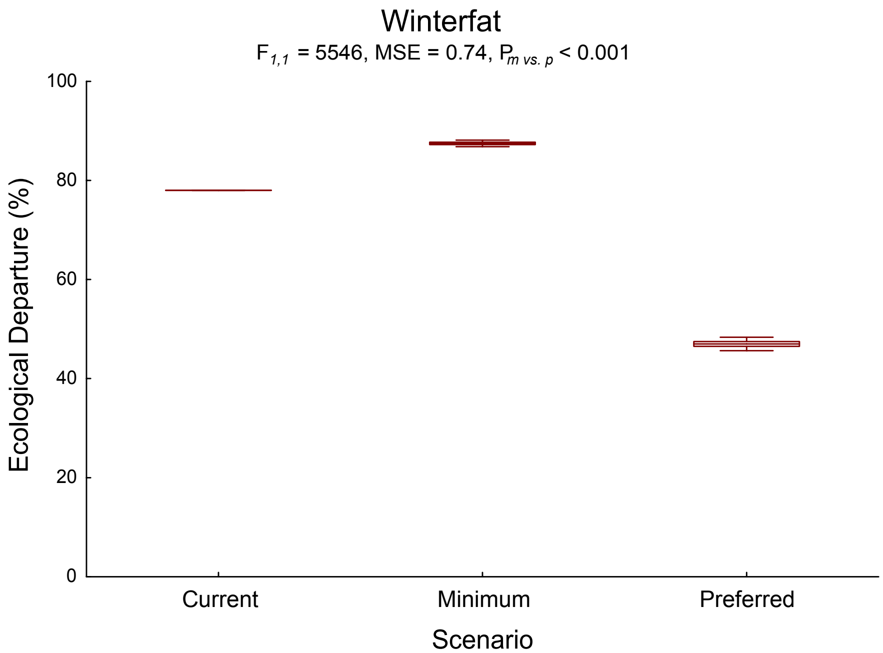
The PREFERRED MANAGEMENT scenario focused actions on restoration of the depleted class of winterfat (Table 18). For the first five years, 75 acres per year were treated for depleted restoration. This rate was reduced to 50 acres per year for the subsequent 15 years. The average annual cost of the PREFERRED MANAGEMENT scenario was $11,250 versus $25,250 (MAXIMUM MANAGEMENT scenario cost).

Outcomes

- In the PREFERRED and MAXIMUM MANAGEMENT scenarios, Ecological Departure was reduced from 75% departed from NRV to 47%.
- High-Risk Vegetation Classes were reduced from 79% in both the MAXIMUM MANAGEMENT (9%) and PREFERRED MANAGEMENT (34%) scenarios.

Table 18. PREFERRED MANAGEMENT scenario for winterfat in the Ward Mountain project area.

Project	Ward Mountain					
Ecological System	Winterfat					
Objective	Improve ecological condition of ~600 acres of Ward Mountain winterfat from 78% departure from NRV (FRCC 3) to ~50% departure (FRCC 2) and reduce "high risk" vegetation classes from 79% to ~35%... over 20 years					
Ave. Acres Treated/Year						56
Total Ecosystem Acres						610
Strategy	Treat depleted winterfat -- approximately 75 acres/year for first five years, then approximately 50 acres/year					
Management Actions		*One Time Costs*	*# Years*	*Acres/Year*	*Cost/Acre*	*Cost/Year*
	Restore depleted winterfat to mid successional classes (includes seeding with natives)		5	75	$ 200	$ 15,000
	same as above for following 15 years		15	50	$ 200	$ 10,000
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
Average Cost/Year	*including one time costs of*	$ -				**$ 11,250**
Number of Years						**20**
Total Cost						**$ 225,000**
Notes						



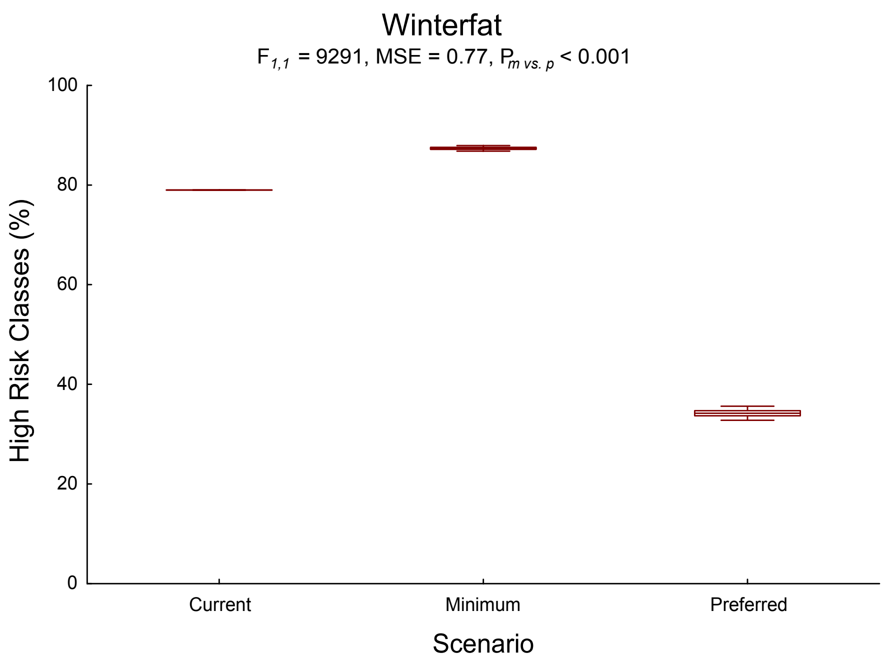


Figure 17. Ecological Departure and high risk classes for winterfat on Ward Mountain, NV. The Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenario. MANOVA for both variables resulted in Wilk's $\lambda_{2,7}$ = 0.0002, P < 0.001. Sample size = 5 replicates. Simulations were for 20 years. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

Wyoming Big Sagebrush

Wyoming big sagebrush comprised 7% (8,333 acres) of the Ward Mountain project area. It is important because it's a preferred browse for wild ungulates; important winter range for big game; and crucial to Greater sage-grouse for nesting cover and food in the winter. Wyoming big sagebrush in the Ward Mountain project area has been identified by Nevada Department of Wildlife as part of the core habitat for Greater sage-grouse which includes lekking, nesting and brood rearing habitat. Much of this core habitat is in the southwest corner of the Ward Mountain project area. Currently, Wyoming big sagebrush is 77% departed from NRV in the Ward Mountain project area, of which 66% of the system is in the depleted (55%) and the rest in shrub-annual grass (11%) class (i.e., High-Risk Vegetation Classes). With no active restoration in Wyoming big sagebrush, Ecological Departure is predicted to be 74% departed from NRV with 61% within high-risk vegetation types in 20 years. With the long disturbance regime intervals and 'inability' for the currently depleted sagebrush to transition to a more desirable class without active management, the similarity in current and conditions predicted for 20 years with MINIMUM MANAGEMENT would be expected.

Management Objectives

In the Ward Mountain project area, there was no Wyoming big sagebrush in the early succession class (class A) and very little in the mid-succession class (class B). Recruiting more vegetation into these classes was one objective for Wyoming big sagebrush.

Objectives of the PREFERRED MANAGEMENT scenario (Table 19) were to:

- Improve ecological condition of ~8,300 acres of Ward Mountain Wyoming big sagebrush from 77% departure from NRV to ~60% departure over 20 years.
- Reduce High-Risk Vegetation Classes from 66% to ~25% over 20 years.

Management Strategies

Treatment of annual grass, restoring depleted sagebrush, shrub-annual grass restoration, and thinning encroached trees were management strategies evaluated in the MAXIMUM MANAGEMENT ($89,250 per year over 20 years) and PREFERRED MANAGEMENT ($51,050 per year over 20 years) scenarios for Wyoming big sagebrush in the Ward Mountain project area.

Prescribed fire was not considered as a strategy option for this system. While burning will remove Wyoming big sagebrush, it will not restore perennial grasses in areas where there is potentially a loss of the native seed bank (e.g., depleted class of Wyoming big sagebrush) or where cheatgrass could become dominant (e.g., shrub-annual grass class). One reason burning was not a preferred strategy for older classes of Wyoming big sagebrush is because of its value as winter habitat for Greater sage-grouse, because the birds rely upon the sagebrush as a primary winter food source. There is, however, an abundance of this structural type in the project area.

Outcomes

- Over 20 years, Ecological Departure of Wyoming big sagebrush improved from 77% departure from NRV to 61% departed in the PREFERRED MANAGEMENT scenario and to 60%

in the MAXIMUM MANAGEMENT scenario. The main reason for a modest reduction in Ecological Departure was the creation of large areas of mixed non-native and native seeded species, which are considered uncharacteristic vegetation unless succession returns them to a native, reference state.

- High-Risk Vegetation Classes were reduced from 66% to 26% in the PREFERRED MANAGEMENT scenario and 3% in the MAXIMUM MANAGEMENT scenario

Table 19. PREFERRED MANAGEMENT scenario for Wyoming big sagebrush in the Ward Mountain project area.

Project	Ward Mountain					
Ecological System	Wyoming Big Sagebrush					
Objective	Improve ecological condition of ~8,300 acres of Ward Mountain Wyoming big sagebrush from 77% departure from NRV (FRCC 3) to ~60% departure (FRCC 2) and reduce "high risk" vegetation classes from 66% to ~25%... over 20 years					
Ave. Acres Treated/Year						245
Total Ecosystem Acres						8,330
Strategy	Treat approximately 250 acres/year of late succession, depleted, tree-encroached, and annual-grass-invaded Wyoming Big Sagebrush					
Management Actions		One Time Costs	# Years	Acres/Year	Cost/Acre	Cost/Year
	Apply Plateau herbicide to annual grass and seed to restore native grasses		20	60	$ 130	$ 7,800
	Mechanically thin and seed Depleted sagebrush to restore native grasses		20	100	$ 180	$ 18,000
	Apply Herbicide Spyke to restore earlier succession class		20	10	$ 25	$ 250
	Restoration of shrubs with annual grass via mechanical thinning, herbicide and seed		20	25	$ 300	$ 7,500
	Mechically thin tree encroached sagebrush, apply herbicide and seed to restore native grasses		20	50	$ 350	$ 17,500
						$ -
						$ -
						$ -
Average Cost/Year	*including one time costs of*	$ -				**$ 51,050**
Number of Years						**20**
Total Cost						**$ 1,021,000**
Notes						

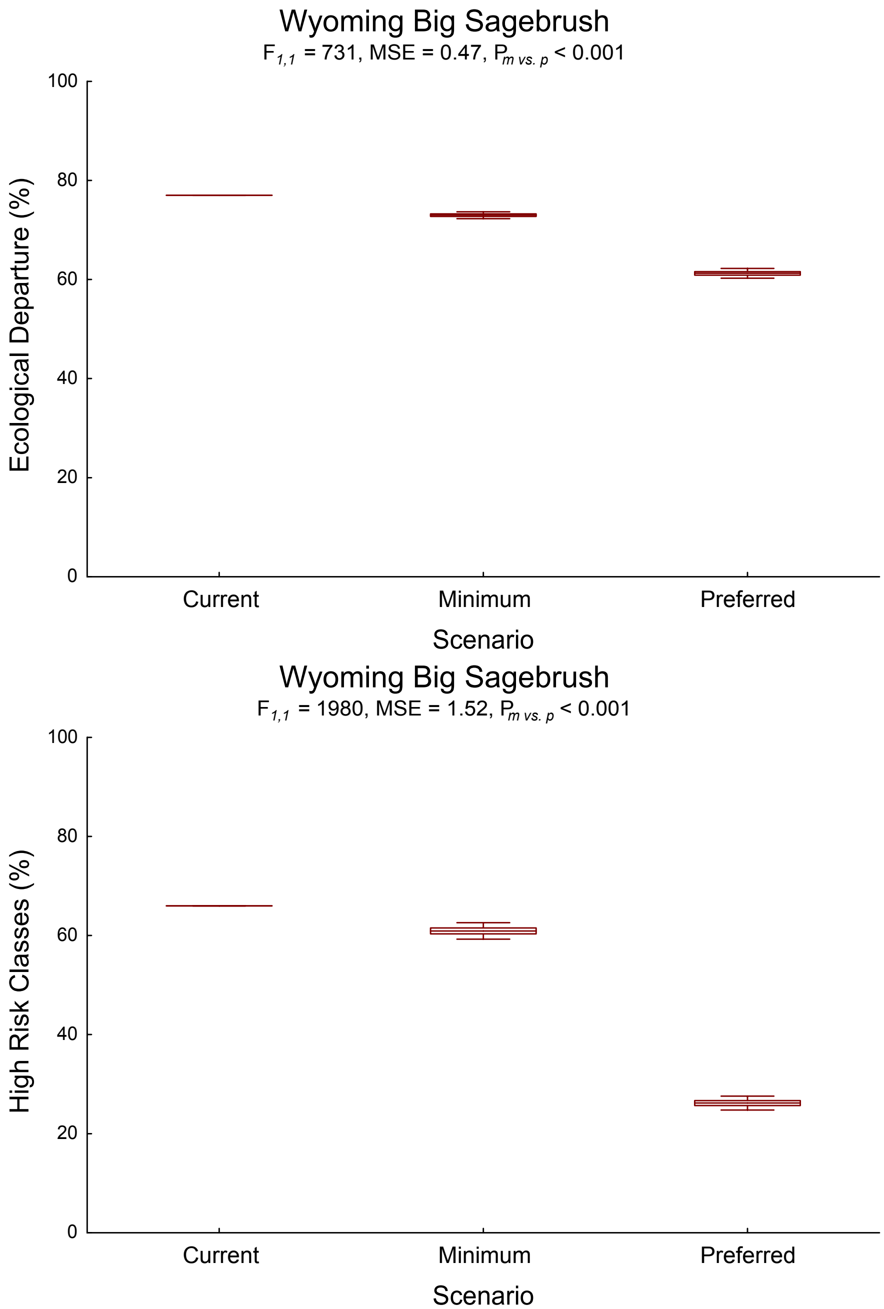


Figure 18. Ecological Departure and high risk classes for Wyoming big sagebrush on Ward Mountain, NV. The Current condition (baseline) was obtained from satellite imagery interpretation. One-way statistical tests were only between the Minimum (m) and Preferred (p) scenario. MANOVA for both variables resulted in Wilk's $\lambda_{2,7}$ = 0.0036, P < 0.001. Sample size = 5 replicates. Simulations were for 20 years. The center line, edges, and error bars are, respectively, the mean, 1± SE, and 95% C.I.

Summary of Management Scenarios

Overall, the MAXIMUM MANAGEMENT scenarios cost nearly twice that of the identified PREFERRED MANAGEMENT scenarios for focal systems of the Ward Mountain project area. With the exception of aspen-mixed conifer, PREFERRED MANAGEMENT scenarios for focal systems were less expensive than the MAXIMUM MANAGEMENT scenarios (Table 20).

Table 20. Average annual costs of MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios for focal ecological systems of the Ward Mountain project area.

Ecological System	Average Annual Cost	
	Maximum Management	Preferred Management
Aspen Mixed-Conifer	$4,250	$5,315
Aspen Woodland	$1,600	$1,000
Basin Wildrye	$33,450	$20,280
Black Sagebrush	$532,000	$257,500
Montane Sagebrush Steppe - Mountain	$0	$0
Montane Sagebrush Steppe - Upland	$94,015	$50,845
Montane-Subalpine Riparian	$5,020	$4,510
Mountain Shrub	$0	$0
Winterfat	$25,250	$11,250
Wyoming Big Sagebrush	$89,250	$51,050
Total costs	$784,835	$401,750

Ecological Departure improved under both the MAXIMUM and PREFERRED MANAGEMENT scenarios, and both scenarios were effective in reducing Ecological Departure (Table 21). The substantial additional costs of the MAXIMUM MANAGEMENT scenarios generally yielded only slightly increased benefits to Ecological Departure. MAXIMUM MANAGEMENT scenarios typically outperformed the PREFERRED MANAGEMENT scenarios in reducing High-Risk Vegetation Classes with the exception of montane-subalpine riparian (Table 22). In their development, PREFERRED MANAGEMENT scenarios were 'streamlined'. Strategies were identified that yielded the greatest ecological benefits while minimizing costs (see intra-system ROI discussion in Prioritizing Actions for Implementation: Return-on-Investment). This optimization contributes to the similar outcomes of the two different scenarios since MAXIMUM MANAGEMENT scenario objectives were designed for ecological benefits.

Table 21. Ecological Departure of focal systems in the Ward Mountain project area in 2009 and in 20 years, under MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios. Ecological Departure equals percent departure from NRV. FRCC is color coded: red = FRCC 3, yellow = FRCC 2, and green = FRCC 1.

Ecological System	Ecological Departure (%)		
	Current Condition (2009)	Maximum Mgmt - 20 yrs	Preferred Mgmt - 20 yrs
Aspen Mixed-Conifer	53	37	25
Aspen Woodland	45	38	24
Basin Wildrye	86	46	43
Black Sagebrush	79	30	36
Montane Sagebrush Steppe - Mountain	47		31
Montane Sagebrush Steppe - Upland	62	28	29
Montane-Subalpine Riparian	59	32	32
Mountain Shrub	47		27
Winterfat	78	47	47
Wyoming Big Sagebrush	77	60	61

Table 22. Percent of High-Risk Vegetation Classes in focal systems in 2009 and in 20 years, under MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios. Systems with high risk class representation that can be characterized as fair or poor, are coded yellow and red, respectively. Ecological systems in good condition relative to the amount of High-Risk Vegetation Classes present are coded green. No color coding is applied for no high-risk classes (i.e., 0%).

Ecological System	High Risk Classes (%)		
	Current Condition	Maximum Mgmt - 20 yrs	Preferred Mgmt - 20 yrs
Aspen Mixed-Conifer	<0.1	5	3
Aspen Woodland	0	8	7
Basin Wildrye	82	2	13
Black Sagebrush	48	9	17
Montane Sagebrush Steppe - Mountain	0		1
Montane Sagebrush Steppe - Upland	18	8	16
Montane-Subalpine Riparian	0	4	4
Mountain Shrub	0		0
Winterfat	79	9	34
Wyoming Big Sagebrush	66	3	26

Implementation: Strategies and Potential Treatment Areas

Although all of the focal ecological systems of the Ward Mountain project area were moderately to highly departed from NRV (Table 7), only a portion of these areas need active management or restoration to improve their condition. For example, the map of Fire Regime Condition Class (Figure 8) displays most of the Ward Mountain project area as moderately (FRCC 2 – yellow) and highly (FRCC 3 – red) departed. It's important to note that this map does not depict that all of the departed areas need treatment. Only a portion of these areas will need treatment in order to reduce Ecological Departure.

Workshop participants identified management strategies for focal ecological systems of the Ward Mountain project area. The performance of PREFERRED MANAGEMENT scenarios which incorporated identified strategies for focal ecosystems was evaluated using ecological models. The PREFERRED MANAGEMENT scenarios yielded the highest return-on-investment within ecological systems (compared to MAXIMUM MANAGEMENT scenarios). The strategies of the PREFERRED MANAGEMENT scenarios included: restoration of areas currently with depleted sagebrush, prescribed fire (RxFire), restoration of areas currently encroached with conifers , restoration of areas currently invaded with annual grasses, aspen thinning, chainsaw lopping, mastication, chaining, temporary fencing of riparian, treatment of exotic forbs, and weed inventory.

Next, workshop participants discussed constraints that would affect locations for potential on-the-ground treatments. Constraints identified were:

- *Fire risk to downwind settlement*. Accordingly, prescribed fire is not used as a treatment within the Wildland Urban Interface area identified by workshop participants.
- *Fire risk to adjoining systems that would be adversely impacted by fire*. Accordingly, prescribed fire is avoided in areas that are adjoining to Pinyon-Juniper (class D), mountain mahogany (classes D & E), limber-bristlecone pine (all classes), winterfat, large patches of shrublands invaded with annual grass (ShAG or AG).
- *Slopes >15%.* Areas with steep slopes were eliminated from consideration for mowing, chaining and other machinery.
- *Patch size and distance between areas suitable for treatment*. Economy of scale in treatment size is accomplished with the following minimum guidelines: 150 acres (mowing), 500 acres (chaining), and 30 acres (RxFire aspen).
- *Areas outside of Greater sage-grouse core habitat*. Commonly, restoration activities are focused within 2-4 miles of leks.
- *Private lands* were not included as areas available for treatment.

TNC incorporated the constraints into the development of maps depicting potential treatment areas by strategy for the Ward Mountain project area. A discussion of treatment strategies and maps of potential treatment areas follows.

Restoration of Depleted Vegetation Classes

Restoration of depleted vegetation classes (i.e., DPL restoration) was a strategy identified for five focal systems of the Ward Mountain project area: basin wildrye, black sagebrush, montane sagebrush steppe – upland, winterfat and Wyoming big sagebrush. For black sagebrush and winterfat, this treatment will restore these systems to a reference class: black sagebrush to early- or mid-succession classes and winterfat to mid- or late-succession classes. Because of cost limitations and uncertainty that a pure native seed mix will result in desired outcomes, some systems are restored to the seeded native-nonnative (SENN) class. Restoration to SENN reduces future amounts of High-Risk Vegetation Classes in basin wildrye, montane sagebrush steppe – upland, and Wyoming big sagebrush.

Restoration of depleted vegetation classes (i.e., DPL restoration) entails:

- Mechanically thinning depleted sagebrush. Mowing and Dixie harrow were identified as tools for thinning.
- Herbicide application to prevent or control cheatgrass.
- Seeding with native or native-nonnative seed mix.

The PREFERRED MANAGEMENT scenarios outlined a total of 1,175 acres per year of DPL restoration for the first five years and 1,150 acres per year for years six through 20 (Table 23). Potential areas for treatment are mapped in Figure 19.

Table 23. Acres of depleted restoration (DPL restoration) identified in PREFERRED MANAGEMENT scenarios for focal ecosystems in the Ward Mountain project area.

Ecological System	Acres/year	Cost/year	Years
Basin Wildrye	210	$37,800	1-5
Black Sagebrush	750	$135,000	1-20
Montane Sagebrush Steppe -upland	40	$7,200	1-5
Winterfat	75	$15,000	1-5
Winterfat	50	$10,000	6-20
Wyoming Big Sagebrush	100	$18,000	1-20

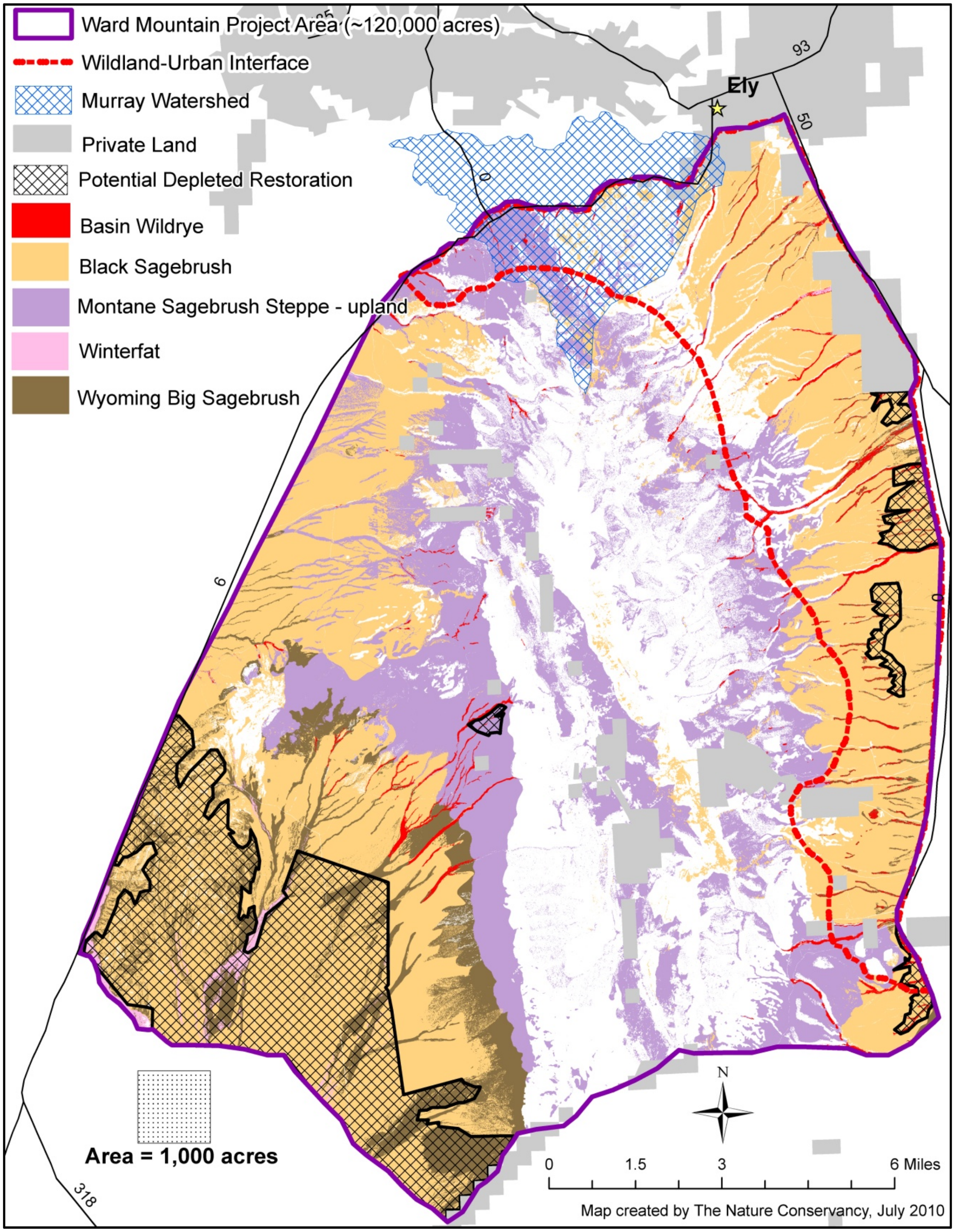


Figure 19. Potential treatment areas for restoration of depleted vegetation classes of basin wildrye, black sagebrush, montane sagebrush steppe – upland, winterfat and Wyoming big sagebrush. Polygons represent current vegetation that may be selected for treatment. Different areas may become available in the future if vegetation transitions to the depleted class.

Prescribed Fire

The PREFERRED MANAGEMENT scenario of Ward Mountain focal systems identified prescribed fire (i.e., RxFire) as a management strategy for aspen-mixed conifer and montane sagebrush – upland. Black sagebrush was a third system evaluated for prescribed fire treatments although it was noted during the workshops that burning in black sagebrush is difficult and risky. Therefore, only 25 acres per year were evaluated in the PREFERRED MANAGEMENT scenario. These acres would likely, but are not restricted to, being in proximity to montane sagebrush steppe – upland prescribed fire treatments.

Two additional focal systems receive carry-over prescribed fire from the above systems: montane sagebrush – mountain and mountain shrub. In evaluating results of model runs, both of these systems demonstrated benefits while incurring no cost for the treatment. All costs of prescribed fire for these two systems were 'accounted for' in the PREFERRED MANAGEMENT scenarios of aspen-mixed conifer, black sagebrush, and montane sagebrush steppe – upland. The strategy has been distinguished from 'RxFire' as 'Free RxFire'.

Employing prescribed fire entails:

- Treating mid- and late-succession classes of aspen-mixed conifer (D & E), late-succession (C)black sagebrush, all late-succession classes (wooded or not) of montane sagebrush steppe – upland (C, D, & E), montane sagebrush – mountain (C, D, &E), and mountain shrub (C & D).
- Treating montane sagebrush steppe – upland that has a small percent of annual grass in the understory that is dominated by native herbaceous understory (i.e., ShAP class)
- Restoration of the early succession class (class A) for all systems

The PREFERRED MANAGEMENT scenarios outlined a total of 391 acres per year of prescribed fire for the first five years and 191 acres per year for years six through 20 (Table 24). Potential areas for treatment are mapped in **Error! Reference source not found.**.

Table 24. Acres of prescribed fire identified in PREFERRED MANAGEMENT scenarios for focal ecosystems in the Ward Mountain project area.

Ecological System	Acres/year	Cost/year	Years
Aspen-Mixed Conifer	200	$10,000	1-5
Black Sagebrush	25	$2,000	1-20
Montane Sagebrush Steppe – upland	156	$12,480	1-20
Montane Sagebrush Steppe – mountain	5	$0	1-20
Mountain Shrub	5	$0	1-20

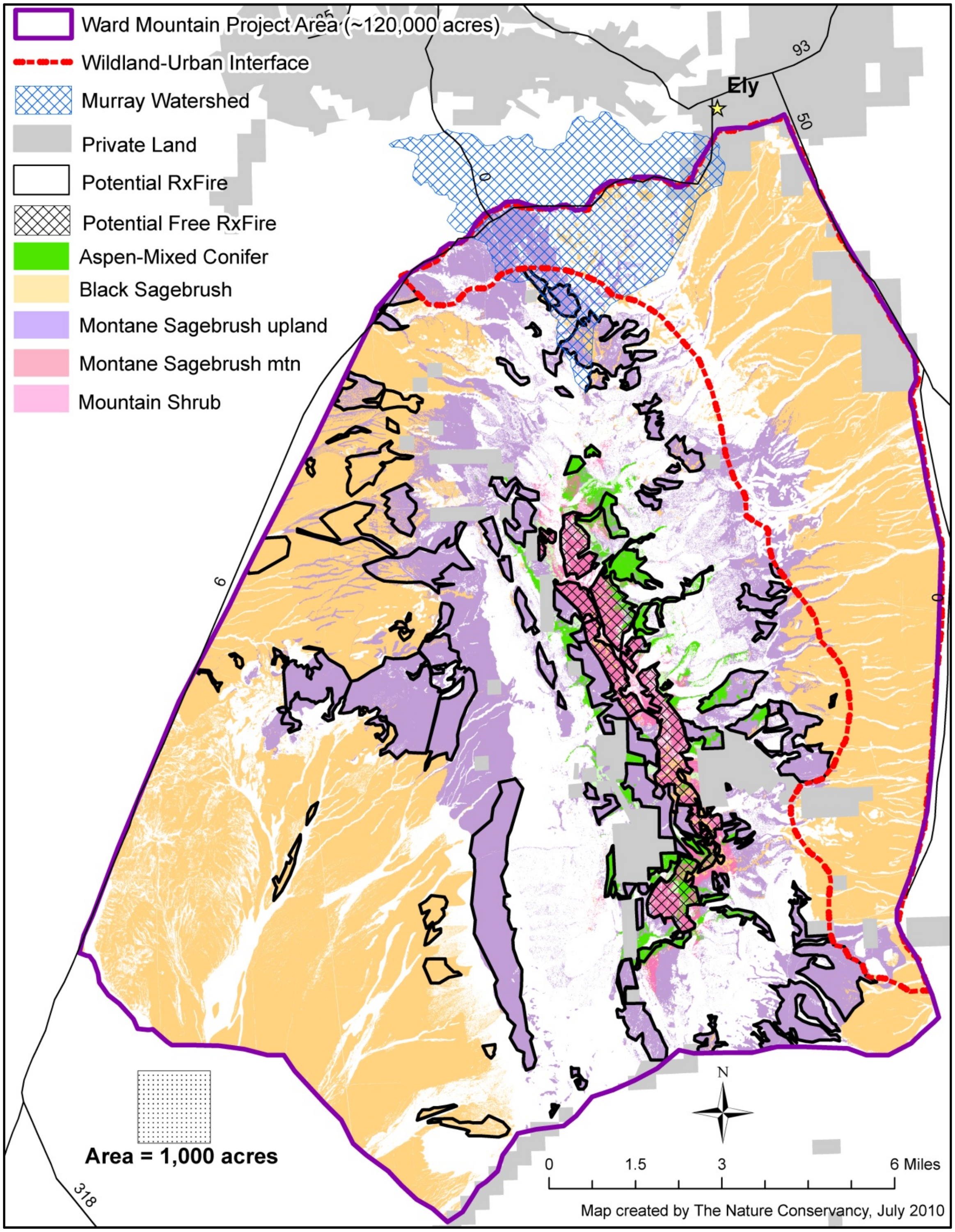


Figure 20. Potential prescribed fire treatment areas for aspen-mixed conifer, black sagebrush, and montane sagebrush – upland in the Ward Mountain project area. Montane sagebrush – mountain and mountain shrub receive carry-over treatments ('Free RxFire') from prescribed fire in other systems.

Restoration of Tree Encroached Sagebrush

Restoration of tree encroached areas (i.e., TrEnc Restoration) was identified for three focal systems in the PREFERRED MANAGEMENT scenarios for Ward Mountain: black sagebrush, montane sagebrush steppe – upland, and Wyoming big sagebrush.

Tree encroached classes of sagebrush have a high percentage of younger trees (as determined by height and 'conical' shape) with an understory mostly lacking shrub and herbaceous components. A pinyon or juniper tree will be considered young if less than 100 to 150 years. Often, dead skeletons of sagebrush are found within the tree encroached areas. In some cases, annual grass (i.e., cheatgrass) is detected (TrAG class) but for most treatments of tree encroached classes, a seed bank of cheatgrass is assumed and accounted for in application of the strategy.

Restoration of tree encroached sagebrush entails:

- Mechanically thinning trees. Workshop participants noted that for this strategy machinery (i.e., not manual thinning with chainsaw) was typically used to reduce cost and increase efficiency.
- Application of herbicide to control or prevent expression of cheatgrass
- Re-seeding with mix that often contains a variety of native and nonnative species

The PREFERRED MANAGEMENT scenarios outlined a total of 265 acres per year of restoration of tree encroached areas for the first five years and 245 acres per year for years six through 20 (Table 25). Potential areas for treatment are mapped in Figure 21.

Table 25. Acres of tree encroached restoration identified in PREFERRED MANAGEMENT scenarios for focal ecosystems in the Ward Mountain project area.

Ecological System	Acres/year	Cost/year	Years
Basin Wildrye	5	$1,750	1-20
Black Sagebrush	150	$52,500	1-20
Montane Sagebrush Steppe – upland	60	$21,000	1-5
Montane Sagebrush Steppe – upland	40	$14,000	6-20
*Wyoming Big Sagebrush	50	$17,500	1-20

*Note: Wyoming big sagebrush had no acres of the tree encroached class in 2009 but was predicted to have continued increases of this class without employing treatment.

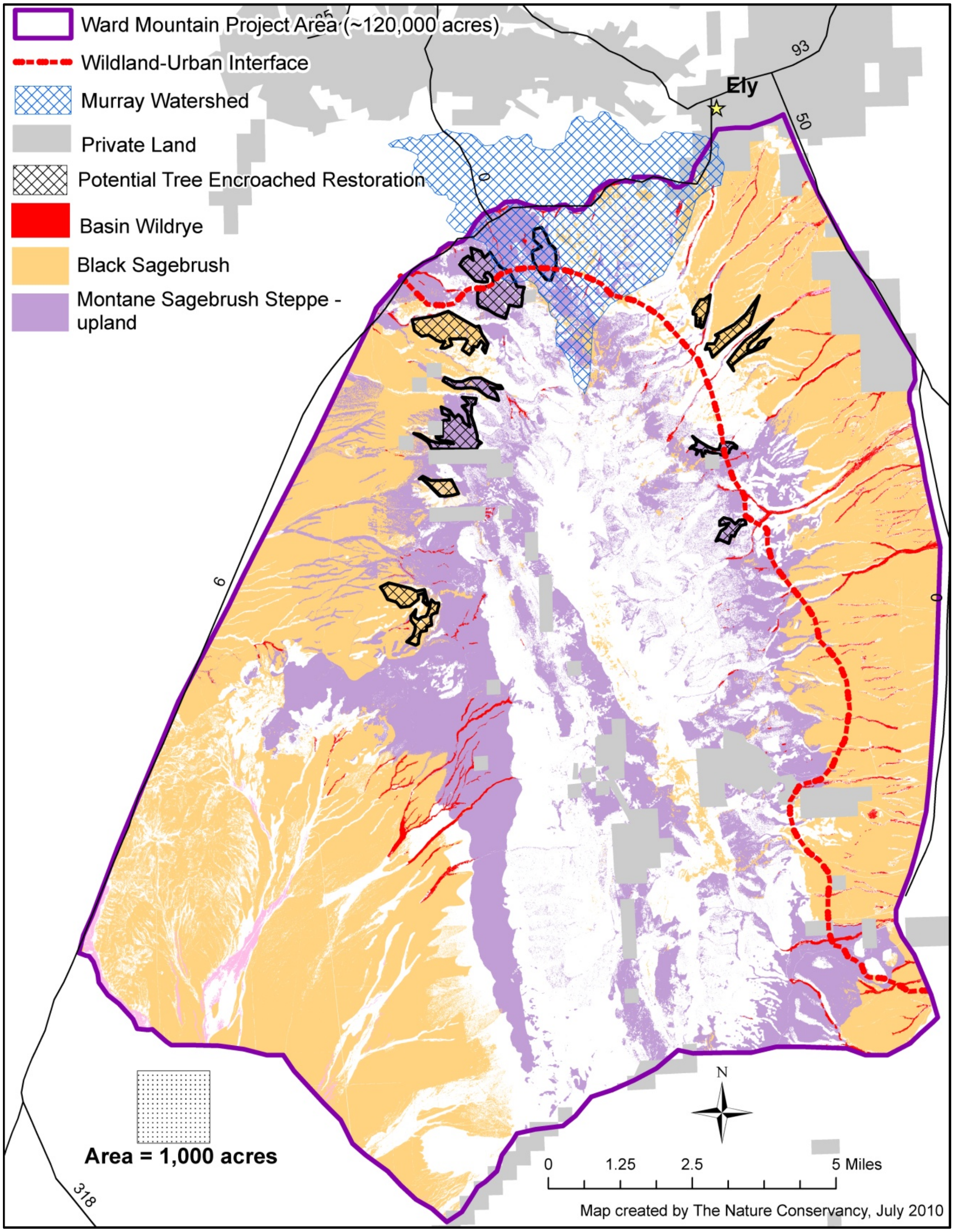


Figure 21. Potential tree encroached restoration areas for basin wildrye, black sagebrush, and montane sagebrush – upland in the Ward Mountain project area.

Treatment of Annual Grasses

Basin wildrye, montane sagebrush steppe – upland, and Wyoming big sagebrush were focal systems that had strategies aimed at reducing or eliminating annual grasses. Vegetation classes of these systems included shrubs with native herbaceous cover that dominated cheatgrass (i.e., ShAP); shrubs with an annual grass component exceeding native grass cover (i.e., ShAG); and annual grasslands (i.e., AG). Management strategies identified in the PREFERRED MANAGEMENT scenarios were:

1. Restoration of shrub-annual-perennial grass areas (i.e., ShAP restoration) in montane sagebrush steppe – upland to restore to early- (A) and mid-succession (B) classes. ShAP restoration entails:
   - Mowing sagebrush and application of herbicide.
   - Seeding is not a component of this strategy because a seed bank of native species is assumed to be present with a high likelihood of recovery following treatment.
2. Restoration of shrub-annual grass areas was identified for basin wildrye, montane sagebrush steppe – upland, and Wyoming big sagebrush. ShAG restoration entails:
   - Mowing sagebrush and application of herbicide (e.g., spot treatments).
   - Seeding with a mix of native-nonnative species, likely via broadcast seed.
   - Workshop participants noted that restoration of areas with depleted shrubland invaded by cheatgrass (ShAG) in montane sagebrush – upland will likely be focused along roadways within the project area.
3. Restoration of areas invaded by annual grass (AG restoration) which entails
   - Application of herbicide (e.g., Plateau) to annual grassland and
   - Seeding to restore native grasses. The seed mix is likely a combination of native-nonnative forbs, grasses and shrubs; therefore annual grasslands are restored to the seeded native-nonnative class (SENN).

Annual grass vegetation classes (i.e., AG) were not present in the Ward Mountain project area but were forecasted to increase under the MINIMUM MANAGEMENT scenario for Wyoming big sagebrush. With no targeted prevention or restoration actions in the ecological model, cheatgrass monocultures replaced Wyoming sagebrush after stand replacing fires within the 20 year simulation. Therefore, treatment of annual grass classes (i.e., AG restoration) was included in the PREFERRED MANAGEMENT scenario.

The PREFERRED MANAGEMENT scenarios outlined a total of 180 acres per year of restoration treatments to control annual grass for the first five years and 85 acres per year for years six through 20 (Table 26). Potential areas for treatment are mapped in Figure 22.

Table 26. Acres of restoration treatments targeted at vegetation classes containing cheatgrass.

Ecological System	Restoration strategy	Acres/year	Cost/year	Years
Basin Wildrye	ShAG	5	$15,000	1-20
Montane Sagebrush Steppe - upland	ShAG	50	$15,000	1-5
Montane Sagebrush Steppe - upland	ShAP	40	$1,600	1-5
Wyoming Big Sagebrush	ShAG	25	$76,200	1-20
Wyoming Big Sagebrush	AG	60	$7,800	1-20

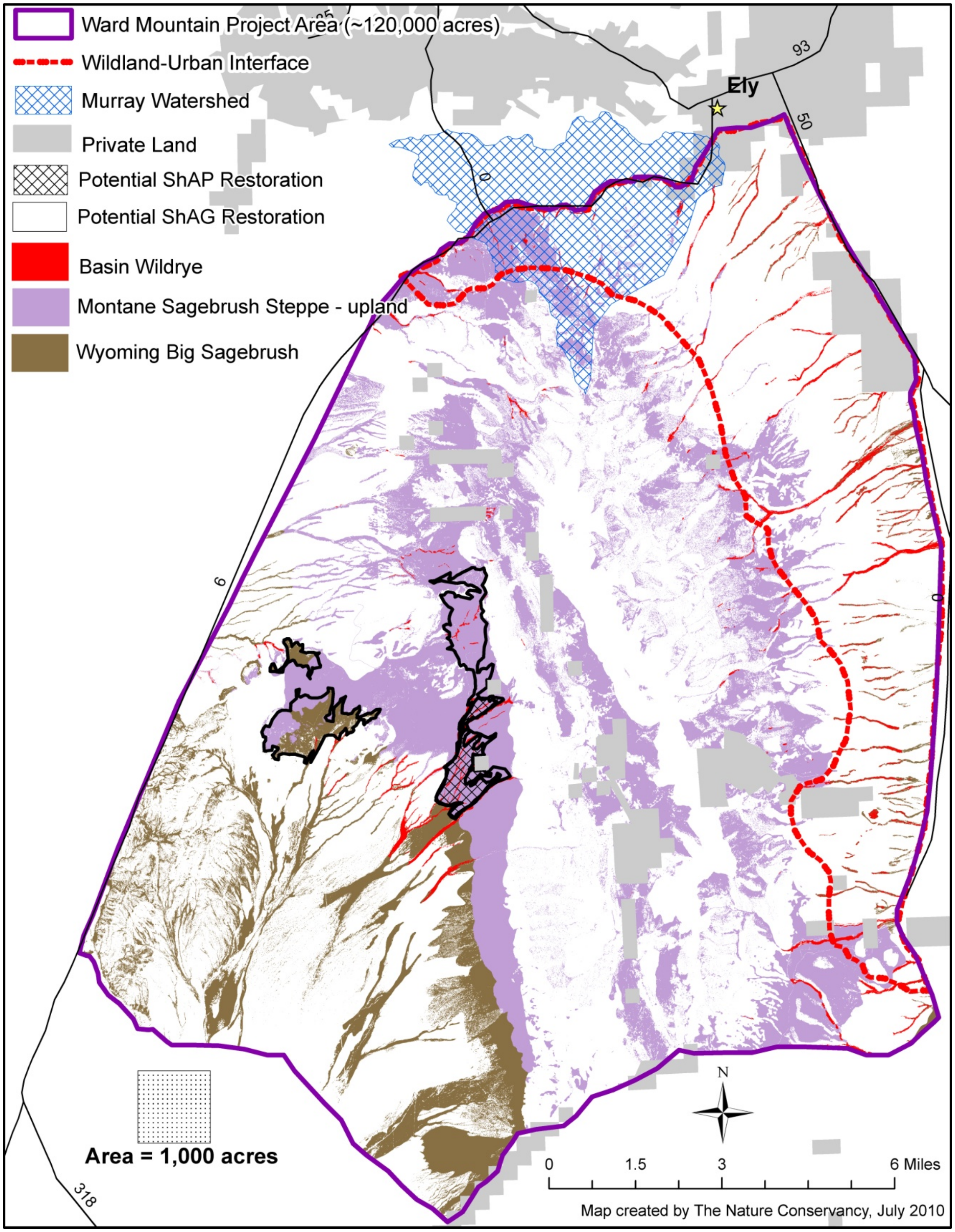


Figure 22. Potential treatment areas for vegetation classes containing an annual grass component. Strategies include ShAP and ShAG restoration for current vegetation (mapped above), and AG restoration for future areas of Wyoming big sagebrush forecasted to transition to an annual grass class.

Mechanical and Herbicide Treatments of Sagebrush Systems

In the Ward Mountain project area, black sagebrush, montane sagebrush steppe – upland, and Wyoming big sagebrush were three focal systems deficient in the early- and mid-succession classes (i.e., classes A & B). Large proportions of these systems were in late succession classes, depleted, or shrubs with an annual grass component. Mechanical treatments in these classes can help to maintain current succession class (e.g., prevent transition to high-risk vegetation class) or, in some cases, restore vegetation to mid-succession classes. Application of the herbicide Spike is another strategy for reducing or eliminating sagebrush cover. The primary difference between the upcoming discussion and the previous of 'Restoration of Tree Encroached Sagebrush' is that the main focus of the following strategies is reducing sagebrush cover and treatment of 'reference' classes of sagebrush versus focus of tree removal in an uncharacteristic class. Strategies of the PREFERRED MANAGEMENT scenarios included:

1. *Chaining.* This strategy reduces stand density and increases shrub vigor. Chaining in late-succession classes of montane sagebrush steppe – upland (i.e., D & E) increased early- and mid-succession vegetation (i.e., classes A & B). Areas of late-succession black sagebrush (i.e., class C) were budgeted for reseeding after chaining to promote desired recovery of herbaceous understory. Chaining the wooded late succession class of black sagebrush restores to mid-succession (i.e., class B). A summary of chaining strategies from Preferred Management scenarios is in Table 27.

Table 27. Acres of chaining in PREFERRED MANAGEMENT scenarios for black sagebrush and montane sagebrush steppe – upland in the Ward Mountain project area.

Ecological System	Acres/year	Cost/year	Years
Black Sagebrush	200	$26,000	1-20
Montane Sagebrush Steppe -upland	300	$25,500	1-5
Montane Sagebrush Steppe -upland	50	$4,250	6-20

2. *Chainsaw lopping*. Lop conifer trees with chainsaw to prevent transition to tree encroached vegetation class. This strategy was identified for both black sagebrush (classes C, DPL, ShAP, and ShAG) and montane sagebrush steppe – upland (classes D, DPL, and ShAP) (Figure 24). Chainsaw lopping maintains vegetation within the treated class.

Table 28. Acres of chainsaw lopping in PREFERRED MANAGEMENT scenarios for black sagebrush and montane sagebrush steppe – upland in the Ward Mountain project area.

Ecological System	Acres/year	Cost/year	Years
Black Sagebrush	100	$7,000	1-20
Montane Sagebrush Steppe -upland	80	$4,800	1-5
Montane Sagebrush Steppe -upland	20	$1,200	6-20

3. *Herbicide Spike.* Spike is an herbicide that effectively kills sagebrush and conifers. This strategy was employed in the PREFERRED MANAGEMENT scenario for Wyoming big sagebrush. Application of Spike was to late-succession classes to restore mid-succession vegetation classes of Wyoming big sagebrush. The application rate was 10 acres per year ($250/year) for years one through 20.
4. *Canopy thinning.* Action to thin the late-succession canopy of sagebrush from the reference condition using various methods requiring no seeding. Strategy to reduce Ecological Departure and prevent High-Risk Vegetation Classes by restoring to early- and mid-succession class. This strategy was identified for montane sagebrush steppe – upland vegetation late-succession classes C (no trees) and D (small trees present). Canopy thinning was applied to 200 acres per year ($20,000/year) for the first five years of the model simulation in the PREFERRED MANAGEMENT scenario.
5. *Mastication.* A masticator is used to remove conifers that have encroached into the wooded late-succession class (D) of black sagebrush for ecological restoration (e.g., reducing Ecological Departure, prevention of High-Risk Vegetation Classes) of mid-succession class. Fuels reduction is another common objective when employing this strategy. The PREFERRED MANAGEMENT scenario for black sagebrush identified mastication as a restoration strategy for 100 acres per year ($35,000/year) for years 1-20.

The PREFERRED MANAGEMENT scenarios outlined a total of 990 acres per year of mechanical and herbicide treatments for the first five years and 480 acres per year for years six through 20. Potential areas for treatment are mapped in Figure 23 (chaining), Figure 24 (chainsaw lopping), Figure 25 (herbicide Spike), Figure 26 (canopy thinning), and Figure 27 (mastication).

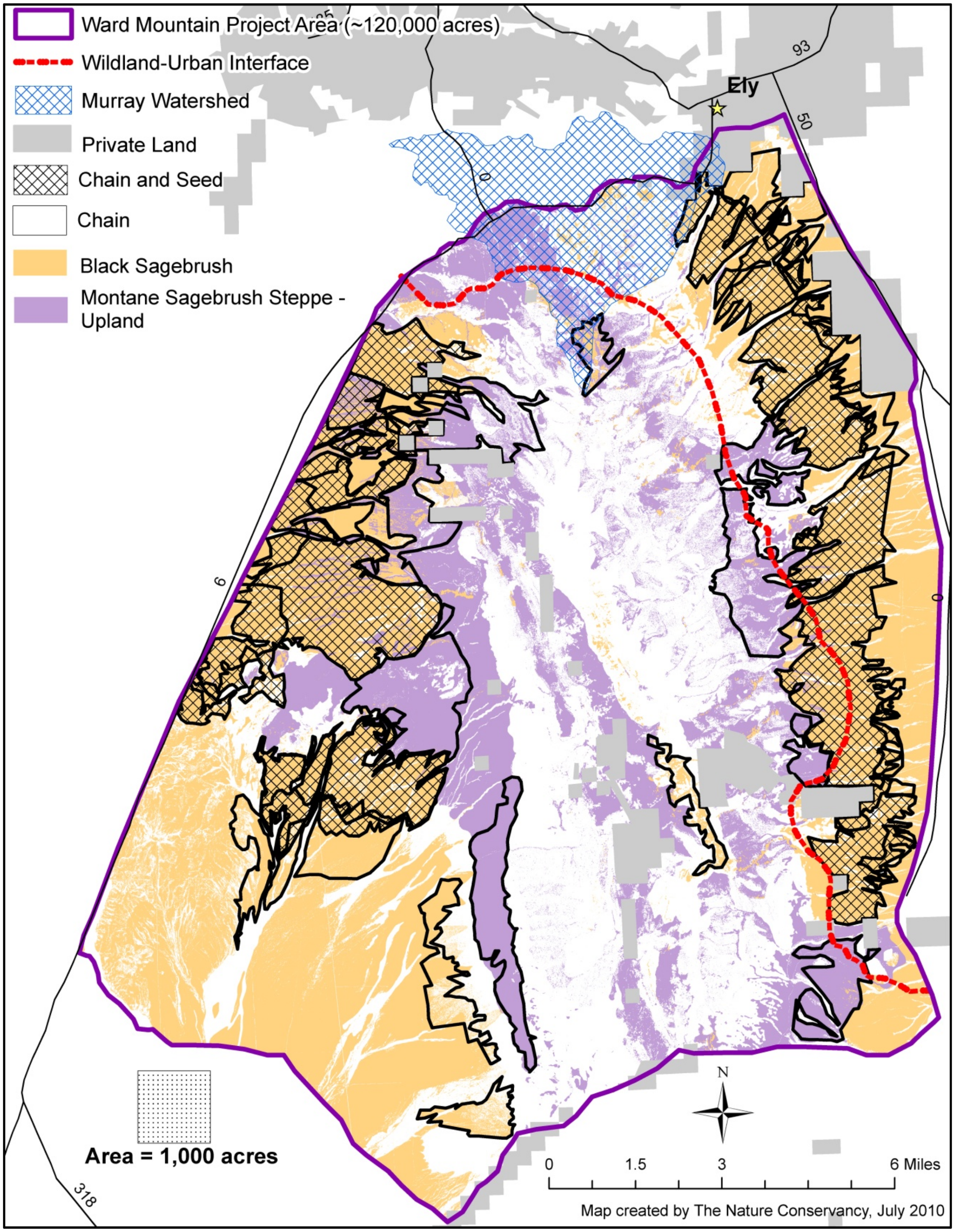


Figure 23. Potential areas for chaining black sagebrush and montane sagebrush steppe – upland in the Ward Mountain project area.

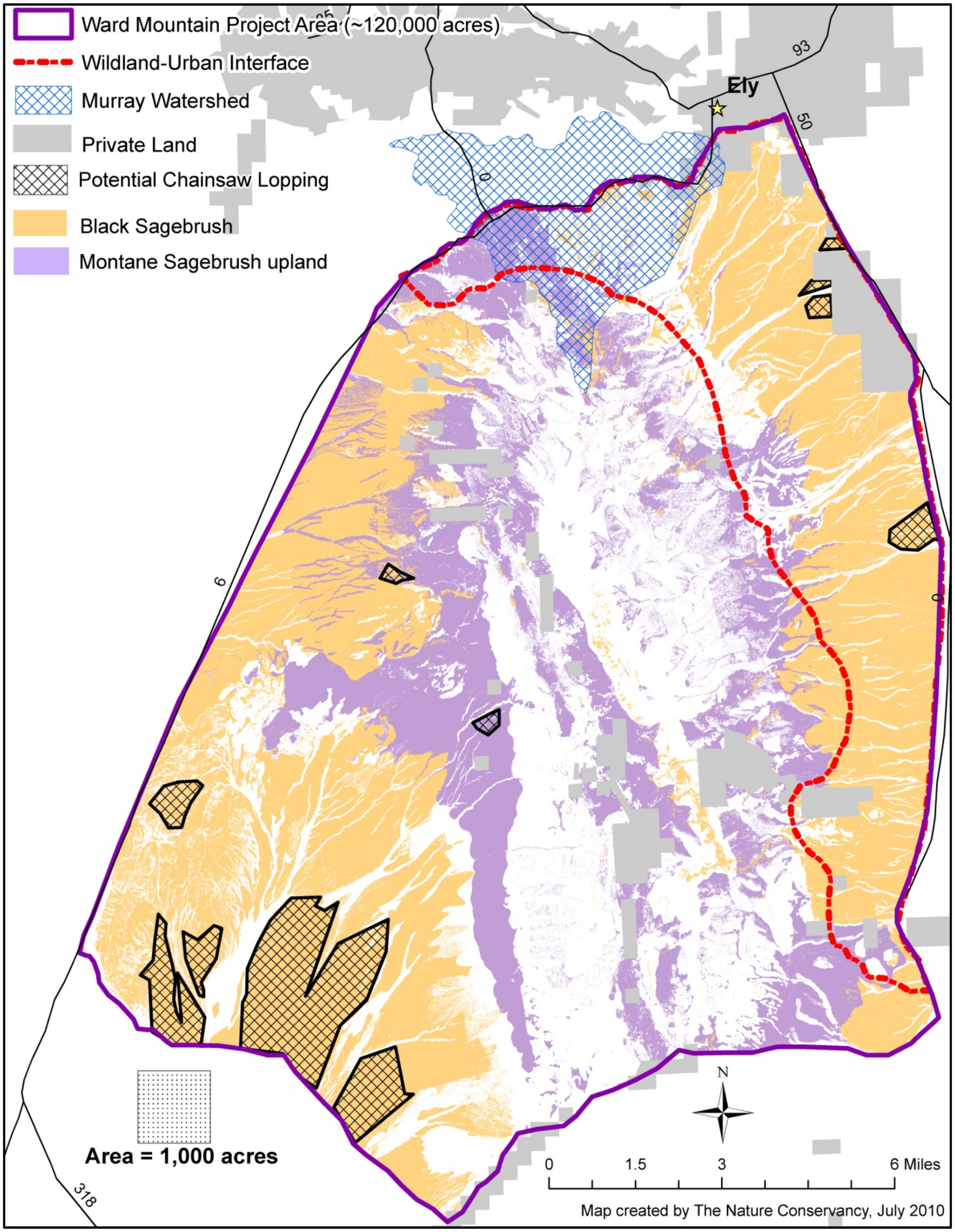


Figure 24. Areas of black sagebrush and montane sagebrush steppe – upland in the Ward Mountain project area that are potential for chainsaw lopping. Note that large areas within southwestern portion of project area currently contain little to no trees for chainsaw-lopping; the use of chainsaw-lopping was modeled for areas where depleted sagebrush is transitioning to tree encroached and chainsaw-lopping is applied after 100 years in this class. Therefore, these areas depict depleted sagebrush that may transition to areas with trees over the modeled timeframe (i.e., potential future treatable areas).

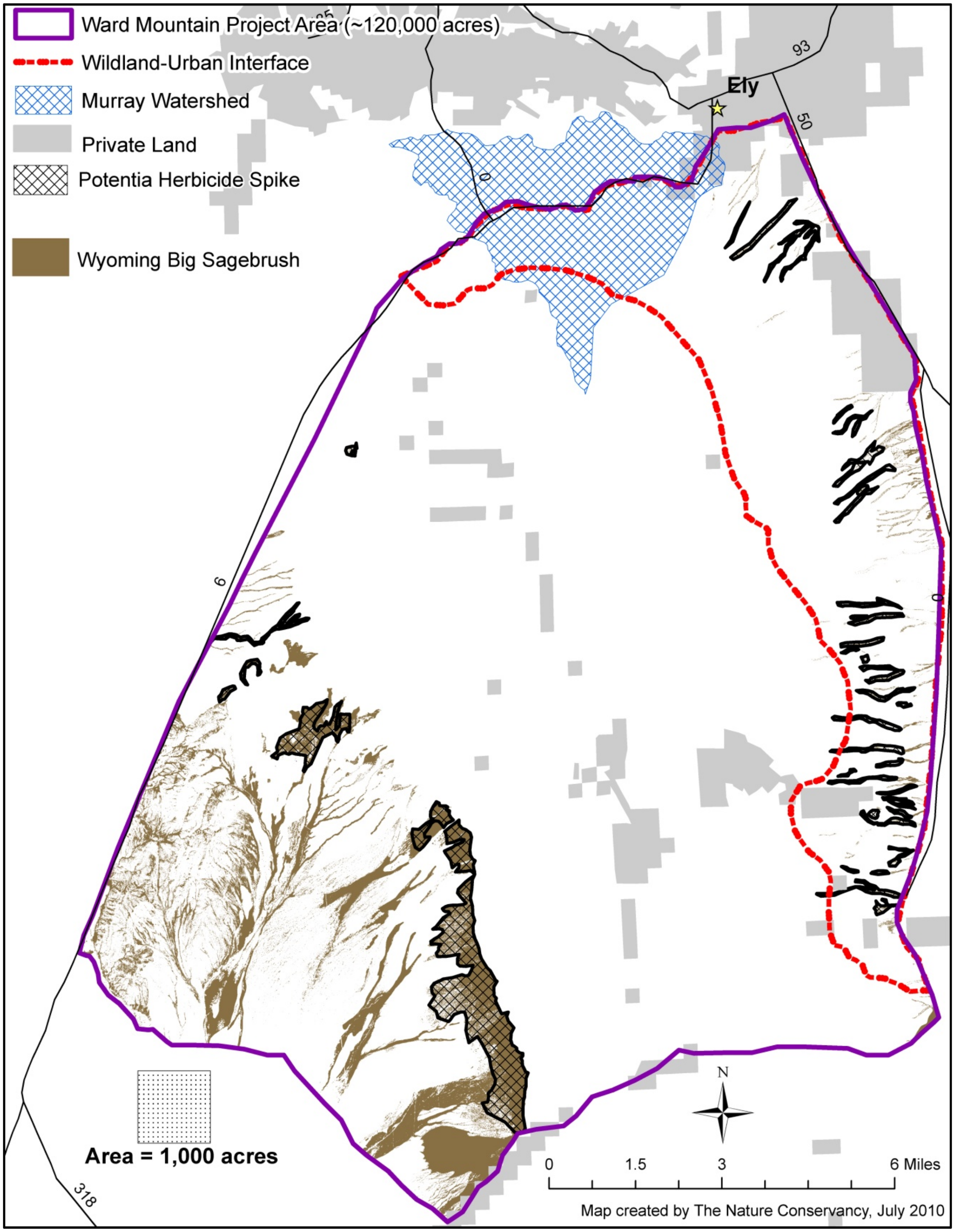


Figure 25. Wyoming big sagebrush available for potential herbicide Spike restoration treatment in the Ward Mountain project area.

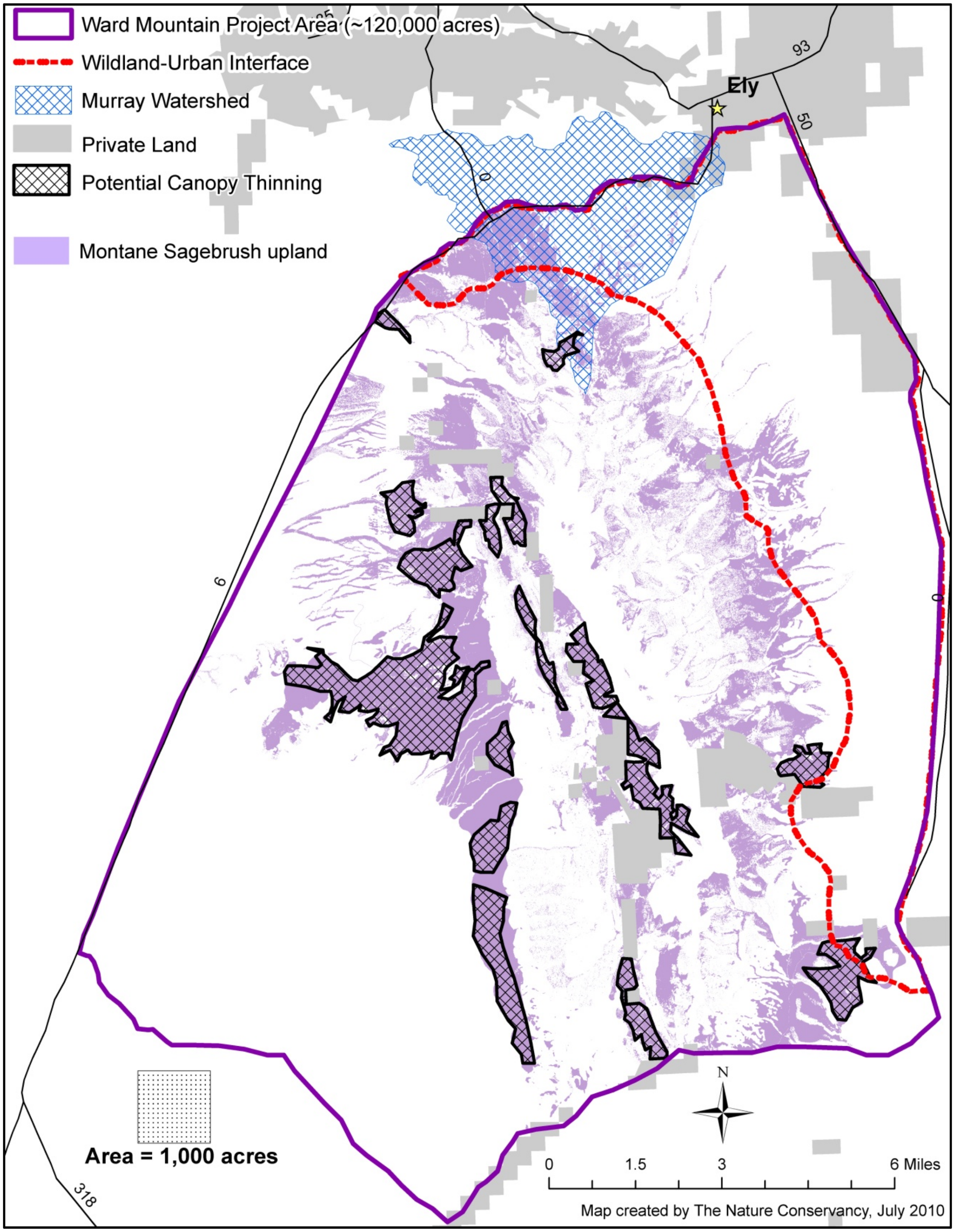


Figure 26. Potential areas for canopy thinning montane sagebrush steppe – upland in the Ward Mountain project area.

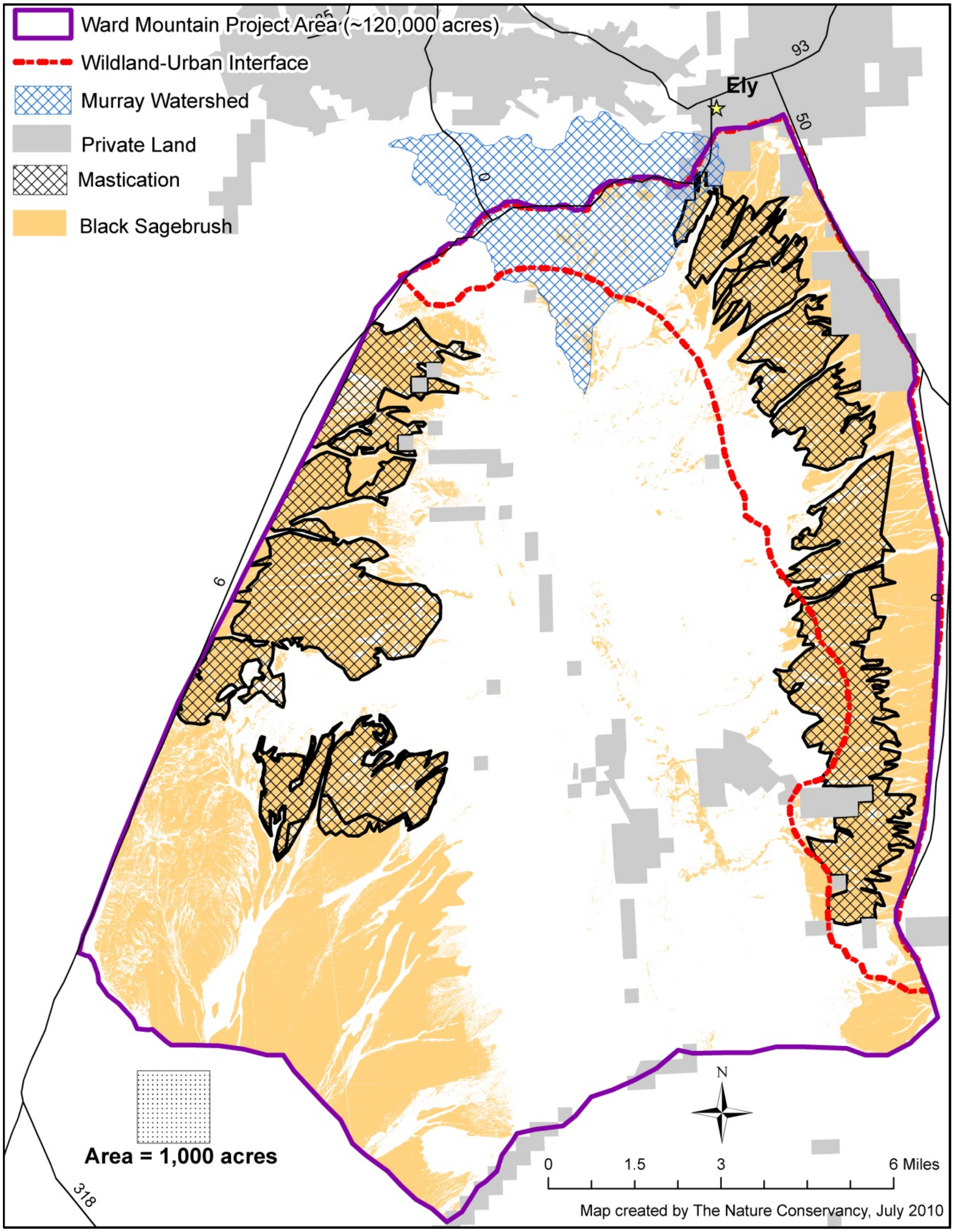


Figure 27. Late-succession wooded class (D) of black sagebrush in the Ward Mountain project area that is potential for treatment by mastication.

Aspen Thinning

Manual thinning of aspen-mixed conifer and aspen woodland was identified as a restoration strategy in the PREFERRED MANAGEMENT scenario. Thinning treatments in aspen-mixed conifer are within mid- and late-succession classes and create a diversity of early- and mid- succession classes of aspen after treatments. Manual thinning is the only strategy identified in the PREFERRED MANAGEMENT scenario for aspen woodland. Thinning is concentrated in late-succession classes and restores a mix of early- and mid- succession aspen woodland.

The PREFERRED MANAGEMENT scenarios outlined a total of 85 acres per year of aspen thinning for the first five years and 10 acres per year for years six through 20 (Table 29). Potential areas for treatment are mapped in Figure 28.

Table 29. Acres of aspen thinning in PREFERRED MANAGEMENT scenarios for aspen-mixed conifer and aspen woodland in the Ward Mountain project area.

Ecological System	Acres/year	Cost/year	Years
Aspen-Mixed Conifer	75	$11,250	1-5
Aspen Woodland	10	$1,000	1-20

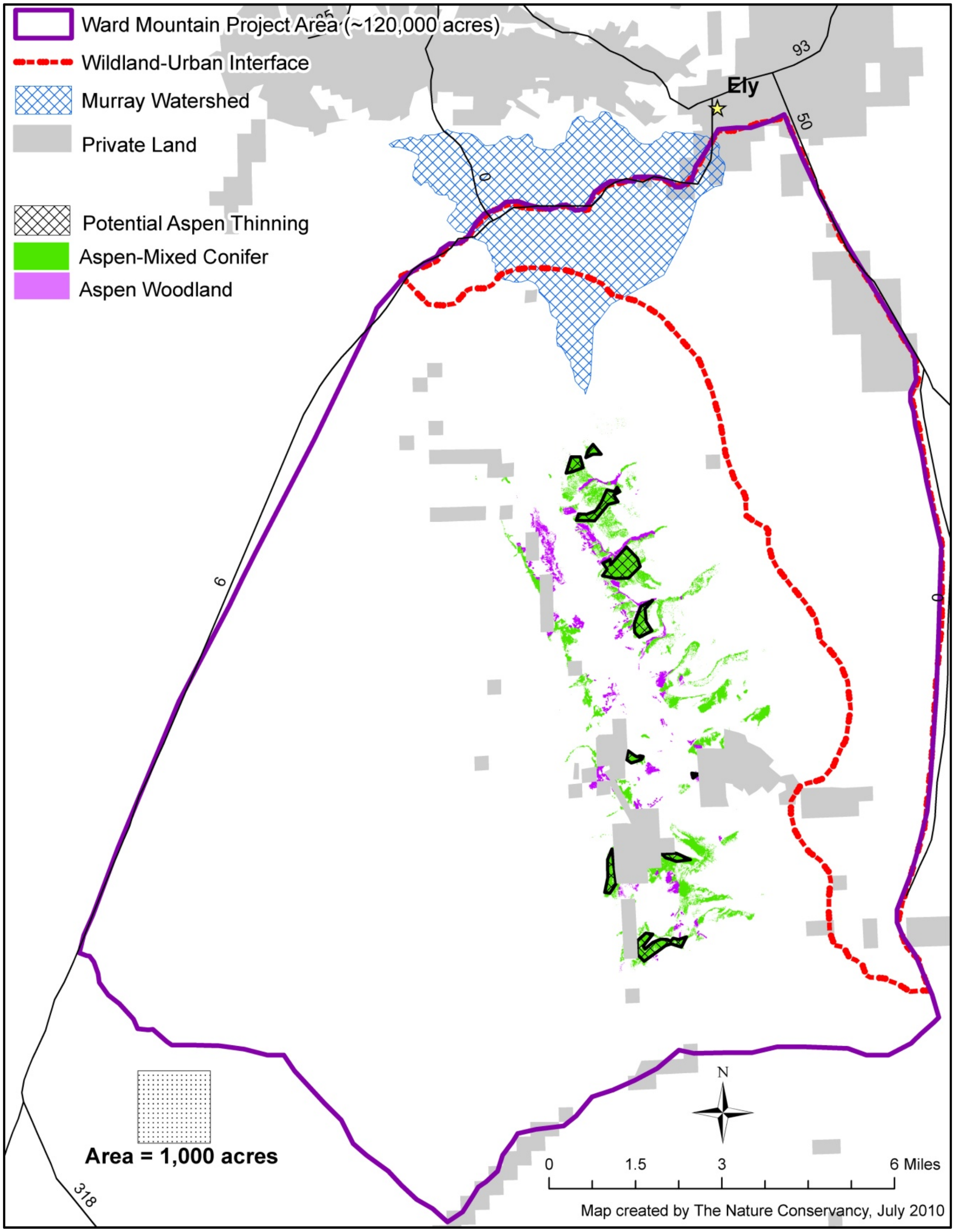


Figure 28. Potential areas for thinning in aspen-mixed conifer and aspen woodland in the Ward Mountain project area.

Control of Exotic Forb Species

In addition to restoring or preventing cheatgrass, herbicides are used to treat exotic forb species (i.e., ExF Restoration). Restoration of vegetation invaded by exotic forbs was identified in the PREFERRED MANAGEMENT scenario for the montane-subalpine riparian system in the Ward Mountain project area. Strategies for controlling exotic forb species include:

1. *Weed inventory.* Periodic weed inventory is conducted in all classes of the montane-subalpine riparian ecological system. Treatment of exotic forb species detected during the inventory is conducted on the spot (e.g., removal, herbicide).
2. *Exotic forb control.* Control of exotic forb species through herbicide application (i.e., ExF restoration).

The exotic forb (ExF) vegetation class was not currently present in montane-subalpine riparian within the Ward Mountain project area. MINIMUM MANAGEMENT scenarios forecast an increase to 6% of the total system being represented by complete transition to exotic forbs (ExF) if left untreated over the next 20 years. The PREFERRED MANAGEMENT scenario identified five acres a year of weed inventory, with one acre a year being treated for exotic forbs ($510 per year for both actions). This effort is forecasted to effectively control the presence of exotic forb class (ExF) in montane-subalpine riparian within the Ward Mountain project area (i.e., 0% transitioned to exotic forbs in 20 years via the PREFERRED MANAGEMENT scenario).

Temporary Fencing in Montane-Subalpine Riparian

Temporary fencing in montane-subalpine riparian was identified as a strategy to support recruitment and establishment of early-, mid- and late-succession classes of the montane-subalpine riparian system. Twenty acres a year are fenced under the PREFERRED MANAGEMENT strategy at a cost of $4,000 per year for twenty years. All classes of vegetation receive fencing since they are usually patchily dispersed within the riparian zone.

Conclusions

The key findings of the Ward Mountain Restoration Project ecological assessment and landscape strategy follow:

1. **The approximately 120,000 acre Ward Mountain project area is a largely unfragmented landscape that includes a diversity of Great Basin ecological systems, ranging from desert shrublands to ancient bristlecone pines.** Recent major fires and invasive species such as cheatgrass have not yet overtaken and highly altered most of the area, as they have done elsewhere in the Great Basin. Lower elevations on the western slopes are invaded by cheatgrass.
2. **The current condition of the Ward Mountain ecological systems varies in terms of departure from their NRV.** Of the area's 19 ecological systems, five are slightly departed from their natural range of variability, ten are moderately departed, and four are highly departed.
3. **The primary cause of high departure is that the sagebrush systems are significantly lacking the earliest succession classes.** For example, black sagebrush comprises almost 47,000 acres, almost 40% of the project area. There is virtually no presence of the early succession classes and is dominated by late-succession classes. In addition, a large portion is depleted of native grasses and forbs and conifer tree species have encroached upon the native sagebrush.
4. **Ten ecological systems require special attention.** Four of the targeted systems are highly departed from NRV and six are moderately departed. Eight of the targeted systems have, or are projected to have, an undesirable percentage of High-Risk Vegetation Classes. Key ecological management issues includes:
    - ***Sagebrush systems*** – lack of early succession classes, diminished herbaceous cover, pinyon-juniper encroachment, and increasing cover of cheatgrass within shrublands.
    - ***Aspen systems*** -- high percentage of vegetation on a pathway of conversion to conifers or loss of aspen clones.
    - ***Riparian*** -- entrenched streams or dominance by associated uncharacteristic species (e.g. Wood's rose or sagebrush).
5. **Varied 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 ecosystems;**
    - ***Sagebrush*** strategies include: prescribed fire; chainsaw lopping of young encroached conifer trees; mechanical thinning of late succession classes or tree-encroached sagebrush, combined with seeding of native species; restoration of depleted sagebrush through mowing and seeding of native species; mowing and

herbicide application in shrublands with both perennial and annual grasses; herbicide application combined with seeding to treat annual grasses

- ***Aspen*** strategies include: prescribed fire and mechanical thinning to prevent the permanent transition (loss of the aspen clone) to mixed conifer or montane sagebrush steppe.
- ***Riparian*** strategies include: continued weed inventory and spot application of herbicides, as well as temporary exclosure fencing.

6. **The PREFERRED MANAGEMENT scenarios significantly reduced Ecological Departure for all ten focal systems -- as compared to current condition and/or minimum management scenarios, and achieved low Ecological Departure for five systems. Moreover, the preferred management strategies reduced or contained High-Risk Vegetation Classes for all ten systems.**
7. **The PREFERRED MANAGEMENT scenarios accrued the highest "return on investment" for all systems, as compared to the MAXIMUM MANAGEMENT scenario.** However, in many cases the MAXIMUM MANAGEMENT scenarios would achieve even greater ecological benefits if additional management funds were to become available. TNC's area-weighted return on investment analysis showed that across the ten ecological systems, the greatest predicted ecological benefits per dollar invested would accrue to aspen-mixed conifer and the sagebrush systems.

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Literature Cited

Anderson, J. E., Inouye, R. S., 2001. Landscape-scale changes in plant species abundance and biodiversity of a sagebrush steppe over 45 years. Ecological Monographs 71: 531-556.

Arno, S. F., Wilson, A. E., 1986. Dating past fires in curlleaf mountain-mahogany communities. Journal of Range Management 39: 241-243.

Barrett, T.M, 2001. Models of vegetation change for landscape planning: a comparison of FETM, LANDSUM, SIMPPLLE, and VDDT. Gen. Tech. Rep. RMRS-GTR-76-WWW. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 14 p.

Bartos, D. L. and R. B. Campbell, Jr. 1998. Decline of Quaking Aspen in the Interior West – Examples from Utah. Rangelands, 20: 17-24.

Beever, E. A., Tausch, R. J., Brussard, P. F., 2003. Characterization grazing disturbance in semiarid ecosystems across broad scales, using diverse indices. Ecological Applications 13, 119-136.

Bestelmeyer, B. T., Brown, J. R., Trujillo, D. A., Havstad, K. M., 2004. Land management in the American Southwest: a state-and-transition approach to ecosystem complexity. Environmental Management 34: 38-51.

Beukema, S. J., Kurz, W. A., Pinkham, C. B., Milosheva, K., Frid, L., 2003. Vegetation Dynamics Development Tool, User's Guide, Version 4.4c. Prepared by ESSA Technologies Ltd.. Vancouver, BC, Canada, 239 p.

Biondi, F., T.J. Kozubowski, A.K. Panorska, and L. Saito. 2007. A new stochastic model of episode peak and duration for eco-hydro-climatic applications. Ecological Modelling 211:383-395.

Blackburn, W. H., Tueller, P. T., 1970. Pinyon and juniper invasion in black sagebrush communities in east central Nevada. Ecology 51: 841-848.

Blaisdell, J. P. and Holmgren, R. C., 1984. Managing Intermountain rangelands – salt-desert shrub ranges. Gen. Tech. Rep. INT-163. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 52 p.

Brown, J. H., McDonald, W., 1995. Livestock grazing and conservation of southwestern rangelands. Conservation Biology 9: 1644-1647.

Brussard, P. F., Murphy, D. D., Tracy, C. R., 1994. Cattle and conservation biology: another view. Conservation Biology 8: 919-921.

Carey, J. H., 1995. Krascheninnikovia lanata. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [accessed 2010, July 27].

Curtin, C. G. Brown, J. H., 2001. Climate and Herbivory in Structuring the Vegetation of the Malpai Borderlands. In C. J. Bahre and G. L. Webster (Editors). Vegetation and Flora of La Frontera: Vegetation Change Along the United States-Mexico Boundary. Albuquerque, NM: University of New Mexico Press. p. 84-94.

Debyle, N. V., Bevins, C. D., Fisher, W. C., 1987. Wildfire occurrence in aspen in the interior western United States. Western Journal of Applied Forestry. 2: 73-76.

Dobkin, D.S., 1998. Conservation and Management of Neotropical Migrant Land Birds in the Great Basin. University of Idaho Press, Moscow.

Fleischner, T. L., 1994. Ecological cost of livestock grazing in Western North America. Conservation Biology 8: 629-644.
Forbis T. A., Provencher, L., Frid, L., Medlyn, G., 2006. Great Basin land management planning using ecological modeling. Environmental Management 38: 62–83.
Freilich, J. E., Emlen, J. E., Duda, J. J., Freeman, D. C., Cafaro, P. J., 2003. Ecological effects of ranching: a six-point critique. BioScience 8: 759-765.
Frelich, L.E. and Reich, P.B., 1998. Disturbance severity and threshold responses in the boreal forest. Conservation Ecology [online] 2(2): 7. Available from the Internet. URL: http://www.consecol.org/vol2/iss2/art7/
Groves, C. R., The Nature Conservancy, 2003. Drafting a conservation blueprint: a practionner's guide to planning for biodiversity. Island Press, Washington, DC.
Hann, W. J., Bunnell, D. L., 2001. Fire and land management planning and implementation across multiple scales. International Journal of Wildland Fire 10: 389–403.
Hann, W.J., Shlisky, A., Havlina, D., Schon, K., Barrett, S., DeMeo, T., Pohl, K., Menakis, J., Hamilton, D., Jones, J., and Levelque, M., 2004. Interagency Fire Regime Condition Class Guidebook. Interagency and The Nature Conservancy fire regime condition class web site. USDA Forest Service, US Department of the Interior, The Nature Conservancy, and Systems for Environmental Management. Available at: www.frcc.gov.
Hardesty, J., Adams, J., Gordon, D., Provencher, L., 2000. Simulating management with models: Lessons from ten years of ecosystem management at Eglin Air Force Base. Conservation Biology in Practice 1: 26-31.
Herbel, C. H., 1986. Seeding shrubs in the field. Reclamation and Revegetation Research. 5:377-385.
Hilborn, R., Walters, C. J., Ludwig, D., 1995. Sustainable exploitation of renewal resources. Annual Review of Ecological Systems 26: 45-67.
Horn, H. S., 1975. Markovian Properties of Forest Successions. In: M. L. Cody and J. M. Diamond (Editors), Ecology and the Evolution of Communities. Cambridge, Mass.: Harvard University Press. p. 196-211.
Kay, C. E., 1997. Is aspen doomed? Journal of Forestry 95: 4-11.
Kay, C. E., 2001a. Evaluation of burned aspen communities in Jackson Hole, Wyoming. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 8 p.
Kay, C. E., 2001b. Long-term aspen exclosures in the Yellowstone ecosystem. Proceedings RMRS-P-18.. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.
Lilles, T. M., Kiefer, R. W., 2000. Remote Sensing and Image Interpretation. Fourth Edition, John Wiley & Sons, Inc., New York, NY. 763 pp.
Low, G., Provencher, L., and Abele, S.A., 2010. Enhanced conservation action planning: assessing landscape condition and predicting benefits of conservation strategies. Journal of Conservation Planning 6:36-60.
Mac, M. J., P. A. Opler, C. E. Puckett Haecker, and P. D. Doran, 1988. Great Basin-Mojave Desert Region. Status and Trends of the Nation's Biological Resources. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.
Margoluis, R., Salafsky, N., 1998 Measures of success: designing, managing, and monitoring conservation and development projects. Island Press, Washington, DC.

McIver, J., Starr, L., 2001. Restoration of degraded lands in the interior Columbia River basin: passive vs. active approaches. Forest Ecology and Management 15: 15-28.
McPherson, G. R., Weltzin, J. F., 2000. Disturbance and climate change in the United States/Mexico Borderland plant communities: a state of knowledge review. Ogden, UT: U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Technical Report RMRS-GTS-50. 20 p.
Melgoza, G, Nowak, R. S., Tausch, R. J., 1990. Soil water exploitation after fire: competition between *Bromus tectorum* (cheatgrass) and two native species. Oecologia 83: 7-13.
Miller, R. F., Rose, J. A., 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management 52: 550-559.
Miller, R. F., Tausch, R. J., 2001. The role of fire in juniper and pinyon woodlands: a descriptive analysis. Proceedings: The First National Congress on Fire, Ecology, Prevention, and Management; Nov. 27- Dec. 1, 2000; San Diego, CA. Tallahassee, FL: Tall Timbers Research Station, Miscellaneous Publication 11. p. 15-30.
Mozingo, H. N., 1987. Shrubs of the Great Basin: A natural history. Reno, NV: University of Nevada Press. 342 p.
Mueggler, W. F., 1988. Aspen Community Types of the Intermountain Region. USDA Forest Service, General Technical Report INT-250. 135 p.
Nachlinger, J., Sochi, K., Comer, P., Kittel, G., Dorfman, D., 2001. Great Basin: an ecoregion-based conservation blueprint. The Nature Conservancy, Reno, NV. 160 pp + appendices.
National Research Council, 1994. Rangeland Health: New Methods to Classify, Inventory, and Monitor Rangelands. Washington, D.C.: National Academy Press.
Pavek, D. S., 1992. Halogeton glomeratus. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [accessed 2010, July 27].
Provencher, L., Campbell, J., Nachlinger, J., 2008. Implementation of mid-scale fire regime condition class mapping. International Journal of Wildland Fire 17: 390-406.
Provencher, L., Forbis, T.A., Frid, L., Medlyn, G., 2007. Comparing alternative management strategies of fire, grazing, and weed control using spatial modeling. Ecological Modelling 209: 249-263, doi:10.1016/j.ecolmodel.2007.06.030
Provencher, L., Low, G., Abele, S.L., 2009. Bodie Hills conservation action planning: final report to the Bureau of Land Management Bishop field office. The Nature Conservancy, Reno, NV.
Pyne, S. J., 2004. Pyromancy: reading stories in the flames. Conservation Biology 18: 874-877.
Ross, C., 1999. Population Dynamics and Changes in Curlleaf Mountain Mahogany (*Cercocarpus ledifolius* Nutt.) in Two Adjacent Sierran and Great Basin Mountain Ranges. PhD. Dissertation, University of Nevada, Reno.
Schmidt, K. M., Menakis, J. P., Hardy, C. C., Hann, W. J., Bunnell, D. L., 2002. Development of coarse-scale spatial data for wildland fire and fuel management. General Technical Report, RMRS-GTR-87. Fort Collins, CO.: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Schultz, B. W., Tausch, R. J., Tueller, P. T., 1996. Spatial relationships among young *Cercocarpus ledifolius* (curlleaf mountain mahogany). Great Basin Naturalist 56: 261-266.
Steel, R. G. D., Torrie, J. H., 1980. Principles and procedures of statistics. Second edition. McGraw-Hill, New York, USA.
Tausch, R. J., Wigand, P. E., Burkhardt, J. W., 1993. Viewpoint: Plant community thresholds, multiple steady states, and multiple successional pathways: legacy of the Quaternary? Journal of Range Management 46: 439-447.
Tausch, R. J., Nowak, R. S., 1999. Fifty years of ecotone change between shrub and tree dominance in the Jack Springs Pinyon Research Natural Area. USDA, Forest Service Proceedings RMRS-P-00.
U.S. General Accounting Office, 1993. Livestock grazing on western riparian areas. Page 44. U.S. General Accounting Office, Gaithersburg, MD.
USDA Natural Resources Conservation Service, 2003. Ecological site descriptions for Nevada. Technical Guide Section IIE. MLRAs 28B, 28A, 29, 25, 24, 23. Nevada State Office, Reno, NV.
Walters, C. J., Holling, C. S., 1990. Large-scale management experiments and learning by doing. Ecology 71: 2060-2068.
West, N. E., Yorks, T. P. 2002. Vegetation responses following wildfire on grazed and ungrazed sagebrush semi-desert. Journal of Range Management 55, 171-181.
Westoby, M., Walker, B. H., Noy-Meir, I., 1989. Opportunistic management for rangelands not at equilibrium. Journal of Range Management 42: 266-274.
Wilhere, G. F., 2002. Adaptive management in habitat conservation plans. Conservation Biology 16, 20-29.
Wuerthner, G., Matteson, M. (Editors), 2002. Welfare Ranching: The subsidized Destruction of the American West. Washington, DC: Island Press. 346 p.
Young, J. A., Evans, R. A., Eckert, Jr., R. E., Kay, B. L., 1987. Cheatgrass. Rangelands 9: 266-270.
Young, J. A., Sparks, B. A., 2002. Cattle in the Cold Desert. Expanded edition. University of Nevada Press, Reno, NV, USA 317 p.

Appendices

Appendix 1. Descriptions of vegetation classes of biophysical settings for Ward Mountain.

Class Code&	Class abbreviation and brief description
	Alpine 1144
A	*Early*: 0-10% cover of graminoids; <90% soil cover; 0-2 yrs
B	*Late-closed:* >11% cover of graminoids and forbs; <10% cover of low shrubs; >2 yrs
U	na
	Aspen-Mixed Conifers (merged with aspen-subalpine conifers) 1061
A	*Early*; 0-100% cover aspen <5m; mountain snowberry and *ribes* common; 0-19 yrs
B	*Mid*1-*closed*: 40-99% cover aspen <5-10m; mountain snowberry and *ribes* common; 11-39 yrs
C	*Mid*2-*closed*: 40-99% cover aspen 10-24m; conifer saplings visible in mid-story; mountain snowberry and *ribes* common; 40-79 yrs
D	*Late*1-*open*: 0-39% cover aspen 10-25 m; 0-25% mixed conifer cover 5-10 m; mountain snowberry and *ribes* common; >80 yrs
E	*Late*1-*closed*: 40-80% cover of mixed conifer 10-50m; <40% cover of aspen 10-25m; mountain snowberry and *ribes* present; >100 yrs
U	*NAS-closed (No Aspen)*: 35-90% cover of mixed conifers 10-49m; mountain snowberry and *ribes* present; conifer litter abundant
	Aspen Woodland 1011
A	*Early*; 0-100% cover of aspen <5m tall; 0-9 yrs
B	*Mid*1-*closed*; 40-99% cover of aspen <5-10m; 10-39 yrs
C	*Late*1-*closed*; 40-99% cover of aspen 10-25m; few conifers in mid-story; >39 yrs
D	*Late*1-*open*; 0-39% cover of aspen 10-25 m; 0-25% conifer cover 10-25 m; >99 yrs
U	*DPL-Open*: 10-50% cover of older aspen 10-25m; no or little aspen regeneration; few conifers in mid-story
U	*NAS(No Aspen)-all*: Very few aspen stems present; dead clone of aspen, dead boles may be visible on the ground; 5-50% cover of mountain sagebrush/mountain shrub; <50% herbaceous cover
U	*Uncharacteristic*: includes several uncharacteristic NAS classes as observed in montane sagebrush steppe biophysical setting (see 1126)
	Basin Wildrye 1080bw
A	*Early*: 0-20% cover of basin wildrye; 0-10 yrs
B	*Mid--Closed*: 21-80% cover of basin wildrye; <11% shrub cover; 11-75 yrs
C	*Late*-*Open*: 11-20% cover of big sagebrush & rabbitbrush; <75% cover of basin wildrye; >75 yrs
U	*DPL*; Depleted; >20% cover of native shrubs; <5% basin wildrye; >20% mineral soil and litter cover
U	*ShAG*; Shrub-Annual-Grass; >10% cover of native shrubs; 0-30% basin wildrye; 5-30% cover of cheatgrass
U	*AG*: Annual-Grass; 5-40% cover of cheatgrass
U	*TrEnc*: Tree-Encroached; 10-40% cover of conifers; <10% herbaceous cover
U	*TrAG*: Tree-Annual-Grass; 10-40% cover of conifers; 5-20% cover annual grasses

Class Code[&]	Class abbreviation and brief description
U	*EXF*: Exotic-Forbs; 5-100% exotic forbs (knapweed, tall whitetop, purple loosestrife)
U	*ESH*: *Early*-Shrub; >20% cover of rabbitbrush species; native grasses present
	Black Sagebrush (merged semi-desert [uncommon] & upland [frequent]) 1079an
A	*Early*: <10% cover rabbitbrush; 10-40% cover of grass; <50% cover mineral soil; 0-25 yrs
B	*Mid*1-*open*: 10-20% cover of black sagebrush and rabbitbrush; 10-30% grass cover; <40% cover of mineral soil; 25-119 yrs
C	*Late1-Open*: 1-10% pinyon-juniper sapling cover; 20-30% cover of black sagebrush; 10-30% cover of grasses; 120-194 yrs
D	*Late*1-*Closed*: 10-40% cover of pinyon or juniper 5-10m high; <10% black sagebrush cover; <10% grass cover; >195 yrs
E	*Mid-Open*: animal burrow; 20-80% cover of mineral soil and rocks; <20% cover of winter fat, Indian ricegrass, spiny hopsage, and salt bushes; 0-999yrs
U	*ESH*: *Early*-Shrub;10-40% cover rabbitbrush species
U	*TrEnc*: Tree-Encroached; >40% pinyon or juniper cover 5-10m; <5% shrub cover; <5% herbaceous cover
U	*DPL*: Depleted; 20-50% cover of black sagebrush; <5% herbaceous cover; <10% pinyon or juniper sapling cover
U	*ShAP*: 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	*ShAG*: 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	*AG:* Annual-Grass; 10-30% cover of cheatgrass
U	*SENN*: Seeded-Non-Native; Seeded-Non-Native; native or non-native (crested wheatgrass, forage koshia) seed mix cover 5-20%
	Limber-Bristlecone Pine Woodland 1020
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	*Mid1-Open*: 11-30% limber and bristlecone pine cover 5-10m high, abundant mineral soil or talus cover; sparse ground cover; 100-249 yrs
C	*Late1-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
U	Na
	Limber-Bristlecone Pine Woodland – mesic 1020m
A	*Early*: 0-10% limber and bristlecone pine cover 0-5m high, abundant soil or talus; *Ribes* and *P*oa present; 0-49 yrs
B	*Mid1-Open*: 11-20% limber and bristlecone pine cover 5-10m high; *Ribes* and *P*oa present; 50-199 yrs
C	*Late1-Closed*; old trees but not ancient; 20-40% limber and bristlecone pine cover 5-25m high; *Ribes* and *P*oa present; >200 yrs
U	Na
	Low Sagebrush 1079aa
A	*Early*: 0-10% cover of rabbitbrush and grasses; 0-24 yrs
B	*Mid*1-*open*: 11-20% cover of low sage <0.5m; 25-119 yrs

Class Code[&]	Class abbreviation and brief description
C	*Late*1-*open*: cover of trees 0-5% <5m; 10-25% cover of low sage, 5-20% herbaceous cover; >120 yrs
U	*ShAG*: Shrub-Annual-Grass; 5-20% cover of low sage <0.5m, 0-15% cheatgrass cover; >25 yrs
U	*AG*: Annual-Grasses; 5-20% cheatgrass cover
U	*TrEnc*: Tree-Encroached; 6-30% cover of trees; <5% herbaceous cover; >200 yrs
U	*SENN*: Crested-Wheatgrass-Monoculture; 10-40% cover of crested wheatgrass
	Low Sagebrush Steppe (8,500 - 9,850+ ft) 1124
A	*Early*: 15-25% herbaceous cover (bluebunch wheatgrass, Thurber's needlegrass); 0-10% cover of rabbitbrush; 0-25 yrs
B	*Mid*1-*open*: 11-20% cover of low sagebrush and mountain snowberry; 15-25% herbaceous cover (bluebunch wheatgrass, Thurber's needlegrass); 25-99 yrs
C	*Late1-Closed*: 21-30% cover of low sagebrush and Utah serviceberry; 10-15% herbaceous cover (bluebunch wheatgrass); >100 yrs
U	*Na*
	Mixed Conifer 1052
A	*Early*; 0-29yrs; 0-15% cover of tree/shrub/grass; <5m; 0-29 yrs
B	*Mid*1-*closed*; 30-99yrs; 35-100% cover of conifers <24m; 30-99 yrs
C	*Mid*1-*open*; 31-99yrs; 0-35% cover of conifers <24m; 30-99 yrs
D	*Late*1-*open*; 100-999yrs; 0-35% cover of conifers 25-49m; >100 yrs
E	*Late*1-*closed*; 100-999yrs; 35-100% cover of conifers 25-49m; >100 yrs
U	Na
	Montane-Subalpine Riparian (merged with 1160 subalpine-upper montane riparian) 1154
A	*Early*: 0-50% cover of cottonwood, willow, Wood's rose <3m; carex present; 0-5 yrs
B	*Mid*1-*open*: 31-100% cover of cottonwood, aspen, willow, Wood's rose <10m; 5-20 yrs;
C	*Late*1-*closed*; 31-100% cover of cottonwood, alder, aspen, willow 10-24m; >20 yrs
U	*SFEnc*: Shrub-Forb-Encroached; 10-50% cover of Wood's rose in open areas or under tree canopy
U	*EXF*: Exotic-Forbs; 20-100% cover of exotic forbs (knapweed, tall whitetop, purple loosestrife), salt cedar, or Russian olive
U	*DES*: Desertification; Entrenched river/creek with 10-50% cover of upland shrubs (e.g., big sage)
U	*AG*: Annual-Grass; 10-30% cover of cheatgrass on dry incised banks; < 10% shrub cover
	Montane Sagebrush Steppe upland (<9,500 ft) 1126u

Class Code[&]	Class abbreviation and brief description
A	*Early*: 0-10% canopy of mountain sage/mountain brush; 10-80% grass/forb cover; 0-12 yrs;
B	*Mid--open*: 11-30% cover of mountain sage/mountain shrub; >50% herbaceous cover; 13-38 yrs
C	*Mid--closed*; 31-50% cover of mountain sage/mountain brush; 25-50% herbaceous cover, <10% conifer sapling cover; 38+ yrs
D	*Late-open*: 10-30% cover conifer <5m for PJ and <10m for mixed conifers; 25-40% cover of mountain sage/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	*ESH*: *Early*-Shrub;20-50% cover rabbitbrush species
U	*TrEnc*: Tree-Encroached; 31-80% conifer cover 10-25m; <5% shrub cover; <5% herbaceous cover, <20% cheatgrass cover; >140 yrs
U	*DPL*: Depleted; 20-50% cover of mountain sage/mountain brush; <5% herbaceous cover; <10% conifer sapling cover; >50 yrs
U	*ShAP*: Shrub-Annual-Grass-Perennial-Grass; 21-50% cover of mountain sage/mountain brush; >5% cover of native grass; 5-10% cheatgrass cover; <10% conifer sapling cover; >50 yrs
U	*AG:* Annual-Grass; 10-30% cover of cheatgrass
	Montane Sagebrush Steppe mountain (≥9,500 ft) **1126m**
A	*Early*: 0-10% canopy of mountain sagebrush/ mountain brush, >50% grass/forb cover; ; 0-12 yrs;
B	*Mid--open*: 11-30% cover of mountain sagebrush / mountain shrub, >50% herbaceous cover; 13-37 yrs;
C	*Mid--closed*; 31-50% cover of mountain sagebrush / mountain brush, 25-50% herbaceous cover, <10% conifer sapling cover; >38 yrs
D	*Late-open*: 10-30% cover conifer <10m, 25-40% cover of mountain sagebrush / mountain brush, <30% herbaceous cover, 80-129 yrs
E	*Late-closed*: 31-80% conifer cover 10-25m, 6-20% shrub cover, <20% herbaceous cover; >129 yrs
U	*ESH*: *Early*-Shrub; 0-40% cover rabbitbrush species
U	*TrEnc*: Tree-Encroached; 31-80% conifer cover 10-25m, <5% shrub cover, <5% herbaceous cover; >130 yrs
	Montane Sagebrush Steppe – mountain shrub **1126ms**
A	*Early*: 0-10% canopy of Utah snowberry/antelope bitterbrush; 10-80% grass/forb cover; 0-12 yrs
B	*Mid--open*: 11-30% cover of Utah snowberry/antelope bitterbrush; >50% herbaceous cover; 13-38 yrs
C	*Mid--closed*: 31-50% cover of Utah snowberry/antelope bitterbrush/mountain big sagebrush; 25-50% herbaceous cover, <10% conifer sapling cover; 38+ 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; 80-129 yrs
U	*ESH*: *Early*-Shrub; 20-50% cover rabbitbrush species
U	*TrEnc*: Tree-Encroached; >21% pinyon pine-white fir cover 10-25m; <5% shrub cover; <5% herbaceous cover

Class Code[&]	Class abbreviation and brief description
U	*DPL*: Depleted; 20-50% cover of Utah snowberry/antelope bitterbrush/mountain big sagebrush; <5% herbaceous cover; <10% pinyon sapling cover
U	*ShAP*: 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	*AG:* Annual-Grass; 10-30% cover of cheatgrass
	Mountain Mahogany 1062
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*1-*Closed*: 30-45% cover of mountain mahogany, mountain sagebrush, snowberry, and mountain snowberry 2-5m high; 60-59 yrs
C	*Mid*1-*Open*: 0-30% cover mountain mahogany 2-5m; mineral soil abundant; grasses and mountain sagebrush, snowberry, and mountain snowberry common; 20-59 yrs
D	*Late*1-*Open*: 0-30% cover of mountain mahogany 5-25m; grasses and mountain sagebrush, snowberry, and mountain snowberry common; >60 yrs
E	*Late*1-*Closed*: 30-55% cover of mountain mahogany, 5-25m; >49 yrs;
U	*TrAG*: Tree-Annual-Grass; 10-55% cover of mountain mahogany; 5-20% cheatgrass cover
U	*AG*: Annual-Grasses; 5-30% cheatgrass cover
	Pygmy Sagebrush 1080p
A	*Early-open*: 1-10% herbaceous cover; badland soil >90% cover, sometimes very bright
B	*Mid*1-*open*: <20% pygmy sage <0.25m; badland soil >80%
U	*Not known*
	Pinyon-Juniper mesic 1019
A	*Early-open*: 5-20% herbaceous cover; 0-9 yrs
B	*Mid*1-*open*: 11-20% cover big sage or black sage <1.0m; 10-40% herbaceous cover; 10-29 yrs
C	*Mid*2-*open*; 11-30% cover of pinyon and/or juniper <5m; 10-40% shrub cover; <20% herbaceous cover; 30-99 yrs
D	*Late*1-*open*: old growth, 31-50% cover of pinyon and/or juniper <5m-9m; 10-40% shrub cover; <20% herbaceous cover; >99 yrs
U	*TrAG*: Tree-Annual-Grass; 31-50% cover of pinyon and/or juniper <5m-9m; 10-40% shrub cover; <20% cheatgrass cover
U	*AG*: Annual-Grasses; 5-30% cheatgrass cover
U	*SEN*; Seeded-Native; herbaceous cover 5-20%; native seed mix for post-fire emergency rehabilitation
	Subalpine Mesic Spruce-Fir 1056
A	*Early*: 0-100% cover of Engelmann spruce seedling/shrub/grass <5m; 0-39 yrs
B	*Mid*1-*closed*: 40-100% cover of Engelmann spruce and aspen 5-24m; 40-129yrs
C	*Mid*1-*open*: 0-40% cover of Engelmann spruce 5-24m pole size; ; 40-129yrs

Class Code&	Class abbreviation and brief description
D	*Late*1-*closed*: 40-100% cover of Engelmann spruce 25-49m; >129 yrs
U	Na
	Wet Meadow 1145wm
A	*Early*-open: 0-60% herbaceous cover — mostly graminoids; 0-2 yrs
B	*Mid*--closed: 61-100% herbaceous cover — mostly graminoids; 3-22 yrs
C	*Late*-open: 0-10% tree-shrub (aspen, willow, Wood's rose, sagebrush), cover; 60-80% herbaceous cover — mostly graminoids; >22 yrs
U	*SFEnc-All*: Shrub-Forb-Encroached; >10%% cover of less palatable grasses and forbs (e.g., *Iris missouriensis*); OR >10% shrub cover; bare ground cover 10-30% cover
U	*EXF*: Exotic-Forbs; 20-100% exotic forbs (knapweed, tall whitetop, purple loosestrife)
U	*DES*: Desertification; Entrenched water table with 10-50% cover of sagebrush
U	*AG*: Annual-Grass; 10-30% cover of cheatgrass; < 10% shrub cover
U	*TrEnc*: Tree-Encroached; 31-80% conifer cover 10-25m; <5% shrub cover; <5% herbaceous cover
	Winterfat 1081wf
A	*Early*: 10-30% Indian ricegrass, squirreltail, other native grasses, 0-5% cover of rabbitbrush, snakeweed, and other salt desert shrubs; <60% mineral soil, <0.5m; 0-49 yrs
B	*Mid1*-open: 5-20% cover winterfat, rabbitbrush, and other desert shrubs <0.5m, 10-20% native grass cover; 50-149 yrs
C	*Late1-closed:* >20% cover winterfat, rabbitbrush, and other salt desert shrubs; 5-20% grass cover;<0.5m; *>150 yrs*
U	*ShAG*: Shrub-Annual-Grass; 5-20% cover of winterfat or other shrubs <0.5m, 5-20% cheatgrass cover
U	*AG*: Annual-Grasses; 5-30% cheatgrass cover
U	*EXF:* >5% cover halogeton, <10% cover of cheatgrass, >50% mineral soil
U	*SENN*: Seeded-Non-Native; Seeded-Non-Native; native or non-native (crested wheatgrass, forage koshia) seed mix cover 5-20%
	Wyoming Big Sagebrush (merged semi-desert [rare] and upland [frequent]) 1080
A	*Early*: 20-40% herbaceous cover, <10% cover of rabbitbrush species and Wyoming big sagebrush; 0-19 yrs
B	*Mid*1-*open*: 11-20% cover Wyoming big sagebrush, 10-40% herbaceous cover; 20-59 yrs
C	*Late*1-*closed:* 20-40% cover of Wyoming big sagebrush; <20% native herbaceous cover; 60-99 yrs
D	*Late*2-*open*: 0-10% pinyon or juniper <5m tall, 20-30% cover of Wyoming big sagebrush; <10% native herbaceous cover; 100-149 yrs
E	*Late*2-*closed*: 11-60% pinyon or juniper <10m tall, 10% cover of Wyoming big sagebrush; <10% native herbaceous cover; >150 yrs
U	*ShAG*: Shrub-Annual-Grass; 10-30% Wyoming big sagebrush <0.5m, 5-30% cover cheatgrass; >10 yrs

Class Code[&]	Class abbreviation and brief description
U	*AG*: Annual-Grass; 10-40% cover of cheatgrass
U	*TrEnc*: Tree-Annual-Grass; 11-60% cover of trees 5-9m, <20% cheatgrass cover; >125 yrs

Appendix 2. Description of ecological model dynamics for Ward Mountain, NV.

Non-spatial state-and-transition models of ecological systems were created with the software Vegetation Dynamics Development Tool (VDDT from ESSA Technologies, Ltd.; Barrett 2001; Beukema et al., 2003; Forbis et al., 2006). In VDDT, succession and disturbance are simulated in a semi-Markovian framework. Each vegetation state has one possible deterministic transition based on time in the state (usually succession) and several possible probabilistic transitions (natural and management). Each of these transitions has a new destination state and probability associated with it. Based on the timing of the deterministic transition and the probabilities of the stochastic transitions, at each time step a pixel may remain the same, undergo a deterministic transition based on elapsed time in the current state or undergo a probabilistic transition based on a random draw (for example, replacement fire). Model parameters (succession duration and disturbance rates) are presented in Appendix 5.

Ecological System State-and-Transition Models

State-and-transition models for the 21 mapped ecological systems were created. Appendix 1 represents the different states, phases, and their abbreviations for each ecological system. Most of the ecological systems identified by interpretation of satellite imagery were common in the Great Basin. The montane sagebrush steppe model was split between upland sites (<9,500 feet) and mountain sites ≥9,500 feet. Mountain sites are not invaded by cheatgrass and can be encroached by mixed and subalpine conifers.

All models had at their core the LANDFIRE reference condition represented by some variation around the A-B-C-D-E classes. Essentially, this meant that models had an early development class and mid-development and/or late-development classes. Mid- and late-development classes may be expressed as open or closed canopy. Alpine was a two-box models that contained either the early and late-development class. The A-E class models simply represented succession from usually herbaceous vegetation to increasing woody species dominance where the dominant woody vegetation might be shrubs or trees. Stable and seral aspen, and curlleaf mountain mahogany started as woody dominated early-development vegetation, not herbaceous vegetation.

For the estimation of the natural range of variability (Table 2), only the A-E components of models were needed. However, for the models to also reflect the effects of management, uncharacteristic vegetation classes were added that represented different states that only exist because of direct or indirect human activity. For shrublands, typical uncharacteristic classes included:

- Sagebrush and winterfat (*Krascheninnikovia lanata*) shrublands with <5% (less productive vegetation) or <10% (more productive vegetation) cover of herbaceous understory (*Depleted* shrubland) that was created by historic livestock grazing, perhaps prior to the Taylor Grazing Act of 1934;
- Shrublands with >5% cover of cheatgrass with >5% cover of native grass (*Shrub-Annual Grass-Perennial Grass*) or ≤5% cover of native grass (*Shrub-Annual Grass*);
- Sagebrush shrubland where pinyon and juniper encroachment has been sufficiently long that native grass cover was <5% (less productive vegetation) or

<10% (more productive vegetation), sagebrush 'skeletons' were common, and trees were mostly conical and generally <125 years old (*Tree-Encroached*);

- Either tree encroached shrubland, or late-development pinyon-juniper or mountain mahogany woodlands with >5% cheatgrass cover (*Tree-Annual Grass*);
- Annual grasslands were the dominant cover is cheatgrass at >10% cover (*Annual Grass*) and generally the result of burning any vegetation class containing cheatgrass; and
- Shrubland dominated by early succession shrubs, such as rabbitbrush (*Early-Shrub*).

Wet meadows and riparian systems harbored more peculiar uncharacteristic vegetation classes. A common class reflecting historic grazing was the dominance of wet meadows and, sometimes, riparian corridors by native forbs and shrub species unpalatable to domestic sheep and cattle (*Shrub-Forb-Encroached*). This vegetation class often set the stage to entrenchment of stream banks or rivulets with future livestock access to water, although entrenchment could also be triggered by water diversions and creation of water retention ponds. The consequence of entrenchment was a drop of the water table, leading to a moist or wet system becoming a sub-xeric shrubland (*Desertification*). These wet to moist ecological systems are also prone to invasion by exotic forbs (*Exotic Forbs*), such as tall whitetop (*Lepidium latifolium*).

Seral and stable aspen were ecological systems with unique uncharacteristic vegetation classes that led to the loss of clones. Stable aspen clones that were dominated by old trees and moderately to widely open canopies with minimal aspen recruitment were considered depleted stands, often called decadent aspen (*Depleted*). Excessive herbivory from past and current uses coupled with lack of fire were generally the causes of depletion of aspen clones. In the ecological model, if intense herbivory and lack of disturbance continued, aspen clone died and became montane sagebrush steppe (*No-Aspen*) or uncharacteristic montane sagebrush steppe. The pathway of clone loss for seral aspen was very different. With lack of fire or other disturbances that removed conifers, or excessive herbivory that accelerated conifer succession, seral aspen became dominated by white fir in model forecasts. Continued dominance by white fir eventually resulted with death of the clone and a permanent establishment of a mixed conifer forest composed of five succession classes.

Four forest systems were modeled: mixed conifer comprised of white fir, subalpine spruce comprised of Engelmann spruce, limber-bristlecone pines (dry type with ancient trees), and limber-bristlecone pine-mesic. These systems have no uncharacteristic classes. Mixed conifer is a five-box model with one early succession phase and parallel closed (main pathway) and open mid- and late-succession phases. Subalpine spruce is composed of four boxes; the early-, mid-, and late-succession closed classes form the main linear pathway, with a mid-succession open class resulting from stand thinning. Both limber-bristlecone pine models are linear, slow growing three-box models. The late-succession class of the dry type can be ancient.

One ecological system was not modeled: pygmy sagebrush (*Artemisia pygmaea*). Occurrences were very small. Pygmy sagebrush is an uncommon and minuscule sagebrush species growing on badland soils, often with sparse and ancient juniper trees.

Natural Disturbances

In all models, any disturbance was quantified by a rate expressed as a probability per year. This rate is the inverse of the return interval of a disturbance or a frequency of spatial events. For example, a mean fire return interval of 100 years is equal to a rate of 0.01/year (0.01 = 1/100). The probability per year rate is used in VDDT because it has the very convenient property of being additive, whereas return intervals are not additive. This rate was further multiplied by proportions that partitioned the main rate in terms of success and failure outcomes, allocation of resources to realize different management objectives, or extent of application (for example, 5% of the ecological system was grazed at a rate of 1.0/year – livestock grazed every year, thus the return interval is 1 year). The rate that was ultimately used was the probability per year multiplied by proportions of allocation. Any rate, which is generally based on return intervals, is converted to a spatial draw per year as a necessary time for space substitution. Although VDDT is a non-spatial simulation software, the underlying process imitates temporal rates with virtual pixel draws. To pursue the fire return interval example, a probability per year of 0.01 means that 1 out of every 100 pixels on average receives fire within a year. Temporal multipliers described in the main text can be used to modify how many pixels are selected per year.

Fire was the primary stochastic disturbance in all vegetation types, except in alpine, limber-bristlecone pine, montane-subalpine riparian, and winterfat (Young and Sparks 2002). The duration of mean fire return intervals generally decreased with soil productivity or moisture (Table II-1). The mean fire return intervals represented natural fire regimes; these wildfire rates were modified by time series that reflected observed fire activity from the Ward Mountain and surrounding area. With the exception of aspen's mixed severity fire, replacement fire restarted the succession clock to age zero within the reference condition, which was labeled the *early development* class (a phase of the reference condition). The *early development* class represented a native condition of shrubland with a dominant cover of usually herbaceous species dominated by perennial cool-season bunch grasses and few shrubs. Replacement fire in vegetation classes that already experienced a threshold transition also caused a threshold transition to less desirable vegetation classes, such as *annual grassland, early shrub, no-aspen, or exotic forb* (Tausch et al., 1993; Frelich and Reich 1998; Tausch, 1999; Anderson and Inouye, 2001).

Table II-1. Fire return intervals of ecological systems.

Ecological System	Mean Fire Return Interval (years)[1]
Alpine	208
Basin Wildrye-Big Sagebrush	43
Limber-Bristlecone Pine	500
Low Sagebrush	250
Mixed Conifer	40
Montane Sagebrush Steppe	48
Montane-Subalpine Riparian	68
Mountain Mahogany	119

Mountain Shrub	48
Pinyon-Juniper Woodland	256
Seral Aspen	50
Stable Aspen	35
Spruce	300
Wet Meadow	42
Winterfat	>1,000
Wyoming Big Sagebrush-upland	118

[1]: The inverse of mean fire return interval is the probability per year used in VDDT models. The mean Fire Return Interval was obtained by simulating the reference condition for 500 years and 10 replicates. Temporal multipliers were not used to evaluate mean fire return interval, which would be different with the influence of temporal multipliers.

Other widespread natural disturbances in almost all models were *drought* or *insect/disease outbreaks* that cause stand replacing events (generally 10% of times) or stand thinning (90% of times). These two disturbances were generally different sides of the same coin: in most cases *drought* created tree and shrub mortality under the assumption that prolonged and decreased soil moisture weakened plants that might ultimately be killed by insects or disease. Therefore, mortality was not double-counted. In the case of aspen and mixed conifer, *insect/disease outbreak* was used because it played a distinctive role that was more prominent than *drought* for natural resource managers. A *drought* and *insect/disease outbreak* return interval rate of every 178 years (a rate of 0.0056/year) was used based on the frequency of severe drought intervals estimated by Biondi et al. (2007) from 2,300 years of western juniper (*Juniperus occidentalis)* tree ring data from the Great Basin. Although it was recognized that droughts may be more common than every 178 years, severe droughts, which were >7-year drought events with consecutive far-below average soil moisture (narrow tree rings), killed naturally drought resistant shrubs and trees. For vegetation classes in the reference condition, drought or insect/disease outbreak induced mortality either caused a transition to the early-development class, or a transition to the previous succession class or a reversal of woody succession within the same vegetation class.

Livestock grazing (*managed herbivory*) was also widespread and implicitly modeled in most ecological systems, but not mixed conifer, mountain mahogany, subalpine spruce, or limber-bristlecone pine. Workshop participants hypothesized that livestock grazing in the project area was based on best management practices and did not cause transitions between phases or states. Therefore, managed herbivory was included to cause no direct transition (but used for indirect dependencies). Ecological systems where livestock grazing was explicitly modeled were stable aspen, seral aspen, basin wildrye-big sagebrush, black sagebrush, montane sagebrush steppe, mountain shrub, wet meadow, montane-subalpine riparian, Wyoming big sagebrush, and winterfat. *Managed herbivory* was used at a rate (5% of pixels per year) to show that livestock grazed five percent of the ecological systems every year.

Other than managed herbivory, livestock grazing was expressed as a disturbance regime in two other forms: *excessive herbivory* and *grazing systems*. Whereas minimal effects of *managed herbivory* were hypothesized for the area, *excessive herbivory* and *grazing systems* were special cases with stronger effects. *Excessive herbivory* represented the case where livestock grazing was concentrated and prolonged enough to cause either a transition to less desirable vegetation classes (for example, *Early Shrub*) or accelerated woody succession within a phase of the reference condition. Cattle and sheep primarily grazed herbaceous vegetation during the spring and summer; therefore they generally increased the cover of woody vegetation, which was equivalent to accelerating succession (West and Yorks, 2002; Beever, et al. 2003). The yearly rate for *excessive herbivory* was 0.1%, which is low. (A rate of 0.1% meant that, on average, 1 out of 1,000 pixels per year were selected to experience *excessive herbivory*.) *Grazing systems* was expressed in the model as a management action by which livestock operators actively move livestock away from wet or sensitive ecological systems to reduce their use.

Two other forms of herbivory included:

- *Native herbivory* where browsing by deer, rodents, and rabbits of mountain mahogany seedlings maintained the early development class (Arno and Wilson, 1986; Schultz et al., 1996; Ross, 1999); and
- *Beaver-herbivory*, applied to montane-subalpine riparian, was considered a non-native disturbance as historical records showed that beaver was never noted or observed in the small drainages of the project area during European explorations and after settlement. *Beaver-herbivory* functioned as a rotating disturbance where beaver felled woody vegetation, left the creek reach, and only returned after substantial regrowth of aspen and willow had occurred, usually after 20-25 years. It was assumed that the effect of beaver decreased from early- to later-development vegetation classes (as little as 1/1,000 if the late-development class).

Other widespread natural disturbances with pivotal roles in simulations were *tree-invasion* (i.e., pinyon-juniper encroachment) and *annual grass-invasion*. Pinyon and juniper encroachment of shrublands was a time-dependent process because seedlings required mature shrubs, such as sagebrush and bitterbrush, for nurse plants. A standard rate of pinyon-juniper encroachment was 0.01/year (1 of 100 pixels per year) often starting in the late-development or uncharacteristic shrub-dominated vegetation classes of shrublands. This rate was chosen because it approximately replicated encroachment levels proceeding in three phases of 50-year each discussed by Miller and Tausch (2001).

Cheatgrass invasion affected all shrublands, and pinyon-juniper and mountain mahogany woodlands. Invasion started at the earliest in the mid-development classes and rates varied among ecological systems and sometimes among vegetation classes. A common low rate was 0.001/year (1 out of 1,000 pixels converted to a cheatgrass-invaded class per year) for low sagebrush, basin wildrye-big sagebrush, pinyon-juniper and mountain mahogany woodlands. The base rate of 0.001/year was estimated from data of northwest Utah collected by the Utah Division of Wildlife Resources in black sagebrush. Black sagebrush is usually considered more resistant to cheatgrass invasion than Wyoming big sagebrush. Because the BLM or USFS did not have similar data, the Utah data was selected by default. Rates were five times higher, although still low, for Wyoming big sagebrush, montane sagebrush steppe, the tree-encroached class of basin wildrye-big sagebrush, and winterfat. The higher rates for these latter systems indicate greater susceptibility to cheatgrass because soils were more productive.

Another important disturbance limited to montane-subalpine riparian, wet meadows, and basin wildrye-big sagebrush was the invasion of exotic forbs (*exotic-invasion*) represented mainly by tall whitetop and knapweeds (*Centaurea* spp.). The rate was moderate (0.01/year) for montane-subalpine riparian and basin wildrye-big sagebrush, but half that (0.005/year) for wet meadows. Differences in rates reflected the fact that montane-subalpine riparian and basin wildrye-big sagebrush where closer to or crossed by roadways and received heavier human activity, whereas wet meadow were generally more removed from major roadways.

Flooding was a disturbance restricted to montane-subalpine riparian. Three levels of *flooding* were 7-yr events (0.13/year) that killed or removed only herbaceous vegetation, 20-year events (0.05/year) that killed or removed shrubs and young trees, and 100-year events (0.01/year) that top-killed larger trees. Most flood events were stand replacing, but 20-year events in the late-development class thinned shrub and young trees without affected older trees.

Management Disturbances

Management activities included various mechanical treatments, controlled burning, seeding, prescribed sheep-grazing, floodplain restoration, weed inventory, fencing, and herbicide. Models contained more management activities than were actually employed in final simulations because all possibilities were explored with workshop participants. The rate of application of each management action was set by the area limit function of VDDT (Appendix 3and Appendix 4) that was reflective of management budgets and minimum treatments required to achieve objectives. Because area limits overrule rates, a default rate of 0.01 was used for all actions – another arbitrary rate could have been chosen; however, the proportional allocation of the area limit to different outcomes of the same management action was controlled by VDDT entries. Some outcomes represented failure rates for an action, such as when seeding failed and was replaced by cheatgrass. As a rule of thumb, management actions not followed by seeding were applied to reference states where the native perennial understory vegetation was present and was assumed to be releasable.

Most management actions applied to uncharacteristic states required seeding of native or, occasionally, introduced (crested wheatgrass, *Agropyron cristatum*) species because these states lost their native understory, and/or the understory was dominated by non-native exotic species. Herbicide Plateau® was also sprayed to control cheatgrass in addition to seeding. Chainsaw lopping of young pinyon and juniper trees was an exception as it did not require seeding and it was applied to uncharacteristic vegetation classes (and reference classes).

Controlled burning (RxFire) was only conducted in black sagebrush, both montane sagebrush steppe, and seral aspen to convert late-development into early-development vegetation. Workshop participants decided that 30% of the burn perimeter contained unburned areas. Cost per unit area increased with smaller burns.

Chainsaw lopping of young trees was a simple activity whose only purpose was to remove trees from Greater sage-grouse habitat, which was primarily late-development open vegetation classes in sagebrush systems. Generally, lopping consisted of felling trees and leaving them behind, perhaps for firewood or Christmas trees.

Fencing was used in montane-subalpine riparian. The sole purpose of fencing was to make an area inaccessible to livestock grazing for a temporary period of 3-5 years while palatable vegetation grew. Moreover, alternative water delivery systems would be supplied if fencing resulted in livestock losing access to drinking water. Fences were used for both recovery after fire and rest of older vegetation from livestock grazing when grazing system was not implemented for selected pixels.

Weed inventory, exotic-invasion, and *weed control* were coupled and complex control activities for *exotic forbs* in basin wildrye-big sagebrush, montane-subalpine riparian, and wet meadow. The most worrisome potential weed invasion were tall whitetop and thistles; while tall whitetop remains undetected in the project area, thistle are present and growing. Workshop participants adopted the northwest Utah approach to modeling weed detection and control because that reflected current procedures, although implementation rates varied. The starting point for weed management was a visit to all creeks, wet meadows, and loamy bottoms of the project area on a rotational basis. Initially, a rotation period of four years was proposed between visits based on current efforts. If a pixel was not selected for *weed inventory* for a period of five consecutive years, *exotic invasion* occurred at a rate 0.01/year, a moderately low rate. This meant that a full pixel equivalent to a 1-meter GeoEye1 pixel was converted to *exotic forbs*. *Exotic control*, which was achieved with registered herbicides, was applied to the *exotic forb* class to create early-development vegetation; however, it was assumed that herbicide treatment failed 40% of times and vegetation remained in *exotic forb*. If a pixel of *exotic forb* remained untreated for 20 consecutive years, it was assumed that it permanently escaped control methods and stayed *exotic forb*.

The largest class of restoration methods was mechanical thinning of vegetation, sometimes followed by seeding when applied in uncharacteristic vegetation classes. This group encompassed *canopy thinning*, *DPL restoration, ShAG restoration*, and *HVG restoration*. Another very expensive method that was included in the model but that was not feasible at large scale was the removal of trees from *Tree Encroached* or *Tree-Annual Grass* vegetation classes followed by seeding (*Thin-Mech-Chem-Seed*).

1. *Canopy thinning* was the simple mowing or chaining of late-development shrublands without a high cover of trees that was used in montane sagebrush steppe, Wyoming big sagebrush-loamy, and the road-fuel-break. Mowers can be set to create early- or mid-development vegetation classes depending on fire and wildlife objectives: the rates used in models reflected these objectives by creating 50% of times early-development vegetation and the rest of times mid-development vegetation classes. The road-fuel-break was maintained with canopy thinning, although the disturbance was termed *fuel-break-maintenance*. Small areas of *canopy thinning* (<1,000 acres over 20 years) were used in models.
2. Restoration of depleted sagebrush (*DPL restoration*) was one of the most widespread actions and deployed in sagebrush systems and winterfat. This action involved canopy thinning and native or introduced plant seeding to create early-development and mid-development vegetation classes in the same proportion used in *canopy thinning*.
3. Restoration of the *Shrub-Annual Grass* and *Early Shrub* vegetation classes (*ShAG restoration*) was conducted in sagebrush and winterfat, and was very similar to *DPL*

restoration. The difference in name the addition of the herbicide Plateau® for cheatgrass control. Mowing and seeding of these vegetation classes created a seeded classes, sometimes formed of introduced species that was assumed to convert back to reference classes after years of succession. The failure outcomes were *Annual Grassland* for *Shrub-Annual Grass* class and perpetuation of the *Early Shrub* class.

4. The *HVG restoration* method only applied to wet meadow and, for some modeling scenarios, montane-subalpine riparian and caused a reduction of the vegetation class dominated by shrubs and forbs unpalatable to livestock (*Shrub-Forb-Encroached*). The label *HVG* is a relict of past planning from Utah where partners described the action as the restoration of meadows that were formerly *HeaVily-Grazed*. Although workshop participants labeled the vegetation class by its composition of *Shrub-Forb-Encroached*, the name of the action was never updated. This method, which was considered untested, required either herbicide application or mechanical removal of roots as forbs were bulb species and shrub have deep roots. Workshop participants assumed mechanical methods would be fully successful if funding was adequate.

Appendix 3. Management strategies of MAXIMUM MANAGEMENT scenarios for focal ecosystems of the Ward Mountain project area. Note: livestock grazing and fire suppression do not count as management actions with cost per area.

Scenario / Ecological system / Management action	Source Class		Outcome Class		Cost/acre	Total Acres Treated/yr
MAXIMUM MANAGEMENT						
Aspen Woodland (also Stable Aspen)						
Grazing Systems#	ALL	ALL	ALL	ALL	$2.00	400
RxFire	Late	CLS, OPN	Early1	CLS	$80.00	10
Aspen-Mixed Conifer (also Seral Aspen)						
RxFire	Late	OPN, CLS	Early1	ALL	$50.00	40
Aspen Thinning	Late	OPN, CLS	Mid1, Mid2, Early	CLS	$150.00	15
Basin Wildrye						
DPL-Restoration	DPL	CLS	Seeded	OPN	$180.00	70
Exotic-Control	EXF	OPN	Early1	OPN	$150.00	5
ShAG-Restoration	ShAG	OPN	Early1	OPN	$300.00	10
TrEnc Restoration (thin-mech-chem-seed)	TrEnc, TrAG	CLS	Seeded	OPN	$350.00	10
Chainsaw Lopping	Late	OPN	Late	OPN	$60.00	10
Weed-Inventory	many classes		many classes		$50.00	260
Black Sagebrush						
Chainsaw Lopping	Late, DPL, ShAG, ShAP	CLS, OPN	Late, DPL, ShAG, ShAP	CLS, OPN	$70.00	100
Chaining	Late	OPN,CLS	Mid, Late	OPN, CLS	$130.00	200
Mastication	Late	CLS	Mid	OPN	$350.00	400
DPL-Restoration	DPL	CLS	Early, Mid, Late	OPN, CLS	$180.00	1,000
RxFire	Late	OPN	Early1	ALL	$80.00	50
TrEnc Restoration	TrEnc, TrAG	CLS	Seeded	OPN	$350.00	500
Montane Sagebrush Steppe – upland						
Chainsaw Lopping	Late, DPL, ShAG, ShAP	CLS, OPN	Late, DPL, ShAG, ShAP	CLS, OPN	$60.00	85 (yrs 1-5), 20 (yrs 6-20)
Chaining	Late	OPN,CLS	Mid, Late	OPN, CLS	$85.00	300 (yrs 1-5), 50 (yrs 6-20)
Canopy-Thinning	Late	CLS, OPN	Early, Mid	ALL, OPN	$100.00	200 (yrs 1-5), 85 (yrs 6-20)
DPL-Restoration	DPL	CLS	Seeded	OPN	$180.00	100 (yrs 1-5)
ShAP Restoration (Mow-Herbicide)	ShAP	CLS	Early, Mid	ALL, OPN	$40.00	40 (yrs 1-5)
ShAG-Restoration	DPL	CLS	Seeded	OPN	$300.00	100 (yrs 1-5)
RxFire	Late1, late2	OPN, CLS	Early1	ALL	$80.00	250
TrEnc Restoration (Thin-Mech-Chem-	TrEnc	CLS	Seeded	OPN	$350.00	140 (yrs 1-5), 100 (yrs 6-20)

Scenario Ecological system Management action	Source Class		Outcome Class		Cost/acre	Total Acres Treated/yr
Seed)						
Montane-Subalpine Riparian						
Exotic-Control	EXF	OPN	Mid1	OPN	$260.00	1
Fencing	ALL	ALL	ALL	ALL	$200.00	20
Weed-Inventory	many classes		many classes		$50.00	5
Winterfat						
AG-Restoration	AG	ALL	Seeded	OPN	$200.00	10
DPL-Restoration	DPL	CLS	Mid1, Mid2	OPN	$200.00	75 (yrs 1-5), 50 (yrs 6-20)
ExF-Restoration	ExF	ALL	Seeded	OPN	$300.00	25
ShAG-Restoration	ShAG	CLS	Seeded	OPN	$300.00	15
Wyoming Big Sagebrush						
AG-Restoration	AG	ALL	Seeded	OPN	$130.00	150
DPL-Restoration	DPL	CLS	Seeded	ALL	$180.00	200
Herbicide-Spike	Late1, Late2	CLS, OPN	Mid	OPN	$25.00	50
ShAG-Restoration	ShAG	CLS	Seeded	OPN	$300.00	50
TrEnc Restoration (Thin-Mech-Chem-Seed)	TrEnc	CLS	Seeded	OPN	$350.00	50

Legend:
1. AG-Restoration = action used to restore annual grasslands with herbicide and seed to succession classes of the reference condition or seeded class;
2. Canopy-Thinning = action to thin the late-succession canopy of shrublands from the reference condition using various methods requiring no seeding (cost variable);
3. DPL-Restoration = action used to restore depleted sagebrush to succession classes of the reference condition;
4. Exotic-Control = action to control exotic forb species and salt cedar with herbicide;
5. Grazing Systems = voluntary action by private livestock operators to move livestock away from sensitive ecological systems such as montane riparian, wet meadows, and aspen;
6. Herbicide-Spike = application of herbicide Spike® to thin sagebrush and pinyon-juniper canopies;
7. RxFire = action of prescribed fire ignited by hand (cost increases with smaller burns);
8. ShAG-Restoration = action to restore shrublands with an understory of annual grass to either the early succession phase of the reference condition;
9. TrEnc Restoration (Thin-Mech-Chem-Seed) = action used to mechanically remove trees from tree-encroached shrublands followed by facultative herbicide application to control annual grasses and by seed; and
10. Weed-Inventory = action to survey for exotic forb and salt cedar invasion.

Appendix 4. Management strategies of PREFERRED MANAGEMENT scenarios for focal ecosystems of the Ward Mountain project area. Note: livestock grazing and fire suppression do not count as management actions with cost per area.

Scenario Ecological system Management action	Source Class		Outcome Class		Cost/acre	Total Acres Treated/yr
PREFERRED MANAGEMENT						
Aspen Woodland (also Stable Aspen)						
Aspen Thinning	Late, NAS	CLS, OPN, ALL	Early1, Mid1	CLS	$100.00	10
Aspen-Mixed Conifer (also Seral Aspen)						
RxFire	Late	OPN, CLS	Early1	ALL	$50.00	200 (yrs 1-5)
Aspen Thinning	Late	OPN, CLS	Mid1, Mid2, Early	CLS	$150.00	75 (yrs 1-5)
Basin Wildrye						
DPL-Restoration	DPL	CLS	Seeded	OPN	$180.00	210 (yrs 1-5)
Exotic-Control	EXF	OPN	Early1	OPN	$150.00	4
ShAG-Restoration	ShAG	OPN	Early1	OPN	$300.00	5
TrEnc Restoration (thin-mech-chem-seed)	TrEnc, TrAG	CLS	Seeded	OPN	$350.00	5
Chainsaw Lopping	Late	OPN	Late	OPN	$60.00	8
Weed-Inventory	many classes		many classes		$50.00	130
Black Sagebrush						
Chainsaw Lopping	Late, DPL, ShAG, ShAP	CLS, OPN	Late, DPL, ShAG, ShAP	CLS, OPN	$70.00	100
Chaining	Late	OPN,CLS	Mid, Late	OPN, CLS	$130.00	200
Mastication	Late	CLS	Mid	OPN	$350.00	100
DPL-Restoration	DPL	CLS	Early, Mid, Late	OPN, CLS	$180.00	750
RxFire	Late	OPN	Early1	ALL	$80.00	25
TrEnc Restoration	TrEnc, TrAG	CLS	Seeded	OPN	$350.00	150
Montane Sagebrush Steppe – upland						
Chainsaw Lopping	Late, DPL, ShAG, ShAP	CLS, OPN	Late, DPL, ShAG, ShAP	CLS, OPN	$60.00	80 (yrs 1-5), 20 (yrs 6-20)
Chaining	Late	OPN,CLS	Mid, Late	OPN, CLS	$85.00	300 (yrs 1-5), 50 (yrs 6-20)
Canopy-Thinning	Late	CLS, OPN	Early, Mid	ALL, OPN	$100.00	200 (yrs 1-5)
DPL-Restoration	DPL	CLS	Seeded	OPN	$180.00	40 (yrs 1-5)
ShAP Restoration (Mow-Herbicide)	ShAP	CLS	Early, Mid	ALL, OPN	$40.00	40 (yrs 1-5)
ShAG-Restoration	DPL	CLS	Seeded	OPN	$300.00	50 (yrs 1-5)
RxFire	Late1, late2	OPN, CLS	Early1	ALL	$80.00	156
TrEnc Restoration (Thin-Mech-Chem-	TrEnc	CLS	Seeded	OPN	$350.00	60 (yrs 1-5), 40 (yrs 6-20)

Scenario Ecological system Management action	Source Class		Outcome Class		Cost/acre	Total Acres Treated/yr
Seed)						
			Montane-Subalpine Riparian			
Exotic-Control	EXF	OPN	Mid1	OPN	$260.00	1
Fencing	ALL	ALL	ALL	ALL	$200.00	20
Weed-Inventory	many classes		many classes		$50.00	5
			Winterfat			
DPL-Restoration	DPL	CLS	Mid1, Mid2	OPN	$200.00	75 (yrs 1-5), 50 (yrs 6-20)
			Wyoming Big Sagebrush			
AG-Restoration	AG	ALL	Seeded	OPN	$130.00	60
DPL-Restoration	DPL	CLS	Seeded	ALL	$180.00	100
Herbicide-Spike	Late1, Late2	CLS, OPN	Mid	OPN	$25.00	10
ShAG-Restoration	ShAG	CLS	Seeded	OPN	$300.00	25
TrEnc Restoration (Thin-Mech-Chem-Seed)	TrEnc	CLS	Seeded	OPN	$350.00	50

Legend:

1. AG-Restoration = action used to restore annual grasslands with herbicide and seed to succession classes of the reference condition or seeded class;
2. Canopy-Thinning = action to thin the late-succession canopy of shrublands from the reference condition using various methods requiring no seeding (cost variable);
3. DPL-Restoration = action used to restore depleted sagebrush to succession classes of the reference condition;
4. Exotic-Control = action to control exotic forb species and salt cedar with herbicide;
5. Herbicide-Spike = application of herbicide Spike® to thin sagebrush and pinyon-juniper canopies;
6. RxFire = action of prescribed fire ignited by hand (cost increases with smaller burns);
7. ShAG-Restoration = action to restore shrublands with an understory of annual grass to either the early succession phase of the reference condition;
8. TrEnc Restoration (Thin-Mech-Chem-Seed) = action used to mechanically remove trees from tree-encroached shrublands followed by facultative herbicide application to control annual grasses and by seed; and
9. Weed-Inventory = action to survey for exotic forb and salt cedar invasion.

Appendix 5. VDDT probabilistic transitions for all biophysical settings of Ward Mountain, NV. Models can be completely reconstructed from these values, with the exception for defining Time-Since-Disturbance dependencies.

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Alpine	Replacement Fire	Late1	CLS	Early1	ALL	3	1002	0	9999	0.005	1	0	FALSE
Alpine	Drought	Late1	CLS	Early1	ALL	3	1002	0	9999	0.0056	1	0	FALSE
Alpine	avalanches	Late1	CLS	Early1	ALL	3	1002	0	9999	0.001	1	0	FALSE
Aspen-Mixed Conifer	Excessive-Herbivory	Early1	ALL	NAS	ALL	0	9	5	9999	0.001	1	0	FALSE
Aspen-Mixed Conifer	Grazing-Systems	Early1	ALL	Early1	ALL	0	9	0	9999	1	0.3	0	FALSE
Aspen-Mixed Conifer	Replacement Fire	Mid1	CLS	Early1	ALL	10	39	0	9999	0.02	1	0	FALSE
Aspen-Mixed Conifer	Grazing-Systems	Mid1	CLS	Mid1	CLS	10	39	0	9999	1	0.3	0	FALSE
Aspen-Mixed Conifer	Mixed Fire	Mid2	CLS	Early1	ALL	40	79	0	9999	0.02	0.75	0	FALSE
Aspen-Mixed Conifer	Mixed Fire	Mid2	CLS	Mid2	CLS	40	79	0	9999	0.02	0.25	0	FALSE
Aspen-Mixed Conifer	Insect/ Disease	Mid2	CLS	Mid1	CLS	40	79	0	9999	0.005	0.8	0	FALSE
Aspen-Mixed Conifer	Insect/ Disease	Mid2	CLS	Early1	ALL	40	79	0	9999	0.005	0.2	0	FALSE
Aspen-Mixed Conifer	Mechanical-Thinning	Mid2	CLS	Early1	ALL	40	79	0	9999	0.01	0.33	0	FALSE
Aspen-Mixed Conifer	Mechanical-Thinning	Mid2	CLS	Mid1	CLS	40	79	0	9999	0.01	0.33	0	FALSE
Aspen-Mixed Conifer	Mechanical-Thinning	Mid2	CLS	Mid2	CLS	40	79	0	9999	0.01	0.33	-40	FALSE
Aspen-Mixed Conifer	Grazing-Systems	Mid2	CLS	Mid2	CLS	40	79	0	9999	1	0.3	0	FALSE
Aspen-Mixed Conifer	Mixed Fire	Late1	OPN	Mid2	CLS	80	1079	0	9999	0.02	0.1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Aspen-Mixed Conifer	Replacement Fire	Late1	OPN	Early1	ALL	80	1079	0	9999	0.02	0.9	0	FALSE
Aspen-Mixed Conifer	Alt Succession	Late1	OPN	Late1	CLS	80	1079	100	9999	1	1	0	FALSE
Aspen-Mixed Conifer	RxFire	Late1	OPN	Early1	ALL	80	1079	0	9999	0.01	1	0	FALSE
Aspen-Mixed Conifer	Mechanical-Thinning	Late1	OPN	Mid2	CLS	80	1079	0	9999	0.01	0.33	0	FALSE
Aspen-Mixed Conifer	Mechanical-Thinning	Late1	OPN	Early1	ALL	80	1079	0	9999	0.01	0.33	0	FALSE
Aspen-Mixed Conifer	Mechanical-Thinning	Late1	OPN	Mid1	CLS	80	1079	0	9999	0.01	0.33	0	FALSE
Aspen-Mixed Conifer	Grazing-Systems	Late1	OPN	Late1	OPN	80	1079	0	9999	1	0.3	0	FALSE
Aspen-Mixed Conifer	Replacement Fire	Late1	CLS	Early1	ALL	100	999	0	9999	0.02	0.9	0	FALSE
Aspen-Mixed Conifer	Insect/ Disease	Late1	CLS	Late1	OPN	100	999	0	9999	0.003	1	0	FALSE
Aspen-Mixed Conifer	Mixed Fire	Late1	CLS	Late1	OPN	100	999	0	9999	0.02	0.1	0	FALSE
Aspen-Mixed Conifer	RxFire	Late1	CLS	Early1	ALL	100	999	0	9999	0.01	1	0	FALSE
Aspen-Mixed Conifer	Mechanical-Thinning	Late1	CLS	Mid2	CLS	100	999	0	9999	0.01	0.75	0	FALSE
Aspen-Mixed Conifer	Mechanical-Thinning	Late1	CLS	Early1	ALL	100	999	0	9999	0.01	0.25	0	FALSE
Aspen-Mixed Conifer	Grazing-Systems	Late1	CLS	Late1	CLS	100	999	0	9999	1	0.3	0	FALSE
Aspen-Mixed Conifer	Losing Clone	Late1	CLS	NAS-Late	CLS	100	999	35	9999	1	0.33	0	FALSE
Aspen-Mixed Conifer	Replacement Fire	NAS-Late	CLS	NAS	ALL	50	999	0	9999	0.008	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Aspen-Mixed Conifer	Insect/ Disease	NAS-Late	CLS	NAS	ALL	50	999	0	9999	0.02	0.6	0	FALSE
Aspen-Mixed Conifer	Mixed Fire	NAS-Late	CLS	NAS-Late	OPN	50	999	0	9999	0.02	1	0	TRUE
Aspen-Mixed Conifer	Insect/ Disease	NAS-Late	CLS	NAS-Late	OPN	50	999	0	9999	0.02	0.4	0	FALSE
Aspen-Mixed Conifer	RxFire	NAS-Late	CLS	NAS	ALL	50	999	0	9999	0.01	1	0	FALSE
Aspen-Mixed Conifer	Drought	NAS-Late	CLS	NAS-Late	OPN	50	999	0	9999	0.0056	1	0	TRUE
Aspen-Mixed Conifer	Replacement Fire	NAS	ALL	NAS	ALL	0	9	0	9999	0.008	1	-999	FALSE
Aspen-Mixed Conifer	Drought	NAS	ALL	NAS	ALL	0	9	0	9999	0.0056	1	-999	FALSE
Aspen-Mixed Conifer	Mixed Fire	NAS-Mid	CLS	NAS-Mid	OPN	10	49	0	9999	0.02	1	0	TRUE
Aspen-Mixed Conifer	Replacement Fire	NAS-Mid	CLS	NAS	ALL	10	49	0	9999	0.008	1	0	FALSE
Aspen-Mixed Conifer	Insect/ Disease	NAS-Mid	CLS	NAS	ALL	10	49	0	9999	0.02	1	0	FALSE
Aspen-Mixed Conifer	Insect/ Disease	NAS-Mid	CLS	NAS-Mid	OPN	10	49	0	9999	0.02	1	0	TRUE
Aspen-Mixed Conifer	Replacement Fire	NAS-Mid	OPN	NAS	ALL	10	63	0	9999	0.0025	1	0	FALSE
Aspen-Mixed Conifer	Insect/ Disease	NAS-Mid	OPN	NAS-Mid	OPN	10	63	0	9999	0.01	1	0	FALSE
Aspen-Mixed Conifer	Surface Fire	NAS-Mid	OPN	NAS-Mid	OPN	10	63	0	9999	0.02	1	-999	FALSE
Aspen-Mixed Conifer	Alt Succession	NAS-Mid	OPN	NAS-Mid	CLS	10	63	35	9999	1	0.33	0	TRUE
Aspen-Mixed Conifer	Drought	NAS-Mid	OPN	NAS-Mid	OPN	10	63	0	9999	0.0056	1	-999	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Aspen-Mixed Conifer	Alt Succession	NAS-Late	OPN	NAS-Late	CLS	64	999	35	9999	1	1	0	TRUE
Aspen-Mixed Conifer	Replacement Fire	NAS-Late	OPN	NAS	ALL	64	999	0	9999	0.0025	1	0	FALSE
Aspen-Mixed Conifer	Surface Fire	NAS-Late	OPN	NAS-Late	OPN	64	999	0	9999	0.02	1	0	FALSE
Aspen-Mixed Conifer	Insect/ Disease	NAS-Late	OPN	NAS-Late	OPN	64	999	0	9999	0.001	1	0	FALSE
Aspen-Mixed Conifer	Drought	NAS-Late	OPN	NAS-Late	OPN	64	999	0	9999	0.0056	1	-999	FALSE
Aspen Woodland	ShAG-Restoration	UnCharact	ALL	Mid1	CLS	12	140	0	9999	0.01	0.7	0	FALSE
Aspen Woodland	Managed-Herbivory	UnCharact	ALL	UnCharact	ALL	0	999	0	9999	1	0.25	0	FALSE
Aspen Woodland	Thin-Mech-Chem-Seed	UnCharact	ALL	Early1	CLS	140	999	0	9999	0.01	0.7	0	FALSE
Aspen Woodland	AG-Restoration	UnCharact	ALL	Early1	CLS	0	999	0	9999	0.01	0.7	0	FALSE
Aspen Woodland	AG-Restoration	UnCharact	ALL	UnCharact	ALL	0	999	0	9999	0.01	0.3	-999	FALSE
Aspen Woodland	ShAG-Restoration	UnCharact	ALL	UnCharact	ALL	0	999	0	9999	0.01	0.3	0	FALSE
Aspen Woodland	Thin-Mech-Chem-Seed	UnCharact	ALL	UnCharact	ALL	0	999	0	9999	0.01	0.3	-999	FALSE
Aspen Woodland	Excessive-Herbivory	UnCharact	ALL	UnCharact	ALL	0	999	0	9999	0.001	1	3	FALSE
Aspen Woodland	Drought	UnCharact	ALL	UnCharact	ALL	0	999	0	9999	0.006	0.1	-999	FALSE
Aspen Woodland	Fenced-Succession	DPL-Fence	OPN	Late1	CLS	40	999	3	9999	0.9	1	0	FALSE
Aspen Woodland	Replacement Fire	DPL-Fence	OPN	Early1	CLS	40	999	0	9999	0.02	0.7	0	FALSE
Aspen Woodland	Replacement Fire	DPL-Fence	OPN	NAS	ALL	40	999	0	9999	0.02	0.3	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Aspen Woodland	Insect/ Disease	DPL-Fence	OPN	Early1	CLS	40	999	0	9999	0.003	0.7	0	FALSE
Aspen Woodland	Insect/ Disease	DPL-Fence	OPN	NAS	ALL	40	999	0	9999	0.003	0.3	0	FALSE
Aspen Woodland	Excessive-Herbivory	Early1	CLS	NAS	ALL	2	9	2	9999	0.001	1	0	FALSE
Aspen Woodland	Replacement Fire	Early1	CLS	Early1	CLS	0	9	0	9999	0.02	1	-10	FALSE
Aspen Woodland	Grazing-Systems	Early1	CLS	Early1	CLS	0	9	0	9999	1	0.5	0	FALSE
Aspen Woodland	Replacement Fire	Mid1	CLS	Early1	CLS	10	39	0	9999	0.02	1	0	FALSE
Aspen Woodland	Excessive-Herbivory	Mid1	CLS	Mid1	CLS	10	39	5	9999	0.001	1	3	FALSE
Aspen Woodland	Grazing-Systems	Mid1	CLS	Mid1	CLS	10	39	0	9999	1	0.5	0	FALSE
Aspen Woodland	Replacement Fire	Late1	CLS	Early1	CLS	40	1039	0	9999	0.02	0.9	0	FALSE
Aspen Woodland	Mixed Fire	Late1	CLS	Late1	CLS	40	1039	0	9999	0.02	0.1	0	FALSE
Aspen Woodland	Insect/ Disease	Late1	CLS	Early1	CLS	40	1039	0	9999	0.005	0.2	0	FALSE
Aspen Woodland	Insect/ Disease	Late1	CLS	Mid1	CLS	40	1039	0	9999	0.005	0.8	0	FALSE
Aspen Woodland	Alt Succession	Late1	CLS	Late1	OPN	40	1039	100	9999	1	1	0	FALSE
Aspen Woodland	RxFire	Late1	CLS	Early1	CLS	40	1039	0	9999	0.01	0.7	0	FALSE
Aspen Woodland	Canopy-Thinning	Late1	CLS	Mid1	CLS	40	1039	0	9999	0.01	0.5	0	FALSE
Aspen Woodland	Excessive-Herbivory	Late1	CLS	Late1	CLS	40	1039	5	9999	0.001	0.8	3	FALSE
Aspen Woodland	Excessive-Herbivory	Late1	CLS	DPL	OPN	40	1039	5	9999	0.001	0.2	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Aspen Woodland	RxFire	Late1	CLS	Late1	CLS	40	1039	0	9999	0.01	0.3	0	FALSE
Aspen Woodland	Canopy-Thinning	Late1	CLS	Early1	CLS	40	1039	0	9999	0.01	0.5	0	FALSE
Aspen Woodland	Grazing-Systems	Late1	CLS	Late1	CLS	40	1039	0	9999	1	0.5	0	FALSE
Aspen Woodland	Replacement Fire	Late1	OPN	Early1	CLS	100	999	0	9999	0.02	0.9	0	FALSE
Aspen Woodland	Mixed Fire	Late1	OPN	Late1	CLS	100	999	0	9999	0.02	0.1	0	FALSE
Aspen Woodland	Insect/ Disease	Late1	OPN	Late1	CLS	100	999	0	9999	0.003	1	0	FALSE
Aspen Woodland	Excessive-Herbivory	Late1	OPN	Late1	OPN	100	999	5	9999	0.001	1	5	FALSE
Aspen Woodland	RxFire	Late1	OPN	Early1	CLS	100	999	0	9999	0.01	1	0	FALSE
Aspen Woodland	Canopy-Thinning	Late1	OPN	Early1	CLS	100	999	0	9999	0.01	0.5	0	FALSE
Aspen Woodland	Canopy-Thinning	Late1	OPN	Mid1	CLS	100	999	0	9999	0.01	0.5	0	FALSE
Aspen Woodland	Alt Succession	Late1	OPN	DPL	OPN	100	999	200	9999	1	1	0	FALSE
Aspen Woodland	Grazing-Systems	Late1	OPN	Late1	OPN	100	999	0	9999	1	0.5	0	FALSE
Aspen Woodland	Excessive-Herbivory	NAS	ALL	NAS	ALL	0	139	0	9999	0.0011	0.75	3	FALSE
Aspen Woodland	RxFire	NAS	ALL	NAS	ALL	50	999	0	9999	0.01	0.3	0	FALSE
Aspen Woodland	Drought	NAS	ALL	NAS	ALL	50	189	0	9999	0.0056	0.9	-10	FALSE
Aspen Woodland	Managed-Herbivory	NAS	ALL	NAS	ALL	0	139	0	9999	1	0.25	0	FALSE
Aspen Woodland	Excessive-Herbivory	NAS	ALL	UnCharact	ALL	0	139	0	9999	0.0012	0.25	0	TRUE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Aspen Woodland	Drought	NAS	ALL	NAS	ALL	50	189	0	9999	0.006	0.1	-999	FALSE
Aspen Woodland	Drought	NAS	ALL	UnCharact	ALL	190	999	0	9999	0.0056	1	0	TRUE
Aspen Woodland	Canopy-Thinning	NAS	ALL	NAS	ALL	50	155	0	9999	0.01	0.75	-30	FALSE
Aspen Woodland	Canopy-Thinning	NAS	ALL	NAS	ALL	50	155	0	9999	0.01	0.25	-999	FALSE
Aspen Woodland	AG-Invasion	NAS	ALL	UnCharact	ALL	0	999	0	9999	0.005	1	0	FALSE
Aspen Woodland	ConversionTo U	NAS	ALL	UnCharact	ALL	140	999	0	9999	0.1	1	0	TRUE
Aspen Woodland	Fence	DPL	OPN	DPL-Fence	OPN	40	250	0	9999	0.01	1	0	TRUE
Aspen Woodland	Replacement Fire	DPL	OPN	Early1	CLS	40	250	0	9999	0.02	1	0	FALSE
Aspen Woodland	Grazing-Systems	DPL	OPN	DPL	OPN	40	250	0	9999	1	0.5	0	FALSE
Aspen Woodland	Replacement Fire	UnCharact	ALL	UnCharact	ALL	0	999	0	9999	0.02	1	-9999	FALSE
Basin Wildrye	Replacement Fire	Early1	OPN	Early1	OPN	0	999	0	9999	0.02	1	-10	FALSE
Basin Wildrye	Exotic-Invasion	Early1	OPN	ExF	OPN	0	999	5	9999	0.01	1	0	FALSE
Basin Wildrye	Weed-Inventory	Early1	OPN	Early1	OPN	0	999	0	9999	0.01	1	0	FALSE
Basin Wildrye	Excessive-Herbivory	Early1	OPN	Early1	OPN	0	9	0	9999	0.002	0.5	3	FALSE
Basin Wildrye	Excessive-Herbivory	Early1	OPN	ESH	CLS	0	9	0	9999	0.002	0.5	0	FALSE
Basin Wildrye	Replacement Fire	Mid1	OPN	Early1	OPN	10	74	0	9999	0.025	1	0	FALSE
Basin Wildrye	Drought	Mid1	OPN	Mid1	OPN	10	74	0	9999	0.0056	1	-75	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Basin Wildrye	Excessive-Herbivory	Mid1	OPN	ESH	CLS	10	74	0	9999	0.0012	0.25	0	FALSE
Basin Wildrye	Exotic-Invasion	Mid1	OPN	ExF	OPN	10	74	5	9999	0.01	1	0	FALSE
Basin Wildrye	Weed-Inventory	Mid1	OPN	Mid1	OPN	10	74	0	9999	0.01	1	0	FALSE
Basin Wildrye	Excessive-Herbivory	Mid1	OPN	Mid1	OPN	10	74	0	9999	0.0011	0.75	3	FALSE
Basin Wildrye	AG-Invasion	Mid1	OPN	ShAG	OPN	10	74	0	9999	0.001	1	0	TRUE
Basin Wildrye	Replacement Fire	Late1	OPN	Early1	OPN	75	999	0	9999	0.015	1	0	FALSE
Basin Wildrye	Drought	Late1	OPN	Late1	OPN	75	999	0	9999	0.0056	0.9	-999	FALSE
Basin Wildrye	Excessive-Herbivory	Late1	OPN	DPL	CLS	75	999	0	9999	0.0012	0.25	0	FALSE
Basin Wildrye	RxFire	Late1	OPN	Early1	OPN	75	999	0	9999	0.01	0.8	0	FALSE
Basin Wildrye	Exotic-Invasion	Late1	OPN	ExF	OPN	75	999	5	9999	0.01	1	0	FALSE
Basin Wildrye	Weed-Inventory	Late1	OPN	Late1	OPN	75	999	0	9999	0.01	1	0	FALSE
Basin Wildrye	Excessive-Herbivory	Late1	OPN	Late1	OPN	75	999	0	9999	0.0011	0.75	3	FALSE
Basin Wildrye	Tree-Invasion	Late1	OPN	TrEnc	CLS	100	999	0	9999	0.01	1	0	FALSE
Basin Wildrye	RxFire	Late1	OPN	Late1	OPN	75	999	0	9999	0.01	0.2	0	FALSE
Basin Wildrye	AG-Invasion	Late1	OPN	ShAG	OPN	75	174	0	9999	0.002	0.5	0	FALSE
Basin Wildrye	AG-Invasion	Late1	OPN	TrAG	CLS	175	999	0	9999	0.002	0.5	0	FALSE
Basin Wildrye	Drought	Late1	OPN	Mid1	OPN	75	999	0	9999	0.0056	0.1	0	FALSE
Basin Wildrye	Chainsaw-Lopping	Late1	OPN	Late1	OPN	75	999	0	9999	0.01	1	-999	FALSE
Basin Wildrye	Replacement Fire	ShAG	OPN	AG	OPN	11	999	0	9999	0.015	1	0	FALSE
Basin Wildrye	Drought	ShAG	OPN	ShAG	OPN	11	999	0	9999	0.0056	0.9	-999	FALSE
Basin Wildrye	Drought	ShAG	OPN	AG	OPN	11	999	0	9999	0.0056	0.1	0	FALSE
Basin Wildrye	ShAG-Restoration	ShAG	OPN	AG	OPN	11	999	0	9999	0.01	0.2	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Basin Wildrye	Exotic-Invasion	ShAG	OPN	ExF	OPN	11	999	5	9999	0.01	1	0	FALSE
Basin Wildrye	Weed-Inventory	ShAG	OPN	ShAG	OPN	11	999	0	9999	0.01	1	0	FALSE
Basin Wildrye	Tree-Invasion	ShAG	OPN	TrAG	CLS	11	999	0	9999	0.01	1	0	FALSE
Basin Wildrye	ShAG-Restoration	ShAG	OPN	SEED	ALL	11	999	0	9999	0.01	0.8	0	FALSE
Basin Wildrye	Exotic-Control	ExF	OPN	SEED	ALL	0	999	0	20	1	0.5	0	FALSE
Basin Wildrye	Exotic-Control	ExF	OPN	ExF	OPN	0	999	0	20	1	0.5	0	FALSE
Basin Wildrye	Replacement Fire	ExF	OPN	ExF	OPN	0	999	0	9999	0.02	1	-999	FALSE
Basin Wildrye	AG-Restoration	AG	OPN	AG	OPN	0	1	0	9999	1	0.3	0	FALSE
Basin Wildrye	Replacement Fire	AG	OPN	Early1	OPN	1	999	0	9999	0.1	1	0	FALSE
Basin Wildrye	Exotic-Invasion	AG	OPN	ExF	OPN	0	9999	5	9999	0.01	1	0	FALSE
Basin Wildrye	Weed-Inventory	AG	OPN	AG	OPN	0	9999	0	9999	0.01	1	0	FALSE
Basin Wildrye	AG-Restoration	AG	OPN	SEED	ALL	0	1	0	9999	1	0.7	0	FALSE
Basin Wildrye	Replacement Fire	TrEnc	CLS	ESH	CLS	76	999	0	9999	0.0068	0.5	0	FALSE
Basin Wildrye	Thin-Mech-Chem-Seed	TrEnc	CLS	SEED	ALL	76	999	0	9999	0.01	0.8	0	FALSE
Basin Wildrye	Thin-Mech-Chem-Seed	TrEnc	CLS	ESH	CLS	76	999	0	9999	0.01	0.2	0	FALSE
Basin Wildrye	AG-Invasion	TrEnc	CLS	TrAG	CLS	76	999	0	9999	0.005	1	0	FALSE
Basin Wildrye	Drought	TrEnc	CLS	TrEnc	CLS	177	999	0	9999	0.0056	0.9	-999	FALSE
Basin Wildrye	Drought	TrEnc	CLS	ESH	CLS	76	176	0	9999	0.0056	0.1	0	FALSE
Basin Wildrye	DPL-Restoration	ESH	CLS	SEED	ALL	0	999	0	9999	0.01	0.8	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Basin Wildrye	Tree-Invasion	ESH	CLS	TrEnc	CLS	20	999	0	9999	0.01	1	0	FALSE
Basin Wildrye	Replacement Fire	ESH	CLS	ESH	CLS	0	999	0	9999	0.01	1	0	FALSE
Basin Wildrye	DPL-Restoration	ESH	CLS	ESH	CLS	0	999	0	9999	0.01	0.2	0	FALSE
Basin Wildrye	AG-Invasion	ESH	CLS	ShAG	OPN	0	999	0	9999	0.001	1	0	FALSE
Basin Wildrye	Thin-Mech-Chem-Seed	TrAG	CLS	SEED	ALL	201	999	0	9999	0.01	0.7	0	FALSE
Basin Wildrye	Thin-Mech-Chem-Seed	TrAG	CLS	AG	OPN	201	999	0	9999	0.01	0.3	0	FALSE
Basin Wildrye	Drought	TrAG	CLS	AG	OPN	201	999	0	9999	0.0056	0.1	0	FALSE
Basin Wildrye	Replacement Fire	TrAG	CLS	AG	OPN	201	999	0	9999	0.008	1	0	FALSE
Basin Wildrye	Drought	TrAG	CLS	TrAG	CLS	201	999	0	9999	0.0056	0.9	-999	FALSE
Basin Wildrye	AG-Invasion	SEED	ALL	AG	OPN	0	999	0	9999	0.005	1	0	FALSE
Basin Wildrye	Replacement Fire	SEED	ALL	SEED	ALL	0	999	0	9999	0.02	1	-999	FALSE
Basin Wildrye	Seeding-to-A-Succession	SEED	ALL	Early1	OPN	3	9	0	9999	0.1	1	0	TRUE
Basin Wildrye	Seeding-to-A-Succession	SEED	ALL	Mid1	OPN	10	999	0	9999	0.1	1	0	TRUE
Basin Wildrye	AG-Invasion	DPL	CLS	ShAG	OPN	11	999	0	9999	0.005	1	0	TRUE
Basin Wildrye	Drought	DPL	CLS	DPL	CLS	11	999	0	9999	0.0056	0.9	-999	FALSE
Basin Wildrye	Drought	DPL	CLS	ESH	CLS	11	999	0	9999	0.0056	0.1	0	FALSE
Basin Wildrye	Exotic-Invasion	DPL	CLS	ExF	OPN	11	999	5	9999	0.01	1	0	TRUE
Basin Wildrye	Replacement Fire	DPL	CLS	ESH	CLS	11	999	0	9999	0.015	1	0	FALSE
Basin Wildrye	DPL-Restoration	DPL	CLS	ESH	CLS	11	999	0	9999	0.01	0.2	0	FALSE
Basin Wildrye	DPL-Restoration	DPL	CLS	SEED	ALL	11	999	0	9999	0.01	0.8	0	FALSE
Basin Wildrye	Tree-Invasion	DPL	CLS	TrEnc	CLS	11	999	0	9999	0.01	1	0	FALSE
Basin Wildrye	Weed-	DPL	CLS	DPL	CLS	11	999	0	9999	0.01	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
	Inventory												
Basin Wildrye	Replacement Fire	CWG	CLS	CWG	CLS	0	999	0	9999	0.001	1	-999	FALSE
Basin Wildrye	CWG-To_Seed	CWG	CLS	SEED	ALL	0	999	0	9999	0.01	0.8	0	FALSE
Basin Wildrye	CWG-To_Seed	CWG	CLS	CWG	CLS	0	999	0	9999	0.01	0.2	0	FALSE
Black Sagebrush	Replacement Fire	Early1	ALL	Early1	ALL	0	24	0	9999	0.004	1	-24	FALSE
Black Sagebrush	Drought	Early1	ALL	Early1	ALL	0	24	0	9999	0.0056	1	-1	FALSE
Black Sagebrush	AG-Invasion	Early1	ALL	ShAP	CLS	10	24	0	9999	0.001	1	0	TRUE
Black Sagebrush	Excessive-Herbivory	Early1	ALL	ESH	CLS	2	24	0	9999	0.001	0.25	0	FALSE
Black Sagebrush	Excessive-Herbivory	Early1	ALL	Early1	ALL	2	24	0	9999	0.001	0.5	2	FALSE
Black Sagebrush	Excessive-Herbivory	Early1	ALL	ExF	CLS	2	24	0	9999	0.001	0.25	0	FALSE
Black Sagebrush	Replacement Fire	Mid1	OPN	Early1	ALL	25	119	0	9999	0.0067	1	0	FALSE
Black Sagebrush	Drought	Mid1	OPN	Mid1	OPN	25	119	0	9999	0.0056	0.5	-999	FALSE
Black Sagebrush	Drought	Mid1	OPN	Early1	ALL	25	119	0	9999	0.0056	0.5	0	FALSE
Black Sagebrush	AG-Invasion	Mid1	OPN	ShAP	CLS	25	119	0	9999	0.005	1	0	TRUE
Black Sagebrush	Excessive-Herbivory	Mid1	OPN	DPL	CLS	25	119	0	9999	0.001	0.5	7	FALSE
Black Sagebrush	Excessive-Herbivory	Mid1	OPN	ExF	CLS	25	119	0	9999	0.001	0.5	0	FALSE
Black Sagebrush	Replacement Fire	Late1	OPN	Early1	ALL	120	999	0	9999	0.0067	1	0	FALSE
Black	Drought	Late1	OPN	Late1	OPN	120	999	0	9999	0.0056	0.75	-999	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Sagebrush													
Black Sagebrush	Drought	Late1	OPN	Mid1	OPN	120	999	0	9999	0.0056	0.25	0	FALSE
Black Sagebrush	AG-Invasion	Late1	OPN	ShAP	CLS	120	999	0	9999	0.005	1	0	TRUE
Black Sagebrush	Excessive-Herbivory	Late1	OPN	DPL	CLS	120	999	0	9999	0.01	1	7	FALSE
Black Sagebrush	RxFire	Late1	OPN	Early1	ALL	120	999	0	9999	0.01	0.7	0	FALSE
Black Sagebrush	RxFire	Late1	OPN	Late1	OPN	120	999	0	9999	0.01	0.3	0	FALSE
Black Sagebrush	Chaining	Late1	OPN	Mid1	OPN	120	999	0	9999	0.01	0.9	0	FALSE
Black Sagebrush	Chaining	Late1	OPN	Late1	OPN	120	999	0	9999	0.01	0.1	-999	FALSE
Black Sagebrush	Chainsaw-Lopping	Late1	OPN	Late1	OPN	120	999	0	9999	0.01	1	-999	FALSE
Black Sagebrush	Tree-Invasion	Late1	OPN	Late1	CLS	120	999	0	9999	0.005	1	0	TRUE
Black Sagebrush	Herbicide-Skype	Late1	OPN	Mid1	OPN	120	999	0	9999	0.01	1	0	FALSE
Black Sagebrush	Canopy-Thinning	Late1	OPN	Mid1	OPN	120	999	0	9999	0.01	1	0	FALSE
Black Sagebrush	Replacement Fire	Late1	CLS	Early1	ALL	121	999	0	9999	0.0068	1	0	FALSE
Black Sagebrush	Drought	Late1	CLS	Late1	CLS	121	999	0	9999	0.0056	0.75	5	FALSE
Black Sagebrush	Drought	Late1	CLS	Late1	OPN	121	999	0	9999	0.0056	0.25	0	FALSE
Black Sagebrush	Chaining-Seed	Late1	CLS	Mid1	OPN	121	999	0	9999	0.01	0.9	0	FALSE
Black Sagebrush	Chaining-Seed	Late1	CLS	Late1	OPN	121	999	0	9999	0.01	0.1	0	FALSE
Black	Loss-	Late1	CLS	TrEnc	CLS	300	399	0	9999	0.005	1	0	TRUE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Sagebrush	Understory												
Black Sagebrush	AG-Invasion	Late1	CLS	TrAG	CLS	121	999	0	9999	0.005	1	0	TRUE
Black Sagebrush	Herbicide-Skype	Late1	CLS	Late1	OPN	121	999	0	9999	0.01	1	0	FALSE
Black Sagebrush	Loss-Understory	Late1	CLS	TrEnc	CLS	400	499	0	9999	0.0075	1	0	TRUE
Black Sagebrush	Loss-Understory	Late1	CLS	TrEnc	CLS	500	999	0	9999	0.01	1	0	TRUE
Black Sagebrush	AG-Restoration	AG	OPN	SENN	OPN	0	3	0	9999	0.01	0.25	0	FALSE
Black Sagebrush	AG-Restoration	AG	OPN	AG	OPN	0	3	0	9999	0.01	0.75	0	FALSE
Black Sagebrush	Replacement Fire	AG	OPN	AG	OPN	0	999	0	9999	0.1	1	-999	FALSE
Black Sagebrush	Replacement Fire	ShAG	OPN	AG	OPN	10	999	0	9999	0.01	1	0	FALSE
Black Sagebrush	ShAG-Restoration	ShAG	OPN	SENN	OPN	10	999	0	9999	0.01	0.7	0	FALSE
Black Sagebrush	ShAG-Restoration	ShAG	OPN	AG	OPN	10	999	0	9999	0.01	0.3	0	FALSE
Black Sagebrush	Tree-Invasion	ShAG	OPN	TrAG	CLS	120	999	0	9999	0.005	1	0	TRUE
Black Sagebrush	Chainsaw-Lopping	ShAG	OPN	ShAG	OPN	10	999	0	9999	0.01	1	-999	FALSE
Black Sagebrush	Drought	ShAG	OPN	ShAG	OPN	10	999	0	9999	0.0056	0.9	-999	FALSE
Black Sagebrush	Drought	ShAG	OPN	AG	OPN	10	999	0	9999	0.0056	0.1	0	FALSE
Black Sagebrush	Alt Succession	SENN	OPN	Early1	ALL	10	24	0	9999	0.2	1	0	TRUE
Black Sagebrush	Replacement Fire	SENN	OPN	SENN	OPN	0	999	0	9999	0.002	1	-999	FALSE
Black Sagebrush	Alt Succession	SENN	OPN	Mid1	OPN	25	119	0	9999	0.2	1	0	TRUE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Black Sagebrush	Alt Succession	SENN	OPN	Late1	OPN	120	999	0	9999	0.2	1	0	TRUE
Black Sagebrush	Alt Succession	SENN	OPN	Late1	OPN	120	999	0	9999	0.2	1	0	TRUE
Black Sagebrush	Thin-Mech-Chem-Seed	TrAG	CLS	SENN	OPN	121	999	0	9999	0.01	0.6	0	FALSE
Black Sagebrush	Thin-Mech-Chem-Seed	TrAG	CLS	AG	OPN	121	999	0	9999	0.01	0.4	0	FALSE
Black Sagebrush	Replacement Fire	TrAG	CLS	AG	OPN	121	999	0	9999	0.0067	1	0	FALSE
Black Sagebrush	Drought	TrAG	CLS	AG	OPN	121	999	0	9999	0.0056	1	0	FALSE
Black Sagebrush	Replacement Fire	DPL	CLS	ESH	CLS	26	999	0	9999	0.0067	1	0	FALSE
Black Sagebrush	AG-Invasion	DPL	CLS	ShAG	OPN	26	999	0	9999	0.005	1	0	TRUE
Black Sagebrush	DPL-Restoration	DPL	CLS	Mid1	OPN	26	119	0	9999	0.01	0.5	0	TRUE
Black Sagebrush	DPL-Restoration	DPL	CLS	AG	OPN	26	999	0	9999	0.01	0.1	0	FALSE
Black Sagebrush	Tree-Invasion	DPL	CLS	TrEnc	CLS	120	999	0	9999	0.005	1	0	TRUE
Black Sagebrush	Drought	DPL	CLS	DPL	CLS	26	999	0	9999	0.0056	0.9	-999	FALSE
Black Sagebrush	Drought	DPL	CLS	ESH	CLS	26	999	0	9999	0.0056	0.1	0	FALSE
Black Sagebrush	Chainsaw-Lopping	DPL	CLS	DPL	CLS	26	999	0	9999	0.01	1	-999	FALSE
Black Sagebrush	DPL-Restoration	DPL	CLS	Late1	OPN	120	999	0	9999	0.01	1	0	TRUE
Black Sagebrush	DPL-Restoration	DPL	CLS	Early1	ALL	26	999	0	9999	0.01	0.2	0	FALSE
Black Sagebrush	DPL-Restoration	DPL	CLS	ShAG	OPN	26	999	0	9999	0.01	0.1	0	TRUE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Black Sagebrush	DPL-Restoration	DPL	CLS	ESH	CLS	26	999	0	9999	0.01	0.1	0	FALSE
Black Sagebrush	Replacement Fire	ShAP	CLS	AG	OPN	10	999	0	9999	0.0067	0.95	0	FALSE
Black Sagebrush	Tree-Invasion	ShAP	CLS	TrAG	CLS	120	999	0	9999	0.005	1	0	TRUE
Black Sagebrush	Replacement Fire	ShAP	CLS	Early1	ALL	10	999	0	9999	0.0067	0.05	0	FALSE
Black Sagebrush	ShAP-Restoration	ShAP	CLS	Early1	ALL	10	24	0	9999	0.01	0.7	0	TRUE
Black Sagebrush	ShAP-Restoration	ShAP	CLS	Mid1	OPN	25	119	0	9999	0.01	0.7	0	TRUE
Black Sagebrush	ShAP-Restoration	ShAP	CLS	ShAP	CLS	25	119	0	9999	0.01	0.3	0	FALSE
Black Sagebrush	ShAP-Restoration	ShAP	CLS	ShAP	CLS	10	24	0	9999	0.01	0.3	0	FALSE
Black Sagebrush	ShAP-Restoration	ShAP	CLS	Late1	OPN	120	999	0	9999	0.01	0.7	0	TRUE
Black Sagebrush	ShAP-Restoration	ShAP	CLS	ShAP	CLS	120	999	0	9999	0.01	0.3	0	FALSE
Black Sagebrush	Chainsaw-Lopping	ShAP	CLS	ShAP	CLS	10	999	0	9999	0.01	1	-999	FALSE
Black Sagebrush	Excessive-Herbivory	ShAP	CLS	ExF	CLS	10	24	0	9999	0.001	0.25	0	FALSE
Black Sagebrush	Excessive-Herbivory	ShAP	CLS	ShAP	CLS	10	24	0	9999	0.001	0.5	2	FALSE
Black Sagebrush	Excessive-Herbivory	ShAP	CLS	AG	OPN	10	24	0	9999	0.001	0.25	0	FALSE
Black Sagebrush	Excessive-Herbivory	ShAP	CLS	ShAG	OPN	25	999	0	9999	0.001	1	0	FALSE
Black Sagebrush	Drought	ShAP	CLS	ShAP	CLS	10	999	0	9999	0.0056	0.9	-999	FALSE
Black Sagebrush	Drought	ShAP	CLS	AG	OPN	10	999	0	9999	0.0056	0.1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Black Sagebrush	Herbicide-Weeds	ExF	CLS	SENN	OPN	0	999	0	9999	0.01	0.6	0	FALSE
Black Sagebrush	Herbicide-Weeds	ExF	CLS	ExF	CLS	0	999	0	9999	0.01	0.4	0	FALSE
Black Sagebrush	Replacement Fire	TrEnc	CLS	ESH	CLS	121	999	0	9999	0.0067	1	0	FALSE
Black Sagebrush	Thin-Mech-Chem-Seed	TrEnc	CLS	SENN	OPN	121	999	0	9999	0.01	0.6	0	FALSE
Black Sagebrush	Thin-Mech-Chem-Seed	TrEnc	CLS	ESH	CLS	121	999	0	9999	0.01	0.4	0	FALSE
Black Sagebrush	AG-Invasion	TrEnc	CLS	TrAG	CLS	121	999	0	9999	0.005	1	0	TRUE
Black Sagebrush	Drought	TrEnc	CLS	ESH	CLS	121	999	0	9999	0.0056	1	0	FALSE
Black Sagebrush	Replacement Fire	ESH	CLS	ESH	CLS	0	999	0	9999	0.0067	1	-999	FALSE
Curlleaf Mountain Mahogany	Replacement Fire	Early1	ALL	Early1	ALL	0	19	0	9999	0.002	1	-20	FALSE
Curlleaf Mountain Mahogany	NativeGrazin g	Early1	ALL	Early1	ALL	0	19	0	9999	1	0.02	-20	FALSE
Curlleaf Mountain Mahogany	Replacement Fire	Mid1	CLS	Early1	ALL	60	149	0	9999	0.007	1	0	FALSE
Curlleaf Mountain Mahogany	NativeGrazin g	Mid1	CLS	Mid1	CLS	60	149	0	9999	0.001	1	0	FALSE
Curlleaf Mountain Mahogany	Mixed Fire	Mid1	CLS	Late1	OPN	60	149	0	9999	0.005	1	0	FALSE
Curlleaf Mountain Mahogany	NativeGrazin g	Mid1	OPN	Mid1	OPN	20	59	0	9999	0.01	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Curlleaf Mountain Mahogany	Replacement Fire	Mid1	OPN	Early1	ALL	20	59	0	9999	0.007	1	0	FALSE
Curlleaf Mountain Mahogany	Replacement Fire	Late1	OPN	Early1	ALL	60	999	0	9999	0.003	1	0	FALSE
Curlleaf Mountain Mahogany	Surface Fire	Late1	OPN	Late1	OPN	60	999	0	9999	0.025	1	0	FALSE
Curlleaf Mountain Mahogany	Alt Succession	Late1	OPN	Late1	CLS	60	999	150	9999	1	1	0	FALSE
Curlleaf Mountain Mahogany	AG-Invasion	Late1	OPN	TrAG	CLS	60	999	0	9999	0.001	1	0	FALSE
Curlleaf Mountain Mahogany	Replacement Fire	Late1	CLS	Early1	ALL	150	999	0	9999	0.002	1	0	FALSE
Curlleaf Mountain Mahogany	AG-Invasion	Late1	CLS	TrAG	CLS	150	999	0	9999	0.001	1	0	FALSE
Curlleaf Mountain Mahogany	Replacement Fire	TrAG	CLS	AG	OPN	60	999	0	9999	0.007	1	0	FALSE
Curlleaf Mountain Mahogany	Replacement Fire	SENN	OPN	AG	OPN	1	19	0	9999	0.002	0.25	0	FALSE
Curlleaf Mountain Mahogany	Replacement Fire	SENN	OPN	SENN	OPN	1	19	0	9999	0.002	0.75	0	FALSE
Curlleaf Mountain Mahogany	AG-Restoration	AG	OPN	SENN	OPN	0	2	0	9999	1	0.25	0	FALSE
Curlleaf Mountain	AG-Restoration	AG	OPN	AG	OPN	0	2	0	9999	1	0.75	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Mahogany													
Curlleaf Mountain Mahogany	Replacement Fire	AG	OPN	AG	OPN	0	999	0	9999	0.1	1	0	FALSE
Limber-Bristlecone Pines	Surface Fire	Early1	ALL	Early1	ALL	0	99	0	9999	0.001	1	0	FALSE
Limber-Bristlecone Pines	Replacement Fire	Early1	ALL	Early1	ALL	0	99	0	9999	0.001	1	-100	FALSE
Limber-Bristlecone Pines	Drought	Early1	ALL	Early1	ALL	0	99	0	9999	0.01	1	0	FALSE
Limber-Bristlecone Pines	Surface Fire	Mid1	OPN	Mid1	OPN	100	249	0	9999	0.002	1	0	FALSE
Limber-Bristlecone Pines	Replacement Fire	Mid1	OPN	Early1	ALL	100	249	0	9999	0.001	1	0	FALSE
Limber-Bristlecone Pines	Replacement Fire	Late1	OPN	Early1	ALL	250	999	0	9999	0.001	1	0	FALSE
Limber-Bristlecone Pines	Surface Fire	Late1	OPN	Late1	OPN	250	999	0	9999	0.002	1	0	FALSE
Limber-Bristlecone Pines-moist	Surface Fire	Early1	ALL	Early1	ALL	0	49	0	9999	0.005	1	0	FALSE
Limber-Bristlecone Pines-moist	Replacement Fire	Early1	ALL	Early1	ALL	0	49	0	9999	0.002	1	-50	FALSE
Limber-Bristlecone Pines-moist	Drought	Early1	ALL	Early1	ALL	0	49	0	9999	0.0056	1	-50	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Limber-Bristlecone Pines-moist	Surface Fire	Mid1	OPN	Mid1	OPN	50	199	0	9999	0.005	1	0	FALSE
Limber-Bristlecone Pines-moist	Replacement Fire	Mid1	OPN	Early1	ALL	50	199	0	9999	0.002	1	0	FALSE
Limber-Bristlecone Pines-moist	Replacement Fire	Late1	OPN	Early1	ALL	200	999	0	9999	0.002	1	0	FALSE
Limber-Bristlecone Pines-moist	Surface Fire	Late1	OPN	Late1	OPN	200	999	0	9999	0.005	1	0	FALSE
Limber-Bristlecone Pines-moist	Insect/ Disease	Late1	OPN	Early1	ALL	200	999	0	9999	0.002	1	0	FALSE
Low Sagebrush-semi-desert	Replacement Fire	Early1	ALL	Early1	ALL	1	24	0	9999	0.004	1	-24	FALSE
Low Sagebrush-semi-desert	Drought	Early1	ALL	Early1	ALL	1	24	0	9999	0.002	1	-1	FALSE
Low Sagebrush-semi-desert	Managed-Herbivory	Early1	ALL	Early1	ALL	1	24	0	9999	1	0.05	2	FALSE
Low Sagebrush-semi-desert	Replacement Fire	Mid1	OPN	Early1	ALL	25	119	0	9999	0.004	1	0	FALSE
Low Sagebrush-semi-desert	Drought	Mid1	OPN	Mid1	OPN	25	119	0	9999	0.0025	1	-1	FALSE
Low Sagebrush-semi-desert	Drought	Mid1	OPN	Early1	ALL	25	119	0	9999	0.0025	1	0	FALSE
Low Sagebrush-	AG-Invasion	Mid1	OPN	ShAP	CLS	25	119	0	9999	0.001	1	0	TRUE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
semi-desert													
Low Sagebrush-semi-desert	Managed-Herbivory	Mid1	OPN	Mid1	OPN	25	119	0	9999	1	0.05	2	FALSE
Low Sagebrush-semi-desert	Replacement Fire	Late1	OPN	Early1	ALL	120	999	0	9999	0.004	1	0	FALSE
Low Sagebrush-semi-desert	Drought	Late1	OPN	Mid1	OPN	120	999	0	9999	0.0025	1	0	FALSE
Low Sagebrush-semi-desert	Drought	Late1	OPN	Late1	OPN	120	999	0	9999	0.0025	1	-1	FALSE
Low Sagebrush-semi-desert	AG-Invasion	Late1	OPN	ShAP	CLS	120	999	0	9999	0.005	1	0	TRUE
Low Sagebrush-semi-desert	Tree-Invasion	Late1	OPN	TrEnc	CLS	200	999	0	9999	0.005	1	0	FALSE
Low Sagebrush-semi-desert	Canopy-Thinning	Late1	OPN	Mid1	OPN	120	999	0	9999	0.01	0.5	0	FALSE
Low Sagebrush-semi-desert	Canopy-Thinning	Late1	OPN	Late1	OPN	120	999	0	9999	0.01	0.5	-999	FALSE
Low Sagebrush-semi-desert	Chainsaw-Lopping	Late1	OPN	Late1	OPN	120	999	0	9999	0.01	1	-999	FALSE
Low Sagebrush-semi-desert	Managed-Herbivory	Late1	OPN	Late1	OPN	120	999	0	9999	1	0.05	2	FALSE
Low Sagebrush-semi-desert	Replacement Fire	TrEnc	CLS	ShAP	CLS	200	999	0	9999	0.004	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Low Sagebrush-semi-desert	Drought	TrEnc	CLS	Late1	OPN	200	300	0	9999	0.0025	1	0	FALSE
Low Sagebrush-semi-desert	Drought	TrEnc	CLS	Mid1	OPN	301	999	0	9999	0.0025	1	0	FALSE
Low Sagebrush-semi-desert	Thin-Mech-Chem-Seed	TrEnc	CLS	Mid1	OPN	200	300	0	9999	0.01	1	0	FALSE
Low Sagebrush-semi-desert	Thin-Mech-Chem-Seed	TrEnc	CLS	Early1	ALL	300	999	0	9999	0.01	1	0	FALSE
Low Sagebrush-semi-desert	Replacement Fire	ShAP	CLS	AG	OPN	25	999	0	9999	0.01	1	0	FALSE
Low Sagebrush-semi-desert	Drought	ShAP	CLS	ShAP	CLS	25	999	0	9999	0.0025	1	-1	FALSE
Low Sagebrush-semi-desert	Drought	ShAP	CLS	AG	OPN	25	999	0	9999	0.0025	1	0	FALSE
Low Sagebrush-semi-desert	ShAG-Restoration	ShAP	CLS	Early1	ALL	25	999	0	9999	0.01	0.75	0	FALSE
Low Sagebrush-semi-desert	ShAP-Mow-Herbicide	ShAP	CLS	Mid1	OPN	25	999	0	9999	0.01	0.75	0	FALSE
Low Sagebrush-semi-desert	ShAG-Restoration	ShAP	CLS	ShAP	CLS	25	999	0	9999	0.01	0.25	0	FALSE
Low Sagebrush-semi-desert	Tree-Invasion	ShAP	CLS	TrEnc	CLS	200	999	0	9999	0.005	1	0	FALSE
Low Sagebrush-	Managed-Herbivory	ShAP	CLS	ShAP	CLS	25	999	1	9999	1	0.05	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
semi-desert													
Low Sagebrush-semi-desert	Alt Succession	ShAP	CLS	Mid1	OPN	25	119	10	9999	1	1	0	TRUE
Low Sagebrush-semi-desert	Alt Succession	ShAP	CLS	Late1	OPN	120	999	10	9999	1	1	0	TRUE
Low Sagebrush-semi-desert	Chainsaw-Lopping	ShAP	CLS	ShAP	CLS	25	999	0	9999	0.01	1	-999	FALSE
Low Sagebrush-semi-desert	ShAP-Mow-Herbicide	ShAP	CLS	ShAP	CLS	25	999	0	9999	0.01	0.25	0	FALSE
Low Sagebrush-semi-desert	Replacement Fire	AG	OPN	AG	OPN	0	999	0	9999	0.05	1	0	FALSE
Low Sagebrush-semi-desert	AG-Restoration	AG	OPN	AG	OPN	0	1	0	9999	1	0.75	0	FALSE
Low Sagebrush-semi-desert	AG-Restoration	AG	OPN	Early1	ALL	0	1	0	9999	1	0.25	0	FALSE
Low Sagebrush Steppe	Replacement Fire	Early1	ALL	Early1	ALL	1	24	0	9999	0.004	1	-24	FALSE
Low Sagebrush Steppe	Drought	Early1	ALL	Early1	ALL	1	24	0	9999	0.0056	1	-1	FALSE
Low Sagebrush Steppe	Excessive-Herbivory	Early1	ALL	Early1	ALL	1	24	5	9999	0.001	1	5	FALSE
Low Sagebrush Steppe	ActiveHerdManagement	Early1	ALL	Early1	ALL	2	24	0	9999	1	0.5	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Low Sagebrush Steppe	Managed-Herbivory	Early1	ALL	Early1	ALL	2	24	1	9999	1	0.05	1	FALSE
Low Sagebrush Steppe	Replacement Fire	Mid1	OPN	Early1	ALL	25	119	0	9999	0.011	1	0	FALSE
Low Sagebrush Steppe	Drought	Mid1	OPN	Mid1	OPN	25	119	0	9999	0.0056	0.8	-1	FALSE
Low Sagebrush Steppe	Drought	Mid1	OPN	Early1	ALL	25	119	0	9999	0.0055	0.2	0	FALSE
Low Sagebrush Steppe	Excessive-Herbivory	Mid1	OPN	DPL	CLS	25	119	5	9999	0.001	1	0	FALSE
Low Sagebrush Steppe	ActiveHerdManagement	Mid1	OPN	Mid1	OPN	25	119	0	9999	1	0.5	0	FALSE
Low Sagebrush Steppe	Managed-Herbivory	Mid1	OPN	Mid1	OPN	25	119	1	9999	1	0.05	1	TRUE
Low Sagebrush Steppe	Replacement Fire	Late1	OPN	Early1	ALL	120	999	0	9999	0.015	1	0	FALSE
Low Sagebrush Steppe	Drought	Late1	OPN	Mid1	OPN	120	999	0	9999	0.0055	0.2	0	FALSE
Low Sagebrush Steppe	Drought	Late1	OPN	Late1	OPN	120	999	0	9999	0.0056	0.8	-1	FALSE
Low Sagebrush Steppe	Tree-Invasion	Late1	OPN	TrEnc	CLS	200	999	0	9999	0.001	1	0	TRUE
Low Sagebrush	Chainsaw-Lopping	Late1	OPN	Late1	OPN	120	999	0	9999	0.01	1	-999	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Steppe													
Low Sagebrush Steppe	Excessive-Herbivory	Late1	OPN	DPL	CLS	120	999	5	9999	0.001	1	0	TRUE
Low Sagebrush Steppe	ActiveHerdManagement	Late1	OPN	Late1	OPN	120	999	0	9999	1	0.5	0	FALSE
Low Sagebrush Steppe	Managed-Herbivory	Late1	OPN	Late1	OPN	120	999	1	9999	1	0.05	1	FALSE
Low Sagebrush Steppe	RxFire	Late1	OPN	Early1	ALL	120	999	0	9999	0.01	0.7	0	FALSE
Low Sagebrush Steppe	RxFire	Late1	OPN	Late1	OPN	120	999	0	9999	0.01	0.3	0	FALSE
Low Sagebrush Steppe	Replacement Fire	TrEnc	CLS	Early1	ALL	200	999	0	9999	0.004	1	0	FALSE
Low Sagebrush Steppe	Drought	TrEnc	CLS	Late1	OPN	200	300	0	9999	0.0056	0.5	0	FALSE
Low Sagebrush Steppe	Drought	TrEnc	CLS	DPL	CLS	301	999	0	9999	0.0056	0.5	0	FALSE
Low Sagebrush Steppe	Chainsaw-Lopping	TrEnc	CLS	DPL	CLS	200	999	0	9999	0.01	1	0	FALSE
Low Sagebrush Steppe	Tree-Invasion	DPL	CLS	TrEnc	CLS	100	999	0	9999	0.005	1	0	TRUE
Low Sagebrush Steppe	Drought	DPL	CLS	DPL	CLS	25	999	0	9999	0.0056	0.9	-999	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Low Sagebrush Steppe	Drought	DPL	CLS	ESH	ALL	25	999	0	9999	0.0056	1	0	FALSE
Low Sagebrush Steppe	Replacement Fire	ESH	ALL	ESH	ALL	0	999	0	9999	0.005	1	-999	FALSE
Low Sagebrush Steppe	Alt Succession	ESH	ALL	Mid1	OPN	0	999	5	9999	0.1	1	0	FALSE
Montane Subalpine Riparian	Flooding-7yr	Early1	ALL	Early1	ALL	0	4	0	9999	0.13	1	-5	FALSE
Montane Subalpine Riparian	Excessive-Herbivory	Early1	ALL	SFEnc	ALL	0	4	5	9999	0.01	1	0	TRUE
Montane Subalpine Riparian	Weed-Inventory	Early1	ALL	Early1	ALL	0	4	0	9999	0.25	1	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	Early1	ALL	Early1	ALL	0	4	0	9999	0.05	1	-1	FALSE
Montane Subalpine Riparian	Managed-Herbivory	Early1	ALL	Early1	ALL	0	4	1	9999	1	0.5	-1	FALSE
Montane Subalpine Riparian	Grazing-Systems	Early1	ALL	Early1	ALL	0	4	0	9999	1	0.5	0	FALSE
Montane Subalpine Riparian	Fence	Early1	ALL	A-Fenced	CLS	0	4	1	9999	0.01	1	0	TRUE
Montane Subalpine Riparian	Replacement Fire	Mid1	OPN	Early1	ALL	5	19	0	9999	0.02	1	0	FALSE
Montane Subalpine	Flooding-7yr	Mid1	OPN	Mid1	OPN	5	19	0	9999	0.13	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Riparian													
Montane Subalpine Riparian	Flooding-20yr	Mid1	OPN	Early1	ALL	5	19	0	9999	0.05	1	0	FALSE
Montane Subalpine Riparian	Excessive-Herbivory	Mid1	OPN	SFEnc	ALL	5	19	5	9999	0.005	1	0	TRUE
Montane Subalpine Riparian	Exotic-Invasion	Mid1	OPN	ExF	OPN	5	19	5	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Weed-Inventory	Mid1	OPN	Mid1	OPN	5	19	0	9999	0.25	1	0	FALSE
Montane Subalpine Riparian	RxFire	Mid1	OPN	Early1	ALL	5	19	0	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	Mid1	OPN	Early1	ALL	5	19	0	9999	0.04	1	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	Mid1	OPN	Mid1	OPN	5	19	0	9999	0.04	1	-20	FALSE
Montane Subalpine Riparian	Managed-Herbivory	Mid1	OPN	Mid1	OPN	5	19	1	9999	1	0.5	-1	FALSE
Montane Subalpine Riparian	Grazing-Systems	Mid1	OPN	Mid1	OPN	5	19	0	9999	1	0.5	0	FALSE
Montane Subalpine Riparian	Fence	Mid1	OPN	B-Fenced	CLS	5	19	1	9999	0.01	1	0	TRUE
Montane Subalpine Riparian	Exotic-Invasion	Late1	CLS	ExF	OPN	20	1019	5	9999	0.01	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Subalpine Riparian	Replacement Fire	Late1	CLS	Early1	ALL	20	1019	0	9999	0.02	1	0	FALSE
Montane Subalpine Riparian	Flooding-20yr	Late1	CLS	Late1	CLS	20	1019	0	9999	0.05	1	0	FALSE
Montane Subalpine Riparian	Flooding-100yr	Late1	CLS	Early1	ALL	20	1019	0	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Excessive-Herbivory	Late1	CLS	SFEnc	ALL	20	1019	5	9999	0.0025	1	0	TRUE
Montane Subalpine Riparian	Weed-Inventory	Late1	CLS	Late1	CLS	20	1019	0	9999	0.25	1	0	FALSE
Montane Subalpine Riparian	RxFire	Late1	CLS	Early1	ALL	20	1019	0	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	Late1	CLS	Mid1	OPN	20	1019	0	9999	0.002	0.5	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	Late1	CLS	Late1	CLS	20	1019	0	9999	0.002	0.5	-5	FALSE
Montane Subalpine Riparian	Grazing-Systems	Late1	CLS	Late1	CLS	20	1019	0	9999	1	0.5	0	FALSE
Montane Subalpine Riparian	Fence	Late1	CLS	C-Fenced	CLS	20	1019	1	9999	0.01	1	0	TRUE
Montane Subalpine Riparian	Floodplain-Enlargement	DES	OPN	Early1	ALL	0	999	0	9999	0.01	1	0	FALSE
Montane Subalpine	Floodplain-Restoration	DES	OPN	Early1	ALL	0	999	0	9999	0.01	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Riparian													
Montane Subalpine Riparian	Replacement Fire	DES	OPN	DES	OPN	0	999	0	9999	0.02	1	-999	FALSE
Montane Subalpine Riparian	Floodplain-Recovery	DES	OPN	Early1	ALL	0	999	5	9999	0.001	1	0	FALSE
Montane Subalpine Riparian	Managed-Herbivory	DES	OPN	DES	OPN	0	999	0	9999	1	0.5	3	FALSE
Montane Subalpine Riparian	Grazing-Systems	DES	OPN	DES	OPN	0	999	0	9999	1	0.5	0	FALSE
Montane Subalpine Riparian	Exotic-Control	ExF	OPN	Mid1	OPN	0	999	0	20	1	0.6	0	TRUE
Montane Subalpine Riparian	Exotic-Control	ExF	OPN	ExF	OPN	0	999	0	20	1	0.4	0	FALSE
Montane Subalpine Riparian	Replacement Fire	ExF	OPN	ExF	OPN	0	999	0	9999	0.02	1	-999	FALSE
Montane Subalpine Riparian	HVG-Restoration	SFEnc	ALL	Early1	ALL	0	4	2	9999	0.01	1	0	TRUE
Montane Subalpine Riparian	HVG-Restoration	SFEnc	ALL	Mid1	OPN	5	19	2	9999	0.01	1	0	TRUE
Montane Subalpine Riparian	HVG-Restoration	SFEnc	ALL	Late1	CLS	20	999	2	9999	0.01	1	0	TRUE
Montane Subalpine Riparian	Entrenchmen t	SFEnc	ALL	DES	OPN	0	4	0	9999	0.05	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Subalpine Riparian	Entrenchment	SFEnc	ALL	DES	OPN	5	999	0	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Exotic-Invasion	SFEnc	ALL	ExF	OPN	0	999	5	9999	0.33	1	0	TRUE
Montane Subalpine Riparian	Replacement Fire	SFEnc	ALL	SFEnc	ALL	5	999	0	9999	0.02	1	-999	FALSE
Montane Subalpine Riparian	Flooding-7yr	SFEnc	ALL	SFEnc	ALL	0	4	0	9999	0.13	1	-999	FALSE
Montane Subalpine Riparian	Weed-Inventory	SFEnc	ALL	SFEnc	ALL	0	999	0	9999	0.25	1	0	FALSE
Montane Subalpine Riparian	Managed-Herbivory	SFEnc	ALL	SFEnc	ALL	0	999	0	9999	1	0.5	-1	FALSE
Montane Subalpine Riparian	Grazing-Systems	SFEnc	ALL	SFEnc	ALL	0	999	0	9999	1	0.5	0	FALSE
Montane Subalpine Riparian	Flooding-7yr	A-Fenced	CLS	A-Fenced	CLS	0	4	0	9999	0.13	1	-5	FALSE
Montane Subalpine Riparian	Weed-Inventory	A-Fenced	CLS	A-Fenced	CLS	0	4	0	9999	0.25	1	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	A-Fenced	CLS	A-Fenced	CLS	0	4	0	9999	0.05	1	-1	FALSE
Montane Subalpine Riparian	Fenced-Succession	A-Fenced	CLS	Early1	ALL	0	4	3	9999	0.9	1	0	TRUE
Montane Subalpine	Replacement Fire	B-Fenced	CLS	A-Fenced	CLS	5	19	0	9999	0.02	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Riparian													
Montane Subalpine Riparian	Flooding-7yr	B-Fenced	CLS	B-Fenced	CLS	5	19	0	9999	0.17	1	0	FALSE
Montane Subalpine Riparian	Flooding-20yr	B-Fenced	CLS	A-Fenced	CLS	5	19	0	9999	0.05	1	0	FALSE
Montane Subalpine Riparian	Exotic-Invasion	B-Fenced	CLS	ExF	OPN	5	19	5	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Weed-Inventory	B-Fenced	CLS	B-Fenced	CLS	5	19	0	9999	0.25	1	0	FALSE
Montane Subalpine Riparian	RxFire	B-Fenced	CLS	A-Fenced	CLS	5	19	0	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	B-Fenced	CLS	A-Fenced	CLS	5	19	0	9999	0.08	0.5	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	B-Fenced	CLS	B-Fenced	CLS	5	19	0	9999	0.08	0.5	-20	FALSE
Montane Subalpine Riparian	Fenced-Succession	B-Fenced	CLS	Mid1	OPN	5	19	3	9999	0.9	1	0	TRUE
Montane Subalpine Riparian	Exotic-Invasion	C-Fenced	CLS	ExF	OPN	20	1019	5	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Replacement Fire	C-Fenced	CLS	A-Fenced	CLS	20	1019	0	9999	0.02	1	0	FALSE
Montane Subalpine Riparian	Flooding-20yr	C-Fenced	CLS	C-Fenced	CLS	20	1019	0	9999	0.05	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Subalpine Riparian	Flooding-100yr	C-Fenced	CLS	A-Fenced	CLS	20	1019	0	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Weed-Inventory	C-Fenced	CLS	C-Fenced	CLS	20	1019	0	9999	0.25	1	0	FALSE
Montane Subalpine Riparian	RxFire	C-Fenced	CLS	A-Fenced	CLS	20	1019	0	9999	0.01	1	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	C-Fenced	CLS	B-Fenced	CLS	20	1019	0	9999	0.002	0.5	0	FALSE
Montane Subalpine Riparian	Beaver-Herbivory	C-Fenced	CLS	C-Fenced	CLS	20	1019	0	9999	0.002	0.5	-5	FALSE
Montane Subalpine Riparian	Fenced-Succession	C-Fenced	CLS	Late1	CLS	20	1019	3	9999	0.9	1	0	TRUE
Montane Sagebrush Steppe-mountain	Replacement Fire	Early1	ALL	Early1	ALL	0	11	0	9999	0.0125	1	-12	FALSE
Montane Sagebrush Steppe-mountain	Excessive-Herbivory	Early1	ALL	ESH	CLS	3	11	0	9999	0.001	0.5	0	FALSE
Montane Sagebrush Steppe-mountain	Managed-Herbivory	Early1	ALL	Early1	ALL	3	11	0	9999	1	0.05	1	FALSE
Montane Sagebrush Steppe-mountain	Replacement Fire	Mid1	OPN	Early1	ALL	12	49	0	9999	0.025	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Sagebrush Steppe-mountain	Excessive-Herbivory	Mid1	OPN	Mid1	OPN	12	49	0	9999	0.0011	0.75	1	FALSE
Montane Sagebrush Steppe-mountain	Excessive-Herbivory	Mid1	OPN	ESH	CLS	12	49	0	9999	0.0012	0.25	0	FALSE
Montane Sagebrush Steppe-mountain	Managed-Herbivory	Mid1	OPN	Mid1	OPN	12	49	0	9999	1	0.05	0	FALSE
Montane Sagebrush Steppe-mountain	Tree-Invasion	Mid1	OPN	Late2	OPN	40	49	0	9999	0.01	1	0	TRUE
Montane Sagebrush Steppe-mountain	Replacement Fire	Late1	CLS	Early1	ALL	50	999	0	9999	0.02	1	0	FALSE
Montane Sagebrush Steppe-mountain	Drought	Late1	CLS	Mid1	OPN	50	999	0	9999	0.0056	0.1	0	FALSE
Montane Sagebrush Steppe-mountain	Excessive-Herbivory	Late1	CLS	DPL	CLS	50	999	0	9999	0.0012	1	0	TRUE
Montane Sagebrush Steppe-mountain	RxFire	Late1	CLS	Early1	ALL	50	999	0	9999	0.01	0.7	0	FALSE
Montane Sagebrush Steppe-	RxFire	Late1	CLS	Late1	CLS	50	999	0	9999	0.01	0.3	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
mountain													
Montane Sagebrush Steppe-mountain	Managed-Herbivory	Late1	CLS	Late1	CLS	50	999	0	9999	1	0.05	1	FALSE
Montane Sagebrush Steppe-mountain	Tree-Invasion	Late1	CLS	Late2	OPN	50	999	0	9999	0.01	1	0	TRUE
Montane Sagebrush Steppe-mountain	Drought	Late1	CLS	Late1	CLS	50	999	0	9999	0.0056	0.9	-999	FALSE
Montane Sagebrush Steppe-mountain	Herbicide-Spike	Late1	CLS	Mid1	OPN	50	999	0	9999	0.01	1	0	FALSE
Montane Sagebrush Steppe-mountain	Replacement Fire	Late2	OPN	Early1	ALL	40	114	0	9999	0.02	1	0	FALSE
Montane Sagebrush Steppe-mountain	Excessive-Herbivory	Late2	OPN	Late2	OPN	40	114	0	9999	0.0011	0.75	3	FALSE
Montane Sagebrush Steppe-mountain	Excessive-Herbivory	Late2	OPN	DPL	CLS	40	114	0	9999	0.0012	0.25	0	TRUE
Montane Sagebrush Steppe-mountain	RxFire	Late2	OPN	Early1	ALL	40	114	0	9999	0.01	0.7	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Sagebrush Steppe-mountain	RxFire	Late2	OPN	Late2	OPN	40	114	0	9999	0.01	0.3	0	FALSE
Montane Sagebrush Steppe-mountain	Managed-Herbivory	Late2	OPN	Late2	OPN	40	114	0	9999	1	0.05	1	FALSE
Montane Sagebrush Steppe-mountain	Chainsaw-Lopping	Late2	OPN	Late2	OPN	40	114	0	9999	0.01	1	-115	FALSE
Montane Sagebrush Steppe-mountain	Herbicide-Spike	Late2	OPN	Mid1	OPN	40	114	0	9999	0.01	1	0	FALSE
Montane Sagebrush Steppe-mountain	Drought	Late2	OPN	Mid1	OPN	40	114	0	9999	0.0057	0.3	0	FALSE
Montane Sagebrush Steppe-mountain	Chaining	Late2	OPN	Mid1	OPN	40	114	0	9999	0.01	0.9	0	FALSE
Montane Sagebrush Steppe-mountain	Chaining	Late2	OPN	Late1	CLS	40	114	0	9999	0.01	0.1	0	FALSE
Montane Sagebrush Steppe-mountain	Drought	Late2	OPN	Late1	CLS	40	114	0	9999	0.0057	0.6	0	FALSE
Montane Sagebrush Steppe-	Drought	Late2	OPN	Late2	OPN	40	114	0	9999	0.0056	0.1	-115	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
mountain													
Montane Sagebrush Steppe-mountain	Replacement Fire	Late2	CLS	Early1	ALL	115	999	0	9999	0.013	1	0	FALSE
Montane Sagebrush Steppe-mountain	Drought	Late2	CLS	Mid1	OPN	115	999	0	9999	0.0056	0.1	0	FALSE
Montane Sagebrush Steppe-mountain	Drought	Late2	CLS	Late2	CLS	115	999	0	9999	0.0056	0.9	5	FALSE
Montane Sagebrush Steppe-mountain	RxFire	Late2	CLS	Early1	ALL	115	999	0	9999	0.01	0.7	0	FALSE
Montane Sagebrush Steppe-mountain	RxFire	Late2	CLS	Late2	CLS	115	999	0	9999	0.01	0.3	0	FALSE
Montane Sagebrush Steppe-mountain	Chaining	Late2	CLS	Early1	ALL	115	999	0	9999	0.01	0.4	0	FALSE
Montane Sagebrush Steppe-mountain	Chaining	Late2	CLS	Mid1	OPN	115	999	0	9999	0.01	0.6	0	FALSE
Montane Sagebrush Steppe-mountain	Managed-Herbivory	Late2	CLS	Late2	CLS	115	999	0	9999	1	0.05	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Sagebrush Steppe-mountain	Tree-Encroachment	Late2	CLS	TrEnc	CLS	140	999	0	9999	0.1	1	0	TRUE
Montane Sagebrush Steppe-mountain	Replacement Fire	DPL	CLS	ESH	CLS	50	999	0	9999	0.02	1	0	FALSE
Montane Sagebrush Steppe-mountain	Tree-Invasion	DPL	CLS	TrEnc	CLS	100	999	0	9999	0.01	1	0	TRUE
Montane Sagebrush Steppe-mountain	DPL-Restoration	DPL	CLS	ESH	CLS	50	999	0	9999	0.01	0.2	0	TRUE
Montane Sagebrush Steppe-mountain	Chainsaw-Lopping	DPL	CLS	DPL	CLS	50	999	0	9999	0.01	1	-999	FALSE
Montane Sagebrush Steppe-mountain	Drought	DPL	CLS	DPL	CLS	50	999	0	9999	0.0056	0.9	-999	FALSE
Montane Sagebrush Steppe-mountain	Drought	DPL	CLS	ESH	CLS	50	999	0	9999	0.006	0.1	0	FALSE
Montane Sagebrush Steppe-mountain	Replacement Fire	ESH	CLS	ESH	CLS	0	999	0	9999	0.02	0.95	0	FALSE
Montane Sagebrush Steppe-	Replacement Fire	ESH	CLS	Early1	ALL	0	999	0	9999	0.02	0.05	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
mountain													
Montane Sagebrush Steppe-mountain	Alt Succession	ESH	CLS	Mid1	OPN	12	49	10	9999	0.001	1	0	TRUE
Montane Sagebrush Steppe-mountain	Alt Succession	ESH	CLS	Late1	CLS	50	999	10	9999	0.001	1	0	TRUE
Montane Sagebrush Steppe-mountain	Replacement Fire	TrEnc	CLS	ESH	CLS	100	999	0	9999	0.0084	0.45	0	FALSE
Montane Sagebrush Steppe-mountain	Drought	TrEnc	CLS	ESH	CLS	100	999	0	9999	0.0056	0.5	0	FALSE
Montane Sagebrush Steppe-mountain	Thin-Mech-Chem-Seed	TrEnc	CLS	Early1	ALL	100	999	0	9999	0.01	1	0	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	Early1	ALL	Early1	ALL	0	11	0	9999	0.0125	1	-12	FALSE
Montane Sagebrush Steppe-upland	Excessive-Herbivory	Early1	ALL	ESH	CLS	0	11	0	9999	0.001	0.5	0	FALSE
Montane Sagebrush Steppe-upland	Managed-Herbivory	Early1	ALL	Early1	ALL	3	11	0	9999	1	0.05	1	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Sagebrush Steppe-upland	Excessive-Herbivory	Early1	ALL	ExF	CLS	0	11	0	9999	0.001	0.5	0	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	Mid1	OPN	Early1	ALL	12	49	0	9999	0.025	1	0	FALSE
Montane Sagebrush Steppe-upland	Excessive-Herbivory	Mid1	OPN	Mid1	OPN	12	49	0	9999	0.0011	0.75	2	FALSE
Montane Sagebrush Steppe-upland	Excessive-Herbivory	Mid1	OPN	ESH	CLS	12	49	0	9999	0.0012	0.25	0	FALSE
Montane Sagebrush Steppe-upland	Managed-Herbivory	Mid1	OPN	Mid1	OPN	12	49	0	9999	1	0.05	1	FALSE
Montane Sagebrush Steppe-upland	Tree-Invasion	Mid1	OPN	Late2	OPN	40	49	0	9999	0.01	1	0	TRUE
Montane Sagebrush Steppe-upland	Replacement Fire	Late1	CLS	Early1	ALL	50	999	0	9999	0.02	1	0	FALSE
Montane Sagebrush Steppe-upland	Drought	Late1	CLS	Mid1	OPN	50	999	0	9999	0.0056	0.1	0	FALSE
Montane Sagebrush Steppe-	Excessive-Herbivory	Late1	CLS	DPL	CLS	50	999	0	9999	0.0012	1	0	TRUE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
upland													
Montane Sagebrush Steppe-upland	Canopy-Thinning	Late1	CLS	Early1	ALL	50	999	0	9999	0.01	0.5	0	FALSE
Montane Sagebrush Steppe-upland	Canopy-Thinning	Late1	CLS	Mid1	OPN	50	999	0	9999	0.01	0.5	0	FALSE
Montane Sagebrush Steppe-upland	RxFire	Late1	CLS	Early1	ALL	50	999	0	9999	0.01	0.7	0	FALSE
Montane Sagebrush Steppe-upland	RxFire	Late1	CLS	Late1	CLS	50	999	0	9999	0.01	0.3	0	FALSE
Montane Sagebrush Steppe-upland	AG-Invasion	Late1	CLS	ShAP	CLS	50	999	0	9999	0.005	1	0	TRUE
Montane Sagebrush Steppe-upland	Managed-Herbivory	Late1	CLS	Late1	CLS	50	999	0	9999	1	0.05	1	FALSE
Montane Sagebrush Steppe-upland	Tree-Invasion	Late1	CLS	Late2	OPN	50	999	0	9999	0.01	1	0	TRUE
Montane Sagebrush Steppe-upland	Drought	Late1	CLS	Late1	CLS	50	999	0	9999	0.0056	0.9	-999	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Sagebrush Steppe-upland	Herbicide-Spike	Late1	CLS	Mid1	OPN	50	999	0	9999	0.01	1	0	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	Late2	OPN	Early1	ALL	40	114	0	9999	0.02	1	0	FALSE
Montane Sagebrush Steppe-upland	Excessive-Herbivory	Late2	OPN	Late2	OPN	40	114	0	9999	0.0011	0.75	3	FALSE
Montane Sagebrush Steppe-upland	Excessive-Herbivory	Late2	OPN	DPL	CLS	40	114	0	9999	0.0012	0.25	0	TRUE
Montane Sagebrush Steppe-upland	RxFire	Late2	OPN	Early1	ALL	40	114	0	9999	0.01	0.7	0	FALSE
Montane Sagebrush Steppe-upland	RxFire	Late2	OPN	Late2	OPN	40	114	0	9999	0.01	0.3	0	FALSE
Montane Sagebrush Steppe-upland	Canopy-Thinning	Late2	OPN	Late1	CLS	40	114	0	9999	0.01	0.1	0	FALSE
Montane Sagebrush Steppe-upland	Canopy-Thinning	Late2	OPN	Mid1	OPN	40	114	0	9999	0.01	0.45	0	FALSE
Montane Sagebrush Steppe-	Canopy-Thinning	Late2	OPN	Early1	ALL	40	114	0	9999	0.01	0.45	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
upland													
Montane Sagebrush Steppe-upland	Managed-Herbivory	Late2	OPN	Late2	OPN	40	114	0	9999	1	0.05	1	FALSE
Montane Sagebrush Steppe-upland	AG-Invasion	Late2	OPN	ShAP	CLS	40	114	0	9999	0.005	1	0	TRUE
Montane Sagebrush Steppe-upland	Chainsaw-Lopping	Late2	OPN	Late2	OPN	40	114	0	9999	0.01	1	-115	FALSE
Montane Sagebrush Steppe-upland	Herbicide-Spike	Late2	OPN	Mid1	OPN	40	114	0	9999	0.01	1	0	FALSE
Montane Sagebrush Steppe-upland	Drought	Late2	OPN	Mid1	OPN	40	114	0	9999	0.0056	0.3	0	FALSE
Montane Sagebrush Steppe-upland	Chaining	Late2	OPN	Mid1	OPN	40	114	0	9999	0.01	0.9	0	FALSE
Montane Sagebrush Steppe-upland	Chaining	Late2	OPN	Late1	CLS	40	114	0	9999	0.01	0.1	0	FALSE
Montane Sagebrush Steppe-upland	Drought	Late2	OPN	Late1	CLS	40	114	0	9999	0.0056	0.6	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Sagebrush Steppe-upland	Drought	Late2	OPN	Late2	OPN	40	114	0	9999	0.0056	0.1	-115	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	Late2	CLS	Early1	ALL	115	999	0	9999	0.013	1	0	FALSE
Montane Sagebrush Steppe-upland	Drought	Late2	CLS	Mid1	OPN	115	999	0	9999	0.0056	0.1	0	FALSE
Montane Sagebrush Steppe-upland	Drought	Late2	CLS	Late2	CLS	115	999	0	9999	0.0056	0.9	5	FALSE
Montane Sagebrush Steppe-upland	RxFire	Late2	CLS	Early1	ALL	115	999	0	9999	0.01	0.7	0	FALSE
Montane Sagebrush Steppe-upland	RxFire	Late2	CLS	Late2	CLS	115	999	0	9999	0.01	0.3	0	FALSE
Montane Sagebrush Steppe-upland	Chaining	Late2	CLS	Early1	ALL	115	999	0	9999	0.01	0.4	0	FALSE
Montane Sagebrush Steppe-upland	Chaining	Late2	CLS	Mid1	OPN	115	999	0	9999	0.01	0.6	0	FALSE
Montane Sagebrush Steppe-	Managed-Herbivory	Late2	CLS	Late2	CLS	115	999	0	9999	1	0.05	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
upland													
Montane Sagebrush Steppe-upland	Alt-Succession1	Late2	CLS	TrEnc	CLS	140	999	0	9999	0.2	1	0	TRUE
Montane Sagebrush Steppe-upland	Replacement Fire	DPL	CLS	ESH	CLS	50	999	0	9999	0.02	1	0	FALSE
Montane Sagebrush Steppe-upland	AG-Invasion	DPL	CLS	ShAG	CLS	50	999	0	9999	0.005	1	0	FALSE
Montane Sagebrush Steppe-upland	Tree-Invasion	DPL	CLS	TrEnc	CLS	100	999	0	9999	0.01	1	0	TRUE
Montane Sagebrush Steppe-upland	DPL-Restoration	DPL	CLS	SENN	ALL	50	999	0	9999	0.01	0.8	0	TRUE
Montane Sagebrush Steppe-upland	DPL-Restoration	DPL	CLS	ESH	CLS	50	999	0	9999	0.01	0.2	0	TRUE
Montane Sagebrush Steppe-upland	Drought	DPL	CLS	DPL	CLS	50	999	0	9999	0.0056	0.9	-999	FALSE
Montane Sagebrush Steppe-upland	Drought	DPL	CLS	ESH	CLS	50	999	0	9999	0.0056	0.1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Sagebrush Steppe-upland	Replacement Fire	ESH	CLS	ESH	CLS	0	999	0	9999	0.02	0.95	0	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	ESH	CLS	Early1	ALL	0	999	0	9999	0.02	0.05	0	FALSE
Montane Sagebrush Steppe-upland	ESH-Restoration	ESH	CLS	SENN	ALL	0	999	0	9999	0.001	0.6	0	FALSE
Montane Sagebrush Steppe-upland	ESH-Restoration	ESH	CLS	ESH	CLS	0	999	0	9999	0.001	0.4	0	FALSE
Montane Sagebrush Steppe-upland	Alt Succession	ESH	CLS	Mid1	OPN	12	49	10	9999	0.001	1	0	TRUE
Montane Sagebrush Steppe-upland	Alt Succession	ESH	CLS	Late1	CLS	50	999	10	9999	0.001	1	0	TRUE
Montane Sagebrush Steppe-upland	Replacement Fire	TrEnc	CLS	ESH	CLS	100	999	0	9999	0.0085	0.45	0	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	TrEnc	CLS	ShAG	CLS	100	999	0	9999	0.0085	0.1	0	FALSE
Montane Sagebrush Steppe-	Drought	TrEnc	CLS	ShAG	CLS	100	999	0	9999	0.0056	0.5	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
upland													
Montane Sagebrush Steppe-upland	Drought	TrEnc	CLS	ESH	CLS	100	999	0	9999	0.0056	0.5	0	FALSE
Montane Sagebrush Steppe-upland	Thin-Mech-Chem-Seed	TrEnc	CLS	SENN	ALL	100	999	0	9999	0.01	0.95	0	FALSE
Montane Sagebrush Steppe-upland	Thin-Mech-Chem-Seed	TrEnc	CLS	AG	ALL	100	999	0	9999	0.01	0.05	0	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	TrEnc	CLS	AG	ALL	100	999	0	9999	0.0085	0.45	0	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	ShAG	CLS	AG	ALL	50	999	0	9999	0.04	1	0	FALSE
Montane Sagebrush Steppe-upland	Tree-Invasion	ShAG	CLS	TrEnc	CLS	100	999	0	9999	0.01	1	0	TRUE
Montane Sagebrush Steppe-upland	ShAG-Restoration	ShAG	CLS	SENN	ALL	50	999	0	9999	0.01	0.95	0	FALSE
Montane Sagebrush Steppe-upland	ShAG-Restoration	ShAG	CLS	AG	ALL	50	999	0	9999	0.01	0.05	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Sagebrush Steppe-upland	Drought	ShAG	CLS	ShAG	CLS	50	999	0	9999	0.0056	0.9	-999	FALSE
Montane Sagebrush Steppe-upland	Drought	ShAG	CLS	AG	ALL	50	999	0	9999	0.0056	0.1	0	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	ShAP	CLS	Early1	ALL	50	999	0	9999	0.04	0.5	0	FALSE
Montane Sagebrush Steppe-upland	Replacement Fire	ShAP	CLS	AG	ALL	50	999	0	9999	0.04	0.5	0	FALSE
Montane Sagebrush Steppe-upland	Tree-Invasion	ShAP	CLS	TrEnc	CLS	100	999	0	9999	0.01	1	0	TRUE
Montane Sagebrush Steppe-upland	Excessive-Herbivory	ShAP	CLS	ShAG	CLS	50	999	0	9999	0.001	1	0	TRUE
Montane Sagebrush Steppe-upland	ShAP-Mow-Herbicide	ShAP	CLS	Early1	ALL	50	999	0	9999	0.01	0.25	0	FALSE
Montane Sagebrush Steppe-upland	ShAP-Mow-Herbicide	ShAP	CLS	Mid1	OPN	50	999	0	9999	0.01	0.65	0	FALSE
Montane Sagebrush Steppe-	RxFire	ShAP	CLS	Early1	ALL	50	999	0	9999	0.01	0.35	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
upland													
Montane Sagebrush Steppe-upland	RxFire	ShAP	CLS	ShAP	CLS	50	999	0	9999	0.01	0.3	0	FALSE
Montane Sagebrush Steppe-upland	Managed-Herbivory	ShAP	CLS	ShAP	CLS	50	59	0	9999	1	0.05	5	FALSE
Montane Sagebrush Steppe-upland	Drought	ShAP	CLS	ShAP	CLS	50	999	0	9999	0.0056	0.9	-999	FALSE
Montane Sagebrush Steppe-upland	Drought	ShAP	CLS	AG	ALL	50	999	0	9999	0.0056	0.1	0	FALSE
Montane Sagebrush Steppe-upland	ShAP-Mow-Herbicide	ShAP	CLS	ShAP	CLS	50	999	0	9999	0.01	0.1	0	FALSE
Montane Sagebrush Steppe-upland	RxFire	ShAP	CLS	AG	ALL	50	999	0	9999	0.01	0.35	0	FALSE
Montane Sagebrush Steppe-upland	Managed-Herbivory	ShAP	CLS	ShAP	CLS	60	999	0	9999	1	0.04	5	FALSE
Montane Sagebrush Steppe-upland	Managed-Herbivory	ShAP	CLS	ShAG	CLS	60	999	0	9999	1	0.01	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Sagebrush Steppe-upland	Replacement Fire	AG	ALL	AG	ALL	1	999	0	9999	0.1	1	0	FALSE
Montane Sagebrush Steppe-upland	AG-Restoration	AG	ALL	SENN	ALL	0	3	0	9999	1	0.8	0	FALSE
Montane Sagebrush Steppe-upland	AG-Restoration	AG	ALL	AG	ALL	0	3	0	9999	1	0.2	0	FALSE
Montane Sagebrush Steppe-upland	Alt Succession	SENN	ALL	Early1	ALL	5	11	5	9999	0.001	1	0	TRUE
Montane Sagebrush Steppe-upland	Alt Succession	SENN	ALL	Mid1	OPN	12	49	10	9999	0.01	1	0	TRUE
Montane Sagebrush Steppe-upland	Alt Succession	SENN	ALL	Late1	CLS	50	999	10	9999	0.05	1	0	TRUE
Montane Sagebrush Steppe-upland	Replacement Fire	SENN	ALL	SENN	ALL	0	999	0	9999	0.02	1	-999	FALSE
Montane Sagebrush Steppe-upland	Managed-Herbivory	SENN	ALL	SENN	ALL	3	999	0	9999	1	0.25	1	FALSE
Montane Sagebrush Steppe-	AG-Invasion	SENN	ALL	AG	ALL	0	11	0	9999	0.001	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
upland													
Montane Sagebrush Steppe-upland	AG-Invasion	SENN	ALL	ShAG	CLS	12	999	0	9999	0.005	1	0	FALSE
Montane Sagebrush Steppe-upland	Herbicide-Weeds	ExF	CLS	Early1	ALL	0	999	0	9999	0.01	0.7	0	FALSE
Montane Sagebrush Steppe-upland	Herbicide-Weeds	ExF	CLS	ExF	CLS	0	999	0	9999	0.01	0.3	0	FALSE
Montane Wet Meadow	Drought	Early1	OPN	Early1	OPN	0	2	0	9999	0.0056	1	-2	FALSE
Montane Wet Meadow	Excessive-Herbivory	Early1	OPN	SFEnc	ALL	0	2	2	9999	0.01	0.9	0	TRUE
Montane Wet Meadow	Weed-Inventory	Early1	OPN	Early1	OPN	0	2	0	9999	0.25	1	0	FALSE
Montane Wet Meadow	Managed-Herbivory	Early1	OPN	Early1	OPN	0	2	1	9999	1	0.5	-1	FALSE
Montane Wet Meadow	Grazing-Systems	Early1	OPN	Early1	OPN	0	2	0	9999	1	0.5	0	FALSE
Montane Wet Meadow	Fence	Early1	OPN	A-Fenced	OPN	0	2	1	9999	0.01	1	0	TRUE
Montane Wet Meadow	Replacement Fire	Mid1	CLS	Early1	OPN	3	22	0	9999	0.025	1	0	FALSE
Montane Wet Meadow	Exotic-Invasion	Mid1	CLS	ExF	OPN	3	22	5	9999	0.005	1	0	FALSE
Montane Wet Meadow	Excessive-Herbivory	Mid1	CLS	SFEnc	ALL	3	22	2	9999	0.01	1	0	TRUE
Montane Wet Meadow	Weed-Inventory	Mid1	CLS	Mid1	CLS	3	22	0	9999	0.25	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Wet Meadow	Managed-Herbivory	Mid1	CLS	Mid1	CLS	3	22	1	9999	1	0.5	-1	FALSE
Montane Wet Meadow	Grazing-Systems	Mid1	CLS	Mid1	CLS	3	22	0	9999	1	0.5	0	FALSE
Montane Wet Meadow	RxFire	Mid1	CLS	Early1	OPN	3	22	0	9999	0.01	1	0	FALSE
Montane Wet Meadow	Drought	Mid1	CLS	Mid1	CLS	3	22	0	9999	0.0056	1	2	FALSE
Montane Wet Meadow	Fence	Mid1	CLS	B-Fenced	CLS	3	22	1	9999	0.01	1	0	TRUE
Montane Wet Meadow	Replacement Fire	Late1	OPN	Early1	OPN	23	999	0	9999	0.025	1	0	FALSE
Montane Wet Meadow	Exotic-Invasion	Late1	OPN	ExF	OPN	23	999	5	9999	0.005	1	0	FALSE
Montane Wet Meadow	Weed-Inventory	Late1	OPN	Late1	OPN	23	999	0	9999	0.25	1	0	FALSE
Montane Wet Meadow	Excessive-Herbivory	Late1	OPN	SFEnc	ALL	23	999	2	9999	0.005	1	0	TRUE
Montane Wet Meadow	Canopy-Thinning	Late1	OPN	Mid1	CLS	23	999	10	9999	0.01	1	-999	FALSE
Montane Wet Meadow	RxFire	Late1	OPN	Early1	OPN	23	999	0	9999	0.01	1	0	FALSE
Montane Wet Meadow	Managed-Herbivory	Late1	OPN	Late1	OPN	23	999	1	9999	1	0.9	-1	FALSE
Montane Wet Meadow	Grazing-Systems	Late1	OPN	Late1	OPN	23	999	0	9999	1	0.5	0	FALSE
Montane Wet Meadow	Fence	Late1	OPN	C-Fenced	OPN	23	999	1	9999	0.01	1	0	TRUE
Montane Wet Meadow	Replacement Fire	DES	CLS	DES	CLS	2	999	0	9999	0.01	0.5	-999	FALSE
Montane Wet Meadow	Weed-Inventory	DES	CLS	DES	CLS	2	999	0	9999	0.25	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Wet Meadow	Tree-Invasion	DES	CLS	TrEnc	CLS	75	999	0	9999	0.005	1	0	FALSE
Montane Wet Meadow	Floodplain-Enlargement	DES	CLS	SFEnc	ALL	2	999	0	9999	0.01	1	0	FALSE
Montane Wet Meadow	Floodplain-Restoration	DES	CLS	SFEnc	ALL	2	999	0	9999	0.01	1	0	FALSE
Montane Wet Meadow	Replacement Fire	DES	CLS	AG	OPN	2	999	0	9999	0.01	0.5	0	FALSE
Montane Wet Meadow	Managed-Herbivory	DES	CLS	DES	CLS	2	999	1	9999	1	0.9	3	FALSE
Montane Wet Meadow	Grazing-Systems	DES	CLS	DES	CLS	2	999	0	9999	1	0.5	0	FALSE
Montane Wet Meadow	Floodplain-Recovery	DES	CLS	Mid1	CLS	2	999	5	9999	0.001	1	0	FALSE
Montane Wet Meadow	Drought	DES	CLS	DES	CLS	2	999	0	9999	0.0056	0.9	-999	FALSE
Montane Wet Meadow	Drought	DES	CLS	AG	OPN	2	999	0	9999	0.0056	0.1	0	FALSE
Montane Wet Meadow	Exotic-Control	ExF	OPN	Early1	OPN	1	999	0	20	1	0.6	0	FALSE
Montane Wet Meadow	Replacement Fire	ExF	OPN	ExF	OPN	1	999	0	9999	0.025	1	-9999	FALSE
Montane Wet Meadow	Exotic-Control	ExF	OPN	ExF	OPN	1	999	0	20	1	0.4	0	FALSE
Montane Wet Meadow	Replacement Fire	TrEnc	CLS	DES	CLS	75	999	0	9999	0.0131	0.75	0	FALSE
Montane Wet Meadow	Drought	TrEnc	CLS	DES	CLS	75	999	0	9999	0.0056	0.1	0	FALSE
Montane Wet Meadow	RxFire	TrEnc	CLS	DES	CLS	75	999	0	9999	0.0131	0.75	0	FALSE
Montane Wet Meadow	Thin-Mech-Chem-Seed	TrEnc	CLS	DES	CLS	75	999	0	9999	0.01	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Wet Meadow	Replacement Fire	TrEnc	CLS	AG	OPN	75	999	0	9999	0.0132	0.25	0	FALSE
Montane Wet Meadow	RxFire	TrEnc	CLS	AG	OPN	75	999	0	9999	0.0132	0.25	0	FALSE
Montane Wet Meadow	Drought	TrEnc	CLS	TrEnc	CLS	75	999	0	9999	0.0056	0.9	-999	FALSE
Montane Wet Meadow	AG-Restoration	AG	OPN	DES	CLS	0	1	0	9999	1	0.75	0	FALSE
Montane Wet Meadow	AG-Restoration	AG	OPN	AG	OPN	0	1	0	9999	1	0.25	0	FALSE
Montane Wet Meadow	Replacement Fire	AG	OPN	AG	OPN	0	999	0	9999	0.1	1	-999	FALSE
Montane Wet Meadow	Entrenchment	SFEnc	ALL	DES	CLS	1	2	0	9999	0.05	1	0	FALSE
Montane Wet Meadow	Entrenchment	SFEnc	ALL	DES	CLS	3	999	0	9999	0.01	1	0	FALSE
Montane Wet Meadow	HVG-Restoration	SFEnc	ALL	Early1	OPN	1	2	0	9999	0.01	1	0	FALSE
Montane Wet Meadow	HVG-Restoration	SFEnc	ALL	Mid1	CLS	3	22	0	9999	0.01	1	0	FALSE
Montane Wet Meadow	HVG-Restoration	SFEnc	ALL	Late1	OPN	23	999	0	9999	0.01	1	0	FALSE
Montane Wet Meadow	Replacement Fire	SFEnc	ALL	Early1	OPN	1	999	0	9999	0.025	1	-999	FALSE
Montane Wet Meadow	Weed-Inventory	SFEnc	ALL	SFEnc	ALL	1	999	0	9999	0.25	1	0	FALSE
Montane Wet Meadow	Exotic-Invasion	SFEnc	ALL	ExF	OPN	1	999	5	9999	0.005	1	0	FALSE
Montane Wet Meadow	Managed-Herbivory	SFEnc	ALL	SFEnc	ALL	1	999	1	9999	1	0.5	-1	FALSE
Montane Wet Meadow	Grazing-Systems	SFEnc	ALL	SFEnc	ALL	1	999	0	9999	1	0.5	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Wet Meadow	RxFire	SFEnc	ALL	Early1	OPN	1	999	0	9999	0.01	0.5	-999	FALSE
Montane Wet Meadow	RxFire	SFEnc	ALL	SFEnc	ALL	1	999	0	9999	0.01	0.5	-999	FALSE
Montane Wet Meadow	Drought	A-Fenced	OPN	B-Fenced	CLS	0	2	0	9999	0.0056	1	-2	FALSE
Montane Wet Meadow	Weed-Inventory	A-Fenced	OPN	B-Fenced	CLS	0	2	0	9999	0.25	1	0	FALSE
Montane Wet Meadow	Fenced-Succession	A-Fenced	OPN	Early1	OPN	0	2	3	9999	0.9	1	0	TRUE
Montane Wet Meadow	Replacement Fire	B-Fenced	CLS	A-Fenced	OPN	3	22	0	9999	0.025	1	0	FALSE
Montane Wet Meadow	Exotic-Invasion	B-Fenced	CLS	ExF	OPN	3	22	5	9999	0.005	1	0	FALSE
Montane Wet Meadow	Weed-Inventory	B-Fenced	CLS	B-Fenced	CLS	3	22	0	9999	0.25	1	0	FALSE
Montane Wet Meadow	RxFire	B-Fenced	CLS	A-Fenced	OPN	3	22	0	9999	0.01	1	0	FALSE
Montane Wet Meadow	Drought	B-Fenced	CLS	B-Fenced	CLS	3	22	0	9999	0.0056	1	2	FALSE
Montane Wet Meadow	Fenced-Succession	B-Fenced	CLS	Mid1	CLS	3	22	3	9999	0.9	1	0	TRUE
Montane Wet Meadow	Replacement Fire	C-Fenced	OPN	A-Fenced	OPN	23	999	0	9999	0.025	1	0	FALSE
Montane Wet Meadow	Exotic-Invasion	C-Fenced	OPN	ExF	OPN	23	999	5	9999	0.005	1	0	FALSE
Montane Wet Meadow	Weed-Inventory	C-Fenced	OPN	C-Fenced	OPN	23	999	0	9999	0.25	1	0	FALSE
Montane Wet Meadow	Canopy-Thinning	C-Fenced	OPN	B-Fenced	CLS	23	999	10	9999	0.01	1	-999	FALSE
Montane Wet Meadow	RxFire	C-Fenced	OPN	A-Fenced	OPN	23	999	0	9999	0.01	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Montane Wet Meadow	Fenced-Succession	C-Fenced	OPN	Late1	OPN	23	999	3	9999	0.9	1	0	TRUE
Mountain Shrub	Replacement Fire	Early1	ALL	Early1	ALL	0	4	0	9999	0.0125	1	-5	FALSE
Mountain Shrub	Drought	Early1	ALL	Early1	ALL	0	4	0	9999	0.0056	1	-2	FALSE
Mountain Shrub	Excessive-Herbivory	Early1	ALL	Early1	ALL	0	2	0	9999	0.001	0.7	2	FALSE
Mountain Shrub	Excessive-Herbivory	Early1	ALL	ESH	CLS	3	4	0	9999	0.001	0.3	0	TRUE
Mountain Shrub	Managed-Herbivory	Early1	ALL	Early1	ALL	0	4	0	9999	1	0.25	0	FALSE
Mountain Shrub	Replacement Fire	Mid1	CLS	Early1	ALL	5	19	0	9999	0.02	1	0	FALSE
Mountain Shrub	Drought	Mid1	CLS	Early1	ALL	5	19	0	9999	0.0056	0.1	0	FALSE
Mountain Shrub	Excessive-Herbivory	Mid1	CLS	Mid1	CLS	5	19	0	9999	0.001	0.7	2	FALSE
Mountain Shrub	Excessive-Herbivory	Mid1	CLS	ESH	CLS	5	19	0	9999	0.001	0.3	0	TRUE
Mountain Shrub	Managed-Herbivory	Mid1	CLS	Mid1	CLS	5	19	0	9999	1	0.25	0	FALSE
Mountain Shrub	Drought	Mid1	CLS	Mid1	CLS	5	19	0	9999	0.0056	0.9	-20	FALSE
Mountain Shrub	Replacement Fire	Late1	CLS	Early1	ALL	20	80	0	9999	0.025	1	0	FALSE
Mountain Shrub	Drought	Late1	CLS	Mid1	CLS	20	80	0	9999	0.0056	0.1	0	FALSE
Mountain Shrub	Excessive-Herbivory	Late1	CLS	Late1	CLS	20	80	0	9999	0.001	0.7	2	FALSE
Mountain Shrub	Excessive-Herbivory	Late1	CLS	ESH	CLS	20	80	0	9999	0.001	0.3	0	TRUE
Mountain Shrub	RxFire	Late1	CLS	Early1	ALL	20	80	0	9999	0.01	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Mountain Shrub	Canopy-Thinning	Late1	CLS	Early1	ALL	20	80	0	9999	0.01	0.5	0	FALSE
Mountain Shrub	Canopy-Thinning	Late1	CLS	Mid1	CLS	20	80	0	9999	0.01	0.5	0	FALSE
Mountain Shrub	Managed-Herbivory	Late1	CLS	Late1	CLS	20	80	0	9999	1	0.25	0	FALSE
Mountain Shrub	Drought	Late1	CLS	Late1	CLS	20	80	0	9999	0.0056	0.9	-80	FALSE
Mountain Shrub	Replacement Fire	Late1	OPN	Early1	ALL	80	999	0	9999	0.0067	1	0	FALSE
Mountain Shrub	Drought	Late1	OPN	Late1	CLS	80	999	0	9999	0.0056	0.1	0	FALSE
Mountain Shrub	Excessive-Herbivory	Late1	OPN	Late1	OPN	80	999	0	9999	0.001	1	3	FALSE
Mountain Shrub	RxFire	Late1	OPN	Early1	ALL	80	999	0	9999	0.01	0.9	0	FALSE
Mountain Shrub	Canopy-Thinning	Late1	OPN	Early1	ALL	80	999	0	9999	0.01	0.2	0	FALSE
Mountain Shrub	RxFire	Late1	OPN	Late1	OPN	80	999	0	9999	0.01	0.1	0	FALSE
Mountain Shrub	Canopy-Thinning	Late1	OPN	Mid1	CLS	80	999	0	9999	0.01	0.5	0	FALSE
Mountain Shrub	Canopy-Thinning	Late1	OPN	Late1	CLS	80	999	0	9999	0.01	0.3	0	FALSE
Mountain Shrub	Tree-Encroachment	Late1	OPN	TrEnc	CLS	80	999	150	9999	1	0.33	0	FALSE
Mountain Shrub	Managed-Herbivory	Late1	OPN	Late1	OPN	80	999	0	9999	1	0.25	0	FALSE
Mountain Shrub	Drought	Late1	OPN	Late1	OPN	80	999	0	9999	0.0056	0.9	-999	FALSE
Mountain Shrub	Replacement Fire	ESH	CLS	ESH	CLS	0	999	0	9999	0.02	1	0	FALSE
Mountain Shrub	DPL-Restoration	ESH	CLS	Early1	ALL	0	999	0	9999	0.01	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Mountain Shrub	Alt Succession	ESH	CLS	Mid1	CLS	0	999	5	9999	0.001	1	0	TRUE
Mountain Shrub	Managed-Herbivory	ESH	CLS	ESH	CLS	0	999	0	9999	1	0.25	0	FALSE
Mountain Shrub	Replacement Fire	TrEnc	CLS	ESH	CLS	106	999	0	9999	0.0067	1	0	FALSE
Mountain Shrub	Thin-Mech-Chem-Seed	TrEnc	CLS	Early1	ALL	106	999	0	9999	0.01	1	0	FALSE
Mountain Shrub	Drought	TrEnc	CLS	ESH	CLS	106	999	0	9999	0.0056	0.1	0	FALSE
Mountain Shrub	Drought	TrEnc	CLS	TrEnc	CLS	106	999	0	9999	0.0056	0.9	-999	FALSE
Pinyon-Juniper	Replacement Fire	Early1	OPN	Early1	OPN	0	9	0	9999	0.005	1	-10	FALSE
Pinyon-Juniper	Replacement Fire	Mid1	OPN	Early1	OPN	10	29	0	9999	0.005	1	0	FALSE
Pinyon-Juniper	Replacement Fire	Mid2	OPN	Early1	OPN	30	99	0	9999	0.005	1	0	FALSE
Pinyon-Juniper	Drought	Mid2	OPN	Mid1	OPN	30	99	0	9999	0.0056	0.1	0	FALSE
Pinyon-Juniper	AG-Invasion	Mid2	OPN	TrAG	CLS	30	99	0	9999	0.001	1	0	TRUE
Pinyon-Juniper	Drought	Mid2	OPN	Mid2	OPN	30	99	0	9999	0.0056	0.9	-99	FALSE
Pinyon-Juniper	Replacement Fire	Late1	OPN	Early1	OPN	100	999	0	9999	0.002	1	0	FALSE
Pinyon-Juniper	Surface Fire	Late1	OPN	Late1	OPN	100	999	0	9999	0.001	1	0	FALSE
Pinyon-Juniper	Drought	Late1	OPN	Late1	OPN	100	999	0	9999	0.0168	0.9	-999	FALSE
Pinyon-Juniper	Drought	Late1	OPN	Mid2	OPN	100	999	0	9999	0.0167	0.07	0	FALSE
Pinyon-Juniper	AG-Invasion	Late1	OPN	TrAG	CLS	100	999	0	9999	0.001	1	0	TRUE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Pinyon-Juniper	Drought	Late1	OPN	Mid1	OPN	100	999	0	9999	0.016	0.03	0	FALSE
Pinyon-Juniper	Replacement Fire	TrAG	CLS	AG	OPN	30	999	0	9999	0.005	1	0	FALSE
Pinyon-Juniper	Drought	TrAG	CLS	TrAG	CLS	30	999	0	9999	0.0056	0.9	-999	FALSE
Pinyon-Juniper	Drought	TrAG	CLS	AG	OPN	30	999	0	9999	0.0056	0.1	0	FALSE
Pinyon-Juniper	Replacement Fire	SENN	OPN	SENN	OPN	3	30	0	9999	0.0051	0.75	-999	FALSE
Pinyon-Juniper	Replacement Fire	SENN	OPN	AG	OPN	3	30	0	9999	0.0052	0.25	0	FALSE
Pinyon-Juniper	AG-Invasion	SENN	OPN	AG	OPN	3	30	0	9999	0.005	1	0	FALSE
Pinyon-Juniper	AG-Restoration	AG	OPN	SENN	OPN	0	2	0	9999	1	0.6	0	FALSE
Pinyon-Juniper	AG-Restoration	AG	OPN	AG	OPN	0	2	0	9999	1	0.4	0	FALSE
Pinyon-Juniper	Replacement Fire	AG	OPN	AG	OPN	0	999	0	9999	0.1	1	-9999	FALSE
Spruce	Replacement Fire	Early1	ALL	Early1	ALL	0	39	0	9999	0.005	1	-40	FALSE
Spruce	Competition/ Maint	Early1	ALL	Early1	ALL	0	39	0	9999	0.002	1	-5	FALSE
Spruce	Replacement Fire	Mid1	CLS	Early1	ALL	40	129	0	9999	0.005	1	0	FALSE
Spruce	Competition/ Maint	Mid1	CLS	Mid1	CLS	40	129	0	9999	0.001	1	-1	FALSE
Spruce	Insect/ Disease	Mid1	CLS	Mid1	OPN	40	129	0	9999	0.007	1	0	FALSE
Spruce	Replacement Fire	Mid1	OPN	Early1	ALL	40	129	0	9999	0.005	1	0	FALSE
Spruce	Mixed Fire	Mid1	OPN	Mid1	OPN	40	129	0	9999	0.001	1	0	FALSE
Spruce	Replacement Fire	Late1	CLS	Early1	ALL	130	1128	0	9999	0.004	1	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Spruce	Insect/ Disease	Late1	CLS	Early1	ALL	130	1128	0	9999	0.002	1	0	FALSE
Spruce	Drought	Late1	CLS	Late1	CLS	130	1128	0	9999	0.001	1	0	FALSE
Winterfat	AG-Invasion	Early1	ALL	AG	CLS	0	49	0	9999	0.005	1	0	TRUE
Winterfat	Excessive-Herbivory	Early1	ALL	Early1	ALL	0	49	0	9999	0.001	0.5	3	FALSE
Winterfat	Excessive-Herbivory	Early1	ALL	ExF	CLS	0	49	0	9999	0.001	0.5	0	FALSE
Winterfat	Flooding	Mid1	OPN	Early1	ALL	50	149	0	9999	0.018	0.1	0	FALSE
Winterfat	Replacement Fire	Mid1	OPN	Early1	ALL	50	149	0	9999	0.001	1	0	FALSE
Winterfat	AG-Invasion	Mid1	OPN	ShAG	CLS	50	149	0	9999	0.005	1	0	TRUE
Winterfat	Flooding	Mid1	OPN	Mid1	OPN	50	149	0	9999	0.018	0.9	-150	FALSE
Winterfat	Excessive-Herbivory	Mid1	OPN	Mid1	OPN	50	99	0	9999	0.001	0.5	3	FALSE
Winterfat	Excessive-Herbivory	Mid1	OPN	DPL	CLS	100	149	0	9999	0.001	0.25	0	TRUE
Winterfat	Excessive-Herbivory	Mid1	OPN	ExF	CLS	100	149	0	9999	0.001	0.25	0	TRUE
Winterfat	Flooding	Mid2	OPN	Early1	ALL	150	999	0	9999	0.018	0.05	0	FALSE
Winterfat	AG-Invasion	Mid2	OPN	ShAG	CLS	150	999	0	9999	0.005	1	0	TRUE
Winterfat	Replacement Fire	Mid2	OPN	Early1	ALL	150	999	0	9999	0.001	1	0	FALSE
Winterfat	Flooding	Mid2	OPN	Mid1	OPN	150	999	0	9999	0.018	0.15	0	FALSE
Winterfat	Flooding	Mid2	OPN	Mid2	OPN	150	999	0	9999	0.018	0.8	-999	FALSE
Winterfat	Excessive-Herbivory	Mid2	OPN	DPL	CLS	150	999	0	9999	0.001	1	0	TRUE
Winterfat	Replacement Fire	ShAG	CLS	AG	CLS	1	999	0	9999	0.025	1	0	FALSE
Winterfat	ShAG-Restoration	ShAG	CLS	SENN	OPN	1	999	0	9999	0.01	0.2	0	FALSE
Winterfat	ShAG-Restoration	ShAG	CLS	ShAG	CLS	1	999	0	9999	0.01	0.8	0	FALSE

Project_Name	Probabilistic Transition Type Name	From Cover	From Structure	To Cover	To Structure	MinAge	MaxAge	TSDMin	TSDMax	Prob.	Prop.	Relative Age	Keep Relative Age
Winterfat	Flooding	ShAG	CLS	AG	CLS	1	999	0	9999	0.018	1	0	FALSE
Winterfat	ExF-Invasion	ShAG	CLS	ExF	CLS	1	999	0	9999	0.005	1	0	FALSE
Winterfat	Replacement Fire	AG	CLS	AG	CLS	0	999	0	9999	0.1	1	-999	FALSE
Winterfat	AG-Restoration	AG	CLS	SENN	OPN	0	1	0	9999	0.33	0.2	0	FALSE
Winterfat	AG-Restoration	AG	CLS	AG	CLS	0	1	0	9999	0.33	0.8	0	FALSE
Winterfat	Alt Succession	SENN	OPN	Mid1	OPN	30	999	0	9999	0.001	1	0	FALSE
Winterfat	ExF-Restoration	ExF	CLS	SENN	OPN	0	999	0	9999	0.01	1	0	FALSE
Winterfat	ExF-Invasion	DPL	CLS	ExF	CLS	100	999	0	9999	0.005	1	0	TRUE
Winterfat	AG-Invasion	DPL	CLS	ShAG	CLS	100	999	0	9999	0.005	1	0	TRUE
Winterfat	DPL-Restoration	DPL	CLS	Mid1	OPN	50	148	0	9999	0.01	0.5	0	TRUE
Winterfat	DPL-Restoration	DPL	CLS	DPL	CLS	50	148	0	9999	0.01	0.5	0	FALSE
Winterfat	DPL-Restoration	DPL	CLS	Mid2	OPN	149	999	0	9999	0.01	0.5	0	TRUE
Winterfat	DPL-Restoration	DPL	CLS	DPL	CLS	149	999	0	9999	0.01	0.5	0	FALSE

Appendix 6. Current acres (by vegetation class), natural range of variability (NRV) and Ecological Departure (ED) calculations for biophysical settings in the Ward Mountain project area. Ecological Departure was not calculated for systems marginally represented within the project area (i.e., low sagebrush semi-desert, pygmy sagebrush, and mixed salt desert scrub.

Black Sagebrush																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	12	256	5,061	14,667	-	-	18,290	1	33	-	4,249	-	19	44	4,028	46,660
NRV	15	50	25	10	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	1	11	31	0	0	39	0	0	0	9	0	0	0	9	100
ED																**79**
Montane Sagebrush Steppe-Upland																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	152	1,905	8,225	7,846	2,479	-	675	1	3	-	267	-	797	214	3,047	25,611
NRV	20	50	15	10	5	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	1	7	32	31	10	0	3	0	0	0	1	0	3	1	12	100
ED																**62**
Pinyon-Juniper Woodland																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	3,183	5,805	6,573	-	-	-	-	-	-	-	-	-	-	-	15,561
NRV	5	10	30	55	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	20	37	42	0	0	0	0	0	0	0	0	0	0	0	100
ED																**18**
Curl-leaf Mountain Mahogany Woodland																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	1,321	3,099	2,337	4,085	-	-	-	-	-	-	-	-	-	-	10,841
NRV	10	10	15	20	45	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	12	29	22	38	0	0	0	0	0	0	0	0	0	0	100
ED																**17**
Wyoming Big Sagebrush																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class																

	A	B	C	D	E	AG	DPL	ESH	EXF	NAS	SENN	SFEnc	ShAG	ShAP	TrEnc	Total
	6	341	842	877	367	-	4,545	-	1	-	401	-	922	28	4	8,333
NRV	15	50	25	5	5	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	4	10	11	4	0	55	0	0	0	5	0	11	0	0	100
ED																**76**
Mixed Conifer Woodland																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	167	14	306	834	1,370	-	-	-	-	-	-	-	-	-	-	2,691
NRV	10	30	30	20	10	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	6	1	11	31	51	0	0	0	0	0	0	0	0	0	0	100
ED																**52**
Montane Sagebrush Steppe- mountain																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	699	1,559	295	21	-	-	-	-	-	-	-	-	-	-	2,575
NRV	20	50	15	10	5	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	27	61	11	1	0	0	0	0	0	0	0	0	0	0	100
ED																**47**
Aspen-Mixed Conifer Woodland																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	137	132	527	403	1,034	-	-	-	-	2	-	-	-	-	-	2,235
NRV	14	40	35	10	1	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	6	6	24	18	46	0	0	0	0	0	0	0	0	0	0	100
ED																**53**
Basin Wildrye																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	90	146	-	-	2	1,156	4	1	-	51	-	140	-	56	1,646
NRV	20	70	10	0	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	5	9	0	0	0	70	0	0	0	3	0	8	0	3	100
ED																**86**
Winterfat																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	47	85	-	-	-	332	-	127	-	-	-	23	-	-	615

NRV	10	50	40	0	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	8	14	0	0	0	54	0	21	0	0	0	4	0	0	100
ED																**78**
Aspen Woodland																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	89	252	-	58	-	-	192	-	-	-	-	-	-	-	-	591
NRV	14	40	45	1	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	15	43	0	10	0	0	33	0	0	0	0	0	0	0	0	100
ED																**45**
Limber-Bristlecone Pine Woodland-mesic																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	4	33	358	-	-	-	-	-	-	-	-	-	-	-	-	395
NRV	15	35	50	0	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	1	8	91	0	0	0	0	0	0	0	0	0	0	0	0	100
ED																**41**
Limber-Bristlecone Pine Woodland																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	6	168	-	-	-	-	-	-	-	-	-	-	-	-	174
NRV	20	20	60	0	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	3	97	0	0	0	0	0	0	0	0	0	0	0	0	100
ED																**37**
Montane-Subalpine Riparian																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	1	142	9	-	-	-	-	-	-	-	-	19	-	-	-	171
NRV	20	35	45	0	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	1	83	5	0	0	0	0	0	0	0	0	11	0	0	0	100
ED																**59**
Low Sagebrush Steppe																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class																

	A	B	C	D	E	AG	DPL	ESH	EXF	NAS	SENN	SFEnc	ShAG	ShAP	TrEnc	Total
	-	31	82	-	-	-	-	-	-	-	-	-	-	-	-	113
NRV	10	50	40	0	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	27	73	0	0	0	0	0	0	0	0	0	0	0	0	100
ED																**33**
Subalpine Spruce-Fir Forest																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	20	-	9	36	-	-	-	-	-	-	-	-	-	-	-	65
NRV	20	25	10	45	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	31	0	13	56	0	0	0	0	0	0	0	0	0	0	0	100
ED																**25**
Alpine																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	3	32	-	-	-	-	-	-	-	-	-	-	-	-	-	35
NRV	5	95	0	0	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	9	91	0	0	0	0	0	0	0	0	0	0	0	0	0	100
ED																**4**
Mountain Shrub																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	1	30	2	-	-	-	-	-	-	-	-	-	-	-	33
NRV	10	40	45	5	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	3	92	6	0	0	0	0	0	0	0	0	0	0	0	100
ED																**47**
Montane Wet Meadow																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	11	0	-	-	-	-	-	1	-	-	-	-	-	-	12
NRV	5	45	50	0	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	91	3	0	0	0	0	0	5	0	0	0	0	0	0	100
ED																**52**
Low Sagebrush-semi-desert																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	2

NRV	10	40	50	0	0	0	0	0	0	0	0	0	0	0	0	100
Current % in Class	0	66	34	0	0	0	0	0	0	0	0	0	0	0	0	100
ED																**26**
Pygmy Sagebrush																
Class	**A**	**B**	**C**	**D**	**E**	**AG**	**DPL**	**ESH**	**EXF**	**NAS**	**SENN**	**SFEnc**	**ShAG**	**ShAP**	**TrEnc**	**Total**
Acres in Class	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2
NRV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Current % in Class	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	100
ED																**-**

Appendix 7. Descriptions of biophysical settings of the Ward Mountain project area (included electronically in PDF version of report).

LANDFIRE Biophysical Setting Model

Biophysical Setting: **wm1144** **Alpine**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 4/26/2006

Modeler 1	Tod Williams	Tod_Williams@nps.gov	**Reviewer**
Modeler 2	Bryan Hamilton	Bryan_Hamilton@nps.gov	**Reviewer**
Modeler 3	Neal Darby	Neal_Darby@nps.gov	**Reviewer**
			FRCC

Vegetation Type

Upland Grasslands and Herbaceous

Dominant Species*

POAL2	CAPH2
POWH	ERHO
POGL	CYNI3
CARO	PHAL2

General Model Sources

☐ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16	0
12	0
17	0
0	0
0	0

Model Zones

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☑ Great Basin ☐ South Central
☐ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Geographic Range

This widespread ecological system occurs above the upper timberline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and north into Canada.

Biophysical Site Description

The alpine belt is above timberline (approximately > 3000 m) and below the permanent snow level (<4,500 m). Found on gentle to moderate slopes, flat ridges, valleys, and basins, where the soil has become relatively stabilized and the water supply is more or less constant.

Vegetation Description

This system is characterized by a dense cover of low-growing, perennial graminoids and forbs. Rhizomatous, sod-forming sedges are the dominant graminoids, and prostrate and mat-forming plants with thick rootstocks or taproots characterize the forbs. Dominant species include Festuca brachyphylla, Poa wheeleri, Poa cusickii, Poa glauca ssp. Rupicola, Phleum alpinum, Antenaria media, Antenaria umbrenella, Carex rossii, Carex phaeocephala, Phlox pulvinata, Erigeron spp., Cymopterus nivalis, Erameria suffruticosus, Trifolium nanum, and Ribes montigenum.. Although alpine tundra dry meadow is the matrix of the alpine zone, it typically intermingles with alpine bedrock and scree, ice field, fell-field, alpine dwarf-shrubland, and alpine/subalpine wet meadow systems.

Disturbance Description

Vegetation in these areas is controlled by snow retention, wind dessication, permafrost, and a short growing season. Dry summers associated with major drought years (mean return interval of 100 years) would favor grasses over forbs, whereas wet summers cause a more diverse mixture of forbs and graminoids.

Avalanches on stepper slopes where soil accumulated can cause infrequent soil-slips, which exposed bare

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

ground.

Very small burns of a few square meters (replacement fire) caused by lightning strikes were included as a rare disturbance, although lightning storms are frequent in those elevations. The calculation of lightning strikes frequency was not based on fire return intervals, but on the number of strikes (in this case 5) per 1000 possible locations per year, thus 0.005.

Native herbivores (Rocky Mountain bighorn sheep, mule deer, and elk) were common in the alpine but probably did not greatly affect vegetation cover because animals move frequently as they reduce vegetation cover.

Adjacency or Identification Concerns

Over the next decades, several experts claim that the alpine is one of the more threatened community type by global climate change. Essentially, the treeline is moving up. A 3 C increase in annual summer temperature will cause a 97% decrease in overall acreage of the alpine (Neal Darby, pers. comm., Great Basin National Park).

The alpine type has a high concentration of rare plants due to its isolation.

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☐ Literature ☐ Local Data ☑ Expert Estimate

This ecological system can occupy large areas of the alpine. Patch size varies from a few acres to 1000 acres on mountain ridges and tops. Stand-replacement fires may be caused by lightning strikes that do not spread due to the sparse cover of fine fuels and extensive barren areas acting as fire breaks.

Issues/Problems

No data on fire or effects of lightning strikes. No data on recovery time after stand-replacing events.

Comments

Other modeler for BpS gb1144 is Ben Roberts (ben_roberts@nps.gov). BpS gb1144 is based on BpS 161144 developed by Louis Provencher (lprovencher@tnc.org). Species composition adapted from 028AY070NV. Cover of vegetation class was increased to 50%.

BPS 1144 for MZs 12 and 17 were adopted as-is from BPS 1114 for MZ 16, which was developed by Louis Provencher (lprovencher@tnc.org). Input to the model was based on discussion with Kimball Harper (retired USFS scientist; UT), an alpine specialist of the Utah High Plateau.

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class A 5%

Early Development 1 All Struc

Description

Very exposed (barren) state following a lightning strike. Soil (not rock) may dominate the area. Grasses are more common that forbs. Succession to class B after 3 years.

Indicator Species* and Canopy Position

CAREX Upper
POA Upper
FEBR2 Upper

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Herb 0m	Herb 0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class B 95%

Late Development 1 Closed

Description

Alpine community is dominated by graminoids and herbaceous perennials and few low-growing shrubs. Plant cover may vary from 2% on exposed sites to as much as 30% on mesic and more protected sites. Infrequent replacement fire in the form of lighting strikes (mean FRI of 500 years), severe summer droughts (mean return interval of 100 years), and rare avalanches on stepper slopes with soil (1/1000) cause a transition to class A.

Indicator Species* and Canopy Position

CAREX Upper
POA Upper
ERDI14 Upper

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11%	50%
Height	Herb 0m	Herb 0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C 0%

Mid Development 1 All Struct

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	0%
Height	NONE	NONE
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class D **0%**

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	0%
Height	NONE	NONE
Tree Size Class	None	

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model

Class E **0%**

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height	NONE	NONE
Tree Size Class	None	

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model

Disturbances

Fire Regime Group:** 5

Historical Fire Size (acres)

Avg 1
Min 1
Max 1

Sources of Fire Regime Data

- [ ] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	208			0.004808	100
Mixed					
Surface					
All Fires	208			0.00483	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [x] Other (optional 1) avalanches
- [ ] Other (optional 2)

References

Baker, W. L. 1980. Alpine vegetation of the Sangre De Cristo Mountains, New Mexico: Gradient analysis and classification. Unpublished thesis, University of North Carolina, Chapel Hill. 55 pp.

Bamberg, S. A. 1961. Plant ecology of alpine tundra area in Montana and adjacent Wyoming. Unpublished

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

dissertation, University of Colorado, Boulder. 163 pp.

Bamberg, S. A., and J. Major. 1968. Ecology of the vegetation and soils associated with calcareous parent materials in three alpine regions of Montana. Ecological Monographs 38(2):127-167.

Cooper, S. V., P. Lesica, and D. Page-Dumroese. 1997. Plant community classification for alpine vegetation on Beaverhead National Forest, Montana. USDA Forest Service, Intermountain Research Station, Report INT-GTR-362. Ogden, UT. 61 pp.

Komarkova, V. 1976. Alpine vegetation of the Indian Peaks Area, Front Range, Colorado Rocky Mountains. Unpublished dissertation, University of Colorado, Boulder. 655 pp.

Komarkova, V. 1980. Classification and ordination in the Indian Peaks area, Colorado Rocky Mountains. Vegetatio 42:149-163.

Schwan, H. E., and D. F. Costello. 1951. The Rocky Mountain alpine type: Range conditions, trends and land use (a preliminary report). Unpublished report prepared for USDA Forest Service, Rocky Mountain Region (R2), Denver, CO. 18 pp.

Thilenius, J. F. 1975. Alpine range management in the western United States--principles, practices, and problems: The status of our knowledge. USDA Forest Service Research Paper RM-157. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 32 pp.

Willard, B. E. 1963. Phytosociology of the alpine tundra of Trail Ridge, Rocky Mountain National Park, Colorado. Unpublished dissertation, University of Colorado, Boulder.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1061 Aspen-Mixed Conifer Woodland

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *BpS gb1061 represents lower elevation (<~9,000') aspen and mixed conifer forests, where ponderosa pine, lodgepole pine, and Douglas-fir are associated conifers; gb1061s represents higher elevation (>~9,000') aspen and mixed conifer forests, where Engelmann spruce is the associated conifer.*

General Information

Contributors (also see the Comments field) **Date** 4/25/2006

Modeler 1	Neal darby	Neal_Darby@nps.gov	**Reviewer**
Modeler 2	Bryan Hamilton	Bryan_Hamilton@nps.gov	**Reviewer**
Modeler 3			**Reviewer**
			FRCC

Vegetation Type

Upland Forest and Woodland

Dominant Species*

POTR	ARPA6
ABCO	SYOR2
PSME	RIMO2
PIFL2	POCU

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
0	0
0	0
0	0

Model Zones

☐ Alaska
☐ California
☑ Great Basin
☐ Great Lakes
☐ Northeast
☐ Northern Plains
☐ N-Cent.Rockies
☐ Pacific Northwest
☐ South Central
☐ Southeast
☐ S. Appalachians
☐ Southwest

Geographic Range

This ecological system occurs on montane slopes and plateaus in Utah, western Colorado, northern Arizona, eastern Nevada, southern Idaho and western Wyoming.

Biophysical Site Description

Occurrences are typically on gentle to steep slopes on any aspect but are often found on clay-rich soils in intermontane valleys. Soils are derived from alluvium, colluvium and residuum from a variety of parent materials but most typically occur on sedimentary rocks. Elevations range from 8500-9700 feet.

Vegetation Description

The tree canopy is composed of a mix of deciduous and coniferous species, codominated by Populus tremuloides and conifers, including Abies concolor, Pseudotsuga menziesii, Pinus flexilis, and Pinus ponderosa. As the occurrences age, Populus tremuloides is slowly reduced until the conifer species become dominant. Common shrubs include Arctostaphylos patula, Amelanchier utahensis, Prunus virginiana, Symphoricarpos oreophilus, Juniperus communis, Ribes, Rosa woodsii, and Mahonia repens. Herbaceous species include Carex spp, Poa spp., Achillea millefolium, Lupinus spp, Astragalus spp., and others.

Disturbance Description

This is a strongly fire adapted community, more so than BPS gb1011 (Rocky Mountain Aspen Forest and Woodland), with FRIs varying for mixed severity fire with the encroachment of conifers. It is important to understand that aspen is considered a fire-proof vegetation type that does not burn during the normal lightning season, yet evidence of fire scars and historical studies show that native burning was the only

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

source of fire that occurred predominantly during the spring and fall. BPS 1061 has elements of Fire Regime Groups II, III, and IV. Mean FRI for replacement fire is every 60 years on average in all development classes, except during early development where no fire is present (as for stable aspen, BPS 1011). The FRI of mixed severity fire increases from 40 years in stands <80 years to 20 years in stand >80 years with conifer encroachment.

Under pre-settlement conditions, disease and insect mortality did not appear to have major impacts, however older aspen stands would be susceptible to outbreaks every 200 years on average. We assumed that 20% of outbreaks resulted in heavy insect/disease stand-replacing events (average return interval 1000 yrs), whereas 80% of outbreaks would thin older trees >40 yrs (average return interval 250 yrs). Older conifers (>100 years) would experience insect/disease outbreaks every 300 years on average.

Some sites are prone to snowslides, mudslides and rotational slumping. Flooding may also operate in these systems.

Adjacency or Identification Concerns

If conifers are not present in the landscape or represent <25% relative cover, the stable aspen model (BPS 1011; Rocky Mountain Aspen Forest and Woodland) should be considered, especially in western and central Nevada.

This type is more highly threatened by conifer replacement than stable aspen. Most occurrences at present represent a late-seral stage of aspen changing to a pure conifer occurrence. Nearly a hundred years of fire suppression and livestock grazing have converted much of the pure aspen occurrences to the present-day aspen-conifer forest and woodland ecological system.

Under current conditions, herbivory can significantly effect stand succession. Kay (1997, 2001a, b, c) found the impacts of burning on aspen stands were overshadowed by the impacts of herbivory. In the reference state the density of ungulates was low due to efficient Native American hunting, so the impacts of ungulates were low. Herbivory was therefore not included in the model.

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☑ Literature ☑ Local Data ☑ Expert Estimate

This type occurs in a landscape mosaic from moderate (10 acres) to large sized patches (1000 acres).

Issues/Problems

East of the Great Basin, Baker (1925) studied closely the pre-settlement period for aspen and noted fire scars on older trees. Bartos and Campbell (1998) support these findings. Results from Baker (1925) and Bartos and Campbell (1998) would apply to eastern Nevada and BPS 1061. We interpreted ground fires that scarred trees, probably started by Native Americans, as mixed severity fire that also promoted abundant suckering. In the presence of conifer fuels, these would be killed and aspen suckering promoted.

In previous models from the Rapid Assessment (e.g., R2ASMClw), experts and modelers expressed different views about the frequency of all fires, citing FRIs longer than those noted by Baker (1925). The FRIs used here were a compromise between longer FRIs proposed by reviewers and the maximum FRI of Baker (1925).

Comments

BpS gb1061 is based on BpS 121061 developed by Julia Richardson (jhrichardson@fs.fed.us) and Louis Provencher (lprovencher@tnc.org). Species composition is based on range site descriptions 028AY080NV

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

and 028AY056NV. Model unchanged.

BPS 1061 for MZ 12 and 17was a compromise among the Rapid Assessment model R2ASMClw (aspen-mixed conifers low-mid elevation), BPS 1011 for mapzone 12 and 17, and BPS 1061 for mapzone 16. BPS 1061 for mapzone 12 and 17 is approximately split into the age classes of R2ASMClw. The FRIs of replacement fire from BPS 1011 were used (60 years). For mixed severity fire, the mean FRIs followed closely BPS 1061 for MZ 16, except that 20 years was used instead of 13 years during periods of conifer encroachment. R2ASMClw was developed by Linda Chappell (lchappell@fs.fed.us), Bob Campbell (rbcampbell@fs.fed.us), and Cheri Howell (chowell02@fs.fed.us), and reviewed by Krista Gollnick-Wade/Sarah Heidi (Krista_Waid@blm.gov), Charles E. Kay (ckay@hass.usu.edu), and Wayne D. Shepperd (wshepperd@fs.fed.us). BPS 1061 for MZ 16 was developed by Linda Chappell, Robert Campbell, Stanley Kitchen (skitchen@fs.fed.us), Beth Corbin (ecorbin@fs.fed.us), and Charles Kay.

As this type has a fairly short fire return interval compared to other aspen types, it should be noted that aspen can act as a tall shrub. Bradley, et al. (1992) state that Loope & Gruell estimated a fire frequency of 25 to 100 years for a Douglas-fir forest with seral aspen in Grand Teton National Park (p39). They later state that fire frequencies of 100 to 300 years appear to be appropriate for maintaining most seral aspen stands. In the Fontenelle Creek, Wyoming draininage, the mean fire-free interval was estimated to be 40 years. Fires in this area burned in a mosaic pattern of severities, from stand-replacement to low fires that scarred but did not kill the relatively thin-barked lodgepole pine on the site (p46).

Aspen stands tend to remain dense througout most of their life-span, hence the open stand description was not used unless it described conifer coverage during initial encroachment. While not dependent upon disturbance to regenerate, aspen was adapted to a diverse array of disturbances.

Vegetation Classes

Class A 14%

Early Development 1 All Struc

Description

Grass/forb and aspen suckers <6' tall. Generally, this is expected to occur 1-3 years post-disturbance. Fire is absent and succession occurs to class B after 10 years.

Indicator Species* and Canopy Position

POTR5 Upper
SYOR2 Middle
RIBES Middle

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	99%
Height	Tree 0m	Tree 5m
Tree Size Class	Seedling <4.5ft	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class B **40%**

Mid Development 1 Closed

Description

Aspen saplings over 6' tall dominate. Canopy cover is highly variable. Replacement fire occurs every 60 yrs on average. Mixed severity fire (average FRI of 40 yrs) does not change the successional age of these stands, although this fire consumes litter and woody debris and may stimulate suckering. Succession to class C after 30 years.

Indicator Species* and Canopy Position

POTR	Upper
SYOR2	Low-Mid
RIBES	Low-Mid

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	40%	99%
Height	Tree 5.1m	Tree 10m
Tree Size Class	Sapling >4.5ft; <5"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C **35%**

Mid Development 2 Closed

Description

Aspen trees 5 - 16" DBH. Canopy cover is highly variable. Conifer seedlings and saplings may be present. Replacement fire occurs every 60 years on average. Mixed severity fire (mean FRI of 40 yrs), while thining some trees, promotes suckering and maintains vegetation in this class. Insect/diseases outbreaks occur every 200 years on average causing stand thinning (transition to class B) 80% of the time and causing stand replacement (transition to class A) 20% of the time. Conifer encroachment causes a succession to class D after 40 years.

Indicator Species* and Canopy Position

POTR	Upper
SYOR2	Middle
RIBES	Middle

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	40%	99%
Height	Tree 10.1m	Tree Medium 10-24m
Tree Size Class	Pole 5-9" DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class D 10%

Late Development 1 Open

Description

Aspen dominate, making up ~80% of the overstory. Conifers which escape fire, or are the more fire resistant species, are present in the understory and will likely cause the progressive suppression of aspen. Mixed severity fire (20 year MFI) keeps this stand open, kills young conifers, and maintains aspen (max FRI from Baker, 1925). Replacement fire occurs every 60 years on average. In the absence of any fire for at least 100 years, the stand will become closed and dominated by conifers (transition to class E).

Indicator Species* and Canopy Position

POTR	Upper
ABCO	Mid-Upper
PSME	
PIFL2	Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	40 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E 1%

Late Development 1 Closed

Description

Conifers dominate at 100+ years. Aspen over 16" DBH, uneven sizes of mixed conifer, and main overstory is conifers (>50% of overstory). FRI for replacement fire is every 60 years. Mixed severity fire (mean FRI of 20 years) causes a transition to class D. Insect/disease outbreaks will thin older conifers (transition to class D) every 300 years on average.

Indicator Species* and Canopy Position

ABCO	Upper
PSME	Upper
POTR	Mid-Upper
PIFL2	Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	Max
Cover	40 %	80 %
Height	Tree 10.1m	Tree 50m
Tree Size Class	Large 21-33"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Fire Regime Group:** 2

Historical Fire Size (acres)

Avg 10
Min 1
Max 100

Sources of Fire Regime Data

- [x] Literature
- [x] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	68	50	300	0.014706	36
Mixed	39	10	50	0.025641	64
Surface					
All Fires	25			0.04036	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [x] Insects/Disease
- [ ] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

References

Baker, F. S., 1925. Aspen in the Central Rocky Mountain Region. USDA Department Bulletin 1291 pp. 1-47.

Bartos, D. L. 2001. Landscape Dynamics of Aspen and Conifer Forests. Pages 5-14 in: Shepperd, W. D.; Binkley, D.; Bartos, D. L.; Stohlgren, T. J.; and Eskew, L. G., compilers. 2001. Sustaining aspen in western landscapes: symposium proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Bartos, D. L. and R. B. Campbell, Jr. 1998. Decline of Quaking Aspen in the Interior West – Examples from Utah. Rangelands, 20(1):17-24.

Campbell, R. B. and Bartos, D. L. 2001. Objectives for Sustaining Biodiversity. In: Shepperd, W. D., D. Binkley, D. L. Bartos, T. J. Stohlgren, and L. G. Eskew, compilers. 2001.

Sustaining aspen in western landscapes: symposium proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Bradley, A. E., Noste, N. V., and W. C. Fischer. 1992. Fire Ecology of Forests and Woodlands in Utah. GTR-INT-287. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 128 p.

Bradley, A. E., W. C. Fischer, and N. V. Noste. 1992. Fire Ecology of the Forest Habitat Types of Eastern Idaho and Western Wypoming. GTR- INT-290. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 92.

Brown, J. K. and D. G. Simmerman. 1986. Appraisal of fuels and flammability in western aspen: a prescribed fire guide. General technical report INT-205. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Brown, J. K., K. Smith, J. Kapler, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain

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Research Station. 257 p.

Campbell, R. B. and , D. L. Bartos. 2001. Objectives for Sustaining Biodiversity. In: Shepperd, W. D., D. Binkley, D. L. Bartos, T. J. Stohlgren, and L. G. Eskew, compilers. 2001. Sustaining aspen in western landscapes: symposium proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Brown, J. K. and D. G. Simmerman. 1986. Appraisal of fuels and flammability in western aspen: a prescribed fire guide. General technical report INT-205. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Debyle, N. V., C. D. Bevins, and W. C. Fisher. 1987. Wildfire occurrence in aspen in the interior western United States. Western Journal of Applied Forestry. 2:73-76.

Kay, C. E. 1997. Is aspen doomed? Journal of Forestry 95: 4-11.

Kay, C. E. 2001a. Evaluation of burned aspen communities in Jackson Hole, Wyoming. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 8 p.

Kay, C. E. 2001b. Long-term aspen exclosures in the Yellowstone ecosystem. Proceedings RMRS-P-18.. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

Kay, C. E. 2001c. Native burning in western North America: Implications for hardwood forest management. General Technical Report NE-274. U.S. Department of Agriculture, Forest Service, Northeast Research Station. 8 p.

Mueggler, W. F. 1988. Aspen Community Types of the Intermountain Region. USDA Forest Service, General Technical Report INT-250. 135 p.

Mueggler, W. F. 1989. Age Distribution and Reproduction of Intermountain Aspen Stands. Western Journal of Applied Forestry, 4(2):41-45.

Romme, W. H, L. Floyd-Hanna, D. D. Hanna ,and E. Bartlett. 2001. Aspen's ecological role in the west. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, RMRS Proceedings-P-18. Pages 243-259.

Shepperd, W. D. and E. W. Smith. 1993. The role of near-surface lateral roots in the life cycle of aspen in the central Rocky Mountains. Forest Ecology and Management 61: 157-160.

Shepperd, W. D. 2001. Manipulations to Regenerate Aspen Ecosystems. Pages 355-365 in: Shepperd, W. D., D. Binkley, D. L. Bartos, T. J. Stohlgren, and L. G. Eskew, compilers. 2001. Sustaining aspen in western landscapes: symposium proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Shepperd, W. D., D. L. Bartos, and A. M. Stepen. 2001. Above- and below-ground effects of aspen clonal regeneration and succession to conifers. Canadian Journal of Forest Resources; 31: 739-745.

USDA Forest Service. 2000. Properly Functioning Condition: Rapid Assessment Process (January 7, 2000

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version). Intermountain Region, Ogden, UT. Unnumbered.

Welsh, S. L, N. D. Atwood, S. l. Goodrich, and L. C. Higgins. 2003. A Utah Flora, Third edition, revised. Print Services, Brigham Young University, Provo, UT. 912 p.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1011 Aspen Forest Woodland

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 4/24/2006

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Vegetation Type

Upland Forest and Woodland

Dominant Species*

POTR5	BRMA
SYOR2	POFE
RIBES	PONE3
PIEN	ELTR7

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
0	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

This widespread ecological system is more common in the southern and central Rocky Mountains, but occurs throughout much of the western U.S. and north into Canada, in the montane and subalpine zones, and in the Great Basin and throughout the western U.S. on drier sites.

Biophysical Site Description

Elevations generally range from 1525 to 3211 m (5000-10,500 feet), but occurrences can be found at lower elevations in some regions. Distribution of this ecological system is limited primarily by adequate soil moisture required to meet its high evapotranspiration demand, and secondarily by the length of the growing season or low temperatures.

Vegetation Description

These are upland forests and woodlands dominated by aspen without a significant conifer component (<25% relative tree cover), often termed "stable aspen". On many ranges of Nevada, conifers other than pinyon and juniper (e.g., limber pine, white fir, and subalpine fir) are largely absent or uncommon. Engelmann's spruce is common in the Snake Range.

The understory structure may be complex with multiple shrub and herbaceous layers, or simple with just an herbaceous layer. The herbaceous layer may be dense or sparse, dominated by graminoids or forbs. Common shrubs include Salix, Symphoricarpos oreophilus, Amelanchier utahensis, Juniperus scopulorum, Mahonia repens, and Ribes. The herbaceous layers may be lush and diverse. Common graminoids may include Bromus marginatus, Bromus anomalus, Elymus trachycaulus, Poa nevadensis, Poa fendleriana, Achnatherum lettermanii, Pascopyrum smithii, and Carex. Associated forbs may include Achillea millefolium, Eucephalus engelmannii (= Aster engelmannii), Delphinium spp., Geranium viscosissimum, Heracleum sphondylium, Ligusticum filicinum, Lupinus argenteus, Osmorhiza berteroi (= Osmorhiza

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chilensis), Pteridium aquilinum, Rudbeckia occidentalis, Thalictrum fendleri, Valeriana occidentalis, Wyethia amplexicaulis, and many others.

Disturbance Description

Replacement fire and ground fire were common in stable aspen and both depended heavily on native burning. It is important to understand that aspen is considered a fire-proof vegetation type that does not burn during the normal lightining season, yet evidence of fire scars and historical studies show that fires occurred mostly during the spring and fall due to native burning.

This BPS has elements of Fire Regime Groups III, II, and IV. Replacement fire has a mean annual FRI of 60 yrs. Mean annual fire return intervals for mixed severity fire may have been as frequent as 20 years, averaging approximately 50 years. Where conifers were present, due to extended periods without fire, the mean FRI of mixed severity fire increased to 20 years while that of replacement fire remained unchanged.

Under pre-settlement conditions, disease and insect mortality did not appear to have major effects, however older aspen stands would be susceptible to outbreaks every 200 years on average. We assumed that 20% of outbreaks resulted in heavy insect/disease stand-replacing events (average return interval 1000 yrs), whereas 80% of outbreaks would thin older trees >40 yrs (average return interval 250 yrs). Disturbance effects would also have varied from clone to clone. Many aspen clones situated on steep slopes are prone to disturbance caused by avalanches and mud/rock slides. Riparian aspen is prone to flooding and beaver clearcutting. Conifers, where co-dominant in aspen stands, would experience insect/disease outbreaks every 300 years on average.

Adjacency or Identification Concerns

If conifers are present in significant amount, please review BpS 1061-- Inter-Mountain Basins Aspen and Mixed Conifer Forest and Woodland. On Great Basin mountain ranges that do not support fir trees, stable aspen occurs at all elevations but tend to be more common at higher elevations. Sagebrush groups, especially mountain big sagebrush and high elevation Wyoming big sagebrush, occurred below and around this group. Forest types such as ponderosa pine or warm/dry mixed conifer with more frequent fire may influence fire frequency in stable aspen to facilitate regeneration.

Aspen decline varies across the region. Declines have been documented in UT, NV, AZ, NM, but not in CO (especially SW CO). Drought is currently impacting many stands in the Great Basin. Nearly a hundred years of fire suppression and uncharacteristic ungulate grazing have reduced clones or created senecent stands lacking suckers (Kay 2001 a,b,c).

Under current conditions, herbivory can significantly effect stand succession. Kay (1997, 2001a, b, c) found the impacts of burning on aspen stands were overshadowed by the impacts of herbivory. In the reference state the density of ungulates was low due to efficient Native American hunting, so the impacts of ungulates were low. Herbivory was therefore not included in the model.

Native Uncharacteristic Conditions

Less than 40% aspen cover in mid and late-development is uncharacteristic. More than 50% conifer is unchar

Scale Description

Sources of Scale Data ☐ Literature ☑ Local Data ☐ Expert Estimate

Patch size for this type ranges from the 10's to 100-1000's of acres. Patches may be linear along riparian areas and cover large areas with aspen reaching on side slopes.

Issues/Problems

East of the Great Basin, Baker (1925) studied closely the pre-settlement period for aspen and noted fire scars on older trees and evidence of frequent fire. Bartos and Campbell (1998) support these findings. We

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interpreted ground fires that scarred trees, probably started by Native Americans, as mixed severity fire that also promoted abundant suckering.

Aspen stands tend to remain dense througout most of their life-span, hence the open stand description was not used unless it described conifer coverage. These are typically self-perpetuating stands. While not dependent upon disturbance to regenerate, aspen was adapted to a diverse array of disturbances.

Comments

BpS gb1011 is based on BpS 121011 with modifications made to species composition and biophysical settings based on the soil survey for Great Basin National Park and range site description 028AY078NV.

BPS 1011 for zones 17 and 12 is intended to represent stable aspen as found on many ranges of Nevada. BPS 1011 for zones 12 and 17 is different from BPS 1011 for zone 16. The model and description for MZ 12 and 17 is a compromise between VDDT model R2ASPN from the rapid assessment and the model for MZ 16. One class (D) representing moderate conifer encroachment to stable aspen (as per NatureServe description of ecological system 1011) was added to the Rapid Assessment model R2ASPN and the mean annual FRIs and insect/disease probabilities of BPS 1011 for MZ16 were adopted. R2ASPN was modeled by Linda Chappell (lchappell@fs.fed.us), Robert Campbell (rbcampbell@fs.fed.us), and Bill Dragt (William_Dragt@nv.blm.gov). R2ASPN was reviewed by Cheri Howell (chowell02@fs.fed.us), Wayne Shepperd (wshepperd@fs.fed.us), and Charles Kay (ckay@hass.usu.edu). BPS 1011 for MZ 16 was modeled by Linda Chappell, Robert Campbell, Stanley Kitchen (skitchen@fs.fed.us), Beth Corbin (ecorbin@fs.fed.us), and Charles Kay.

Vegetation Classes

Class A 14%

Early Development 1 Closed

Description

Aspen suckers less than 6' tall. Grass and forbs present. Succession to class B after 10 yrs.

Indicator Species* and Canopy Position

POTR5 Upper
SYOR2 Middle
RIBES Middle

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	99%
Height	Tree 0m	Tree 5m
Tree Size Class	Seedling <4.5ft	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class B 40%

Mid Development 1 Closed

Description

Aspen over 6' tall dominate. Canopy cover is highly variable. Replacement fire occurs every 60 yrs on average. Mixed severity fire (average FRI of 50 yrs) maintains this class, but may consume litter and woody debris and stimulate suckering. Succession to class C after 30 years.

Indicator Species* and Canopy Position

POTR5 Upper
SYOR2 Lower
RIBES Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	40%	99%
Height	Tree 5.1m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C 45%

Late Development 1 Closed

Description

Aspen trees 5 - 16in DBH. Canopy cover is highly variable. Replacement fire occurs every 60 years on average. Mixed severity fire (mean FRI of 50 yrs), while thining some trees, promotes suckering and maintains vegetation in this class. Insect outbreaks and diseases occur every 200 years on average, causing stand thinning (transition to class B) 80% of the time and stand replacement (transition to class A) 20% of the time. Succession maintains vegetation in this class, however a lack of fire for 100 years will allow moderate conifer encroachment with a transition to class D.

Indicator Species* and Canopy Position

POTR5 Upper
SYOR2 Lower
RIBES Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	40%	99%
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class D 1%

Late Development 1 Open

Description

Aspen 5-16+" DBH and conifers co-dominate, with conifers present in the mid-story and overtopping aspen in older stands. Aspen comprises 80% of the overstory in younger stands, whereas conifers can reach up to 40% cover in overstory in older stands. Mean FRIs for replacement and mixed severity fire, respectively, are 60 and 20 years. Mixed severity fire and insect/disease outbreaks (mean return interval of 300 years) thin conifers, thus causing a return to class C.

Indicator Species* and Canopy Position

POTR5 Upper
PIEN Upper
ABCO Upper
PIFL2 Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	39%
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E 0%

Late Development 1 Closed

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	0%
Height		
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

Fire Regime Group:** 3

Historical Fire Size (acres)

Avg 10
Min 1
Max 100

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	68	50	300	0.014706	46
Mixed	57	20	60	0.017544	54
Surface					
All Fires	31			0.03226	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Additional Disturbances Modeled

- [x] Insects/Disease
- [ ] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

References

Baker, F. S., 1925. Aspen in the Central Rocky Mountain Region. USDA Department Bulletin 1291 pp. 1-47.

Bartos, D. L. 2001. Landscape Dynamics of Aspen and Conifer Forests. Pages 5-14 in: Shepperd, W. D.; Binkley, D.; Bartos, D. L.; Stohlgren, T. J.; and Eskew, L. G., compilers. 2001. Sustaining aspen in western landscapes: symposium proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Bartos, D. L. and R. B. Campbell, Jr. 1998. Decline of Quaking Aspen in the Interior West – Examples from Utah. Rangelands, 20(1):17-24.

Bradley, A. E., Noste, N. V., and W. C. Fischer. 1992. Fire Ecology of Forests and Woodlands in Utah. GTR-INT-287. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 128 p.

Bradley, Anne E., W. C. Fischer, and N. V. Noste. 1992. Fire Ecology of the Forest Habitat Types of Eastern Idaho and Western Wypoming. GTR- INT-290. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 92.

Brown, J.K. and D.G. Simmerman. 1986. Appraisal of fuels and flammability in western aspen: a prescribed fire guide. General technical report INT-205. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Brown, J. K., K. Smith, J. Kapler, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Campbell, R. B. and , D. L. Bartos. 2001. Objectives for Sustaining Biodiversity. In: Shepperd, W. D.; Binkley, D.; Bartos, D. L.; Stohlgren, T. J.; and Eskew, L. G., compilers. 2001. Sustaining aspen in western landscapes: symposium proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Debyle, N.V., C.D. Bevins, and W.C. Fisher. 1987. Wildfire occurrence in aspen in the interior western United States. Western Journal of Applied Forestry. 2:73-76.

Kay, C. E. 1997. Is aspen doomed? Journal of Forestry 95: 4-11.

Kay, C. E. 2001a. Evaluation of burned aspen communities in Jackson Hole, Wyoming. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 8 p.

Kay, C.E. 2001b. Long-term aspen exclosures in the Yellowstone ecosystem. Proceedings RMRS-P-18.. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Kay, C.E. 2001c. Native burning in western North America: Implications for hardwood forest management. General Technical Report NE-274. U.S. Department of Agriculture, Forest Service, Northeast Research Station. 8 p.

Mueggler, W. F. 1988. Aspen Community Types of the Intermountain Region. USDA Forest Service, General Technical Report INT-250. 135 p.

Mueggler, W. F. 1989. Age Distribution and Reproduction of Intermountain Aspen Stands. Western Journal of Applied Forestry, 4(2):41-45.

Romme, W.H., Floyd, M.L, Hanna, D. and Barlett, E.J. 1999. Chapter 5: Aspen Forests in Landscape Condition Analysis for the South Central Highlands Section, Southwestern Colorado and Northwestern New Mexico.

Shepperd, W. D. 1990. A classification of quacking aspen in the central Rocky Mountains based on growth and stand characteristics. Western Journal of Applied Forestry 5:69-75.

Shepperd, W.D. and E.W. Smith. 1993. The role of near-surface lateral roots in the life cycle of aspen in the central Rocky Mountains. Forest Ecology and Management 61: 157-160.

Shepperd, W. D. 2001. Manipulations to Regenerate Aspen Ecosystems. Pages 355-365 in: Shepperd, Wayne D.; Binkley, Dan; Bartos, Dale L.; Stohlgren, Thomas J.; and Eskew, Lane G., compilers. 2001. Sustaining aspen in western landscapes: symposium proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Shepperd, W. D., D. L. Bartos, and A. M. Stepen. 2001. Above- and below-ground effects of aspen clonal regeneration and succession to conifers. Canadian Journal of Forest Resources; 31: 739-745.

USDA Forest Service. 2000. Properly Functioning Condition: Rapid Assessment Process (January 7, 2000 version). Intermountain Region, Ogden, UT. Unnumbered.

Welsh, S. L, N. D. Atwood, S. l. Goodrich, and L. C. Higgins. 2003. A Utah Flora, Third edition, revised. Print Services, Brigham Young University, Provo, UT. 912 p.

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LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1080bw Basin Wildrye (loamy bottom)

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *BpS 121080 was split into a basin wildrye (=bw)-basin big sagebrush BpS (wr1080bw), and a moist system (wr1080m). These BpSs vary vary with soil texture, moiture, slope, and depth to bedrock.*

General Information

Contributors (also see the Comments field) **Date** 1/18/2007

Modeler 1	Louis Provencher	lprovencher@tnc.org	**Reviewer**
Modeler 2			**Reviewer**
Modeler 3			**Reviewer**
			FRCC

Vegetation Type

Upland Savannah/Shrub Steppe

Dominant Species*

LECI4 PASM
ARTR ACHY
ERTE1
LETR5

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
0	0
0	0
0	0
0	0

Model Zones

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☑ Great Basin ☐ South Central
☐ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Geographic Range

This BpS occurs throughout the Great Basin, northward onto the Columbia-Snake River Plateau and south into portions of Mojave Desert (Schultz 1986, West 1983a,b).

Biophysical Site Description

Described here is the ecological site dominated by basin wildrye (Leymus cinereus) with a small component of basin big sagebrush (Artemisia tridentata spp tridentata) found on small floodplains or dry washes with moist, productive soils (NRCS 2003). This group, therefore, differs from basin big sagebrush-dominant ecological sites situated on the apron of mountain toes. This BpS ranges in elevation from about 1680 to 2285 m (5500-7500 ft) (NRCS 2003). Typically soils are deep to very deep with fine loamy to fine sandy loamy textures. Soils are well drained with water tables below the rooting zone of the dominant shrubs. Salts, if present, can increase with depth. Soils formed through alluvial processes and typically form valley bottoms with slopes generally less than 8% and typically between 0 and 4% (NRCS 2003).

Annual precipitation ranges from 200 to 350 mm (8 to 14 in). Many locations will occur along valley bottoms outside of the wet meadow areas, but within zones where water tables may attain heights of 150 to 75 cm (60 to 30 in), but >150cm for the seasonal high water table is typical. On lower precipitation sites (200 to 250 mm or 8 to 10 in) these locations may be positioned at the base of slopes such that water may run onto these sites.

Growing degree days range from 90 to 120 days.

Vegetation Description

Not much is written specifically about the dynamics of this vegetation community. What is known is drawn

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from general descriptions of the differences among the big sagebrush subspecies. West (1983a,b) lists the communities of this subspecies in both the Great Basin sagebrush semi-desert (NV, western UT, and eastern CA) and in the sagebrush steppe of northern NV and southern ID. The major differences among these subspecies are that sagebrush steppe sites tend to be more productive, but the dynamics should be roughly the same. West (1983a,b) diagrams the relationships among the subspecies and places basin big sagebrush and Wyoming big sagebrush in roughly the same climatic zones with the major difference being that soils development would indicate that basin big sagebrush occurs on colder and moister soils than Wyoming big sagebrush. However, soil moisture will overlap as elevation increases.

This is a shrub grassland mixture dominated by basin wildrye (average 60% dry weight), a deep-rooted cool-season bunchgrass, and basin big sagebrush (average 10% dry weight) in the shrub layer as codominants (NRCS 2003). The cover of basin big sagebrush increases with time since fire.

Good data regarding plant cover of these sites are difficult to find. NRCS is now providing estimates of canopy cover in their newer ecological site descriptions (NRCS 2003). Based on those estimates, total vascular plant cover will range between 30 to 70% with the higher amounts occuring on the dry meadows with deep soils on valley bottom locations with higher precipitation.

Other shrubs will generally represent less than 10% of the overall cover and will include various species and subspecies of rabbitbrush (e.g., Ericameria teretifolia). Other grasses, such as beardless wildrye and western wheatgrass, will generally be cool season bunchgrasses, with the exception of some rhizomatous grasses on the dry meadows with deep soils and high precipitation. Forbs will represent less than 10% of the herbaceous cover.

Disturbance Description

Fire -- Plant community composition will change dramatically in the shrub composition immediately after fires. Basin big sagebrush is intolerant to fire (Tirmenstein 1999), thus the community will become a grassland immediately after a fire. Recovery of sagebrush is most often been studied with Wyoming and mountain big sagebrush, but little is known specifically for basin big sagebrush. Wyoming big sagebrush can recover to prefire conditions in Montana within 40 years (Wambolt et al. 2001). Mountain big sagebrush communities are known to have 12 to 25 year fire return intervals (Miller & Tausch 2001). Replacement fire was the dominant disturbance with FRI ranging from 40 yrs for mid-development, 50 yrs for early development, and to 67 yrs for late-development.

Insects - Aroga moth -- Population explosions of the webworm larvae of this moth can kill patches of sagebrush in areas (West 1983a). When these explosions occur, sagebrush is eliminated or reduced severely in density.

Adjacency or Identification Concerns

Basin big sagebrush-dominant types situated on mountain toes on thinner sandy soils (less than 75cm or 30") were placed in gr1080 (Inter-Mountain Basins Big Sagebrush) and can be confused with gr1080bw during the early seral phase of gr1080 when basin wildrye dominates.

Mountain big sagebrush may occur in similar precipitation zones, especially the 250 to 350 mm (10 to 14 in), but will generally be on higher elevation locations that may have a shorter growing season. However, both basin and mountain big sagebrush will hybridize in zones where they co-occur.

Salt desert shrub and and greasewood communities will likely occur on sites with higher calcium or salts in the soils and can be found in playas of basins in the Great Basin.

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Dry meadow communities will occupy similar locations as the productive basin big sagebrush communities along valley bottoms, but dry meadows naturally occupy these areas because water tables will likely be shallower and potentially closer to streams and riparian communities.

These communities were historically grazed heavily by livestock. Basin wildrye is intolerant of inappropriate grazing, thus the current coverage of this species is often much lower than what it once was within these communities.

Native Uncharacteristic Conditions

More than 30% shrub cover is uncharacteristic. Tree cover is uncharacteristic.

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

The scales used for these descriptions were based on the ecological site descriptions. This follows the mapping scale of the order 3 soils classifications provided by the NRCS; BpS is generally found in long and smooth patches with slopes 0-4% (max 8%).

Issues/Problems

Good information on the fire return information, including Native American burning, recovery and the plant coverages in an undisturbed environment are difficult.

Comments

BpS gr1080bw is closely based on BpS wr1080bw for the Wassuk Range, with the following modification. 1) Mixed severity fire was deleted to reflect new fire type definitions used in LANDFIRE. Sagebrush is fire sensitive and does not underburn. 2) The total FRI of class B in wr1080bw was 2.5% (replacement + mixed severity); therefore this value was kept for the FRI of replacement fire. Resulting NRV is close to 5% of wr1080bw.

BpS wr1080bw was modified from R2SBBB by David Pyke (david_a_pyke@usgs.gov) by narrowing the description to systems dominated by basin wildrye. Canopy cover reflects the grassier system. Fire refime and model are largely unchanged.

Original R2SBBB model by David Pyke (david_a_pyke@usgs.gov) and reviewed by Mike Zielinski (mike_zielinski@nv.blm.gov) and Jolie Pollet (jpollet@blm.gov). Original model was modified to account more strictly for the grassy (basin wildrye), micro-floodplain version found on the Wassuk Range, western NV. The soil used to modify the original model is Tornillo Variant fine sandy loam, 0 to 4 percent slope from soil survey 744 (Mineral County).

Vegetation Classes

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Class A **20%**

Early1 Open

Description

Duration of this class is 0 to 10 years. The probability of a replacement fire is 2% (1 in 50 years).

Vegetation is dominated by tall perennial cool-season bunchgrasses (basin wildrye) with a mixture of perennial forbs. The perennial forbs generally will be more prominent immediately after fires, but will decrease in cover within 5 years after disturbance often representing less than 5 % canopy coverage. Shrubs will slowly increase as seedlings establish, grow and begin to expand their cover.

Indicator Species* and Canopy Position

ARTRT Lower
ERTE18 Lower
LECI4 Upper
ACHY Mid-Upper

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0%	20%
Height	Herb 0m	Herb 1.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class B **70%**

Mid1 Closed

Description

Duration of this class is 11- 75 years. Fires are generally replacement fires at 2.5% probability (1 in 40 years). Insects and drought are the two other disturbances that can impact the community and occur about 1% of the time (1 in 100 years), but they will keep the community in class B by selective thinning of shrubs.

Tall perennial cool-season bunchgrasses (mostly basin wildrye) dominate with basin big sagebrush recovering or codominant. Grasses and forbs will tend to reduce there coverage as shrubs increase their coverage.

Indicator Species* and Canopy Position

ARTRT Low-Mid
ERTE18 Low-Mid
ACHY Mid-Upper
LECI4 Upper

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21%	80%
Height	Herb 0.6m	Herb >1.1m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

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Class C **10%**

Late1 Open

Description

Duration of this stage is in excess of 75 years. The probability of replacement fires are slightly reduced with a probability of 1.5 % (1 in 67 years). All other disturbance probabilities remain the same, but they drive the class to B.

At class C, shrub coverage may reduce the coverage of the herbaceous component, however, the total coverage should remain about the same.

Indicator Species* and Canopy Position

ARTRT Upper
ERTE18 Mid-Upper
LECI4 Mid-Upper
ACHY Middle

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11%	20%
Height	Shrub 0.6m	Shrub 1.0m
Tree Size Class	None	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Dominant vegetation is herbaceous with basin wildrye up to 75% cover.

Class D **0%**

Late1 Open

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	%
Height		
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E **0%**

Late1 Closed

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	%
Height		
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

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Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 50
Min 10
Max 100

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	43	10	100	0.023256	100
Mixed					
Surface					
All Fires	43			0.02328	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [x] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

References

Brown, J. K. and J. K. Smith, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Miller, R.F. and R.J. Tausch. 2001. The role of fire in juniper and pinyon woodlands: a descriptive analysis, p. 15-30. In: K.E.M. Galley and T.P. Wilson (eds.), Proceedings of the Invasive Species Workshop: the Role of Fire in the Control and Spread of Invasive Species. Misc. Pub. No. 11, Tall Timbers Res. Sta. Tallahassee, Fl.

NRCS (Natural Resources Conservation Service). 2003. Nevada ecological site descriptions: central Nevada Basin and Range. USDA NRCS, Reno NV.

Shultz, L.M. 1986. Taxonomic and geographic limits of Artemisia subgenus Tridentatae (Beetle) McArthur (Asteraceae: Anthemideae). In: McArthur, E.D., Welch, B.L. (comps) Proceedings -- symposium on the biology of Artemisia and Chrysothamnus; 1984 July 9-13. USDA Forest Service, Intermountain Research Station, Gen Tech Rep INT-200, Ogden UT

Tirmenstein, D. 1999. Artemisia tridentata spp. Tridentata. IN: Fire effects Information System [Online]. USDA Forest Service, Rocky Mtn. Res Stn, Fire Sciences Laboratory (Producer). Http://www.fs.fed.us/database/feis/ 18 Nov 2004

Wambolt, C.L., K.S. Walhof, and M.R. Frisina. 2001. Recovery of big sagebrush communities after burning in south-western Montana. J. Environmental Manage. 61:243-252.

West, N.E. 1983a. Great Basin-Colorado Plateau sagebrush semi-desert. Pages 331-349 IN: West, NE (ed) Temperate deserts and semi-deserts. Elsevier Scientific Publishing, Amsterdam, Netherlands.

West, N.E. 1983b. Western intermountain sagebrush steppe. Pages 351-374 IN: West, NE (ed) Temperate deserts and semi-deserts. Elsevier Scientific Publishing, Amsterdam, Netherlands.

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LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1079an Black Sagebrush - no burrows

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *BpS 121079 is split between black sagebrush (gr1079an) and low sagebrush (gr1079aa) due to the large differences in cover and fire behavior between the two species.*

General Information

Contributors (also see the Comments field) **Date** 1/16/2007

Modeler 1	Louis Provencher	lprovencher@tnc.org	**Reviewer**
Modeler 2			**Reviewer**
Modeler 3			**Reviewer**
			FRCC

Vegetation Type

Upland Shrubland

Dominant Species*

ARNO	PUST
ACHY	EPNE
ACSP1	ARTR
HECO	PIMO

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
0	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

Western Utah, eastern/central/northern Nevada.

Biophysical Site Description

This type describes black sagebrush, mostly on convex slopes with Wyoming sagebrush and basin big sagebrush occurring in concave slopes and inset alluvial fans. Great Basin alluvial fans, piedmont, bajadas, rolling hills and mountain slopes. Can also be found on flats and plains. Elevation ranges from 1500m to 2600m. Black sagebrush tends to grow where there is a root-limiting layer in the soil profile and is often found over calcareous hardpans or hardpans formed by aeolian calcareous dust additions originating from local playas or another source. Wyoming sagebrush and basin big sagebrush generally occur on moderately deep to deep soils that are well-drained.

Vegetation Description

This type includes communities dominated by black sagebrush (Artemisia nova), with a small component of Wyoming sagebrush (Artemisia tridentata spp wyomingensis), where there is a potential for pinyon (Pinus monophylla) and/or juniper (Juniperus osteosperma) establishment. Black sagebrush is the dominant shrub in this system with Wyoming big sagebrush and basin big sagebrush occurring in minor compositions, sometimes scattered but mostly continuous. Black sagebrush generally has relatively low fuel loads with low growing and cushion forbs and scattered bunch grasses such as needlegrasses (Achnatherum spp.), needleandthread (Hesperostipa comata), Sandberg's bluegrass (Poa secunda), Indian ricegrass (Achnatherum hymenoides), and bluebunch wheatgrass (Pseudoroegneria spicata). Forbs often include buckwheats (Eriogonum spp.), fleabanes (Erigeron spp.), phloxs (Phlox spp.), paintbrushes (Castilleja spp.), globemallows (Sphaeralcea spp.), and lupines (Lupinus spp.). Characteristic shrubs include Stansbury cliffrose (Purshia stansburiana) and Nevada ephedra (Ephedra nevadensis)

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Disturbance Description

Black sagebrush generally supports more fire than other dwarf sagebrushes. This type generally burns in small patches due to relatively low fuel loads and herbaceous cover. Bare ground acts as a micro-barrier to fire between low statured shrubs. Fire is more likely when successive years of above average precipitation are followed by an average or dry year. Replacement fire dominates the small patches (average FRI of 150-250 yrs) because sagebrush is fire-sensitive. Late successional classes have shorter FRIs (150 yrs) than the early development class (250 yrs) because the herbaceous component, although diminishsed compared to the early development class, can cause a chain reaction of canopy ignition in sagebrush or trees. This type fits best into Fire Regime Group IV.

Severe drought occurs on average every 60 years and causes two equally probable transitions in older woody vegetation: moderate thinning of the stand (maintaining conditions in the current class), or severe thinning (causing a transition to the previous development class). In younger woody vegetation, severe drought every 200 yrs will have the same effect. Severe drought will cause insect outbreaks in trees, which were included in the weather tress disturbance.

Grazing by wild ungulates occurs in this type due to it's high palatability. Native browsing tends to open up the canopy cover of shrubs but does not often change the successional stage. Native grazing was not included in the model.

Burrowing animals and ants breaking through the root restrictive zone of black sagebrush create mounds of mineral soil (seedbed) that is readily colonized by big sagebrush. Burrowing creates small patches (i.e., generally less than 200 sq. ft) of big sagebrush in black sagebrush, which could affect fuel loads. This patchiness was not considered in the model.

Adjacency or Identification Concerns

The black sagebrush type tends to occur adjacent to either Wyoming big sagebrush or basin big sagebrush types. The Wyoming big sagebrush and basin big sagebrush types create a mosaic within the black sagebrush types. These big sagebrush types have a different fire regime that acts to carry the fire, with black sagebrush serving as fire breaks most of the time.

After fires, composition is primarily islands of black sagebrush with interspaces dominated by low rabbitbrush that resprouts, and with time, increases of shadscale and herbaceous composition.

Native Uncharacteristic Conditions

More than 40% shrub cover is uncharacteristic and more than 50% tree cover is uncharacteristic.

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

Black sagebrush can occupy extremely large areas (>100,000 acres) in eastern Nevada and western Utah, but occurences are typically smaller in western Nevada (5,000 acres). Disturbance patch size for this type is not well known but is estimated to be 10s to 100s of acres due to the relatively small proportion of the sagebrush matrix it occupies and the limited potential for fire spread. Where these sites exist in a more herbaceous state, fire expands readily where there is continuity of fine fuels to carry it to the extent that there is wind in a low intensity burn. Fire sizes up to 800 acres are possible in situations like this.

Issues/Problems

A 60 yrs return interval for severe drought was adopted to mimic weather pattern when the Atlantic Multi-decadal Oscillation is coupled with the Pacific Decadal Oscillation. Whether this severe drought will cause 50% thinning to a more open development class and 50% maintenance thinning needs to be determined.

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Comments

BpS gr1079an ("gr" stands for Grouse Creek-Raft River Mtns) was based on wr1079an, but substantially modifed to reflect new fire type definitions used in LANDFIRE. It was decided that surface and mixed severity fire do not play a role in fire sensitive sagebrush (this type does not underburn), whereas replacement is the dominant fire type. Therefore, all mixed severity fire was removed and fire assumed to burn completely vegetation (i.e., replacement) in small patches. Therefore, only replacement fire was used. Furthermore, the duplicative effect of insects/disease and severe weather stress was simplified to only weather stress occurring every 60 yrs. Resulting simulation created a NRV nearly identical to the original model, but a longer total FRI, which makes more sense.

BpS wr1079an was closely based on BpS 121079 without the low sagebrush component and Time Since Disturbance removed by succession from class B to C after 95 years (long FRI are similar to the TSD). Plant composition is based of the Beelem soil from the NRCS soil survey for Mineral County (#744). BpS 121079 was developed by Crystal Kolden (ckolden@gmail.com) and Gary Medlyn (gmedlyn@nv.blm.gov) and reviewed by Mike Zielinski (mike_zielinski@nv.blm.gov).

BPS 1079 was originally based on the Rapid Assessment model R2SBDW (dwarf sagebrush) developed by Gary Medlyn (gmedlyn@nv.blm.gov) and Sarah Heidi (sarah_heidi@blm.gov). Following expert review, choice of model was switched to R2SBDWwt (dwarf sagebrush with trees) developed by Gary Medlyn and Sarah Heidi) because the NatureServe description includes pinyon and juniper encroachment and the appropriate elevation. Also, the reviewer indicated that black sagebrush is usually associated with juniper or pinyon in northcentral Nevada and recommended the version of the model with tree encroachment. Modifications were made to weather stress pathways and probabilities for R2SBDWwt. R2SBDW was reviewed by Paul Blackburn (paul.blackburn@usda.gov), Gary Back (gback@srk.com), and Paul Tueller (ptt@intercomm.com), whereas R2SBDWwt was reviewed by Paul Tueller.

Vegetation Classes

Class A 15%

Early Development 1 All Struc

Description

Early seral community dominated by herbaceous vegetation; less than 6% sagebrush canopy cover; up to 24 years post-disturbance. Fire-tolerant shrubs (green/low rabbitbrush) are first sprouters after stand-replacing, high-severity fire. Replacement fire (mean FRI of 250 yrs) maintains vegetation in state A. Prolongued drought every 200 yrs on average maintains vegetation in class A. Succession to B after 25 years.

Indicator Species* and Canopy Position

ACSP12 Mid-Upper
ARNO4 Upper
ACHY Mid-Upper
HECO2 Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Shrub Dwarf <0.5m	Shrub Dwarf <0.5m
Tree Size Class	None	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Dominant lifeform is primarily herbaceous with some resprouting rabbitbrush. Canopy cover 4-10%, height 18-36cm (0.2-0.4m).

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class B **50 %**

Mid Development 1 Open

Description

Mid-seral community with a mixture of herbaceous and shrub vegetation; 6 to 25% sagebrush (sagebrush/brush) canopy cover present; between 20 to 59 years post-disturbance. Drought every 200 yrs causes two transitions: 50% of times drought thins shrubs while maintaining vegetation in class B, whereas 50% of times drought causes a stand replacing event. Replacement fire (FRI of 150 yrs) causes a transition to A. Succession to class C after 95 years.

Indicator Species* and Canopy Position

ARNO4 Upper
ACSP12 Mid-Upper
ACHY Mid-Upper
HECO2 Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	30 %
Height	Shrub Dwarf <0.5m	Shrub Dwarf <0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C **25 %**

Late Development 1 Open

Description

Late seral community with a mixture of herbaceous and shrub vegetation; 10-25% sagebrush canopy cover present; and dispersed conifer seedlings and saplings established at <6% cover. Severe droughts (return interval of 60 yrs) causes two thinning disturbances: to class B (50% of times) and within class C. Replacement fire is every 150 years on average. Succession is to class D after 75 yrs.

Indicator Species* and Canopy Position

ARNO4 Upper
PIMO Upper
PUST Mid-Upper
ACHY Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	10 %
Height	Tree Regen <5m	Tree Regen <5m
Tree Size Class	Seedling <4.5ft	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Juniper, and maybe pinyon, overtopping shrubs. Tree cover <6%. Shrub canopy cover may reach 25%

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class D 10%

Late Development 1 Closed

Description

Late seral community with a closed canopy of conifer trees (6-40% cover). The herbaceous and shrub component would be greatly reduced (<1%) by tree dominance in black sagebrush communities. The only fire is replacement (FRI of 150 yrs) and driven by a greater amount of woody fuel than in previous states. Prolongued droughts, including associated Ips outbreaks, have the same thinning and maintenance effects as before. Succession from class D to D without fire.

Indicator Species* and Canopy Position

PIMO	Upper
EPNE	Middle
ARNO4	Middle
PUST	Middle

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	40 %
Height	Tree Regen <5m	Tree Short 5-9m
Tree Size Class	Pole 5-9" DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E 0%

Late Development 1 Open

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 50
Min 1
Max 1000

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	154	150	250	0.006494	100
Mixed					
Surface					
All Fires	154			0.00651	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Additional Disturbances Modeled

☐ Insects/Disease	☐ Native Grazing	☐ Other (optional 1)
☑ Wind/Weather/Stress	☐ Competition	☐ Other (optional 2)

References

Blackburn, W.H. and P.T. Tueller. 1970. Pinyon and juniper invasion in black sagebrush communities in east-central Nevada. Ecology 51(5):841-848.

Ratzlaff, T.D. and J.E. Anderson. 1995. Vegetal recovery following wildfire in seeded and unseeded sagebrush steppe. Journal of Range Managenent 48:386-391.

Young, J.A. and D.E. Palmquist. 1992. Plant age/size distributions in black sagebrush (Artemisa nova): effects on community structure. Great Basin Naturalist 52(4):313-320.

USDA-NRCS 2003. Ecological site descriptions for Nevada. Technical Guide Section IIE. MLRAs 28B, 28A, 29, 25, 24, 23.

Zamora, B. and P. T. Tueller. 1973. Artemisia arbuscula, A. longiloba, and A. nova habitat types in northern Nevada. Great Basin Naturalist 33: 225-242.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1062 Curlleaf Mountain Mahogany Woodland

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 4/25/2006

Modeler 1	Neal Darby	Neal_Darby@nps.gov	**Reviewer**
Modeler 2	Bryan Hamilton	Bryan_Hamilton@nps.gov	**Reviewer**
Modeler 3	Ben Roberts	ben_roberts@nps.gov	**Reviewer**
			FRCC

Vegetation Type

Upland Forest and Woodland

Dominant Species*

CELE3	SYOR2
ARTR	PSSP6
ARPA6	POFE
SYMP	ACLE9

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16	0
12	0
17	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

The curlleaf mountain mahogany (Cercocarpus ledifolius var. intermontanus) community type occurs in the Sierra Nevada and Cascade Range to Rocky Mountains from Montana to northern Arizona, and in Baja California, and Mexico (Marshall, 1995).

Biophysical Site Description

Curlleaf mountain mahogany (Cercocarpus ledifolius var. intermontanus) communities are usually found on upper slopes and ridges between 7,000 to 9,500 ft. elevations (NRCS, 2003). Most stands occur on rocky shallow soils and outcrops to moderately deep soils with a high volume of coarse rock fragments.

Vegetation Description

Mountain big sagebrush and snowberry are the most common codominants with curlleaf mountain mahogany, although chaparral species such as greenleaf manzanita (Arctostaphylos patula) often codominate on some sites. Curlleaf mountain mahogany is both a primary early succssesional colonizer rapidly invading bare mineral soils after disturbance and the dominant long-lived species. Where curlleaf mountain mahogany has reestablished quickly after fire, rabbitbrush (Chrysothamnus viscidiflorus) may co-dominate. Litter and shading by woody plants inhibits establishment of curlleaf mountain mahogany. Reproduction often appears dependent upon geographic variables (slope, aspect, and elevation) more than biotic factors. Singleleaf pinyon, Utah juniper, white fir, limber pine, and ponderosa pine may be present, with less than 10% total cover. In old, closed canopy stands, understory may consist of aster, lupine, and yarrow.

Disturbance Description

Fire: Curlleaf mountain mahogany does not resprout, and is easily killed by fire (Marshall, 1995). Curlleaf mountain mahogany is a primary early succession colonizer rapidly invading bare mineral soils after

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

disturbance. Fires are not common in early seral stages, when there is little fuel, except in chaparral. Replacement fires (mean FRI of 150-500 yrs) become more common in mid-seral stands, where herbs and smaller shrubs provide ladder fuels. By late succession, two classes and fire regimes are possible depending on the history of mixed severity and surface fires. In the presence of surface fire (FRI of 50 yrs) and past mixed severity fires in younger classes, the stand will adopt a savanna-like woodland structure with a grassy understory with mountain big sagebrush.. Trees can become very old and will rarely show fire scars. In late, closed stands, the absence of herbs and small forbs makes replacement fires uncommon (FRI of 500 yrs), requiring extreme winds and drought, because thick duff provides fuel for more intense fires. Mixed severity fires (mean FRI of 50-200 yrs) are present in all classes, except the late closed one, and more frequent in the mid-development classes.

Ungulate herbivory: Heavy browsing by native medium-sized and large mammals reduces mountain mahogany productivity and reproduction (NRCS, 2003). This is an important disturbance in early and mid-seral stages, when mountain mahogany seedlings are becoming established. Browsing by small mammals has been documented (Marshall, 1995), but is relatively unimportant and was incorporated as a minor component of native herbivory mortality.

Windthrow and snow creep on steep slopes are also sources of mortality.

Adjacency or Identification Concerns

Littleleaf mountain mahogany, Cercocarpus intricatus, is restricted to limestone substrates and very shallow soils in California, Nevada, and Utah. It has similar stand structure and disturbance regime, so the curlleaf mountain mahogany model should be applicable to it.

Some existing curlleaf mountain mahogany stands may be in the big sagebrush BpS, now uncharacteristic because of fire exclusion.

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

Because these communities are restricted to rock outcrops and thin soils, stands usually occur on a small-medium scale, and are spatially separated from each other by other communities that occur on different aspects or soil types. Curlleaf mountain mahogany stands are often larger than 100 acres.

Issues/Problems

Data for the setback in succession caused by native grazing are lacking, but consistently observed by experts; in the model, only class A had a setback of -20 for native grazing, whereas no setback was specified for classes B and C, which do not have many seedlings.

Several fire regimes affect this community type. It is clear that being very sensitive to fire and very long-lived would suggest FRG V. This is true of late development classes, but younger classes can resemble more the surrounding chaparral or sagebrush communities in their fire behavior and exhibit a FRG IV. Experts had divergent opinions on this issue; some emphasized infrequent and only stand replacing fires whereas others suggested more frequent replacement fires, mixed severity fires, and surface fires. The current model is a compromise reflecting more frequent fire in early development classes, surface fire in the late, open class, and infrequent fire in the late, closed class.

Comments

BpS gb1062 was based on BpS 1210620 developed by Chris Ross (c1ross@nv.blm.gov), Don Major (dmajor@tnc.org), Louis Provencher (lprovencher@tnc.org), Sandy Gregory (s50grego@nv.blm.gov), Julia

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Richardson (jhrichardson@fs.fed.us), and Cheri Howell (chowell@fs.fed.us). Modifications were made to species composition and biophysical site descriptions to reflect GBNP soil surveys and range site descriptions. Current model includes litleleaf mountain mahogany.

BPS 1062 for mapping zones 12 and 17 (additional modelers are Sandy Gregory, s50grego@nv.blm.gov, Julia Richardson, jhrichardson@fs.fed.us, and Cheri Howell, chowell@fs.fed.us) was based on one model modifications (and associated HRV) of BPS 1062 for mapping zone 16 developed by Stanley Kitchen (skitchen@fs.fed.us) and Don Major (dmajor@tnc.org). Layout of VDDT model for BPS was corrected (switched class B and C). 1062 BPS 1062 for mapping zone 16 was based on R2MTMA with moderate revisions to the original model. Current description is close to original. Original modelers were Michele Slaton (mslaton@fs.fed.us), Gary Medlyn (gmedlyn@nv.blm.gov), and Louis Provencher (lprovencher@tnc.org). Reviewers of R2MTMA were Stanley Kitchen (skitchen@fs.fed.us), Christopher Ross (c1ross@nv.blm.gov), and Peter Weisberg (pweisberg@cabnr.unr.edu).

Data from a thesis in Nevada and expert observations suggests some large mountain mahogany may survive less intense fires. Therefore, surface fires were added as a disturbance to late seral stages, but this is a more recent concept in curlleaf mountain mahogany ecology. Surface fires were assumed to occur on a very small scale, perhaps caused by lightning strikes.

An extensive zone of mixed mountain mahogany and pinyon pine exists in western Nevada and Eastern California, and perhaps elsewhere. This type was not incorporated into the model, and is probably more appropriately included in the pinyon pine model.

Vegetation Classes

Class A 10%

Early Development 1 All Struc

Description

Curlleaf mountain mahogany rapidly invades bare mineral soils after fire. Litter and shading by woody plants inhibits establishment. Bunch grasses and disturbance-tolerant forbs and resprouting shrubs, such as snowberry, may be present. Rabbitbrush and sagebrush seedlings are present. Vegetation composition will affect fire behavior, especially if chaparral species are present. Replacement fire (average FRI of 500 yrs), mixed severity (average FRI of 100 yrs), and native herbivory (2 out every 100 seedlings) of seedlings all affect this class. Replacement fire and native herbivory will reset

Indicator Species* and Canopy Position

CELE3 Upper
PSSP6 Mid-Upper
CHRYS Upper
SYMPH Upper

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	55%
Height	Shrub 0m	Shrub >3.1m
Tree Size Class	Seedling <4.5ft	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

the ecological clock to zero. Mixed severity fire does not affect successional age. Succession to class C after 20 years.

Class B 10%

Mid Development 1 Closed

Description

Young curlleaf mountain mahogany are common, although shrub diversity is very high. One out of every 1000 mountain mahogany are taken by herbivores but this has no effect on model dynamics. Replacement fire (mean FRI of 150 yrs) causes a transition to class A. Mixed severity fire can result in either maintenance (mean FRI of 80 yrs) in the class or a transition to Class D (mean FRI of 200 yrs). Succession to class E after 90 years.

Indicator Species* and Canopy Position

CELE3 Upper
ARTRV Mid-Upper
SYOR2 Mid-Upper
SYMPH Mid-Upper

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	30%	45%
Height	Tree 5.1m	Tree 10m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Various shrub species typically dominate. However, under mixed severity fire disturbance various grass species may dominate.

Class C 15%

Mid Development 1 Open

Description

Curlleaf mountain mahogany may co-dominate with mature sagebrush, snowberry, rabbitbrush co-dominant. Few mountain mahogany seedlings are present. Replacement fire (mean FRI is 150 yrs) will cause a transition to class A, whereas mixed severity fire (mean FRI of 50 yrs) will thin this class but not cause a transition to another class. Native herbivory of seedlings and young saplings occurs at a rate of 1/100 seedlings but does not cause an ecological setback or transition. Succession to class B after 40 yrs.

Indicator Species* and Canopy Position

CELE3 Upper
ARTRV Low-Mid
SYMPH Low-Mid
PSSP6 Lower

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	10%	30%
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class D 20%

Late Development 1 Open

Description

Moderate cover of mountain mahogany. This class represents a combined Mid2-Open and Late1/Open cover/strucute resulting from mixed severity fire in class C (note: the combined class results in a slightly inflated representation in the landscape). Further, this class describes one of two late-successional endpoints for curlleaf mountain mahogany that is maintained by surface fire (mean FRI of 50 yrs). Evidence of infrequent fire scars on older trees and presence of open savanna-like woodlands with herbaceous-dominated understory are evidence for this condition. Other shrub species may be abundant, but decadent. In the absence of fire for 150 yrs (2-3 FRIs for mixed severity and surface fires), the stand will become closed (transition to class E) and not support a herbaceous understory. Stand replacement fire every 300 yrs on average will cause a transition to class A. Class D maintains itself with infrequent surface fire and trees reaching very old age.

Indicator Species* and Canopy Position

CELE3	Upper
ARTRV	Low-Mid
SYOR2	Low-Mid
PSSP6	Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0%	30%
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Various shrub species typically dominate. However, under mixed severity fire disturbance various grass species may dominate.

Class E 45%

Late Development 1 Closed

Description

High cover of large shrub- or tree-like mountain mahogany. Very few other shrubs are present, and herb cover is low. Duff may be very deep. Scattered trees may occur in this class. This class describes one of two late-successional endpoints for curlleaf mountain mahogany.

Indicator Species* and Canopy Position

CELE3	Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	30%	55%
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Replacement fire every 500 yrs on average is the only disturbance and causes a transition to class A. Class will become old-growth with trees reported to reach 1000+ years.

Disturbances

Fire Regime Group:** 3

Historical Fire Size (acres)

Avg 50
Min 1
Max 500

Sources of Fire Regime Data

☐ Literature
☐ Local Data
☑ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	285	100	500	0.003509	24
Mixed	149	50	150	0.006711	47
Surface	238	50	200	0.004202	29
All Fires	69			0.01442	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

☐ Insects/Disease ☑ Native Grazing ☐ Other (optional 1)
☐ Wind/Weather/Stress ☐ Competition ☐ Other (optional 2)

References

Arno, S. F. and A. E. Wilson. 1986. Dating past fires in curlleaf mountain-mahogany communities. Journal of Range Management 39:241-243.

Billings, W.D. 1994. Ecological impacts of cheatgrass and resultant fire on ecosystems in the western Great Basin. In: Proc. Ecology and management of annual rangelands. USDA USFS GTR-INT-313.

Brown, J. K. and J. K. Smith, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Gruell, G., S. Bunting, and L. Neuenschwander. 1984. Influence of fire on curlleaf mountain mahogany in the Intermountain West. Proc. Symposium on fire's effects on wildlife habitat. Missoula, Montana.

Marshall, K.A. 1995. Cercocarpus ledifolius. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2004, November 16].

Monsen, S. B. and E. D. Mc Arthur. 1984. Factors influencing establishment of seeded broadleaf herbs and shrubs following fire. Pp 112-124. In: K. Sanders and J. Durham (eds). Proc. Symp.: Rangelands fire effects. USDI Bureau of Land Management, Idaho Field Office, Boise, Idaho.

Natural Resources Conservation Service. 2003. Major land resource area 29. Southern Nevada Basin and Ragne. Ecological site descriptions. US Department of Agriculture.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Peters, E. F. and S. C. Bunting. 1994. Fire conditions pre- and post-occurrence of annula grasses on the Snake River plain. In: In: Proc. Ecology and management of annual rangelands. USDA USFS GTR-INT-313.

Ross, C. 1999. Population dynamics and changes in curlleaf mountain mahogany in two adjacent sierran and Great Basin mountain ranges. Pp. 111.

Schultz, B.W., R.J. Tausch, P.T. Tueller. 1996. Spatial relationships amoung young Cercocarpus ledifolius (curlleaf mountain mahogany). Great Basin Naturalist 56: 261-266.

Tausch, R. J., P. E. Wigand, and J. W. Burkhardt. 1993. Viewpoint: Plant community thresholds, multiple steady states, and multiple successional pathways: legacy of the Quaternary? Journal of Range Management 46:439-447.

Whisenant, S. G. 1990. Changing fire frequencies on Idaho's Snake River plains: Ecological and management implications. In: Proc. Symp., Cheatgrass Invasion, shrub die-off, and other aspects of shrub biology and management. USDS USFS INT 276, Ogden, Utah.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1020 Limber-Bristlecone Pine Woodland

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models: BpS gb1020 exist as old growth open stands (BpS gb1020) and moist stands on deeper Piar soils (BpS gb1020m).*

General Information

Contributors (also see the Comments field) **Date** 4/25/2006

Modeler 1	Bryan Hamilton	Bryan_Hamilton@nps.gov	**Reviewer**
Modeler 2	Neal Darby	Neal_Darby@nps.gov	**Reviewer**
Modeler 3	Ben Roberts	ben_roberts@nps.gov	**Reviewer**
			FRCC

Vegetation Type

Upland Forest and Woodland

Dominant Species*

PILO	RIBES
PIFL2	ERDI1
POA	JUCO6
CARO	

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16	0
12	0
17	0
0	0
0	0

Model Zones

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☑ Great Basin ☐ South Central
☐ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Geographic Range

Dry wind-swept ridges and exposed upper elevations of Nevada, Utah, southern Idaho and eastern California. In Great Basin National Park, this BpS is limited to a few polygons on the west side of the slope.

Biophysical Site Description

Elevation ranges from 8,000 to 11,500 feet on mid to upper slopes. The areas are typically in rain shadows, and are the dry and cold extent of tree cover. Stands occur on thin, stony soils, high windswept ridges and open slopes with minimal ground cover.

Vegetation Description

Pinus longaeva and Pinus flexilis can exist separately or as mixed stands. In Nevada, Picea Engelmannii and Pseudotsuga menziesii occur incidentally with Pinus longaeva. Sparse understories, of forbs, grass and short shrubs form an understory. Carex rossii and Poa spp are the principal understory grasses. Ericameria discoidea and Juniperus communis var depressa are the principal understory shrubs. Seed dispersal of limber and bristlecone pines highly dependent on seed-caching birds.

Disturbance Description

This group contains some of the oldest trees in the area, with Pinus longaeva 1000 years old or more and Pinus flexilis ages of 500 years+. Understories are often sparse, with little to carry fires across the surface. Fire occurrence is typically low frequency and surface fires (mean FRI of 500 years). In the absence of wind, fires are likely limited in extent (2 acres or less). Stand replacement fires (mean FRI of 1000 years) are usually wind-driven, especially in older stands (class C). Susceptible to bark beetles (esp. Pinus flexilis), but generally drought-tolerant.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Adjacency or Identification Concerns

A new and uncharacteristic disturbance is the potential for the introduction of white pine blister rust in both of these species. Blister rust is not yet occurring in the Utah High Plateau and western Great Basin. Note: blister rust has been found in NV in PIAL. Surveys in 2004 in NV bristlecone found no blister rust in PILO.

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

Stands vary from tens to hundreds of acres in size. Stand replacement fires of 1/10th acres to 100 acres have been experienced.

Issues/Problems

Comments

BpS gb1020 is based on BpS 121020 developed by Julia H Richardson (jhrichardson@fs.fed.us) and Cheri Howell (chowell02@fs.fed.us). Gretchen Baker (gretchen_baker@nps.gov) was the other modeler for BpS gb1020. Two types of modifications were made toBpS 1210120: 1) species composition was modified as per the Bricone soil type and 2) FRIs were doubled.

BpS 121020 was adopted with minor edits on species composition from the mapzone 16 version created by Bruce Short (bshort@fs.fed.us), Stanley Kitchen (skitchen@fs.fed.us), Linda Chappell (lchappell@fs.fed.us).

For mapzone 16, BPS 1057 was included in BPS 1020 as both are ecologically similar and have very small coverage.

Vegetation Classes

Class A 20%

Early Development 1 All Struc

Description

Bare ground and talus with sparse ground cover of forbs, grasses and low shrubs. Occasional old survivors may be present. Infrequent stand replacement fires (mean FRI of 1000 years) will setback succession to age zero. Surface fire (mean FRI of 1000 years) and weather-related stress affect this class, but without consequences to dynamics. Succession to class B after 100 years.

Indicator Species* and Canopy Position

PILO All
PIFL2 All

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class B **20%**

Mid Development 1 Open

Description

Open woodland < 30% crown closure of seedlings, saplings, and survivors. The only disturbances are surface (FRI of 500 yrs) and replacement fires (FRI = 1000 yrs). Succession to class C after 150 years.

Indicator Species* and Canopy Position

PILO Upper
PIFL2 Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	30 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C **60%**

Late Development 1 Open

Description

Open woodland < 30% crown cover of mixed diameters- 40" dbh to seedling. Sparse ground cover of grasses and low shrubs. Very old trees can develop in this class. Fire frequency and severity as in previous classes.

Indicator Species* and Canopy Position

PILO Upper
PIFL2 Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	30 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D **0%**

Late Development 1 Open

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height	None	None
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E **0%**

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height	NONE	NONE
Tree Size Class	None	

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model

Disturbances

Fire Regime Group:** 3

Historical Fire Size (acres)

Avg 5
Min 1
Max 100

Sources of Fire Regime Data

☑ Literature
☑ Local Data
☐ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	1000			0.001	34
Mixed					
Surface	526			0.001901	65
All Fires	345			0.00291	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

☐ Insects/Disease
☑ Wind/Weather/Stress
☐ Native Grazing
☐ Competition
☐ Other (optional 1)
☐ Other (optional 2)

References

Howard, J. L. 2004. Pinus longaeva. In: Fire Effects Information Systems [Online]. USDA, Forest Service, Rocky Mountain Research Station, Forest Sciences Lab (Producer). Available: http://www.fs.fed.us/database/feis [2005, February 23].

Johnson, K. A. 2001. Pinus flexilis. In: Fire Effects Information System [Online]. USDA, Forest Service, Fire Sciences Lab (Producer). Available: http://www.fs.fed.us/database/feis [2005, February 23].

Little, E. L. 1971. Atlas of United States Trees:Volume 1, Conifers and Important Hardwoods. USDA Forest Service, Misc. Pub. 1146, Washington, DC.

Steele, R. in: Burns, R. M., and B. H. Honkala, tech coords. 1990. Silvics of North America: 1. Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. Vol 2, 877 p

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1020m Limber-Bristlecone Pine Woodland-mesic

☐ *This BPS is lumped with:*
☑ *This BPS is split into multiple models: BpS gb1020 exist as old growth open stands (BpS gb1020) and moist stands on deeperr Piar soils (BpS gb1020m).*

General Information

Contributors (also see the Comments field) **Date** 4/25/2006

Modeler 1	Bryan Hamilton	Bryan_Hamilton@nps.gov	**Reviewer**	
Modeler 2	Neal Darby	Neal_Darby@nps.gov	**Reviewer**	
Modeler 3	Ben Roberts	ben_roberts@nps.gov	**Reviewer**	
			FRCC	

Vegetation Type

Upland Forest and Woodland

Dominant Species*

PILO RIBES
PIFL2 ERDI1
POA JUCO6
CARO

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16	0
12	0
17	0
0	0
0	0

Model Zones

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☑ Great Basin ☐ South Central
☐ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Geographic Range

Dry wind-swept ridges and exposed upper elevations of Nevada, Utah, southern Idaho and eastern California.

Biophysical Site Description

Elevation ranges from 9,000 to 11,500 feet on mid to upper slopes. This woodland type occurs on upper sideslopes of high mountains. Slopes range from 2-75% but ar typically 15 to 50%. Soils are deep or very deep and well drained. These soils have formed in highly calcareous colluvium and residuum of limestone and dolomite parent material.

Vegetation Description

Pinus longaeva and Pinus flexilis can exist separately or as mixed stands. In Nevada, Picea Engelmannii and Pseudotsuga menziesii occur incidentally with Pinus longaeva. Sparse understories, of forbs, grass and short shrubs form an understory. Carex rossii and Poa spp are the principal understory grasses. Ericameria discoidea and Juniperus communis var depressa are the principal understory shrubs. Seed dispersal of limber and bristlecone pines highly dependent on seed-caching birds.

Disturbance Description

This group contains old trees, with Pinus longaeva 1000 years old or more on dryer site and Pinus flexilis ages of 500 years+. On these deeper soils, longevity is shorter than on dry, shallow soils (see BpS gb1020). Understories are often sparse, with little to carry fires across the surface. Fire occurrence is typically low frequency and surface fires (mean FRI of 200 years). In the absence of wind, fires are likely limited in extent (2 acres or less). Stand replacement fires (mean FRI of 500 years) are usually wind-driven, especially in older stands (class C). Susceptible to bark beetles (esp. Pinus flexilis), but generally drought-tolerant.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Heartrot is assumed to kill only older trees, mostly bristlecone pine, every 250 yrs on average.

Adjacency or Identification Concerns

A new and uncharacteristic disturbance is the potential for the introduction of white pine blister rust in both of these species. Blister rust is not yet occurring in the Utah High Plateau and western Great Basin. Note: blister rust has been found in NV in PIAL. Surveys in 2004 in NV bristlecone found no blister rust in PILO.

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

Stands vary from tens to hundreds of acres in size. Stand replacement fires of 1/10th acres to 100 acres have been experienced.

Issues/Problems

Comments

BpS gb1020m is based on BpS 121020 developed by Julia H Richardson (jhrichardson@fs.fed.us) and Cheri Howell (chowell02@fs.fed.us). Gretchen Baker (gretchen_baker@nps.gov) was the other modeler for BpS gb1020m. Three types of modifications were made to BpS 1210120: 1) canopy cover reached 40% in vegetation development classes B and C, 2) heartrot was introduced as a minor disturbance to class C, and 3) species composition was modified to that of the Piar soil type - mesic bristlecone pine/limber pine.

BpS 121020 was adopted with minor edits on species composition from the mapzone 16 version created by Bruce Short (bshort@fs.fed.us), Stanley Kitchen (skitchen@fs.fed.us), Linda Chappell (lchappell@fs.fed.us).

For mapzone 16, BPS 1057 was included in BPS 1020 as both are ecologically similar and have very small coverage.

Vegetation Classes

Class A 15%

Early Development 1 All Struc

Description

Bare ground and talus with sparse ground cover of forbs, grasses and low shrubs. Occasional old survivors may be present. Infrequent stand replacement fires (mean FRI of 500 years) will setback succession to age zero. Surface fire (mean FRI of 200 years) and weather-related stress affect this class, but without consequences to dynamics. Succession to class B after 50 years.

Indicator Species* and Canopy Position

PILO	All
PIFL2	All
CARO5	All
POA	All

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class B **35%**

Mid Development 1 Open

Description

Open woodland < 20% crown closure of seedlings, saplings, and survivors. The only disturbances are surface and replacement fires with the same FRIs as in class A. Succession to class C after 150 years.

Indicator Species* and Canopy Position

PILO	Upper
PIFL2	Upper
CARO5	Lower
RIBES	Middle

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11%	20%
Height	Tree 5.1m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C **50%**

Late Development 1 Closed

Description

Open woodland 20-40% crown cover of mixed diameters- 40" dbh to seedling. Sparse ground cover of grasses and low shrubs. Old trees can develop in this class. Fire frequency and severity as in previous classes. Heartrot has a return rate of 500 yrs.

Indicator Species* and Canopy Position

PILO	Upper
PIFL2	Upper
CARO5	Lower
RIBES	Middle

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21%	40%
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D **0%**

Late Development 1 Open

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height	None	None
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E **0%**

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height	NONE	NONE
Tree Size Class	None	

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model

Disturbances

Fire Regime Group:** 3

Historical Fire Size (acres)

Avg 5
Min 1
Max 1000

Sources of Fire Regime Data

☑ Literature
☑ Local Data
☐ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	500			0.002	29
Mixed					
Surface	200			0.005	71
All Fires	143			0.00701	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

☑ Insects/Disease
☑ Wind/Weather/Stress
☐ Native Grazing
☐ Competition
☐ Other (optional 1)
☐ Other (optional 2)

References

Howard, J. L. 2004. Pinus longaeva. In: Fire Effects Information Systems [Online]. USDA, Forest Service, Rocky Mountain Research Station, Forest Sciences Lab (Producer). Available: http://www.fs.fed.us/database/feis [2005, February 23].

Johnson, K. A. 2001. Pinus flexilis. In: Fire Effects Information System [Online]. USDA, Forest Service, Fire Sciences Lab (Producer). Available: http://www.fs.fed.us/database/feis [2005, February 23].

Little, E. L. 1971. Atlas of United States Trees:Volume 1, Conifers and Important Hardwoods. USDA Forest Service, Misc. Pub. 1146, Washington, DC.

Steele, R. in: Burns, R. M., and B. H. Honkala, tech coords. 1990. Silvics of North America: 1. Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. Vol 2, 877 p

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1124 Low Sagebrush Steppe

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 4/25/2006

Modeler 1	Neal Darby	Neal_Darby@nps.gov	**Reviewer**
Modeler 2	Bryan Hamilton	Bryan_Hamilton@nps.gov	**Reviewer**
Modeler 3	Ben Roberts	ben_roberts@nps.gov	**Reviewer**
			FRCC

Vegetation Type

Upland Savanna and Shrub-Steppe

Dominant Species*

ARAR	SYMP
PSSP6	CHVI8
ACTH	AMUT
POSE	ACHY

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
0	0
0	0
0	0

Model Zones

☐ Alaska
☐ California
☑ Great Basin
☐ Great Lakes
☐ Northeast
☐ Northern Plains
☐ N-Cent.Rockies
☐ Pacific Northwest
☐ South Central
☐ Southeast
☐ S. Appalachians
☐ Southwest

Geographic Range

Eastern Oregon, northern, central, and Nevada (at higher elevations) and southern Idaho. BPS will occur in large patches in eastern and central Nevada where similar substrates are found on higher elevation mountain tops and mesas.

Biophysical Site Description

This type describes low sagebrush on shallow soils where a claypan produces seasonally perched water. Elevations range from 2,580 to 3000m (8,500 - 9,850+ ft). Occurs on erosional fan remnants, pediments of volcanic, granitic or quartzite base material, rock pedimant remnants, sideslopes and summits of mountains, and foothills. Subsoils swell on wetting and crack on drying and tend to have a high percentage of course fragments (gravels, cobbles, rocks or stones). Depth to a fine-textured subsoil ranges from 5 to 10". Claypan is typically 20" thick. Where soils are influenced by aeolian calcareous dust additions originating from local playas or another source, black sagebrush can occur. Where concave areas or drainages occur, mountain big sagebrush will dominate. Slope ranges from 0-15%. Precipitiation in these sites ranges from 14-20+" per year.

Vegetation Description

This type includes communities dominated by low sagebrush (Artemisia arbuscula). Other shrubs growing on site may include Douglas rabbitbrush (Chrysothamnus viscidiflorous), snowberry (Symphoricarpos spp.), and Utah serviceberry (Amelanchier utahensis). Dwarf sagebrushes generally have relatively low fuel loads with low growing and cushion forbs and scattered bunch grasses such as bluebunch wheatgrass (Pseudoroegneria spicata), needlegrasses (Achnatherum spp.), Sandberg's bluegrass (Poa secunda), Thurber's needlegrass (Achnatherum thurberanium) and Indian ricegrass (Achnatherum hymenoides). Forbs often include buckwheats (Eriogonum spp.), fleabanes (Erigeron spp.), phloxes (Phlox spp.), paintbrushes (Castilleja spp.), goldenweeds (Haplopapus spp.), and lupines (Lupinus spp.).

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Disturbance Description

Low sagebrush generally supports less fire than black sagebrush, but at higher elevations above the 14" PZ fine fuels are twice as abundant than in low-mid elevation low sagebrush. This type generally burns more frequently with mixed severity (average FRI of 75-125 yrs) because of the dominance of fine fuels on the site. Less bare ground than black sagebrush sites, allowing for more frequent mixed severity fire and less stand-replacing. Stand-replacing fires (average FRI of 230-250 yrs) can occur in this type when successive years of above average precipitation are followed by a dry winter, dry spring and high winds are present with dry lightning (Miller and Rose 1999). Stand-driven replacing fires are primarily wind-driven and only cover small areas. This type fits best into Fire Regime Group III.

Grazing by wild ungulates occurs in this type due to it's high palatability (mostly for A. nova and A. arbuscula) compared to other browse. Native browsing tends to open up the canopy cover of shrubs but does not often change the successional stage.

Low sagebrushh can be pockmarked by burrowing animals, especially ants, breaking through the root restrictive zone and creating a seedbed that is readily colonized by sagebrush. Burrowing creates small patches (i.e., generally less than 200 sq. ft) of big sagebrush in the low sagebrush types, which could affect fuel loads. This was not considered in the model.

Adjacency or Identification Concerns

In Nevada, where low sagebrush occurs at higher elevations, in rocky, open stands, pockets of curlleaf mountain mahogany with an understory of mountain sagebrush occur along the drainages.

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

Low sagebrush communities can occur in small to 10,000 acres areas on mountains ranges. Disturbance patch size for this type is not well known but is estimated to be 10s to 100s of acres due to the relatively small proportion of the sagebrush matrix it occupies and the limited potential for fire spread.

Issues/Problems

Comments

BpS gb1124 was based on BpS wr1124 (modified from 121124 by Louis Provencher, lprovencher@tnc.org, for the Wassuk Range, western NV) and 121124 .developed by Crystal Kolden (ckolden@gmail.com) and Gary Medlyn (gmedlyn@nv.blm.gov) and reviewed by Mike Zielinski (mike_zielinski@nv.blm.gov) and Terri Barton (terri_barton@nv.blm.gov). BpS gb1124 was modified to reflect species composition and biophysical site descriptions for the NRCS Great Basin National Park soil survey and range site description 028AY061NV.

BPS 1124 was based on the Rapid Assessment model R2SBDW developed by Gary Medlyn (gmedlyn@nv.blm.gov) and Sarah Heidi (sarah_heidi@blm.gov). Reviewers of R2SDDW were Mike Zielinski (mike_zielinski@nv.blm.gov), Gary Back (gback@srk.com), and Paul Tueller (ptt@intercomm.com). Modifications were made to BPS 1124 after reviews: 1) longer mean FRI for mixed severity fire in mid-development; 2) shorter mean FRI in late development; 3) longer mean FRI for replacement fire in late development; and 5) removal of short term drought effects throughout.

Suggested reviewers for BPS 1124 MZ 12 and 17: Mike Zielinski (mike_zielinski@nv.blm.gov) and Ed Horn (ed_horn@or.blm.gov).

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Vegetation Classes

Class A 10%

Early Development 1 All Struc

Description

Early seral community dominated by herbaceous vegetation; less than 6% sagebrush canopy cover; up to 24 years post-disturbance. Replacement fire occurs every 250 yrs on average. Succession to B after 24 years.

Indicator Species* and Canopy Position

PSSP6	Middle
CHVI8	Upper
POSE	Middle
ACTH7	Middle

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	10 %
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Dominant lifeform is herbaceous (15-25% cover), however rabbitbrush will be the upper layer lifeform at <6% cover.

Class B 50%

Mid Development 1 Open

Description

Mid-seral community with a mixture of herbaceous and shrub vegetation; 6 to 15% sagebrush canopy cover present; between 20 to 59 years post-disturbance. Replacement fire (FRI of 250 yrs) causes a transition to A, whereas mixed severity fire (FRI of 150 yrs) maintains the site in its present condition. Succession to class C after 95 yrs.

Indicator Species* and Canopy Position

ARAR	Upper
SYMPH	Middle
PSSP6	Middle
ACTH7	Middle

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	20 %
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Dominant lifeform is herbaceous with cover 15-25%. Height 0.2-0.4m.

Class C 40%

Late Development 1 Closed

Description

Late seral community with a mixture of herbaceous and shrub vegetation; >15% sagebrush canopy cover present; 75 or more years post-disturbance. In class C, replacement fire is every 250 yrs on average (transition to A), whereas mixed severity fire happens on average every 100 yrs. Mixed severity fire causes a transition to

Indicator Species* and Canopy Position

ARAR	Upper
AMUT	Middle
SYMPH	Upper
PSSP6	Middle

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	21 %	30 %
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Herbaceous component is co-subdominant with shrub cover. Canopy cover 10-15%. Height 0.2-0.4m.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

B. Succession will keep the site in class C without fire.

Class D **0%**

Late Development 1 Open

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class	None	

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model

Class E **0%**

Late Development 1 Open

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class	None	

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model

Disturbances

Fire Regime Group:** 3

Historical Fire Size (acres)

Avg 90
Min 1
Max 2000

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	255	250	250	0.003922	34
Mixed	132	70	100	0.007576	66
Surface					
All Fires	87			0.01151	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Sources of Fire Regime Data

☑ Literature
☐ Local Data
☑ Expert Estimate

Additional Disturbances Modeled

☐ Insects/Disease
☐ Wind/Weather/Stress
☐ Native Grazing
☐ Competition
☐ Other (optional 1)
☐ Other (optional 2)

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

References

Chambers, J. C. and Miller, J. editors. 2004. Great Basin riparian areas: ecology, management, and restoration. Society for Ecological Restoration International, Island Press. Pp 24-48.

Blackburn, W. H. and P. T. Tueller. 1970. Pinyon and juniper invasion in black sagebrush communities in east-central Nevada. Ecology 51(5):841-848.

Miller, R. F. and J. A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management 52:550-559.

USDA-NRCS 2003. Ecological site descriptions for Nevada. Technical Guide Section IIE. MLRAs 28B, 28A, 29, 25, 24, 23.

Young, J. A., and R. A. Evans. 1978. Population Dynamics after Wildfires in Sagebrush Grasslands. Journal of Range Management 31:283-289.

Young, J. A., and R. A. Evans. 1981. Demography and Fire History of a Western Juniper Stand. Journal of Range Management 34:501-505.

Young, J. A. and D. E. Palmquist. 1992. Plant age/size distributions in black sagebrush (Artemisa nova): effects on community structure. Great Basin Naturalist 52(4):313-320.

Ratzlaff, T. D. and J. E. Anderson. 1995. Vegetal recovery following wildfire in seeded and unseeded sagebrush steppe. Journal of Range Managenent 48:386-391.

Zamora, B. and P. T. Tueller. 1973. Artemisia arbuscula, A. longiloba, and A. nova habitat types in northern Nevada. Great Basin Naturalist 33: 225-242 .

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1079aa Low Sagebrush semi-desert

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *121079 is split between black sagebrush (wr1079an) and low sagebrush (wr1079aa) due to the large differences in cover and fire behavior between the two species. Also, PJ is a component of black sagebrush potential, but not low sagebrush.*

General Information

Contributors (also see the Comments field) **Date** 1/18/2007

Modeler 1	lprovencher@tnc.org lprovencher@tnc.org	**Reviewer**	
Modeler 2		**Reviewer**	
Modeler 3		**Reviewer**	
		FRCC	

Vegetation Type

Upland Shrubland

Dominant Species*

ARAR	ACHY
ACTH	GRSP
ACLE9	ARTR2
POSE	HECO

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
0	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

Western Utah and throughout Nevada.

Biophysical Site Description

This type describes low sagebrush, mostly on convex slopes with big sagebrush occurring in concave slopes and inset alluvial fans. Great Basin alluvial fans, piedmont, bajadas, rolling hills and mountain slopes. Can also be found on flats and plains. Elevations range from 1500m to 2600m; however, this type can also be used to represent alpine low sagebrush communities situated on the windswept mountain tops above 10,000 ft (>3,050m; not to be confused with Columbia Plateau Low sagebrush Steppe). Low sagebrush tends to grow where claypan layers exist in the soil profile and soils are often saturated during a portion of the year.

Vegetation Description

This type includes communities dominated by low sagebrush (Artemisia arbuscula), and, depending on elevation, Wyoming big sagebrush (Artemisia tridentata spp wyomingensis) or mountain big sagebrush (A. tridentata spp vaseyana). Due to the harsh soil, trees are not included in the potential for low sagebrush. Low sagebrush is the dominant shrub in this system with big sagebrush occurring in minor compositions, sometimes scattered but mostly continuous. Spiny hopsage (Grayia spinosa), low or green rabbitbrush (Chrysothamnus viscidiflorus or Ericameria teretifolia), and Nevada ephedra (Ephedra nevadensis) are also present. Low sagebrush generally has relatively low fuel loads with low growing and cushion forbs and scattered bunch grasses such as Thurber's needlegrass (Achnatherum thurberianum), Letterman's needlegrass (Achnatherum lettermanii) at higher elevations, needleandthread (Hesperostipa comata) at higher elevations, Sandberg's bluegrass (Poa secunda) and Indian ricegrass (Achnatherum hymenoides) at mid-lower elevations. Forbs often include buckwheats (Eriogonum spp.), fleabanes (Erigeron spp.), phloxs

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

(Phlox spp.), paintbrushes (Castilleja spp.), globemallows (Sphaeralcea spp.), and lupines (Lupinus spp.). Alpine low sagebrush communities will contain alpine cushion-like forbs (Phlox spp.) and grasses.

Disturbance Description

Low sagebrush generally supports less fire than other dwarf sagebrushes, such as black sagebrush. This type generally burns in small patches due to relatively low fuel loads and herbaceous cover. Bare ground acts as a micro-barrier to fire between low statured shrubs. Fire is more likely when successive years of above average precipitation are followed by an average or dry year and sevre weather conditions prevail. Replacement fire dominates the small patches (average FRI of 250 yrs) because sagebrush is fire-sensitive. This type fits best into Fire Regime Group IV.

Severe drought occurs on average every 200 years and causes two equally probable transitions in older woody vegetation (classes B and C): moderate thinning of the stand (maintaining conditions in the current class), or severe thinning (causing a transition to the previous development class). In younger woody and herbaceous vegetation (class A), severe drought every 500 yrs will have the same effect.

Grazing by wild ungulates occurs in this type due to it's high palatability. Native browsing tends to open up the canopy cover of shrubs but does not often change the successional stage. Native grazing was not included in the model.

Burrowing animals and ants breaking through the root restrictive zone of low sagebrush create mounds of mineral soil (seedbed) that is readily colonized by big sagebrush. Burrowing creates small patches (i.e., generally less than 200 sq. ft) of big sagebrush in the low sagebrush types, which could affect fuel loads. This was not considered in the model.

Adjacency or Identification Concerns

Low sagebrush tends to occur adjacent to big sagebrush at different elevations. Big sagebrush types create a mosaic within the low sagebrush type. These big sagebrush types have a different fire regime that acts to carry the fire, with low sagebrush serving as fire breaks most of the time.

BpS gr1079aa in the 10-14" PZ is very similar in composition to BpS 1124, however the latter supports greater grass cover and is found at higher elevation in the 14+" PZ zone.

After mixed- or low-severity fires, composition is primarily islands of low sagebrush with interspaces dominated by low rabbitbrush that resprouts, and with time, increases of shadscale and herbaceous composition.

Native Uncharacteristic Conditions

Any tree cover is uncharacteristic.

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

Low sagebrush can occupy extremely large areas (>100,000 acres) in eastern Nevada and western Utah. Occurrences are typically smaller towards western Nevada. Disturbance patch size for this type is not well known but is estimated to be 10s to 100s of acres due to the relatively small proportion of the sagebrush matrix it occupies and the limited potential for fire spread. Where these sites exist in a more herbaceous state, fire expands readily where there is continuity of fine fuels to carry it to the extent that there is wind in a low intensity burn. Fire sizes up to 800 acres are possible in situations like this.

Alpine low sagebrush occupies a small area restricted to the highest peaks above 10,000 ft and rarely experiences fire.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Issues/Problems

Comments

BpS gr1079aa is closely based on BpS wr1079aa with a few major changes. Mixed severity fire was removed to reflect new fire type definitions by LANDFIRE. Sagebrush does not underburn. Class D with conifer invasion is not part of the potential of the northwest UT landscape; therefore the model has only three classes. The replacement FRI was set at 250 years in all classes. Except for class A, the return interval of drought was set at 200 years, 1/2 for thinning and 1/2 for maintenenace. NRV results changed for class B and C, but not class A.

BpS wr1079aa was closely based on BpS 121079 but retained mostly cover values for low sagebrush and retained relevant aspect of black sagebrush ecology. BpS 121079 was developed by Crystal Kolden (ckolden@gmail.com) and Gary Medlyn (gmedlyn@nv.blm.gov) and reviewed by Mike Zielinski (mike_zielinski@nv.blm.gov). Significant changes were made to the model: 1) Time Since Disturbance was replaced with a succession to class C at year 120 because the FRI for low sagebruish was longer than the TSD; 2) All drought and insect attacks caused a transition to the previous class, but not a split between maintaince and thinning because the process of tree invasion on low sagebrush is slow and more stressful to trees than on a black sagebrush soil; and 3) the FRI for mixed severity and replacement fire was, respectively, extended to the maximum of 150 and 250 years.

BPS 121079 was originally based on the Rapid Assessment model R2SBDW (dwarf sagebrush) developed by Gary Medlyn (gmedlyn@nv.blm.gov) and Sarah Heidi (sarah_heidi@blm.gov). Following expert review, choice of model was switched to R2SBDWwt (dwarf sagebrush with trees) developed by Gary Medlyn and Sarah Heidi) because the NatureServe description includes pinyon and juniper encroachment and the appropriate elevation. Also, the reviewer indicated that black sagebrush is usually associated with juniper or pinyon in northcentral Nevada and recommended the version of the model with tree encroachment. Modifications were made to weather stress pathways and probabilities for R2SBDWwt. R2SBDW was reviewed by Paul Blackburn (paul.blackburn@usda.gov), Gary Back (gback@srk.com), and Paul Tueller (ptt@intercomm.com), whereas R2SBDWwt was reviewed by Paul Tueller.

Vegetation Classes

Class A 10%

Early Development 1 All Struc

Description

Early seral community dominated by herbaceous vegetation; less than 6% sagebrush canopy cover; up to 24 years post-disturbance. Fire-tolerant shrubs (green/low rabbitbrush) are first sprouters after stand-replacing, high-severity fire. Replacement fire (mean FRI of 250 yrs) maintains vegetation in state A. Prolongued drought every 500 yrs on average maintains vegetation in class A. Succession to B after 25

Indicator Species* and Canopy Position

CHRYS	Upper
ACLE9	Mid-Upper
ACHY	Mid-Upper
ACTH7	Middle

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Dominant lifeform is primarily herbaceous with some resprouting rabbitbrush. Canopy cover 4-10%, height 18-36cm (0.2-0.4m).

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

years.

Class B **40%**

Mid Development 1 Open

Description

Mid-seral community with a mixture of herbaceous and shrub vegetation; 6 to 25% sagebrush (sagebrush/brush) canopy cover present; between 20 to 59 years post-disturbance. Prolongued drought every 200 yrs causes 50% of times thinning of the canopy to the previous development class (A) and 50% of times maintenance thinning. Replacement fire (FRI of 250 yrs) causes a transition to A. Succession to class C after 95 years.

Indicator Species* and Canopy Position

ARAR8 Upper
POSE Lower
ACLE9 Mid-Upper
ACTH7 Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11%	20%
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C **50%**

Late Development 1 Open

Description

Late seral community with a mixture of herbaceous and shrub vegetation; 10-25% sagebrush canopy cover present; and dispersed conifer seedlings and saplings may be present at <6% cover. Prolongued drought every 200 yrs causes 50% of times thinning of the canopy to the previous development class (A) and 50% of times maintenance thinning. Replacement fire is every 250 years on average.

Indicator Species* and Canopy Position

ARAR8 Mid-Upper
POSE Lower
ACLE9 Mid-Upper
ACTH7 Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Juniper, and maybe pinyon, overtopping shrubs. Tree cover <6%. Shrub canopy cover may reach 20%

Class D **0%**

Late Development 1 Closed

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model

Class E **0%**

Late Development 1 Open

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class	None	

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model

Disturbances

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 50
Min 1
Max 2000

Sources of Fire Regime Data

☑ Literature
☐ Local Data
☑ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	250	100	250	0.004	100
Mixed					
Surface					
All Fires	250			0.00402	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

☐ Insects/Disease
☑ Wind/Weather/Stress
☐ Native Grazing
☐ Competition
☐ Other (optional 1)
☐ Other (optional 2)

References

Blackburn, W.H. and P.T. Tueller. 1970. Pinyon and juniper invasion in black sagebrush communities in east-central Nevada. Ecology 51(5):841-848.

Ratzlaff, T.D. and J.E. Anderson. 1995. Vegetal recovery following wildfire in seeded and unseeded sagebrush steppe. Journal of Range Managenent 48:386-391.

Young, J.A. and D.E. Palmquist. 1992. Plant age/size distributions in black sagebrush (Artemisa nova): effects on community structure. Great Basin Naturalist 52(4):313-320.

USDA-NRCS 2003. Ecological site descriptions for Nevada. Technical Guide Section IIE. MLRAs 28B,

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

28A, 29, 25, 24, 23.

Zamora, B. and P. T. Tueller. 1973. Artemisia arbuscula, A. longiloba, and A. nova habitat types in northern Nevada. Great Basin Naturalist 33: 225-242.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1052 Mixed Conifer Woodland

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 1/19/2007

Modeler 1	Louis Provencher lprovencher@tnc.org	**Reviewer**	
Modeler 2		**Reviewer**	
Modeler 3		**Reviewer**	
		FRCC	

Vegetation Type

Upland Forest and Woodland

Dominant Species*

ABCO
PIFL2
ABLA
PICO

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16	0
17	0
12	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

Rocky Mountains west into the ranges of the Great Basin. BPS may be more common in eastern portion on MZ 12 and in MZ 17.

Biophysical Site Description

Elevations range from 1200 to 3300 m (4000-11,000 ft). Occurrences of this system are found on cooler and more mesic sites than Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland (1051). Such sites include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions and north- and east-facing slopes which burn somewhat infrequently.

Vegetation Description

Abies concolor is the most common canopy dominant, but Picea engelmannii, Pinus flexilis, and Pinus longeava are also possible. Pseudotsuga menziesii will be rare and restricted to northern Nevada and Utah. A number of cold-deciduous shrub species can occur, including Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Jamesia americana, Physocarpus malvaceus, Vaccinium membranaceum, and Vaccinium myrtillus. Herbaceous species include Bromus ciliatus, Carex geyeri, Carex rossii, Carex siccata, Muhlenbergia virescens, Pseudoroegneria spicata, Erigeron eximius, Fragaria virginiana, Luzula parviflora, Osmorhiza berteroi, Packera cardamine, Thalictrum occidentale, and Thalictrum fendleri.

Disturbance Description

Naturally occurring fires are of variable return intervals, and mostly light, erratic, and infrequent due to the cool, moist conditions. These ecological systems are in a Fire Regime Group III or I, but some portions of these sites are transition zones to Fire Regime Group IV. This vegetation is a transition between the frequent surface and mixed severity fires and the more stand replacement regimes common in high elevation fir and spruce ecosystems.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Surface fire and mixed severity fire intervals were about 35 to 50 years (Brown et al. 1994). Stand replacement fires occurred at intervals of 120 to 400+ years (Crane 1986; Barrett 1988; Bradley 1992a,b; Brown et al. 1994; Morgan et al. 1996). Likelihood of stand replacement fires increased with canopy closure and fuel ladders caused by white fir growth, however ground fires acted as replacement fires during early stand development (class A).

Other disturbances included insect, disease, drought, and wind and ice damage. Fire was by far the dominant disturbance agent.

Adjacency or Identification Concerns

This ecological system is often transitional between Fire Regime Group I and Fire Regime Groups II, IV, and V at higher elevations. Sites are dry/steep montane with a variety of aspects (often northerly) and soil conditions. In MZ 12 and 17, BPS 1051is uncommon and should be included in BPS 1052.

This system includes mixed conifer/Populus tremuloides (aspen) stands. If aspen is present and soils show a clear organic layer, BPS 1061 Intermountain Basins Aspen-Mixed Conifer Forest and Woodland should be used.

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☐ Literature ☐ Local Data ☑ Expert Estimate

This PNVG occurs in patches ranging from 100's to 1,000's of acres.

Issues/Problems

Comments

BpS gr1052 was adapted from BpS 171052 by removing mixed severity fire from class A. BpS 171052 was developed by Julia H. Richardson (jhrichardson@fs.fed.us).

BpS 171052 was adopted with minor edits on species composition from the mapzone 16 version created by Mrk Loewen (mloewen@fs.fed.us), Doug Page (doug_page@blm.gov) and Beth Corbin (ecorbin@fs.fed.us). Further review is needed to make sure this type is appropriately described for zones 12 and 17 - especially species occurrence.

This model was originally coded as R2PSMEnr and was changed to R2PSMEms on 12/13/2004 by Lynn Bennett (lmbennett@fs.fed.us). This model was changed into BPS 1052 by Mark Loehen, Doug Page, Beth Corbin, and Linda Chappell on 3/3/05. Reviewers of R2PSMEms were: Hugh Safford (hughsafford@fs.fed.us), Steve Barrett (sbarrett@mtdig.net), and Clinton K Williams (cwiliam03/@fs.fed.us).

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class A 10%

Early Development 1 All Struc

Description

Tree seedling-shrub-grass-forb. Succession to B after 30 yrs unless replacement fire occurs (average FRI of 120 yrs).

Indicator Species* and Canopy Position

ABCO Upper
PICO Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	15%
Height	Tree Regen <5m	Tree Regen <5m
Tree Size Class	Seedling <4.5ft	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class B 30%

Mid Development 1 Closed

Description

Forest canopy closure is >35%. This class includes closed trees, sapling, large poles, grass and scattered shrubs. Composition is 75 to 100% white fir, some lodgepole pine, and spruces at higher elevations. Primary succession is to class E, the closed late development condition after 70 yrs. Mixed severity fire (FRI of 47 yrs) and wind/weather/stress every 200 yrs on average will open the stand, thus causing a transition to class C. Insects/disease (50 years mean return interval) cause minor mortality to this stage.

Indicator Species* and Canopy Position

ABCO Upper
PICO Upper
PIFL2 Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	Max
Cover	35%	100%
Height	Tree Short 5-9m	Tree Medium 10-24m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C 30%

Mid Development 1 Open

Description

Forest canopy closure is <35%. Open pole-sapling/ grass scattered shrubs, maybe 90% white fir. This state will succeed to the closed mid-development condition (B) after 35 yrs in the absence of fire (FRI of 40 yrs on average). With fire, insect outbreaks (every 100 yrs) and weather-related stress (every 1000 yrs), the vegetation will become

Indicator Species* and Canopy Position

ABCO Upper
PICO Upper
ABLA Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	35%
Height	Tree Short 5-9m	Tree Medium 10-24m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

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open late-development after 70 years. Stand replacement fire occurs on average every 400 yrs.

Class D **20%**

Late Development 1 Open

Description

Forest canopy closure is < 35%. Open large tree/ grass and scattered shrubs; potentially 90% whitefir. Replacement fire occurs every 400 yrs on average, whereas surface fire (FRI of 40 yrs) maintains the open condition of the stand. Insects/disease every 100 yrs also maintain the structure of the stand open. After 35 years without fire, existing trees will fill out the stand and cause succession to the late closed condition (E).

Indicator Species* and Canopy Position

ABCO	Upper
PIFL2	Upper
ABLA	Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	35 %
Height	Tree Tall 25-49m	Tree Tall 25-49m
Tree Size Class	Large 21-33"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E **10%**

Late Development 1 Closed

Description

Forest canopy closure is >35%. Closed medium to large trees, scattered shrubs, 60 to 100% white fir. Replacement fire every 120 yrs will remove the canopy, whereas mixed severity fire every 50 yrs will return the stand to the open structure (D). Surface fire (FRI of 50 yrs) will not affect the structure and age of trees. Occasional weather-related stress every 200 yrs will open the structure of the stand and cause a transition to class D. Insect/diseases damage occurs every 50 years causing 60% of times a transition to class C and 40% to class C.

Indicator Species* and Canopy Position

ABCO	Upper
ABLA	Upper
PIFL2	Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	35 %	100 %
Height	Tree Tall 25-49m	Tree Tall 25-49m
Tree Size Class	Large 21-33"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

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Fire Regime Group:** 1

Historical Fire Size (acres)

Avg 100
Min 10
Max 1000

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	185	120	400	0.005405	20
Mixed	120	35	50	0.008333	30
Surface	72	35	50	0.013889	50
All Fires	36			0.02763	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☑ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

References

Barrett, S. W., 1988. Fire Suppression effects on Forest Succession within a Central Idaho Wilderness. Western J. of Applied Forestry. 3(3):76-80July 1988.

Barrett, S. W., 1994. Fire Regimes on the Caribou National Forest, Southern Idaho. Final Report – Contract No. 53-02S2-3-05071. September 1994.

Barrett, S. W. 2004. Altered fire intervals and fire cycles in the northern Rockies. Fire Management Today 64(2):25-29.

Barrett, S. W. 2004. Fire regimes in the northern Rockies. Fire Management Today 64(2):32-38.

Bradley, A. F., W. C. Fische and, N. V. Noste. 1992. Fire Ecology of the Forest Habitat Types of Eastern Idaho and Western Wyoming. Intermountain Research Station, Ogden UT 84401. GTR-INT-290, 1992.

Bradley, A. F., N. V. Noste, and W. C. Fischer. 1992. Fire Ecology of the Forests and Woodland in Utah. Intermountain Research Station, Ogden UT 84401. GTR-INT-287, 1992.

Brown, J. K., S. F. Arno, S. W. Barrett, and J. P. Menakis. 1994. Comparing the Prescribed Natural Fire Program with Presettlement Fires in the Selway-Bitterroot Wilderness. Int. J. Wildland Fire 4(3): 157-168, 1994 @ IAWF.

Crane, M. F. 1986. Fire Ecology of the Forest Habitat Types of Central Idaho. Intermountain Research Station, Ogden UT 84401. GTR-INT-218, 1986.

Morgan, P., S. C. Bunting, A. E. Black, T. Merrill, and S. Barrett. 1996. Fire Regimes in the Interior Columbia River Basin: Past and Present. Final Report For RJVA-INT-94913: Course-scale classification and mapping of disturbance regimes in the Columbia River Basin. Submitted to: Intermountain Fire Science Lab., Intermountain Research Station, Missoula, Montana, USDA Forest Service.

Steele, R., R. D. Pfister, R. A. Ryker,and J. A. Kittams. 1981. Forest Habitat Types of Central Idaho. USDA For. Serv. Tech. Rep. INT-114, 138 p. Intermt. For. And Range Exp. Stn., Ogden, Utah 84401.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Swetnam, T. W., B. E. Wickman, H. G. Paul, and C. H. Baisan. 1995. Historical patterns of western spruce budworem and Douglas-fir tussock moth outbreaks in the northern Blue Mountains, Oregon, since A.D. 1700. USDA ForesT Service. Pacific Northwest Research Station,. Research Paper PNW-RP-484. 27 pp.

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LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1126m Montane Sagebrush Steppe - mountain site

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *Split three ways among BpS gr1126mt (mountain mountain big sagebrush), gr1126up (upland mountain big sagebrush) and BpS gr1126bw, where basin wildrye is dominant in micro-floodplains.*

General Information

Contributors (also see the Comments field) **Date** 10/12/2006

Modeler 1	Louis Provencher	lprovencher@tnc.org	**Reviewer**	
Modeler 2			**Reviewer**	
Modeler 3			**Reviewer**	
			FRCC	

Vegetation Type

Upland Savanna and Shrub-Steppe

Dominant Species*

ARTR	ACNE
PUTR2	BRMA
SYOR2	POFE
PSSP6	ACLE9

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
16	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

Upper montane and subalpine elevations across the western U.S. above 1,890 m (6,200 ft) within the mountains of northern Nevada, north western Utah, southeast Wyoming, and southern Idaho.

Biophysical Site Description

This ecological system occurs in many of the western United States, usually at middle to hiher elevations elevations (1890-2895 m) in the northern Great Basin mapping zone. Elsewhere this system can reach upper elevations of 1370 m in Idaho to 3200 m in the White Mountains of California (Winward and Tisdale 1977, Blaisdell et al. 1982, Cronquist et al. 1994, Miller and Eddleman 2000). The climate regime is cool, semi-arid to subhumid, with yearly precipitation ranging from 40 to 80 cm/year (16-30 in; NRCS 1997) in northwest Utah, although 20 to 90 cm/yr is reported elsewhere (Mueggler and Stewart 1980, Tart 1996). Much of this precipitation falls as snow. Temperatures are continental with large annual and diurnal variation. In general this system shows an affinity for mild topography, fine soils, and some source of subsurface moisture. Soils generally are moderately deep to deep, well-drained, and of loam, sandy loam, clay loam, or gravelly loam textural classes; soils often have a substantial volume of coarse fragments, and are derived from a variety of parent materials. This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. Soils are typically deep and have well developed dark organic surface horizons (Hironaka et al. 1983, Tart 1996). However, at the high ends of its precipitation and elevation ranges mountain big sagebrush occurs on shallow and/or rocky soils. All aspects are represented, but the higher elevation occurrences may be restricted to south- or west-facing slopes.

At mid-level elevations, mountain sagebrush begins to move into more southerly slopes intermingling with black sagebrush and low sagebrush and with mountain mahogany occurring on north-facing slopes. With

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continued elevation, curlleaf mountain mahogany generally crowds it out. Mountain big sagebrush then occupies drier sites at higher elevations.

Vegetation Description

Vegetation types within this ecological system are usually less than 1.5 m tall and dominated by Artemisia tridentata ssp vaseyana, or Artemisia tridentata ssp spiciformis. A variety of other shrubs can be found in some occurrences, but these are seldom dominant. They include Artemisia arbuscula, Ericameria nauseosa, Ericameria discoides, Chrysothamnus viscidiflorus, Ephedra viridis, Symphoricarpos oreophilus, Purshia tridentata, Peraphyllum ramosissimum, Ribes, and Amelanchier utahensis. The canopy cover is usually between 20-80%. The herbaceous layer is usually well represented, but bare ground may be common in particularly arid or disturbed occurrences. Graminoids that can be abundant include Pseudoroegneria spicata,Achnatherum Hesperostipa comata, Elymus trachycaulus, Festuca thurberi, Elymus elymoides, Deschampsia caespitosa, Danthonia intermedia, Leymus cinereus, Achnatherum hymenoides, Stipa spp., Pascopyrum smithii, Bromus marginatus, Poa fendleriana, or Poa secunda. Forbs are often numerous and an important indicator of health. Forb species may include Castilleja, Potentilla, Erigeron, Phlox, Astragalus, Geum, Lupinus, and Eriogonum, Balsamorhiza sagittata, Achillea millefolium, Antennaria rosea, Eriogonum umbellatum, and Artemisia ludoviciana, etc. Mueggler and Stewart (1980), Hironaka et al. (1983), and Tart (1996) described several of these types. This ecological system is critical summer habitat for Greater Sage Grouse. Moreover, resprouting bitterbrush in mountain big sagebrush types is potentially important to wildlife in early stand development.

Disturbance Description

Mean fire return intervals in and recovery times of mountain big sagebrush are subjects of lively debate in recent years (Welch and Criddle 2003). Mountain big sagebrush communities were historically subject to stand replacing fires with a mean return interval ranging from 40+ years at the Wyoming big sagebrush ecotone, and up to 80 years in areas with a higher proportion of low sagebrush in the landscape (Crawford et al. 2004, Johnson 2000, Miller et al. 1994, Burkhardt and Tisdale 1969 and 1976, Houston 1973, Miller and Rose 1995, Miller et al. 2000). Under pre-settlement conditions mosaic burns generally exceeded 75% topkill due to the relatively continuous herbaceous layer. Therefore, replacement fire with a mean FRI of 40-80 years was adopted here. Brown (1982) reported that fire ignition and spread in big sagebrush is largely (90%) a function of herbaceous cover. These communities were also subject to periodic mortality due to insects, disease, rodent outbreaks, drought, and winterkill (Anderson and Inouye 2001, Winward 2004). Periodic mortality events may result in either stand-replacement or patchy die-off depending on the spatial extent and distribution of these generally rare (50 to 100 years) events.

Recovery rates for shrub canopy cover vary widely in this type, depending on post fire weather conditions, sagebrush seed-bank survival, abundance of resprouting shrubs (e.g., snowberry, bitterbrush), and size and severity of the burn. Mountain big sagebrush typically reaches 5% canopy cover in 8 to 14 years. This may take as little as 4 years under favorable conditions and longer than 25 years in unfavorable situations (Pedersen et al. 2003, Miller unpublished data). Mountain big sagebrush typically reaches 25% canopy cover in about 25 years, but this may take as few as nine years or longer than 40 years (Winward 1991, Pedersen et al. 2003, Miller unpublished data). Mountain snowberry and resprouting forms of bitterbrush may return to pre-burn cover values in a few years. Bitterbrush plants less than fifty years old are more likely to resprout than older plants (Simon 1990).

Adjacency or Identification Concerns

Mountain big sagebrush is commonly found adjacent to or intermingled with low sagebrush and mountain shrublands.

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Some difficulty might be encountered in separating upland and mountain sites of mountain big sagebrush.

Due to its generally higher elevation and more abundant precipitation, this BpS is not threatened by cheatgrass, unlike the upland version (BpS gr1126up).

Native Uncharacteristic Conditions

Uncharacteristic conditions in this type include herbaceous canopy cover less than 40% in the absence of con

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

This type occupies areas ranging in size from 10's to 10,000's of acres. Disturbance patch size can also range from from 10's to 1,000's of acres. The distribution of past burns was assumed to consist of many small patches in the landscape.

Issues/Problems

This was initially 1126_a (Mountain Big Sagebrush) model from Map Zone 16, which was itself based on Rapid Assessment models R2SBMT and R2SBMTwc where the reviewers and modelers had very differents opinions on the range of mean FRIs and mountain big sagebrush recovery times (see Welch and Criddle 2003). It is increasingly agreed upon that a MFI of 20 years, which used to be the accepted norm, is simply too frequent to sustain populations of Greater Sage Grouse and mountain big sagebrush ecosystems whose recovery time varies from 10-70 years. Reviewers consistently suggested longer FRIs and recovery times. The revised model is a compromise with longer recovery times and FRIs. Modeler and reviewers also disagreed on the choice of FRG: II (modeler) vs. IV (reviewers). For Map zones 12 and 17, modelers place this system in Fire Regime Group IV.

If conifers are not adjacent to this system, such as in the Tuscarora range, Santa Rose range, and similar regions, use a three-box model with the following percentages per box: 20% A, 45% B, 35% C.

Comments

BpS gr1126mt resulted from splitting BpS gr 1126 into NRCS mountain (Bickmore series of soil for Utah; R025XY412UT and R025XY610UT) and upland ecological sites.

BpS gr1126 was taken as is from gb1126 because the only fire type was replacement. BpS gb1126 was developed by Great Basin National Park staff Tod Williams (Tod_Williams@nps.gov), Bryan Hamilton (Bryan_Hamilton@nps.gov), and Neal Darby (Neal_Darby@nps.gov), and Louis Provencher (lprovencher@tnc.org). The VDDT model for BpS gr1126mt was reviewed by Shane Green, Utah NRCS.

BpS gb1126 was based on BpS 121126 developed by Gary Medlyn (gary_medlyn@nv.blm.gov) and Crystal Kolden (ckolden@gmail.com). Modifications to 121126 were completed for species composition and biophysical site descriptions based on the Great Basin National Park soil survey and several range site descriptions: 028AY057NV, 028AY064NV, 028AY065NV, 028AY067NV, 028AY068NV. Model unchanged.

BPS 1126 for MZ 12 and 17 was based on BPS 1126_a (Mountain Big Sagebrush) from LF Maping Zone 16. BPS 1126_a is essentially PNVG R2SBMTwc (mountain big sagebrush with potential for conifer invasion) developed by Don Major (dmajor@tnc.org), Alan R. Sands (asands@tnc.org), David Tart (dtart@fs.fed.us), and Steven Bunting (sbunting@uidaho.edu). R2SBMTwc was itself based on R2SBMT developed by David Tart. R2SBMtwc was revised by Louis Provencher (lprovencher@tnc.org) following critical reviews by Stanley Kitchen (skitchen@fs.fed.us), Michele Slaton (mslaton@fs.fed.us), Peter Weisberg (pweisberg@cabnr.unr.edu), Mike Zielinski (mike_zielinski@nv.blm.gov), and Gary Back (gback@srk.com).

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The first three development classes chosen for this PNVG correspond to the early, mid-, and late seral stages familiar to range ecologists. The two classes with conifer invasion (classes D and E) approximately correspond to Miller and Tausch's (2001) phases 2 and 3 of pinyon and juniper invasion into shrublands.

Vegetation Classes

Class A 20%

Early Development 1 Open

Description

Herbaceous vegetation is the dominant lifeform. Herbaceous cover is variable but typically >50% (50-80%). Shrub cover is 0 to 5%. Replacement fire (mean FRI of 80 years) setbacks succession by 12 years. Succession to class B after 12 years.

Indicator Species* and Canopy Position

PSSP6	Upper
POFE	Upper
SYOR2	Lower
ARTRV	Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Dominant vegetation is herbaceous with scattered shrubs. Herbaceous cover is 0-80%.

Class B 50%

Mid Development 1 Open

Description

Shrub cover 6-25%. Mountain big sagebrush cover up to 20%. Herbaceous cover is typically >50%. Initiation of conifer seedling establishment. Replacement fire mean FRI is 40 years. Succession to class C after 38 years.

Indicator Species* and Canopy Position

ARTRV	Upper
PUTR2	Upper
CONIF	Lower
SYMPH	Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11%	30%
Height	Shrub 0.6m	Shrub 3.0m
Tree Size Class	Seedling <4.5ft	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Herbaceous cover is the dominant lifeform with canopy >50%. Shrub cover is 6-25% and the upper lifeform.

Class C 15%

Late Development 1 Closed

Description

Shrubs are the dominant lifeform with canopy cover of 26-45+%. Herbaceous cover is typically <50%. Conifer (juniper, pinyon-juniper, white fir,Douglas-fir, ponderosa pine, or limber pine) cover <10%. Insects and disease every 75 yrs on average will thin

Indicator Species* and Canopy Position

ARTRV	Upper
PUTR2	Upper
SYMPH	Low-Mid
CONIF	Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31%	50%
Height	Shrub 0.6m	Shrub 3.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

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the stand and cause a transition to class B. Replacement fire occurs every 50 years on average. In the absence of fire for 80 years, vegetation will transition to class D. Otherwise, succession keeps vegetation in class C.

Class D 10%

Late Development 1 Open

Description

Conifers are the upper lifeform (juniper, pinyon-juniper, white fir,Douglas-fir, ponderosa pine, or limber pine). Conifer cover is 11-25%. Shrub cover generally less than mid-development classes, but remains between 26-40%. Herbaceous cover <30%. The mean FRI of replacement fire is 50 years. Insects/diseases thin the sagebrush, but not the conifers, every 75 years on average, without causing a transition to other classes. Succession is from D to E after 50 years.

Indicator Species* and Canopy Position

CONIF	Upper
ARTRV	Mid-Upper
PUTR2	Mid-Upper
SYMPH	Low-Mid

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	10 %	30 %
Height	Tree 0m	Tree 10m
Tree Size Class	Sapling >4.5ft; <5"DBH	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Shrub cover generally decreasing but remains between 26-40% Conifers cover 10-25%.

Class E 5%

Late Development 2 Closed

Description

Conifers are the dominant lifeform (juniper, pinyon-juniper, white fir,Douglas-fir, ponderosa pine, or limber pine). Conifer cover ranges from 26-80% (pinyon-juniper 36-80%(Miller and Tausch 2000), juniper 26-40% (Miller and Rose 1999), white fir 26-80%). Shrub cover 0-20%. Herbaceous cover <20%. The mean FRI for replacement fire is longer than in previous states (75 yrs). Conifers are susceptible to insects/diseases that cause diebacks (transition to class D) every 75 years on average.

Indicator Species* and Canopy Position

CONIF	Upper
ARTRV	Mid-Upper
PUTR2	Mid-Upper
SYMPH	Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	80 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Pole 5-9" DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Disturbances

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 100
Min 10
Max 10000

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	49	15	100	0.020408	100
Mixed					
Surface					
All Fires	49			0.02043	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [x] Insects/Disease
- [ ] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

References

Anderson, J. E. and R. S. Inouye 2001. Landscape-scale changes in plant species abundance and biodiversity of a sagebrush steppe over 45 years. Ecological Monographs 71:531-556.

Brown, David E., ed. 1982. Biotic communities of the American Southwest--United States and Mexico. Desert Plants: Special Issue. 4(1-4): 342 p.

Burkhardt, W. J. and E. W. Tisdale. 1969. Nature and successional status of western juniper vegetation in Idaho. Journal of Range Management 22(4):264-270.

Burkhardt, W. J. and E. W. Tisdale. 1976. Causes of juniper invasion in southwestern Idaho. Ecology 57: 472-484.

Crawford, J. A., R. A. Olson, N. E. West, J. C. Mosley, M. A. Schroeder, T. D. Whitson, R. F. Miller, M. G. Gregg, and C. S. Boyd. 2004. Ecology and management of sage-grouse and sage-grouse habitat. Journal of Range Management 57:2-19.

Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-Grass Habitat Types of Southern Idaho. University of Idaho Forest, Wildlife and Range Experiment Station, Bulletin Number 35. Moscow, ID. 44p.

Houston, D. B. 1973. Wildfires in northen Yellowstone National Park. Ecology 54(5): 1111-1117.

Johnson, K. 2000. Artemisia tridentata ssp. Vaseyana. In: Fire Effects Information System [Online], U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2004, September 17].

Miller, Richard E.; Fowler, Norma L. 1994. Life history variation and local adaptation within two populations of Bouteloua rigidiseta (Texas grama). Journal of Ecology. 82: 855-864.

Miller, R. F. and J. A. Rose. 1995. Historic expansion of Juniperus occidentalis (western juniper) in southeastern Oregon. The Great Basin Naturalist 55(1):37-45.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Miller, R. F. and J. A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management 52. Pp. 550-559.

Miller, R. F., T. J. Svejcar, and J. A. Rose. 2000. Impacts of western juniper on plant community composition and structure. Journal of Range Management 53(6):574-585.

Miller, R. F. and R. J. Tausch. 2001. The role of fire in juniper and pinyon woodlands: a descriptive analysis. Proceedings: The First National Congress on Fire, Ecology, Prevention, and Management. San Diego, CA, Nov. 27- Dec. 1, 2000. Tall Timbers Research Station, Tallahassee, FL. Miscellaneous Publication 11, p:15-30.

Mueggler, W. F. and W. L. Stewart. 1980. Grassland and shrubland habitat types of Western Montana. USDA Forest Service GTR INT-66.

NRCS. 1997. Soil survey for western Box Elder County, UT. U.S. Department of Agriculture Natural Resource Conservation Service. Salt Lake State office, Utah.

Pedersen, E. K., J. W. Connelly, J. R. Hendrickson, and W. E. Grant. 2003. Effect of sheep grazing and fire on sage grouse populations in southeastern Idaho. Ecological Modeling 165:23-47.

Simon, S. A. 1990. Fire effects from prescribed underburning in central Oregon ponderosa pine plant communities: first and second growing season after burning. Pp. 93-109. In Fire in Pacific Northwest Ecosystems. Thomas E. Bedell, editor. Department of Rangeland Resources, Oregon State University, Covallis, OR. 145p.

Tart, D. L. 1996. Big sagebrush plant associations of the Pinedale Ranger district. Pinedale, WY: USDA For. Serv. Bridger-Teton National Forest. Jackson, WY. 97 p.

Welch, B. L, C. Criddle. 2003. Countering Misinformation Concerning Big Sagebrush. Research Paper RMRS-RP-40. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 28 p.

Winward, A. H. 1991. A renewed commitment to management in sagebrush grasslands. In: Management in the Sagebrush Steppes. Oregon State University Agricultural Experiment Station Special Report 880. Corvallis OR. Pp.2-7.

Winward, A. H. 2004. Sagebrush of Colorado; taxonomy, distribution, ecology, & management. Colorado Division of Wildlife, Department of Natural Resources, Denver, CO.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1126ms **Montane Sagebrush Steppe - Mountain Shrub**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 3/13/2008

Modeler 1	Louis Provencher	lprovencher@tnc.org	**Reviewer**
Modeler 2			**Reviewer**
Modeler 3			**Reviewer**
			FRCC

Vegetation Type

Upland Shrubland

Dominant Species*

SYOR LECI4
ARTR
RIBES
PUTR2

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

6
12

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☑ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

This ecological system is found in the foothills, canyon slopes and lower mountains of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico extending north into Wyoming, and west into the Intermountain region.

Biophysical Site Description

These shrublands occur between 1500-2900 m elevation. They are usually associated with deep upland loamy or rocky loamy soils on concave or north facing slopes that accumulate deep snow, which melts later in the year than adjacent areas.

Vegetation Description

Vegetation is typically dense and dominated by a variety of shrubs including Symphoricarpos oreophilus var. utahensis (Utah snowberry), Purshia tridentata (bitterbrush), Ribes spp. (currant), and Artemisia tridentata var. vaseyana (mountain big sagebrush). Grasses and forbs are common and the same species as found in mountain big sagebrush. Basin wildrye (Leymus cinereus) is conspicuous.

Fire plays an important role in this system as the dominant shrubs are usually effected by severe die-back, although some plants will stump sprout. When trees are present, they include pinyon pine, juniper, white fir, and limber pine.

Disturbance Description

This ecological system could be in FRG IV. This is a fire-dependent system, and is strongly influenced by the fire regime of the surrounding shrublands. Dominant species are resprouters (Uchytil 1990, Esser 1995, Howard 1007, Zlatnik 1999, Anderson 2001). Average FRIs for replacement fire vary between 50-100 yrs with longer intervals for older stands. The high cover of shrubs makes mixed severity and surfaces fires improbable.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Severe weather events, such as frost, can cause replacement type mortality every 200 yrs on average.

Sites on steep slopes experience rockslides and avalanches that favor resprouting shrubs. The effect is assumed to be small in extent and is not included in the model.

Adjacency or Identification Concerns

This type occurs in association or a complex with mountain big sagebrush, although mountain shrublands are differentiated here by greater diversity.

This type may be difficult to identify today on more mesic sites where fire suppression has allowed tree invasion.

Dwarf aspen, willows, and alder may be present on moist sites. If those species are dominant, an aspen or riparian model would be more appropriate (e.g., Rocky Mountain Aspen Forest and Woodland, 1011; Rocky Mountain Montane Riparian Systems 1159).

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☐ Literature ☑ Local Data ☑ Expert Estimate

Usually, this community occurs on a small scale, on mesic sites near or within the mountain big sagebrush zone. However, it may occur on mesic sites outside this zone.

Issues/Problems

Comments

Louis Provencher adapted BPS 1610860 conceived by Beth Corbin (ecorbin@fs.fed.us) and Stanley Kitchen skitchen@fs.fed.us) for drier mountain browse and more eastern vegetation into a mesic mountain browse model bd1086 by changing species composition (snowberry is the key indicator), biophysical characteristics, and shortening FRI from 100 to 50 yrs. Also, mixed severity fire was removed from the previous BPS and so was the Time Since Disturbance function, which is irrelevant with repacement fire only.

Based on Rapid Assessment PNVG R2MSHBwt - Mountain Shrubland with trees developed by Michele Slaton (mslaton@fs.fed.us), Joanne Baggs (jbaggs@fs.fed.us), and Cheri Howell (chowell@fs.fed.us) for the western and eastern Great Basin. Reviewers of R2MSHBwt were Stanley Kitchen (skitchen@fs.fed.us), Crystal Golden (kolden@unr.edu), and Clinton Williams (cwilliams03@fs.fed.us).

Cover breaks were adjusted by Pohl on 3/30/05 to facilitate mapping process. A was changed from 10-40 to 0-40; B was changed from 10-50 to 10-30; C was changed from 25-60 to 30-60.

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class A **10%**

Early1 All Structures

Description

Grasses and forbs are abundant, as are resprouting shrubs. Shrub seedlings are also present. Replacement fire every 100 yrs and severe weather-related mortality will replace the vegetation. Succession from class A to B after 5 yrs.

Indicator Species* and Canopy Position

SYORU Upper
LECI4 Upper
RIBES

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	40%
Height	Shrub Dwarf <0.5m	Shrub Dwarf <0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class B **40%**

Mid1 Closed

Description

Shrubs are dominant, and grasses and forbs may be present, especially in gaps between shrubs. Many shrubs are small and immature. Both replacement fire every 50 yrs and severe weather-related mortality every 200 yrs will cause a transition to class A. Succession to class C after 15 yrs.

Indicator Species* and Canopy Position

SYORU Upper
LECI4 Mid-Upper
ARTRV Mid-Upper
PUTR2 Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	10%	30%
Height	Shrub Short 0.5-0.9m	Shrub Medium 1.0-2.9m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C **45%**

Late1 Closed

Description

Shrubs are dominant, with little decadence. Grasses and forbs may be present. Small tree seedlings may be present. Shrubs are larger and many are reproducing. Fire and severe weather events return interval are the same as in class B. Vegetation will transition to class D in the absence of replacement fire after 60 yrs, thus allowing tree encroachment.

Indicator Species* and Canopy Position

SYORU Upper
ARTRV Mid-Upper
PUTR2 Mid-Upper
RIBES Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	30%	60%
Height	Shrub Short 0.5-0.9m	Shrub Medium 1.0-2.9m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class D **5%**

Late1 Open

Description

Shrubs are dominant, with more decadence and accumulation of woody biomass. Trees are over-topping the shrub canopy. Vegetation is considered open because trees do not form a closed canopy. Replacement fire every 50 yrs and severe weather every 200 yrs will cause transitions to A.

Indicator Species* and Canopy Position

JUNIP Upper
PIFL2 Upper
ARTR2 Middle
SYORU Middle

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	5%	15%
Height	Tree Short 5-9m	Tree Medium 10-24m
Tree Size Class	None	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Dominant lifeform medium shrubs (Symphoricarpos, Amelanchier, Prunus, Holodiscus), as in class C, but being overtopped by trees. Min canopy 25%, maximum canopy 50%; minimum height short shrub, maximum height medium shrub.

Class E **0%**

Late1 Closed

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	%
Height		
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 100
Min 10
Max 500

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	48	100	200	0.020833	100
Mixed					
Surface					
All Fires	48			0.02085	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

References

Anderson, M. 2001. Acer glabrum. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis [2004, November 18].

Brown, J. K. and J. K. Smith, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Esser, L.L. 1995. Prunus emarginata. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis [2004, November 18].

Howard, J. L. 1997. Amelanchier alnifolia. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis [2004, November 18].

Howell, C, R. Hudson, B Glover, K Amy. 2004. Resource implementation protocol for rapid assessment matrices. USDA Forest Service, Humboldt-Toiyabe National Forest, Sparks, NV.

Uchytil, R.J. 1990. Acer grandidentatum. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis [2004, November 18].

Zlatnik, E. 1999. Amelanchier utahensis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis [2004, November 18].

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1126u Montane Sagebrush Steppe - upland

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *Split three ways among BpS gb1126 where antelope bitterbrush is present but not dominant, BpS gb1126ab where antelope bitterbrush is dominant (see range site 028AY066NV), and BpS gb1126bw, where basin wildrye is dominant.*

General Information

Contributors (also see the Comments field) **Date** 4/26/2006

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			FRCC

Vegetation Type

Upland Savanna and Shrub-Steppe

Dominant Species*

ARTR	ACNE
PUTR2	BRMA
SYOR2	POFE
PSSP6	ACLE9

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
16	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

Montane and subalpine elevations across the western U.S. from 1000 m in eastern Oregon and Washington to over 3000 m in the southern Rockies, and within the mountains of Nevada, western Utah, southeast Wyoming, and southern Idaho.

Biophysical Site Description

This ecological system occurs in many of the western United States, usually at middle elevations (1000-2500 m). Within the Great Basin mapping zone, elevation ranges from 1370 m in Idaho to 3200 m in the White Mountains of California (Winward and Tisdale 1977, Blaisdell et al. 1982, Cronquist et al. 1994, Miller and Eddleman 2000). Elevations ranges from 1,981 to 2,895 m in Great Basin National Park. The climate regime is cool, semi-arid to subhumid, with yearly precipitation ranging from 25 to 90 cm/year (Mueggler and Stewart 1980, Tart 1996). Much of this precipitation falls as snow. Temperatures are continental with large annual and diurnal variation. In general this system shows an affinity for mild topography, fine soils, and some source of subsurface moisture. Soils generally are moderately deep to deep, well-drained, and of loam, sandy loam, clay loam, or gravelly loam textural classes; soils often have a substantial volume of coarse fragments, and are derived from a variety of parent materials. This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. Soils are typically deep and have well developed dark organic surface horizons (Hironaka et al. 1983, Tart 1996). However, at the high ends of its precipitation and elevation ranges mountain big sagebrush occurs on shallow and/or rocky soils. All aspects are represented, but the higher elevation occurrences may be restricted to south- or west-facing slopes.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

At lower elevations, mountain big sagebrush occurs on upper fan piedmonts, where it typically intermixes with Wyoming big sagebrush on north facing slopes. On mountain sideslopes at this elevation, it occurs on north-facing slopes and where pinyon and juniper is present, it is usually on south-facing slopes with pinyon and juniper generally increasing on north-facing slopes within the sagebrush community. At mid-level elevations, mountain sagebrush begins to move into more southerly slopes intermingling with black sagebrush and low sagebrush and with mountain mahogany occurring on north-facing slopes. With continued elevation, curlleaf mountain mahogany generally crowds it out. Mountain big sagebrush then occupies drier sites at higher elevations.

Vegetation Description

Vegetation types within this ecological system are usually less than 1.5 m tall and dominated by Artemisia tridentata ssp vaseyana, or Artemisia tridentata ssp spiciformis. A variety of other shrubs can be found in some occurrences, but these are seldom dominant. They include Artemisia arbuscula, Ericameria nauseosa, Ericameria discoides, Chrysothamnus viscidiflorus, Ephedra viridis, Symphoricarpos oreophilus, Purshia tridentata, Peraphyllum ramosissimum, Ribes, and Amelanchier utahensis. The canopy cover is usually between 20-80%. The herbaceous layer is usually well represented, but bare ground may be common in particularly arid or disturbed occurrences. Graminoids that can be abundant include Pseudoroegneria spicata,Achnatherum Hesperostipa comata, Elymus trachycaulus, Festuca thurberi, Elymus elymoides, Deschampsia caespitosa, Danthonia intermedia, Leymus cinereus, Achnatherum hymenoides, Stipa spp., Pascopyrum smithii, Bromus marginatus, Poa fendleriana, or Poa secunda. Forbs are often numerous and an important indicator of health. Forb species may include Castilleja, Potentilla, Erigeron, Phlox, Astragalus, Geum, Lupinus, and Eriogonum, Balsamorhiza sagittata, Achillea millefolium, Antennaria rosea, Eriogonum umbellatum, and Artemisia ludoviciana, etc. Mueggler and Stewart (1980), Hironaka et al. (1983), and Tart (1996) described several of these types. This ecological system is critical summer habitat for Greater Sage Grouse. Moreover, resprouting bitterbrush in mountain big sagebrush types is potentially important to wildlife in early stand development.

Disturbance Description

Mean fire return intervals in and recovery times of mountain big sagebrush are subjects of lively debate in recent years (Welch and Criddle 2003). Mountain big sagebrush communities were historically subject to stand replacing fires with a mean return interval ranging from 40+ years at the Wyoming big sagebrush ecotone, and up to 80 years in areas with a higher proportion of low sagebrush in the landscape (Crawford et al. 2004, Johnson 2000, Miller et al. 1994, Burkhardt and Tisdale 1969 and 1976, Houston 1973, Miller and Rose 1995, Miller et al. 2000). Under pre-settlement conditions mosaic burns generally exceeded 75% topkill due to the relatively continuous herbaceous layer. Therefore, replacement fire with a mean FRI of 40-80 years was adopted here. Brown (1982) reported that fire ignition and spread in big sagebrush is largely (90%) a function of herbaceous cover. These communities were also subject to periodic mortality due to insects, disease, rodent outbreaks, drought, and winterkill (Anderson and Inouye 2001, Winward 2004). Periodic mortality events may result in either stand-replacement or patchy die-off depending on the spatial extent and distribution of these generally rare (50 to 100 years) events.

Recovery rates for shrub canopy cover vary widely in this type, depending on post fire weather conditions, sagebrush seed-bank survival, abundance of resprouting shrubs (e.g., snowberry, bitterbrush), and size and severity of the burn. Mountain big sagebrush typically reaches 5% canopy cover in 8 to 14 years. This may take as little as 4 years under favorable conditions and longer than 25 years in unfavorable situations (Pedersen et al. 2003, Miller unpublished data). Mountain big sagebrush typically reaches 25% canopy cover in about 25 years, but this may take as few as nine years or longer than 40 years (Winward 1991, Pedersen et al. 2003, Miller unpublished data). Mountain snowberry and resprouting forms of bitterbrush may return to pre-burn cover values in a few years. Bitterbrush plants less than fifty years old are more likely to resprout than older plants (Simon 1990).

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Adjacency or Identification Concerns

Mountain big sagebrush is commonly found adjacent to or intermingled with low sagebrush and mountain shrublands.

At lower elevational limits on southern exposures there is a high potential for cheatgrass invasion/occupancy where the native herbaceous layer is depleted. This post-settlement, uncharacteristic condition is not considered here.

Native Uncharacteristic Conditions

Uncharacteristic conditions in this type include herbaceous canopy cover less than 40% in the absence of con

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

This type occupies areas ranging in size from 10's to 10,000's of acres. Disturbance patch size can also range from from 10's to 1,000's of acres. The distribution of past burns was assumed to consist of many small patches in the landscape.

Issues/Problems

This was initially 1126_a (Mountain Big Sagebrush) model from Map Zone 16, which was itself based on Rapid Assessment models R2SBMT and R2SBMTwc where the reviewers and modelers had very differents opinions on the range of mean FRIs and mountain big sagebrush recovery times (see Welch and Criddle 2003). It is increasingly agreed upon that a MFI of 20 years, which used to be the accepted norm, is simply too frequent to sustain populations of Greater Sage Grouse and mountain big sagebrush ecosystems whose recovery time varies from 10-70 years. Reviewers consistently suggested longer FRIs and recovery times. The revised model is a compromise with longer recovery times and FRIs. Modeler and reviewers also disagreed on the choice of FRG: II (modeler) vs. IV (reviewers). For Map zones 12 and 17, modelers place this system in Fire Regime Group IV.

If conifers are not adjacent to this system, such as in the Tuscarora range, Santa Rose range, and similar regions, use a three-box model with the following percentages per box: 20% A, 45% B, 35% C.

Comments

BpS gb1126 is based on BpS 121126 developed by Gary Medlyn (gary_medlyn@nv.blm.gov) and Crystal Kolden (ckolden@gmail.com). Modifications to 121126 were completed for species composition and biophysical site descriptions based on the Great Basin National Park soil survey and several range site descriptions: 028AY057NV, 028AY064NV, 028AY065NV, 028AY067NV, 028AY068NV. Model unchanged.

BPS 1126 for MZ 12 and 17 was based on BPS 1126_a (Mountain Big Sagebrush) from LF Maping Zone 16. BPS 1126_a is essentially PNVG R2SBMTwc (mountain big sagebrush with potential for conifer invasion) developed by Don Major (dmajor@tnc.org), Alan R. Sands (asands@tnc.org), David Tart (dtart@fs.fed.us), and Steven Bunting (sbunting@uidaho.edu). R2SBMTwc was itself based on R2SBMT developed by David Tart. R2SBMtwc was revised by Louis Provencher (lprovencher@tnc.org) following critical reviews by Stanley Kitchen (skitchen@fs.fed.us), Michele Slaton (mslaton@fs.fed.us), Peter Weisberg (pweisberg@cabnr.unr.edu), Mike Zielinski (mike_zielinski@nv.blm.gov), and Gary Back (gback@srk.com).

The first three development classes chosen for this PNVG correspond to the early, mid-, and late seral stages familiar to range ecologists. The two classes with conifer invasion (classes D and E) approximately correspond to Miller and Tausch's (2001) phases 2 and 3 of pinyon and juniper invasion into shrublands.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Vegetation Classes

Class A 20%

Early Development 1 Open

Description

Herbaceous vegetation is the dominant lifeform. Herbaceous cover is variable but typically >50% (50-80%). Shrub cover is 0 to 5%. Replacement fire (mean FRI of 80 years) setbacks succession by 12 years. Succession to class B after 12 years.

Indicator Species* and Canopy Position

PSSP6 Upper
POFE Upper
SYOR2 Lower
ARTRV Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Dominant vegetation is herbaceous with scattered shrubs. Herbaceous cover is 0-80%.

Class B 50%

Mid Development 1 Open

Description

Shrub cover 6-25%. Mountain big sagebrush cover up to 20%. Herbaceous cover is typically >50%. Initiation of conifer seedling establishment. Replacement fire mean FRI is 40 years. Succession to class C after 38 years.

Indicator Species* and Canopy Position

ARTRV Upper
PUTR2 Upper
CONIF Lower
SYMPH Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11%	30%
Height	Shrub 0.6m	Shrub 3.0m
Tree Size Class	Seedling <4.5ft	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Herbaceous cover is the dominant lifeform with canopy >50%. Shrub cover is 6-25% and the upper lifeform.

Class C 15%

Late Development 1 Closed

Description

Shrubs are the dominant lifeform with canopy cover of 26-45+%. Herbaceous cover is typically <50%. Conifer (juniper, pinyon-juniper, white fir,Douglas-fir, ponderosa pine, or limber pine) cover <10%. Insects and disease every 75 yrs on average will thin the stand and cause a transition to class B. Replacement fire occurs every 50 years on average. In the absence of fire for 80 years, vegetation will transition to class

Indicator Species* and Canopy Position

ARTRV Upper
PUTR2 Upper
SYMPH Low-Mid
CONIF Mid-Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31%	50%
Height	Shrub 0.6m	Shrub 3.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

D. Otherwise, succession keeps vegetation in class C.

Class D **10%**

Late Development 1 Open

Description

Conifers are the upper lifeform (juniper, pinyon-juniper, white fir,Douglas-fir, ponderosa pine, or limber pine). Conifer cover is 11-25%. Shrub cover generally less than mid-development classes, but remains between 26-40%. Herbaceous cover <30%. The mean FRI of replacement fire is 50 years. Insects/diseases thin the sagebrush, but not the conifers, every 75 years on average, without causing a transition to other classes. Succession is from D to E after 50 years.

Indicator Species* and Canopy Position

CONIF Upper
ARTRV Mid-Upper
PUTR2 Mid-Upper
SYMPH Low-Mid

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	10%	30%
Height	Tree 0m	Tree 10m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Shrub cover generally decreasing but remains between 26-40% Conifers cover 10-25%.

Class E **5%**

Late Development 2 Closed

Description

Conifers are the dominant lifeform (juniper, pinyon-juniper, white fir,Douglas-fir, ponderosa pine, or limber pine). Conifer cover ranges from 26-80% (pinyon-juniper 36-80%(Miller and Tausch 2000), juniper 26-40% (Miller and Rose 1999), white fir 26-80%). Shrub cover 0-20%. Herbaceous cover <20%. The mean FRI for replacement fire is longer than in previous states (75 yrs). Conifers are susceptible to insects/diseases that cause diebacks (transition to class D) every 75 years on average.

Indicator Species* and Canopy Position

CONIF Upper
ARTRV Mid-Upper
PUTR2 Mid-Upper
SYMPH Mid-Upper

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31%	80%
Height	Tree 10.1m	Tree 25m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 100
Min 10
Max 10000

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	49	15	100	0.020408	100
Mixed					
Surface					
All Fires	49			0.02043	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [x] Insects/Disease
- [ ] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

References

Anderson, J. E. and R. S. Inouye 2001. Landscape-scale changes in plant species abundance and biodiversity of a sagebrush steppe over 45 years. Ecological Monographs 71:531-556.

Brown, David E., ed. 1982. Biotic communities of the American Southwest--United States and Mexico. Desert Plants: Special Issue. 4(1-4): 342 p.

Burkhardt, W. J. and E. W. Tisdale. 1969. Nature and successional status of western juniper vegetation in Idaho. Journal of Range Management 22(4):264-270.

Burkhardt, W. J. and E. W. Tisdale. 1976. Causes of juniper invasion in southwestern Idaho. Ecology 57: 472-484.

Crawford, J. A., R. A. Olson, N. E. West, J. C. Mosley, M. A. Schroeder, T. D. Whitson, R. F. Miller, M. G. Gregg, and C. S. Boyd. 2004. Ecology and management of sage-grouse and sage-grouse habitat. Journal of Range Management 57:2-19.

Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-Grass Habitat Types of Southern Idaho. University of Idaho Forest, Wildlife and Range Experiment Station, Bulletin Number 35. Moscow, ID. 44p.

Houston, D. B. 1973. Wildfires in northen Yellowstone National Park. Ecology 54(5): 1111-1117.

Johnson, K. 2000. Artemisia tridentata ssp. Vaseyana. In: Fire Effects Information System [Online], U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2004, September 17].

Miller, Richard E.; Fowler, Norma L. 1994. Life history variation and local adaptation within two populations of Bouteloua rigidiseta (Texas grama). Journal of Ecology. 82: 855-864.

Miller, R. F. and J. A. Rose. 1995. Historic expansion of Juniperus occidentalis (western juniper) in southeastern Oregon. The Great Basin Naturalist 55(1):37-45.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Miller, R. F. and J. A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management 52. Pp. 550-559.

Miller, R. F., T. J. Svejcar, and J. A. Rose. 2000. Impacts of western juniper on plant community composition and structure. Journal of Range Management 53(6):574-585.

Miller, R. F. and R. J. Tausch. 2001. The role of fire in juniper and pinyon woodlands: a descriptive analysis. Proceedings: The First National Congress on Fire, Ecology, Prevention, and Management. San Diego, CA, Nov. 27- Dec. 1, 2000. Tall Timbers Research Station, Tallahassee, FL. Miscellaneous Publication 11, p:15-30.

Mueggler, W. F. and W. L. Stewart. 1980. Grassland and shrubland habitat types of Western Montana. USDA Forest Service GTR INT-66.

Pedersen, E. K., J. W. Connelly, J. R. Hendrickson, and W. E. Grant. 2003. Effect of sheep grazing and fire on sage grouse populations in southeastern Idaho. Ecological Modeling 165:23-47.

Simon, S. A. 1990. Fire effects from prescribed underburning in central Oregon ponderosa pine plant communities: first and second growing season after burning. Pp. 93-109. In Fire in Pacific Northwest Ecosystems. Thomas E. Bedell, editor. Department of Rangeland Resources, Oregon State University, Covallis, OR. 145p.

Tart, D. L. 1996. Big sagebrush plant associations of the Pinedale Ranger district. Pinedale, WY: USDA For. Serv. Bridger-Teton National Forest. Jackson, WY. 97 p.

Welch, B. L, C. Criddle. 2003. Countering Misinformation Concerning Big Sagebrush. Research Paper RMRS-RP-40. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 28 p.

Winward, A. H. 1991. A renewed commitment to management in sagebrush grasslands. In: Management in the Sagebrush Steppes. Oregon State University Agricultural Experiment Station Special Report 880. Corvallis OR. Pp.2-7.

Winward, A. H. 2004. Sagebrush of Colorado; taxonomy, distribution, ecology, & management. Colorado Division of Wildlife, Department of Natural Resources, Denver, CO.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1145wm Montane Wet Meadow

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models: Because no LANDFIRE code exists for this system, it was added to the one for BpS 121145 with the "wm" qualifier to indicate "wet meadow."*

General Information

Contributors (also see the Comments field) **Date** 4/26/2006

Modeler 1	Tod Williams	Tod_Williams@nps.gov	**Reviewer**
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Modeler 3	Neal Darby	Neal_Darby@nps.gov	**Reviewer**
			FRCC

Vegetation Type

Wetlands/Riparian

Dominant Species*

PONEJ	HOBR
DECA	MURI
CARE	LUPIN
JUNC	SALIX

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
16	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

The Rocky Mountain Alpine-Montane Wet Meadow (CES306.812) occurs to the east of the coastal and Sierran mountains, in the semi-arid interior regions of western North America. Found in the Great Basin on high elevation ranges.

Biophysical Site Description

These are high-elevation communities found throughout the Rocky Mountains and Intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from montane to alpine (1000-3600 m). In the Great Basin National Park, elevation ranges from 6800 to 10,000ft (2,072 to 3,048m). These types occur as large meadows in montane or subalpine valleys, as narrow strips bordering ponds, lakes, and streams, and along toeslope seeps. They are typically found on flat areas or gentle slopes, but may also occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late-melting snow patches or on snowbeds. Soils of this system may be mineral or organic. In either case, soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features.

Vegetation Description

This system often occurs as a mosaic of several plant associations, often dominated by graminoids, including Sandberg's bluegrass (Poa secunda), sedges (Carex spp), tufted harigrass (Deschampsia cespitosa; drier meadows), rushes (Juncus spp), slender whetgrass (Elymus trachycaulus), mat muhly (Muhlenbergia richardsonis), meadow barley (Hordeum brachyantherum), mountain brome (Bromus marginatus), alpine timothy (Phleum alpinum), and ticklegrass (Agrostis scabra). Often alpine dwarf-shrublands, especially those dominated by willows (Salix spp.), Wood's rose (Rosa woodsii), western serviceberry (Amelanchier alnifolia), and aspen (Populus termuloides) are immediately adjacent to the wet meadows and intergrade

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into them.

Disturbance Description

Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding. Severe drought years (return interval of 60 yrs) following post replacement fire will maintain the open condition of the early development class.

Fires are primarily replacement and occur about every 40 years in mid- and late-development classes. No fire occurs during the first 2 years post-replacement due to the green and low fuel accumulation. Fire Regime groups could be IV or II (chosen). Mixed severity fire (mean FRI of 75 years) occurs in late development meadows and removes shrubs. The ignition source in this type is probably associated with fire spreading from an adjacent shrub or tree dominated sites, such as mountain big sagebrush, basin big sagebrush with basin wildrye dominance, and aspen.

Adjacency or Identification Concerns

Could be confused with either the grassy portion of BpS gb1160 (Rocky Mountain Subalpine/Upper Montane Riparian Systems) and early-mid seral mountain big sagebrush dominated by basin wildrye (BpS wr1080bw).

With heavy grazing these sites can convert to undesirable forbs and grasses.

Wet meadows are often drained or water diverted for livestock.

Roads and trails can impact these sites.

Native Uncharacteristic Conditions

More than 20% shrub cover is uncharacterisitc.

Scale Description

Sources of Scale Data ☐ Literature ☐ Local Data ☑ Expert Estimate

This type ranges in size from less than 10 acres to 300 acres.

Issues/Problems

Comments

Other modeler for BpS gb1145wm is Ben Roberts (ben_roberts@nps.gov). BpS gb1145wm was based on BpS wr1145wm developed by Louis Provencher (lprovencher@tnc.org) for the Wassuk Range. Species composition and biophysical site description were based on range site 028AY072NV.

There is not much information about this type. We estimated the fire frequency of 40 years based on adjacent aspen, herbaceous and sagebrush communities. Also, because fire was assumed to occur in the late summer when the dry portion of the meadow would be cured. Fires would affect encroaching shrubs. Model is closely based on BpS 121145 without fire in class A.

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
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Class A **5%**

Early Development 1 Open

Description

Vegetation is typically dominated by graminoids, with forbs contributing up to 10% of dry weight. Graminoid cover does not exceed 60%. Typical species are Poa spp,, sedges, rushes, and tufted hairgrass. Willow may be reprouting near riparian corridor, if present. Succession to class B after 3 years. Severe drought on average every 60 years will thin herbaeous cover and maintain the class.

Indicator Species* and Canopy Position

POA	Upper
DECA1	Upper
CAREX	Upper
JUNCU	Upper

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	60 %
Height	Herb Short <0.5m	Herb Short <0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class B **45%**

Mid Development 1 Closed

Description

Vegetation is typically dominated by graminoids, with forbs contributing up to 10% of dry weight. Graminoid cover exceeds 60%. Typical species are bluegrasses, sedges, rushes, and tufted hairgrass. Lupines and other forbs may be common. Willow will be present near riparian corridor, if present. There is some increase in forb and shrub component, but shrubs will occupy less than 5% cover. Replacement fire has a mean FRI of 40 years. Succession to C after 20 years.

Indicator Species* and Canopy Position

POA	Upper
DECA1	Upper
CAREX	Upper
JUNCU	Upper

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	60 %	100 %
Height	Herb Short <0.5m	Herb Tall > 1m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class C 50%

Late Development 1 Open

Description

Vegetation is typically dominated by graminoids, with forbs contributing up to 10% of dry weight and shrubs (willows and others) increasing in cover up to 10%. Graminoid cover exceeds 60%. Typical species are bluegrasses, sedges, rushes, and tufted hairgrass. Willow will be expanding from the riparian corridor, if present. Five to 10% of cover in this class may be woody species from adjacent plant communities such as Populus tremuloides, Artemisia tridentata, Rosa woodsii, Ribes spp and Amelanchier spp. Mixed severity fire (mean FRI of 75 years) removes shrubs from overstory (causing a transition to class B). Replacement fire (mean FRI of 40 years) sets site back to class A.

Indicator Species* and Canopy Position

SALIX Upper
ROWO Mid-Upper
POA Middle
DECA1 Middle

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Shrub Dwarf <0.5m	Shrub Tall >3.0 m
Tree Size Class	Seedling <4.5ft	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Graminoid cover remains high from 60-90%.

Class D 0%

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	0%
Height	NONE	NONE
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E 0%

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height	NONE	NONE
Tree Size Class	None	

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model

Disturbances

Fire Regime Group:** 2

Historical Fire Size (acres)

Avg 50
Min 1
Max 300

Sources of Fire Regime Data

☑ Literature
☑ Local Data
☑ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	42			0.02381	79
Mixed	161			0.006211	21
Surface					
All Fires	33			0.03003	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

☐ Insects/Disease
☑ Wind/Weather/Stress
☐ Native Grazing
☐ Competition
☐ Other (optional 1)
☐ Other (optional 2)

References

Cooper, D. J. 1986b. Community structure and classification of Rocky Mountain wetland ecosystems. Pages 66-147 in: J. T. Windell, et al. An ecological characterization of Rocky Mountain montane and subalpine wetlands. USDI Fish & Wildlife Service Biological Report 86(11). 298 pp.

Crowe, E. A., and R. R. Clausnitzer. 1997. Mid-montane wetland plant associations of the Malheur, Umatilla, and Wallowa-Whitman national forests. USDA Forest Service, Pacific Northwest Region. Technical Paper R6-NR-ECOL-TP-22-97.

Kovalchik, B. L. 1987. Riparian zone associations - Deschutes, Ochoco, Fremont, and Winema national forests. USDA Forest Service Technical Paper 279-87. Pacific Northwest Region, Portland, OR. 171 pp.

Kovalchik, B. L. 1993. Riparian plant associations on the national forests of eastern Washington - Draft version 1. USDA Forest Service, Colville National Forest, Colville, WA. 203 pp.

Manning, M. E., and W. G. Padgett. 1995. Riparian community type classification for Humboldt and Toiyabe national forests, Nevada and eastern California. USDA Forest Service, Intermountain Region. 306 pp.

Meidinger, D., and J. Pojar, editors. 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests Special Report Series No. 6. 330 pp.

Padgett, W. G., A. P. Youngblood, and A. H. Winward. 1988a. Riparian community type classification of Utah and southeastern Idaho. Research Paper R4-ECOL-89-0. USDA Forest Service, Intermountain Region, Ogden, UT.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Reed, P. B., Jr. 1988. National list of plant species that occur in wetlands: 1988 national summary. USDI Fish & Wildlife Service. Biological Report 88(24).

Sanderson, J., and S. Kettler. 1996. A preliminary wetland vegetation classification for a portion of Colorado's west slope. Report prepared for Colorado Department of Natural Resources, Denver, CO, and U.S. Environmental Protection Agency, Region VIII, Denver, CO. Colorado Natural Heritage Program, Ft. Collins, CO. 243 pp.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1154 Montane-Subalpine Riparian Systems

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 4/26/2006

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Modeler 3	Neal Darby	Neal_Darby@nps.gov	**Reviewer**
			FRCC

Vegetation Type

Wetlands and Riparian

Dominant Species*

POPUL	ROWO
SALIX	CARE
PRVIM	JUNC
BETU	ELTR7

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
0	0
0	0
0	0

Model Zones

☐ Alaska
☐ California
☑ Great Basin
☐ Great Lakes
☐ Northeast
☐ Northern Plains
☐ N-Cent.Rockies
☐ Pacific Northwest
☐ South Central
☐ Southeast
☐ S. Appalachians
☐ Southwest

Geographic Range

Great Basin, eastern slopes of the Sierra Nevada of California, Columbia Plateau, and western edge of northern Rockies. This BpS is more specific to the Great Basin ecoregions without beaver activity.

Biophysical Site Description

This ecological system is found within a broad elevation range from about 6,000ft (1828m) over 2286 m (7500 feet). These forests and woodlands require flooding and some gravels for reestablishment. They are found in low-elevation canyons and draws, on floodplains, or in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff. Underlying gravels may keep the water table just below ground surface, and are favored substrates for cottonwood. Large bottomlands may have large occurrences, but most have been cut over or cleared for agriculture. Rafted ice and logs in freshets may cause considerable damage to tree boles. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Surface water is generally high for variable periods. Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition

Vegetation Description

This ecological system occurs as a mosaic of multiple communities that are tree dominated with a diverse shrub component. In the Great Basin and eastern Sierra Nevada, dominant trees may include Abies concolor, Betula occidentalis, Populus angustifolia, Populus balsamifera ssp trichocarpa, Populus fremontii, Populus tremuloides, Acer glabrum, and Salix spp. Dominant shrubs include Cornus sericea, Rosa woodii, Salix spp., and Prunus virgiana, and Rhus trilobata. Herbaceous layers are often dominated by species of Carex and Juncus, and perennial grasses and mesic forbs such Deschampsia caespitosa, Elymus trachycaulus, Poa spp, Leymus cinereus, Achillea millefolium, Clematis angustifolia, Maianthemum stellata, Aquilegia spp., Senicio spp.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Disturbance Description

These are disturbance-driven systems that require flooding, scour and deposition for germination and maintenance. This system is dependent on a natural hydrologic regime, especially annual to episodic flooding with flooding of increasing magnitude causing more stand replacement events: 7-yr events for herbaceous and seedling cover; 20-yr events for shrubs and pole size trees; and 100-yr events for mature trees. Beaver (Castor canadensis) were not present in this BpS for the Mojave Desert and most of the central and western Great basin ecoregion (Hall 1946).

Although fuels are continuous and abundant, they are high in moisture, but dry out during the summer. Therefore, replacement fire sweeps through BpS gb1154 and is caused by importation from adjacent systems, that may include basin big sagebrush (total FRI of 50 yrs), aspen (total FRI of 31 yrs), mountain big sagebrush (total FRI of 49 yrs) and other types. Native American burning was somewhat present in these Great Basin montane riparian systems but camps were generally located at the mouth of canyons (Kay Fowler from University of Nevada, Reno, pers. communication, 09/2005). An average FRI of about 50 yrs was used in mid-development and late-development classes of vegetation. Therefore, FRG is IV because the total FRI is about 67 years and dominated by replacement fire.

Adjacency or Identification Concerns

Livestock grazing is a major influence in the alteration of structure, composition, and function of the community. Livestock can result in the nearly complete removal of willow and cottonwood regeneration, and bank slumping in places where water is accessible.

Water withdrawal and diversion are common in most systems, causing desertification of the community.

Poa pratensis, Phleum pratense, and the weedy annual Bromus tectorum are often present in disturbed stands.

Native Uncharacteristic Conditions

Tree cover can reach 100% in the presettlement condition.

Scale Description

Sources of Scale Data	☐ Literature	☐ Local Data	☑ Expert Estimate

This system can exist as small to large linear features in the lansdscape (e.g., lower Truckee, Carson, Walker, and Humboldt Rivers). In larger, low-elevation riverine systems, this system may exist as mid to large patches.

Issues/Problems

Comments

Other modeler for BpS gb1154 is Ben Roberts (ben_roberts@nps.gov). BpS gb1154 is a modification of BpS wr1154, developed by Louis Provencher (lprovencher@tnc.org), where we increased the flood event for trees from 50 yr to 100yr for trees and corrected error in class C; 20-yr flood event is a maintenance event, not a thinning event.

BpS wr1154 was based on BpS 121154 (and 171154), but with the model of BpS 131154. Modifications to BpS wr1154 for the wassuk range are the removal of beaver activity, changes to species composition (no Columbia Plateau influence), and the introduction of 50 yr FRI due to adjacent upland systems. Also, flood events that caused stand replacement were greatly shortened to reflect similar dynamics to those of BpS 131155 (North American Warm Desert Riparian Systems; 7, 20, and 50-yr events, respectively, scour herbaceous cover, poles, and mature trees). As a result, flood events are one order of magnitude shorter than for old model and more in line with literature. Also, the duration of class B was reduced from 50 to 20 years; cottonwood are pole size within 10-20 years after flooding.

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

BpS 1211540 by Don Major (dmajor@tnc.org) attempted to combine the Columbia Basin Foothill and Lower Montane Riparian woodland and shrubland (CES304.768) and Great Basin Foothill and Lower Montane Riparian woodland and shrubland (CES304.045). This model is similar to BPS 1159 with only slight modifications to vegetation species composition because BPS 1154 and 1159 overlap in elevations and describe the lower part of meandering river systems of the Great Basin.

Vegetation Classes

Class A 20%

Early Development 1 All Struc

Description

Immediate post-disturbance responses are dependent on pre-disturbance vegetation composition. Generally, this class is expected to occur 1-5 years post-disturbance. Typically shrub dominated, but grass may co-dominate. Salix spp dominates after fire, whereas Populus spp and Salix spp co-dominate after flooding. Silt, gravel, cobble, and woody debris may be common. Composition highly variable. Modeled disturbances include weather-related stress expressed as 7-year annual flooding events. Succession to class B after 5 years.

Indicator Species* and Canopy Position

POPUL	Upper
SALIX	Upper
JUNCU	Upper
CAREX	Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 3

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	50%
Height	Shrub 0m	Shrub 3.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class B 35%

Mid Development 1 Open

Description

Highly dependent on the hydrologic regime. Vegetation composition includes tall shrubs and small trees (cottonwood, aspen, conifers). Modeled disturbances include 1) weather-related stress expressed as 7-yr annual flooding events, which maintains vegetation in class B, and 2) 20-yr flooding events (weather-related stress) causing stand replacement. Replacement fire occurs about every 50 yrs on average.

Indicator Species* and Canopy Position

POPUL	Upper
CAREX	Upper
SALIX	Mid-Upper
ROWO	Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 3

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31%	100%
Height	Tree 0m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Succession to class C after 15 years.

Class C **45%**

Late Development 1 Closed

Description

This class represents the mature, large cottonwood, conifer, etc. woodlands. 100-yr flooding events (weather-related stress) cause a transition to class A, whereas 20-yr flood events maintains vegetation in class C. Replacement fire occurs about every 50 yrs on average.

Indicator Species* and Canopy Position

POPUL	Upper
ALNUS	Mid-Upper
SALIX	Mid-Upper
ROWO	Lower

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 3

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D **0%**

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	0 %
Height	NONE	NONE
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E **0%**

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height	NONE	NONE
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 10
Min 1
Max 100

Sources of Fire Regime Data

- [ ] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	64	31	112	0.015625	100
Mixed					
Surface					
All Fires	64			0.01565	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

References

Barbour, M. G., and W. D. Billings, editors. 1988. North American terrestrial vegetation. Cambridge University Press, New York. 434 pp.

Barbour, M. G., and J. Major, editors. 1977. Terrestrial vegetation of California. John Wiley and Sons, New York. 1002 pp.

Hall, E. R. 1946. Mammals of Nevada. University of Nevada Press. Reno, NV.

Johnson, C. G., and S. A. Simon. 1985. Plant associations of the Wallowa Valley Ranger District, Part II: Steppe. USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 258 pp.

Manning, M. E., and W. G. Padgett. 1995. Riparian community type classification for Humboldt and Toiyabe national forests, Nevada and eastern California. USDA Forest Service, Intermountain Region. 306 pp.

Nachlinger, J. and G. A. Reese. 1996. Plant community classification of the Spring Mountains National Recreation Area, Clark and Nye Counties, Nevada. Report submitted to USDA Forest Service, Humboldt-Toiyabe National Forest.

Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: **wm1019** **Pinyon-Juniper Woodland**

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *BpS 121019 was split into dry wr1019d and moist wr1019m woodlands to account for greater canopy cover in moist woodlands. A site index greater than 40 represents moist BpS gb1019.*

General Information

Contributors (also see the Comments field) **Date** 4/24/2006

Modeler 1	Neal Darby	Neal_Darby@nps.gov	**Reviewer**
Modeler 2	Ben Roberts	ben_roberts@nps.gov	**Reviewer**
Modeler 3	Bryan Hamilton	Bryan_Hamilton@nps.gov	**Reviewer**

FRCC

Vegetation Type

Upland Forest and Woodland

Dominant Species*

PIMO	ARTR
JUOS	PSSP6
CELE3	POFE
ARAR	AMUT

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
0	0
0	0
0	0

Model Zones

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☑ Great Basin ☐ South Central
☐ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Geographic Range

This ecological system occurs on dry mountain ranges of the Great Basin region and eastern foothills of the Sierra Nevada.

Biophysical Site Description

System typically found at elevations ranging from 1,737-2,591m (5,700-8,500 ft). This type generally occurred on shallow, rocky, stony, and sandy soils, or rock dominated sites that are protected from frequent fire (rocky ridges, steep to very steep slopes (15-75%), broken topography, mountain crest and side slopes). Although the BpS is often on north to east facing slopes, some sites occur on south facing slopes on moderatly deep soils or higher elevations (above 7,000 ft). Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. Soils supporting this system vary in texture ranging from very gravelly coarse sandy loam and very stony coarse sandy loam, very stony sandy loam, and loamy skeletal.

Vegetation Description

Woodlands dominated by a mix of Pinus monophylla and Juniperus osteosperma, pure or nearly pure occurrences of Pinus monophylla, or woodlands dominated solely by Juniperus osteosperma comprise this system. Cercocarpus ledifolius is a common associate. Understory layers are variable. Associated species include shrubs such as Arctostaphylos patula, Artemisia arbuscula, Artemisia tridentata spp vaseyna, Amelanchier utahensis, Arctostaphylos patula, Symphoricarpos oreophilus, Cercocarpus ledifolius, Cercocarpus intricatus, and bunch grasses Pseudoroegneria spicata, Poa secunda, Poa fendleriana, Leymus cinereus (higher elevation), Elymus elymoides (higher elevation), and Bouteloua gracilis (higher elevation).

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Achnatherum hymenoides is absent from or not diagnotic for this BpS (NRCS range site descriptions for 028AY075NV and 028AY077NV. Common forbs are Phlox spp., Eriogonum spp., Astragalus spp., and Arabidopsis spp.

Since disturbance was uncommon to rare in this ecological system and the overstory conifers may live for over 1000 years, patches were primarily composed of later seral stages that did not occur as extensive woodlands, and that should be distinguished from shrubland ecological sites encroached by pinyon or juniper during the last 150 years. It is estimated that 400 years is required for old juniper woodland stands to develop (Romme et al. 2002). The age structure may vary from uneven to even aged. The overstory cover is normally less than 40% where pinyon occurs.

Disturbance Description

Uncertainty exists about the fire frequencies of this ecological system, especially since this ecological system groups different types of pinyon-juniper communities for different slopes, exposures, and elevations. Fire occurrence may be influenced by fires spreading from shrub and grassland dominated vegetation of lower and higher altitudinal zones. Replacement fires were uncommon to rare (average FRI of 200 yrs) and occurred primarily during extreme fire behavior conditions. Mixed severity fire (average FRI of 200 yrs) was characterized as a mosaic of replacement and surface fires distributed through the patch at a fine scale (<0.1 acres). There is limited evidence for surface fires (Gruell 1994; Bauer and Weisberg, unpublished data), which likely occurred only in the more productive sites during years where understory grass cover was high, providing adequate fuel. Although fire scars are only rarely found in pinyon-juniper of the Colorado Plateau and elsewhere (Baker and Shinneman 2004, Eisenhart 2004), ongoing studies in the central Great Basin are observing fire-scarred trees, suggesting that surface fires historically occurred at low frequency. Limited evidence to date suggests that while lightning ignitions in this biophysical setting may have been common, the resulting fires only rarely spread to affect more than a few trees (average surface FRI of 1000 yrs).

Prolongued weather-related stress (drought mostly) and insects and tree pathogens are coupled disturbances that thin trees to varying degrees and kills small patches every 250-500 years on average, with greater frequency in more closed stands.

Adjacency or Identification Concerns

Consider gb10190d on south-west facing slopes or areas on steep slopes with thin soils and naturally low cover of trees.

Inter-Mountain Basins Juniper Savanna (BPS 1115) is generally found at elevations below the physiological tolerance of Pinus monophylla.

In modern days, surrounding matrix vegetation has changed to young-mid aged woodlands that burn more intensely than the former sagebrush matrix. Also, stand densification (younger trees filling up gaps between older trees) possible in areas with more moderate slopes accessible to livestock (mostly historic sheep grazing).

Two major modern issues, climate change and invasive plant species (especially cheatgrass), lead to non-equilibrial vegetation dynamics for this ecological system, making it difficult to categorize and usefully apply natural disturbance regimes. Sites with an important cheatgrass component in the understory experience greater fire frequency, and will respond differently to fire.

Native Uncharacteristic Conditions

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Tree cover greater than 60% is uncharacteristic.

Scale Description

Sources of Scale Data	☑ Literature	☐ Local Data	☐ Expert Estimate

The most common disturbance in this type is very small-scale - either single-tree, or small groups. If the conditions are just right, then it will have replacement fires that burn stands up to 1000's of acres. This type may also have mixed-severity fires of 10-100's of acres.

Issues/Problems

There is much uncertainty in model parameters, particularly the fire regime, including Native American burning. Quantitative data are lacking and research is on-going. The literature for this ecological system's fire history is based on the chronologies from other pines species that are better fire recorders, growing under conditions that may not represent fire environments typical of infrequent-fire pinyon and juniper communities. For example, surface fire, which leaves scars on these other pine species (but not generally on fire-sensitive pinyon or juniper), has no effect on the dynamics of the model, although surface fire maintains the open structure of class D by thinning younger trees.

Further study is needed to better elucidate the independent and interactive effects of fire, insects, pathogens, climate, grazing, and anthropogenic impacts on historical and current vegetation dynamics in the Great Basin Pinyon-Juniper Woodland type.

Comments

BpS BG1019m is based on BpS 121019 and BpS wr1019m from the Wassuk Range with modifications made to species composition and biophysical settings based on the soil survey for Great Basin National Park and range site descriptions 028AY075NV and 028AY077NV. The 4-box model with former vegetation classes D and E merged into class D was retained.

BpS wr1019m is based on 1210190 by modifying the biophysical site description, species composition, and merging classes D and E into a new late-development class D to help with remote sensing analysis. Landform positon, slope, soil type, and species composition were based on descriptions fo pinyon or juniper woodland on sites with a site index of >40 from NRCS soil survey for Lyon (#625) and Mineral (#744) counties, and Hawthorne Army Depot (#799).

BpS 1210190 developed by Peter Weisberg (pweisberg@cabnr.unr.edu) was based on the model from zone 16 for the same BpS. The model structure came from the Rapid Assessment model for PNVG R2PIJU. However, fire return intervals were made considerably longer to fit the Great Basin context. Elements of the model for the Colorado Plateau Pinyon-Juniper Woodland and Shrubland (BPS 1016), which was developed by Bob Unnasch (bunnasch@tnc.org) for zone 16, were also incorporated. Insects/disease are incorporated in the model in both "patch mortality" and "woodland thinning" manifestations, and are intended to also represent associated drought mortality influences.

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class A 5%

Early Development 1 Open

Description

Initial post-fire community dominated by annual grasses and forbs. Later stages of this class contain greater amounts of perennial grasses and forbs. Evidence of past fires (burnt stumps and charcoal) should be observed. Duration 10 years with succession to class B, mid-development open. Replacement fire occurs every 200 yrs on average.

Indicator Species* and Canopy Position

ELEL5 Upper
PSSP6 Upper
POFE Upper
LECI4 Upper

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	20%
Height	Herb 0.6m	Herb >1.1m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class B 10%

Mid Development 1 Open

Description

Dominated by shrubs, perennial forbs and grasses. Tree seedlings starting to establish on favorable microsites. Total cover remains low due to shallow unproductive soil. Duration 20 years with succession to class C unless infrequent replacement fire (FRI of 200 yrs) returns the vegetation to class A. Mixed severity fire (average FRI of 200 yrs) thins the woody vegetation but does not change its succession age.

Indicator Species* and Canopy Position

ARTEM Mid-Upper
PSSP6 Mid-Upper
PIMO Upper
JUOS Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 5

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11%	20%
Height	Shrub 0m	Shrub 1.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C 30%

Mid Development 2 Open

Description

Shrub and tree-dominated community with young juniper and pinyon seedlings becoming established. Duration 70 years with succession to class D unless replacement fire (average FRI of 200 yrs) causes a transition to class A. Mortality from insects, pathogens, and drought occurs at a

Indicator Species* and Canopy Position

PIMO Upper
JUOS Upper
ARTEM Middle
CELE Middle

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 5

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11%	30%
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

- [x] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Dominant lifeform is shrub. Canopy cover is10-40%. Height is 0.5-1.5m.

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

rotation of approximately 500 yrs and cause a transtion to class B by killing older trees.

Class D 55%

Late Development 1 Open

Description

Community dominated by young (100-300 yrs) to old (>300 yrs) juniper and pine of mixed age structure. Trees are considered old once they reach an age of 400 years. Tree cover and height does not vary appreaciably beyond 100 yrs, although tree diameter increases greatly. Juniper and pinyon becoming competitive on site and beginning to affect understory composition. Duration 900+ years unless replacement fire (average FRI of 200 yrs) causes a transition to class A. Mixed severity is less frequent than in previous states (1000 yrs). Surface fire (mean FRI of 1000 yrs) is infrequent and does not change successional dynamics. Tree pathogens and insects such as pinyon Ips become more important for woodland dynamics occurring at a rotation of 250 yrs, including both patch mortality (500 yr rotation) and thinning of isolated individual trees (500 yr rotation).

Indicator Species* and Canopy Position

PIMO	Upper
JUOS	Upper
CELE	Middle
ARTEM	Middle

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31%	50%
Height	Tree Regen <5m	Tree Short 5-9m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E 0%

Late Development 2 Open

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Disturbances

Fire Regime Group:** 5

Historical Fire Size (acres)

Avg 10
Min 1
Max 5000

Sources of Fire Regime Data

- [x] Literature
- [x] Local Data
- [x] Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	303	10	1000	0.003300	51
Mixed	384	10	1000	0.002604	40
Surface	1666	5	1000	0.000600	9
All Fires	154			0.00650	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [x] Insects/Disease
- [ ] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

References

Alexander, R. R, F. Ronco, Jr. 1987. Classification of the forest vegetation on the National Forests of Arizona and New Mexico. Res. Note RM-469. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 10 p.

Anderson, H. E. 1982. Aids to Determining Fuel Models For Estimating Fire Behavior. Gen. Tech. Rep. INT-122. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 22 p.

Arno, S. F. 2000. Fire in western forest ecosystems. In: Brown, James K.; Kapler-Smith, Jane, eds. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 97-120.

Baker, W. L. and D. J. Shinneman. 2004. Fire and restoration of pińon-juniper woodlands in the western United States. A review. Forest Ecology and Management 189:1-21.

Barney, MA. And NC Frischknecht. 1974. Vegetation changes following fire in the Pinyon-Juniper type of West-Central Utah. Jour. Range Manage. 27:91-96

Bradley, A. F., N. V. Noste, and W. C. Fischer. 1992. Fire Ecology of Forests and Woodlands in Utah. Gen. Tech. Rep. GTR- INT-287. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 127 p.

Brown, J. K. and J. K. Smith, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Despain, D.W., Mosely, J.C., 1990. Fire history and stand structure of a pinyon-juniper woodland at Walnut Canyon National Monument, Arizona. USDI National Park Service Technical Report No. 34. Cooperative National Park Resources Studies Unit, University of Arizona, Tucson AZ. 27p

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Eisenhart 2004 - PhD dissert, CU Boulder Geography

Erdman, J. A. 1970. Pinyon-juniper succession after natural fires on residual soils of Mesa Verde, Colorado. Science Bulletin, Biological Series - -Volume XI, No. 2. Brigham Young University, Provo, UT. 26 p.

Everett, R. L. and , K. Ward. 1984. Early Plant Succession on Pinyon-Juniper Controlled Burns. Northwest Science 58:57-68.

Eyre, F. H., ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p.

Goodrich, S. and B. Barber. 1999. Return Interval for Pinyon-Juniper Following Fire in the Green River Corridor, Near Dutch John, Utah. In: USDA Forest Service Proceedings RMRS-P-9.

Gruell, George E. 1999. Historical and modern roles of fire in pinyon-juniper. In: Monsen, Stephen B.; Stevens, Richard, compilers. Proceedings: ecology and management of pinyon-juniper communities within the Interior West: Sustaining and restoring a diverse ecosystem; 1997 September 15-18; Provo, UT. Proceedings RMRS-P-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 24-28.

Gruell, G. E., L. E. Eddleman, and R. Jaindl. 1994. Fire History of the Pinyon-Juniper Woodlands of Great Basin National Park. Technical Report NPS/PNROSU/NRTR-94/01. U.S. Department of Interior, National Park Service, Pacific Northwest Region. 27 p.

Hardy, C. C., K. M. Schmidt, J. P. Menakis, R. N. Samson. 2001. Spatial data for national fire planning and fuel management. Int. J. Wildland Fire. 10(3&4):353-372.

Hessburg, P.F., B. G. Smith, R. B. Salter, R. D. Ottmar., and E. Alvarado. 2000. Recent changes (1930s-1990s) in spatial patterns of interior northwest forests, USA. Forest Ecology and Management 136:53-83.

Kilgore, B.M. 1981. Fire in ecosystem distribution and structure: western forests and scrublands. P. 58-89. In: H.A. Mooney et al. (Technical
Coordinators). Proceedings: Conference on Fire Regimes and Ecosystem Properties, Honolulu, 1978. Gen. Tech. Rep. WO-GTR-26.

Kuchler, A.W. 1964. Potential Natural Vegetation of the Conterminous United States. American Geographic Society Special Publication No. 36. 116 p.

Ogle, K. and V. DuMond. 1997. Historical Vegetation on National Forest Lands in the Intermountain Region. U.S. Department of Agriculture, Forest Service, Intermountain Region, Ogden, UT. 129 p.

NatureServe. 2004. International Ecological Classification Standard: Terrestrial Ecological Classifications. Terrestrial ecological systems of the Great Basin US: DRAFT legend for Landfire project. NatureServe Central Databases. Arlington, VA. Data current as of 4 November 2004.

Ott, J., E., E. D. McArthur, and S. C. Sanderson. 2001. Plant Community Dynamics of Burned and Unburned Sagebrush and Pinyon-Juniper Vegetation in West-Central Utah. In: Proceedings, USDA Forest Service RMRS-P-9. p. 177-190.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Romme, W. H., L. Floyd-Hanna, and D. Hanna. 2002. Ancient Pinyon-Juniper forests of Mesa Verde and the West: A cautionary note for forest restoration programs. In: Conference Proceedings – Fire, Fuel Treatments, and Ecological Restoration: Proper Place, Appropriate Time, Fort Collins, CO, April 2002. 19 p.

Rondeau, R. 2001. Ecological System Viability Specifications for Southern Rocky Mountain Ecoregion. Colorado Natural Heritage Program. 181p.

Schmidt, K. M., J. P. Menakis, C. C. Hardy, W. J. Hann, and D. L. Bunnell. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. Gen. Tech. Rep. RMRS-GTR-87. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 41 p. + CD.

Soule', P. T. and P. A. Knapp. 1999. Western juniper expansion on adjacent disturbed and near-relict sites. Journal of Range Management 52:525-533.

Soule', P. T. and P. A. Knapp. 2000. Juniperus occidentalis (western juniper) establishment history on two minimally disturbed research natural areas in central Oregon. Western North American Naturalist (60)1:26-33.

Stein, S. J. 1988. Fire History of the Paunsaugunt Plateau in Southern Utah. Great Basin Naturalist. 48:58-63.

Tausch, R. J., N.E. West, and A.A. Nabi. 1981. Tree Age and Dominance Patterns in Great Basin Pinyon-Juniper Woodlands. Jour. Range. Manage. 34:259-264.

Tausch, R. J. and N. E. West. 1987. Differential Establishment of Pinyon and Juniper Following Fire. The American Midland Naturalist 119(1). P. 174-184.

U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2002, December). Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/ [Accessed: 11/15/04].

Ward, K. V. 1977. Two-Year Vegetation Response and Successional Trends for Spring Burns in the Pinyon-Juniper Woodland. M.S. Thesis, University of Nevada, Reno. 54 p.

Wright, H. A., L. F. Neuenschwander, and C. M. Britton. 1979. The role and use of fire in Sagebrush-Grass and Pinyon-Juniper Plant Communities. Gen. Tech. Rep. INT-GTR-58. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 48 p.

Young, J. A., and R. A. Evans. 1978. Population Dynamics after Wildfires in Sagebrush Grasslands. Journal of Range Management 31:283-289.

Young, J. A., and R. A. Evans. 1981. Demography and Fire History of a Western Juniper Stand. Journal of Range Management 34:501-505.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: **wm1056** **Subalpine Mesic Spruce-Fir Forest**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 4/26/2006

Modeler 1	Bryan Hamilton	Bryan_Hamilton@nps.gov	**Reviewer**	
Modeler 2	Neal Darby	Neal_Darby@nps.gov	**Reviewer**	
Modeler 3			**Reviewer FRCC**	

Vegetation Type

Forest and Woodland

Dominant Species*

PIEN	POCU
POTR5	ACLE9
CARO	RUID
RIBES	SYMP

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16
12

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

Utah, Colorado, northern New Mexico and parts of Arizona. Occurs in eastern Nevada. BpS described here for Great Basin National Park, eastern Nevada.

Biophysical Site Description

Elevations typically range from 8,500-11,000 feet in the subalpine zone on gentle to moderately steep terrain (e.g., 10-60% slope). These forests are found on gentle to very steep mountain slopes, high-elevation ridge tops and upper slopes, plateau like surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. Occurrences are typically found in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, such as north-facing slopes and high-elevation ravines. They can extend down in elevation below the subalpine zone in places where cold-air ponding occurs; northerly and easterly aspects predominate.

Vegetation Description

The overstory is typically dominated by Engelmann spruce (Picea engelmannii). Other tree species may include Populus tremuloides, Pinus flexilis, Pinus longaeva, and Pseudotsuga menziesii. Common understory species include Ribes spp., Pachistima myrsinites, and Arnica spp. Mesic understory shrubs include Rubus idaeus and Symphoricarpos oreophilus. Herbaceous species include Carex rossii, Poa cusickii, Pascopyrum smithii, Achnatherum lettermanii, Trifolium spp, and Achillea millefolium var. occidentalis.

Disturbance Description

Fire Regime V: Primarily long-interval (e.g., 200-500 yr) stand replacement fires, with mixed severity fire (e.g., 1000 yr) occurring in open conditions. Disturbances also include insect/disease (every 500 years on average) and windthrow events than thin younger closed stands.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Adjacency or Identification Concerns

If aspen is present in large patches or if conifers are not coming in after ~30 years, the BPS is probably misclassified and one of the Aspen types should be examined (Rocky Mountain Aspen Forest and Woodland (1011)).

Lodgepole pine does not occur in this BPS south of 38 degrees 30 minutes (approximate).

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

Patch sizes vary but are mostly in the hundreds of acres, with rare very large patches (disturbances) in the thousands of acres. There may be frequent small disturbances in the 10s of acres or less.

Issues/Problems

Comments

BpS gb1056 is based on BpS 161056 developed by Mark Loewen (mloewen@fs.fed.us), Doug Page (doug_page@blm.gov), Beth Corbin (ecorbin@fs.fed.us) and Jim Griffin (jgriffin01@fs.fed.us). Species composition was changed to fit range site description 028AAY84NV. The insect/disease return interval was doubled to reflect the fact that the isolation of the Snake Range from the Rockies might reduce likelihood of insect attacks.

Additional author of BpS 161056 was Beth Corbin, ecorbin@fs.fed.us. This model was originally based on R3SPFI (authored by Jim Griffin; jgriffin01@fs.fed.us), and was revised on 3/3/05 in Cedar City. Revisions included deleting the late-development, open box.

Modelers were not convinced that enough of this BPS exists in zone 16 to be mappable. The dry-mesic spruce-fir is more common and shares the same successional dynamics.

Vegetation Classes

Class A **20%**

Early1 All Structures

Description

Early succession after moderately long- to long interval replacement fires. Within 40 years, conifers will replace herbaceous vegetation and shrubs. Occasionally, a lack of seed source of conifer may maintain this condition (modeled as competition/maintenance prob/yr of 1/500). The average FRI for replacement fire is 200 years.

Indicator Species* and Canopy Position

BRMA4 Lower
PIEN Upper
POCUE Lower

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	100%
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class B **25%**

Mid1 Closed

Description

Shade tolerant- and mixed conifer saplings to poles (>40% canopy cover). Spruce and fir dominates and canopy is dense. At 130 years, this class succeeds to D (late-development closed). Replacement fire will cause a transition to class A every 200 yrs on average. Insects and disease may open up the canopy, causing a transition to class C (approximately 0.7% of the class per year). Dog-hair conditions in this state may maintain the mid-development closed condition.

Indicator Species* and Canopy Position

PIEN Upper
POTR5 Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	Max
Cover	40 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C **10%**

Mid1 Open

Description

Primarily moderately tolerant saplings to poles (1" - 6.9" dbh) and <40% canopy cover of spruce and fir. At 90 years, this condition succeeds to class D. Replacement fire (mean FRI of 200 years) will cause a transition to class A. Mixed severity fires may occur on small portions of this class (approximately 0.1% per year) and maintain the mid-development open condition.

Indicator Species* and Canopy Position

PIEN Upper
POTR5 Middle

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	40 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class D **45%**

Late1 Closed

Description

Pole- and larger diameter moderately to shade tolerant conifer species (>40% canopy cover), in moderate to large size patches, all aspects. Spruce dominates. This class will self-perpetuate if no disturbances cause a transition. Replacement fire will cause a transition to class A every 250 year on average. Insects and disease will replace the stand every 500 years on average.

Indicator Species* and Canopy Position

PIEN Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	40 %	100 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Large 21-33"DBH	

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 10

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E **0%**

Late1 Closed

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height	None	None
Tree Size Class	None	

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

Fuel Model

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

Fire Regime Group:** 5

Historical Fire Size (acres)

Avg 100
Min 1
Max 1000

Sources of Fire Regime Data

☐ Literature
☐ Local Data
☑ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	217	200	300	0.004608	98
Mixed	10000			0.0001	2
Surface					
All Fires	212			0.00472	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

☑ Insects/Disease
☑ Wind/Weather/Stress
☐ Native Grazing
☑ Competition
☐ Other (optional 1)
☐ Other (optional 2)

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

References

Bradley, A. F., N. V. Noste, and W. C. Fisher. 1992. Fire ecology of forests and woodlands in Utah. Ge. Tech. Rep. INT-287. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermoutain Research Station. 128 p.

DeVelice, Robert L. et al. 1986. A Classification of Forest Habitat Types of Northern New Mexico and Southern Colorado. USDA, Forest Service. Rocky Mountain Forest and Range Experiment Station. GTR RM-131.

Komarkova, Vera et al. 1988. Forest Vegetation of the Gunnison and Parts of the Uncompahgre National Forests: A Preliminary Habitat Type Classification. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. GTR RM-163.

Veblen, T. T., K. S. Hadley, E. M. Nel. T. Kitzberger, M. Reid,, R. Vellalba. 1994. Disturbance regime and disturbance interactions in a Rocky Mountain subalpine forest. Journal of Ecology 82:125-135.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: **wm1081wf** **Winterfat**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 3/17/2005

Modeler 1	Louis Provencher	lprovencher@tnc.org	**Reviewer**
Modeler 2			**Reviewer**
Modeler 3			**Reviewer**
			FRCC

Vegetation Type

Upland Shrubland

Dominant Species*

KRLA
ARSP5
ATCO
ELEL5

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

16	0
12	0
17	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☑ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☐ Southwest

Geographic Range

Great Basin; OR, ID, UT, NV, CA, and Colorado Plateau. This ecological system occupies sites west of the Wasatch Mountains, east of the Sierras, south of the Idaho batholith and north of the Mojave Desert.

Biophysical Site Description

This type occurs from lower slopes to valley bottoms ranging in elevation from 3,800 - 6,500 feet. Soils are silty and alkaline or calcareous. Soil permeability ranges from high to low, with more impermeable soils occurring in valley bottoms. Water ponds on alkaline bottoms. Texture is fine, sometimes with coarse substrate mixed in fine silty soil. Average annual precipitation ranges from 3 to 10 inches, however, this system is in 5-8" of effective moisture within this broader range. Thus, other sites characteristics (e.g. aspect, drainage, soil type) should be considered in identifying this ecotype. At the precipitation extremes, this system generally occurs as small patches and stringers. Summers are hot and dry with many days reaching 100 degrees F. Spring is the only dependable growing season with moisture both from winter and spring precipitation. Cool springs can delay the onset of plant growth and drought can curtail the length of active spring growth. Freezing temperatures are common from November through April.

Vegetation Description

This ecological system includes low (<3 ft) and medium-sized shrubs found at relatively high density (3-5 plants per sq. m) shrubs interspersed with low to mid-height bunch grasses. The dominant shrubs are winterfat and low rabbitbrush. Other common shrubs are shadscale, budsage, broom snakeweed, and saltbush. Common bunch grass species are Indian ricegrass, needle-and-thread, purple three-awn, and bottlebrush squirreltail, and where monsoonal influences are present you will find common rhizomatous/sod forming grasses such as galleta grass, sand dropseed, and blue grama. Globe mallows are the most common and widespread forbs. The understory grasses and forbs are salt-tolerant, not particularly drought tolerant, and are variably abundant.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Disturbance Description

Disturbance was unpredictable. But flooding, drought, and insects may all occur in these systems. Fire was very rare. For the MODEL, extended wet periods occurred every 55 (30-80 years) years, and drought periods occurred every 55 years (30-80 years).

Documented Mormon cricket/grasshopper outbreaks since settlement have corresponded with drought; outbreaks cause shifts in composition amongst dominant species, but do not typically cause shifts to different seral stages. Therefore insect disturbance was not modeled. During outbreaks Mormon crickets prefer open, low plant communities. Herbaceous communities and the herbaceous component of mixed communities were more susceptible to cricket grazing.

Fire was rare and limited to more mesic sites (and moist periods) with high grass productivity. Mixed severity fire with mean FRI of 1,000 years (for the MODEL).

Extended wet periods tended to favor perennial grass development, while extended drought tended to favor shrub development. Shrubs, however, were always dominant.

Native American manipulation of salt desert shrub plant communities was minimal. Grass seed may have been one of the more important salt desert shrub crops. It is unlikely that native Americans manipulated the vegetation to encourage grass seed.

Adjacency or Identification Concerns

Upland salt desert shrub communities are easily invaded and, in the short term at least, replaced by cheatgrass. Other nonnative problematic annuals include halogeton, Russian thistle, and several mustards. Through central UT and east central NV this group is susceptible to invasion by squarrose knapweed. More mesic areas can be invaded by tall whitetop and hoary cress. All three are noxious weeds in Great Basin states.

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☑ Literature ☑ Local Data ☑ Expert Estimate

Winterfat communities are generally limited to linear features such as lower levations dry washes and depressions. Unlike other salt desert communities, Disturbance scale was variable during pre-setlement. Droughts and extended wet periods could be region wide, or more local. A series of high water years or drought could affect whole basins.

Most fires were rare and less than 1acre, but may exceed hundreds of acres with a good grass crop.

Issues/Problems

Comments

The winterfat model was developed from the mixed salt desert (BpS 1081) models, originally created by Gary Medlin (gary_medlyn@nv.blm.gov), Crystal Golden (ckolden@gmail.com), and Don major (dmajor@tnc.org; don_major@blm.gov).

BpS gr1081 was was taken as-is from BpS wr1081.

BpS wr1081 was taken as-is from BpS 1210810 with minor changes to species composition (e.g., adding Bailey's greasewood, SABA14).

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

BpS 1081 for MZ 12 & 17 was modified from BPS 1081 for MZ 16. 1) Pinyon-juniper steppe was removed as potential adjacent type in vegetation description. 2) The model was clearly defined following the dynamics of shadscale and bud sagebrush where mortality of shadscale in class B causes a transition to bud sagebrush dominant class C for a short period before abundant shadscale seed allow the return to class B. 3) In this revised model it is not possible to have an alternate succession from class A to C.

BPS 1081 for MZ 16 was initially based on R2SDSH. Greasewood box was removed from R2SDSH by Jolie Pollet, Annie Brown, and Stanley Kitchen to build BPS 1081 for MZ 16. The model was greatly simplified at this time. Original descriptions by Bill Dragt were kept. Reviewers of R2SDSH were Stanley Kitchen (skitchen@fs.fed.us), Mike Zielinski (mike_zielinski@nv.blm.gov), and Jolie Pollet (jpollet@blm.gov).

Vegetation Classes

Class A 10%

Early Development 1 All Struc

Description

Dominated by perennial grasses and low rabbitbrush. Succession to class B after X years. Extended wet period (every 55 years) will have a stand replacing effect, with an ecological setback of 50 years. Fire absent.

Indicator Species* and Canopy Position

ACHY Upper
CHRYS Mid-Upper
HECO2 Upper
ELEL5 Low-Mid

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11%	50%
Height	Herb 0m	Herb 1.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class B 50%

Mid Development 1 Open

Description

Co-dominated by winterfat (5-20% cover) and perennial grasses (20-50% cover). Extended wet periods (every 55 years on average) will cause a stand replacing transition to Class A. Succession to class C after 100 years. Replacement fire is rare (mean FRI of 1000 years).

Indicator Species* and Canopy Position

KRLA2 Upper
CHRYS Mid-Upper
ELEL5 Lower
HECO2 Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	5%	20%
Height	Shrub Dwarf <0.5m	Shrub Dwarf <0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class C 40%

Mid Development 2 Open

Description

Dominated by winterfat at >20% cover. Grass cover 10-20% cover. Extended wet periods (every 55 years on average) will cause a i) stand replacing transition to Class A 50% of times and ii) thiining to class B 50% of times. Replacement fire is rare (mean FRI of 1000 years).

Indicator Species* and Canopy Position

KRLA2 Upper
CHRYS Mid-Upper
ELEL5 Lower
HECO2 Upper

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 4

Structure Data (for upper layer lifeform)

	Min	Max
Cover	21%	80%
Height	Shrub Dwarf <0.5m	Shrub Dwarf <0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D 0%

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	0%
Height	NONE	NONE
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class E 0%

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height	NONE	NONE
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Fire Regime Group:** 5

Historical Fire Size (acres)

Avg 1
Min 1
Max 1

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	1250			0.0008	98
Mixed					
Surface					
All Fires	1247			0.00082	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

References

Blaisdell, J. P., and R. C. Holmgren. 1984. Managing intermountain rangelands-salt-desert shrub ranges. General Technical Report INT-163. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 52 pp.

NRCS. 2003. Major Land Resource Area 28A Great Salt Lake Area. Nevada Ecological Site Descriptions. Reno, NV.

NRCS. 2003. Major Land Resource Area 28B Central Nevada Basin and Range. Nevada Ecological Site Descriptions. Reno, NV.

NRCS. 2003. Major Land Resource Area 29 Southern Nevada Basin and Range. Nevada Ecological Site Descriptions. Reno, NV.

Tiedemann, A. R., E. D. McArthur, H. C. Stutz. R. Stevens, and K. L. Johnson, compilers. 1984. Proceedings--symposium on the biology of Atriplex and related chenopods; 1983 May 2-6; Provo, UT. Gen. Tech. Rep. INT-172. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment. 309 pp.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: wm1080up   Wyoming Big Sagebrush-upland

☐ *This BPS is lumped with:*
☑ *This BPS is split into multiple models: BpS 121080 was split into 3 BpSs. Gr1080s and gr1080up, respectively, the semi-desert and upland versions of 1080. gr1080bw is another big sagebrush system dominated by basin wildrye on small floodplains and washes in deep soils.*

General Information

Contributors (also see the Comments field)   **Date** 1/16/2007

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Modeler 2			**Reviewer**
Modeler 3			**Reviewer**
			FRCC

Vegetation Type

Upland Shrubland

Dominant Species*

ARTR	ELMA
CHVI8	ELEL5
ACHY	ACSP1
HECO	ACTH

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16	0
12	0
17	0
0	0
0	0

Model Zones

☐ Alaska
☐ California
☑ Great Basin
☐ Great Lakes
☐ Northeast
☐ Northern Plains
☐ N-Cent.Rockies
☐ Pacific Northwest
☐ South Central
☐ Southeast
☐ S. Appalachians
☐ Southwest

Geographic Range

This ecological system is found in eastern CA, central NV, and UT and is distinct from Wyoming big sagebrush semi-desert in the 8-12 PZ and sagebrush steppe (Inter-Mountain Basins Big Sagebrush Steppe) found on the Columbia Plateau and in Wyoming.

Biophysical Site Description

This widespread system is common to the Basin and Range province. In elevation it ranges from 5,000 - 7,500 ft, and occurs on well-drained loamy, sandy loam, sandy, and granitic loamy soils on foothills, terraces, 2-15% slopes, fan piedmonts, mountain toe slopes, small concave intraplateau basins, and plateaus. BpS is found on soil depths greater than 60" to bedrock. Elevationally it is found between low elevation salt desert shrub and mountain big sagebrush zones where pinyon and juniper can establish. Occurs from 10 to 12' precipitation zones (PZ) or 8-12 PZ in the more productive soils.

Vegetation Description

The BpS describes types dominated by big sagebrush at 10-12" PZ, and Wyoming and basin (sandy soils only) big sagebrush at 8-12" PZ. Shrub canopy cover generally ranges from 5 to 25%, but can exceed 30% at the upper elevation and precipitation zones. Wyoming big sagebrush sites have fewer understory species relative to other big sagebrush types. Rubber rabbitbrush is co-dominant. Dominant grasses are Thurber's needlegrass on loamy soil at 10-12" PZ, Indian ricegrass at 8-12" PZ on sandy loam, sandy (thickspike wheatgrass co-dominant), and loamy soils. Desert needlegrass is dominant on granitic loam at 8-10" PZ. Bottlebrush squirreltail is common, but not dominant on all sites.

Perennial forb cover is usually <10% with perennial grass cover reaching 20 - 25% on the more productive sites. Bluebunch wheatgrass may be a dominant species following replacement fires and as a co-dominant

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after 20 years, but only in precipitation zones above 10". Percent cover and species richness of understory are determined by site limitations. Pinyon (generally Pinus monophyla) and juniper (generally Juniper osteosperma) present, occasionally reaching 60% canopy cover in areas that have escaped fire. Wyoming big sagebrush semi-desert is critical habitat for the Greater Sage Grouse and many sagebrush obligates.

Disturbance Description

Total fire return interval is 100 yrs in mid- late development shrubland. This ecological system is characterized by replacement fires (100-yr FRI) where shrub canopy exceeds 25% cover (i.e., class C) or where grass cover is >15% and shrub cover is > 20% (i.e., class B). Replacement fires occur where shrub cover is <10% (i.e., class A) and is generally uncommon (FRI of 500 years) after 10 years of post-fire recovery. Where pinyon or juniper has encroached after 150 years without fire, mean FRI of fire replacement increases from 100 to 150 years.

The Aroga moth is capable of defoliating large acreages (i.e., > 1,000 ac; mean return interval of 75 years), but usually 10 to 100 acres.

Weather stress: Prolonged drought (1 in 100 years) on the more xeric sites may reduce shrub cover. Flooding may also cause mortality if the soil remains saturated for an extended period of time (i.e., 1 in 300 year flood events). In years with high winter precipitation, flooding (i.e. soil saturation for extended periods) results in mortality and die-back.

Herbivory (non-insect); Herbivory can remove the fine fuels that support Mixed Severity fires and result in woody fuel build up that leads to severe Replacement fires.

Adjacency or Identification Concerns

The BpS includes basin big sagebrush on sandy soils of mountain toe slopes that is structurally similar to Wyoming big sagebrush, but does not include the basin big sagebrush communities that are dominanted by basin wildrye and found on small floodplains (see gr1080LECI).

Identification concerns include instances of Wyoming big sagebrush semi-desert (BpS gr1080s) ususally at the next lower elevation zone.

This community may be adjacent to mountain big sagebrush at elevations above 6,500 ft., or adjacent to pinyon-juniper at mid- to high-elevations. Salt desert shrub may be adjacent, but usually this is an identification concern for semi-desert ARTRW at lower elevations. Low sagebrush or black sagebrush may form large islands within this community where soils are shallow or have root-restrictive layers.

Post-settlement conversion to cheatgass is common, although not as much as found in semi-desert Wyoming big sagebrush, and results in change in fire frequency and vegetation dynamics. Lack of disturbance can result in pinyon-juniper encroachment where adjacent to pinyon-juniper woodlands.

Post-settlement issues center around the high amount of big sagebrush with minimal to no understory, and whether these decadent stands are related to fire suppression or natural physiological/ecologcal progression.

Native Uncharacteristic Conditions

More than 60% cover of trees in uncharacteristic in late development closed patches (class D). More than 50

Scale Description

Sources of Scale Data ☑ Literature ☐ Local Data ☑ Expert Estimate

BPS can occupy vast areas (>100,000 acres). Historic disturbance (fire) likely ranged from small (< 10 ac) to large (> 10,000 acres) depending on conditions, time since last ignition, and fuel loading. The average

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patch size is assumed to be 250 acres.

Issues/Problems

Uncertainty on fire regimes exists.

Comments

BpS gr1080 is very similar to BpS wr1080m, except that surface and mixed severity were removed and replaced with only replacement fire to adopt new LANDFIRE definitions of fire types. Big sagebrush does not underbrun without stand replacing topkill. The total FRI of 100 yrs was maintained in classes B-D, however the FRI of replacement fire was set at 500-yr to indicate a rare event in class A starting at age 10 to 19 yrs. Other paprameters not changed. NRV remained the same.

BpS wr1080m was nearly identical to 1210800, except that soil, landform position, elevation, and dominant grasses species were made more specific to moist big sagebrush, Wyoming big sagebrush, and basin big sagebrush on fan piedmonts, mountain toe slopes, alluvial fans, and small concave depressions as described in NRCS soil surveys for Mineral (#744) and Lyon (#625) Counties, and Hawthorne Army Depot (#799).

BpS 1210800 developed by Don Major (dmajor@tnc.org), Gary Medlyn (gmedlyn@nv.blm.gov), and Crystal Kolden (ckolden@gmail.com) was closely based on R2SBWY and R2SBWYwt originally modeled by Gary Back (gback@srk.com) and modified by Louis Provencher (lprovencher@tnc.org) based on reviews by Stanley G. Kitchen (skitchen@fs.fed.us), Peter Weisberg (pweisberg@cabnr.unr.edu), and Jolie Pollet (jpollet@blm.gov). This model assumes the sites are near pinyon-juniper savanna or woodlands and without frequent fire, pinyon or juniper will encroach into the sagebrush range site. In areas without a potential for tree invasion (e.g., lower elevation), the Historic Range of Natural Variability for classes A, B, and C, respectively, is 10%, 55%, and 35% (results of R2SBWY).

NOTE regarding depleted sagebrush: Late seral stage was not modelled as it was identified that sagebrush depletion rate is much slower than the rate of juniper invasion. Further, sagebrush is unable to exclude grass/forb, thereby maintaining fire and moving the system back to earlier classes.

The first three development classes chosen for this ecological system correspond to the early, mid-, and late seral stages familiar to range ecologists. The two classes with conifer invasion (classes D and E) approximately correspond to Miller and Tausch's (2001) phases 2 and 3 of pinyon and juniper invasion into shrublands.

Vegetation Classes

Class A 15%

Early Development 1 All Struc

Description

Post-replacement disturbance; grass dominated with scattered shrubs. Fuel loading discontinuous. Replacement fire occurs every 500 years on average starting at age 10. Succession to class B after 20 years.

Indicator Species* and Canopy Position

ACHY Upper
ACSP12 Upper
CHVI8 Upper
ARTR Upper

Upper Layer Lifeform

☐ Herbaceous
☑ Shrub
☐ Tree

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	10%
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Early development is dominanted by grasses and forbs (>15% cover) with scattered shrubs representing <10% upper canopy cover.

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Fuel Model 1

Class B **50%**

Mid Development 1 Open

Description

Shrubs and herbaceous vegetation can be co-dominant, fine fuels bridge the woody fuels, but fuel discontinuities are possible. Replacement fire has a mean FRI of 100 years. Succession to class C after 40 years.

Indicator Species* and Canopy Position

ARTR Upper
ACHY Lower
CHVI8 Mid-Upper
ACSP12 Lower

Upper Layer Lifeform

☐ Herbaceous
☑ Shrub
☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11%	30%
Height	Shrub 0.6m	Shrub 1.0m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C **25%**

Mid Development 1 Closed

Description

Shrubs dominate the landscape; fuel loading is primarily woody vegetation. Shrub density sufficient in old stands to carry the fire without fine fuels. Establishment of pinyon and juniper seedlings and saplings widely scattered. Replacement fire (mean FRI of 100 years) and rare flood events (return interval of 333 years) cause a transition to class A. Prolonged drought (mean return interval of 100 years) and insect/disease (every 75 years on average) cause a transition to class B. Succession to class D after 40 years.

Indicator Species* and Canopy Position

ARTR Upper
CHVI8 Mid-Upper
ELEL5 Lower
ACSP12 Lower

Upper Layer Lifeform

☐ Herbaceous
☑ Shrub
☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	31%	40%
Height	Shrub 0.6m	Shrub 1.0m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D **5%**

Late Development 1 Open

Description

Pinyon-juniper encroachment where disturbance has not occurred for at least 125 years (tree species cover <15%). Saplings and young trees are the dominant lifeform. Sagebrush cover (<25%) and herbaceous cover decreasing

Indicator Species* and Canopy Position

JUNIP Upper
PIMO Upper
ARTR Mid-Upper
ELEL5

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0%	10%
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Shrubs may still represent the dominant lifeform with pinyon and juniper saplings common (1-15% upper canopy cover).

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compared to class C. Replacement fire occurs every 100 years on average. Insect/disease (every 75 years) and prolonged drought (every 100 years) thin both trees and shrubs, causing a transition to class C. Succession to class E after 50 years.

Fuel Model 2

Class E **5%**

Late Development 1 Closed

Description

Shrubland encroached with mature pinyon and/or juniper (cover 16-60%) where disturbance does not occur for at least 50 years in Class D. Shrub cover <10% and graminoids scattered. Replacement fire occurs every 125 years on average. Prolonged drought thins trees, causing a transition to class B. Succession from class E to E.

Indicator Species* and Canopy Position

JUNIP	Upper
PIMO	Upper
SYOR	Lower
ELEL5	Lower

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	60 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 500
Min 10
Max 10000

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	119	30	500	0.008403	100
Mixed					
Surface					
All Fires	119			0.00842	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☑ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

References

Brown, J. K. and J. K. Smith, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Cook, J. G., T. J. Hershey, and L. L. Irwin. 1994. Vegetative response to burning on Wyoimng mountain-

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shrub big game ranges. Journal of Range Management 47: 296-302.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1994. Intermountain Flora: Vascular Plants of the Intermountain West, U.S.A. Asterales. Volume 5. New York Botanical Garden, Bronx, NY.

Gruell, G. E. 1999. Historical and modrern roles of fire in pinyon-juniper. P. 24-28. In: S. B. Monsen & R. Stevens (compilers). Proceedings: ecology and management of pinyon-juniper communities within the Interior West; 1997, Provo, UT. Proc. RMRS-P-9. Ogden, UT. U.S. Dept. Ag., Forest Service, Rocky Mountain Research Station.

Kinney,W. C. 1996. Conditions of rangelands before 1905. Sierra Nevada ecosysttem project: Final report to Congress, Vol. II. Davis: University of California, Centers for water and wildland resources. P31-45.

Kuchler, A. W. 1985. Potential natural vegetation (map at scale of 1:7,500,000). In: U.S. Geological survey, The National Atlas of the USA. U.S. Govt. Print. Off. Washington, D.C.

Miller, R. F. and J. A. Rose. 1999. Fire history and western juniper encroachment in sagebrush-steppe. Journal of Range Management. 550-559.

Miller, R. F. and L. L. Eddleman. 2000. Spatial and temporal changes of sage grouse habitat in the sagebrush biome. Oregon State Univ. Agr. Exp. Stat. Technical Bull. 151. 35pp.

Miller, R. F. and R. J. Tausch. 2001. The role of fire in juniper and pinyon woodlands: a descriptive analysis. Proceedings: The First National Congress on Fire, Ecology, Prevention, and Management. San Diego, CA, Nov. 27- Dec. 1, 2000. Tall Timbers Research Station, Tallahassee, FL. Miscellaneous Publication 11, p:15-30.

NRCS. 2003. Major Land Resource Area 28A Great Salt Lake Area. Nevada Ecological Site Descriptions. Reno, NV.

NRCS. 2003. Major Land Resource Area 28B Central Nevada Basin and Range. Nevada Ecological Site Descriptions. Reno, NV.

NRCS. 2003. Major Land Resource Area 29 Southern Nevada Basin and Range. Nevada Ecological Site Descriptions. Reno, NV.

NRCS. 2003. Major Lannd Resource Area 25 Owyhee High Plateau. Oregon and Nevada Ecological Site Descriptions. Reno, NV.

NRCS. 2003. Major Land Resource Area 24 Humboldt Area. Nevada Ecological Site Descriptions. Reno, NV.

NRCS. 2003. Major Land Resource Area 27 Fallon-Lovelock Area. Nevada Ecological Site Descriptions. Reno, NV.

Tausch, R. J. and R. S. Nowak. 1999. Fifty years of ecotone change between shrub and tree dominance in the Jack Springs Pinyon Research Natural Area. P.71-77. In: E. D. McArthur, W. K. Ostler, & C. L Wambolt (compilers). Proceedings: shrubland ecotones. 1998. Ephram, UT. Proc. RMRS-P-11. Ogden, UT. U.S. Dept. Ag., Forest Service, Rocky Mountain Research Station.

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Tilsdale, E. W. 1994. Great Basin region: sagebrush types. P. 40-46. In: T.N. Shiflet (ed.) Rangeland Cover Types. Soc. Range Manage., Denver, CO.

Vale, T. R. 1973. The sagebrush landscape of the intermountain west. Dissertation. Berkeley: University of California. 508pp.

Vale, T. R. 1975. Presettlement vegetation in the sagebrush-grass area of the intermountain west. Journal of Range Management 28(1): 32-36.

West, N. E. 1983. Western Intermountain sagebrush steppe. P. 351-297. In: N.E. West (ed.) Ecosystems of the World 5: Temperate deserts and semi-deserts. Elsevier Scientific Publishing Company, New York, NY.

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