Spatial Modeling of the Cumulative Effects of Land Management Actions on Ecological Systems of the Grouse Creek Mountains–Raft River Mountains Region, Utah

Seral aspen and subalpine conifer woodlands of Raft River Mountains, Utah. Photo: Louis Provencher, 22 June 2007

Final Report to the Utah Partners for Conservation and Development

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1. Executive Summary

Many vegetative systems of the Grouse Creek Mountains and Raft River Mountains landscape may be outside their range of natural variability due to past land management practices, cheatgrass or exotic forb invasion, and altered fire regimes. As a consequence, wildlife and associated habitats, and agricultural lands are predicted to be harmed, and state and federal agencies have funded restoration of affected ecological systems or conversion of land to agriculture uses important to this northwest Utah community. Utah Partners for Conservation and Development, The Nature Conservancy, Bureau of Land Management (BLM), U.S. Forest Service (USFS) Sawtooth National Forest, U.S. Department of Agriculture Natural Resources Conservation Services (NRCS), Utah Division of Wildlife Resources, and Intermountain West Rangelands and Woodlands Regional Fire Learning Network (a partnership facilitated by The Nature Conservancy) shared a mutual interest in quantitatively modeling the cumulative impact of past land management projects and exploring alternative future management scenarios on the integrity of ecological systems of the Grouse Creek Mountains–Raft River Mountains landscape.

Through stakeholder workshops, partners

(a) chose two measures of success to compare management scenarios: (i) ecological departure from the natural range of variability (proportional distribution of each vegetation succession class per biophysical setting [i.e., potential natural vegetation type]) and (ii) structural vegetation complexity; and

(b) built 17 quantitative state-and-transition models identified through the interpretation of soil surveys and based on the inter-agency LANDFIRE descriptions.

Remote sensing, Geographic Information System (GIS) analysis, partner land management data and computer simulations were used to:

(a) calculate the a-spatial and spatial natural range of variability per biophysical setting;

(b) measure the cumulative impact of 5 years of vegetation and fire management projects from 2001 to 2006;

(c) compare combinations of four core management scenarios simulated for 50 years that were based on (i) whether or not management funds stayed within ownership boundaries, (ii) biophysical settings were assigned priorities based on the highest return on the investment, (iii) 30-meter fuels breaks were placed on every paved and dirt roads, and (iv) treatments were placed adjacent to desirable vegetation classes;

(d) compare three fine-tuning management scenarios simulated for 50 years that focused on (i) whether or not restoration increased succession vegetation complexity, (ii) the cost of archeological surveys, seed mix, and mechanical thinning were reduced, and (iii) fire and vegetation management was only

conducted adjacent to human communities at risk. Fine-tuning scenarios were simulated using as baseline the combination of core scenarios that yielded the lowest ecological departure and, if also possible, highest structural vegetation complexity; and

(e) compare the effects of higher rates of long-distance cheatgrass dispersal, short-distance exotic forb dispersal, and excessive herbivory on ecological departure and vegetation complexity in conjunction with the effects of core scenarios.

The overall results and management conclusions for all scenarios based on patterns in ecological departure and structural vegetation complexity (Shannon diversity index) were:

(a) **The a-spatial natural range of variability is generally adequate.** The natural range of variability for each biophysical setting was generally not affected by spatial effects during reference simulations, except to reduce late-development vegetation classes of biophysical settings with longer fire return intervals often surrounded by mountain big sagebrush (pinyon-juniper woodlands, curlleaf mountain mahogany, and low sagebrush).

(b) **Small projects do not affect landscape-level ecological condition**. Vegetation management projects, including fire rehabilitation, distributed across the landscape from 2001 to 2006 had no detectable landscape-level effects on ecological departure because they were too small, created outcomes that were either no different or worse than the condition they attempted to fix, converted degraded range to pasture, or realized improvements to ecological departure were masked by continued deterioration of the landscape due to mainly cheatgrass invasion. Local vegetation management projects that were not in response to post-fire rehabilitation might have achieved local objectives.

(c) **Core management scenarios were never successful at restoring lower to middle elevation biophysical settings invaded by cheatgrass**. New scenarios not examined here will be required to control cheatgrass infestation.

(d) **Prioritizing biophysical settings for management can backfire**. Managers should not decide restoration activities based on biophysical setting's ability to respond to treatments. Biophysical settings with a higher return on the investment usually occupy a smaller area and higher elevations in the landscape; therefore, concentrating limited resources means that biophysical settings with lower returns on the investment, which are generally at middle to lower elevations and more widespread, will be neglected while also being more susceptible to cheatgrass invasion. This scenario often had the strongest and more frequent effect, and managing biophysical settings according to priorities had detrimental effects by increasing ecological departure. Biophysical setting priorities had no effect on structural vegetation complexity.

(e) **Funding distributed across ownership boundaries made a difference in a limited number of cases**. Utah Partners for Conservation and Development have the ability to distribute funds for fire and vegetation management across ownership boundaries, including private ownership. Results suggest that this should be encouraged to especially restore black sagebrush and montane wet meadows, and marginally so for Wyoming big sagebrush semi-desert, and to increase structural vegetation complexity. On the other hand, curlleaf mountain mahogany and montane riparian benefit more by keeping funding within their original ownership.

(f) **Fuel breaks increased structural vegetation complexity**. Fuel breaks had the strongest effect on increasing structural vegetation complexity, even under high rates of cheatgrass dispersal. Fuel breaks along paved and dirt roads made of introduced species, also called "green strips", should be implemented below the 30.5 centimeter (12 inch) precipitation zone, where this action was most needed, and perhaps from 30.5 to 35.6 centimeter (12 to 14 inches) of precipitation. Although we simulated a 30-meter (98 feet) wide fuel break, 61-meter (200 foot) corridors might be more effective, although more expensive.

(g) **Placing vegetation treatments adjacent to desirable habitat had no effect**.

(h) **Managing vegetation only around communities at risk does not help**. Focusing resources within 2 km of communities at risk will generally have no effect or caused greater ecological departure to Wyoming big sagebrush semi-desert and basin wildrye. Only riparian systems, which are often near towns and generally not the object of National Fire Plan hazardous fuels reduction funding, showed decreased ecological departure.

(i) **Increasing seral complexity helped at the margin**. The strategy that increased seral complexity had only small effects, although they generally decreased ecological departure, except for riparian systems.

(j) **Reduction of budget items did not have effects**.

(k) **Increased rates for excessive herbivory was more consequential than for cheatgrass and exotic forb dispersal.** A two-fold (four-fold relative to the lower tested rate) increase in the rate of excessive herbivory increased ecological departure of stable and seral aspen, wet meadows, and montane riparian although this activity was infrequent in vegetation models. Livestock operators have the ability to reduce detrimental forms of grazing on smaller, more mesic biophysical settings through either passive or active grazing systems.

(l) **Greater rates of long-distance cheatgrass dispersal and exotic forb dispersal were detrimental and somewhat indirect.** It appears that management scenarios are fairly resistant to different rates of cheatgrass and exotic forb dispersal.

This study revealed that the Utah Partners for Conservation and Development should (a) not restrict vegetation treatments to biophysical settings with the most desirable restoration responses, (b) at least share resources across ownerships and (c) implement fuel breaks along most paved and dirt roads. However, the Utah Partners for Conservation and Development need to develop new approaches to both reduce cheatgrass-infested states at lower to middle elevations (15.2 -30.5 centimeter or 6-12 inch precipitation zone) and to restore higher elevation biophysical settings that are or will become highly departed in the next decade: stable and seral aspen, upland and mountain sites of mountain big sagebrush, and upland sites of Wyoming big sagebrush. This situation is not unique to this Intermountain West landscape. The Nature Conservancy is proposing two hypothetical approaches as food for thought to improve ecological condition by economically linking restoration of upper and lower elevation biophysical settings while offering incentives to improve both the profitability and ecological impacts of grazing management systems: (i) the implementation of incentive-sponsored forage reserves in degraded rangelands and (ii) third-party purchase of grazing management contracts from livestock operators.

2. INTRODUCTION

2.1. Study Area and Conservation Significance

The slopes and cliffs of the Grouse Creek Mountains and Raft River Mountains intersect in Utah's northwest corner to form an impressive 1,000,000+-acre landscape bordered by Nevada and Idaho (Figure 1). The landscape overlaps with the Great Basin ecoregion while including a smaller portion of the Columbia Plateau ecoregion to the northwest. With elevations ranging from approximately 4,300 to 9,600 feet, vegetation types include salt desert shrublands, sagebrush shrublands, woodlands of pinyon-juniper, stable and seral aspen, curlleaf mountain mahogany, and subalpine conifers, and mountain streams and springs support riparian corridors and wet meadows (Figure 2).

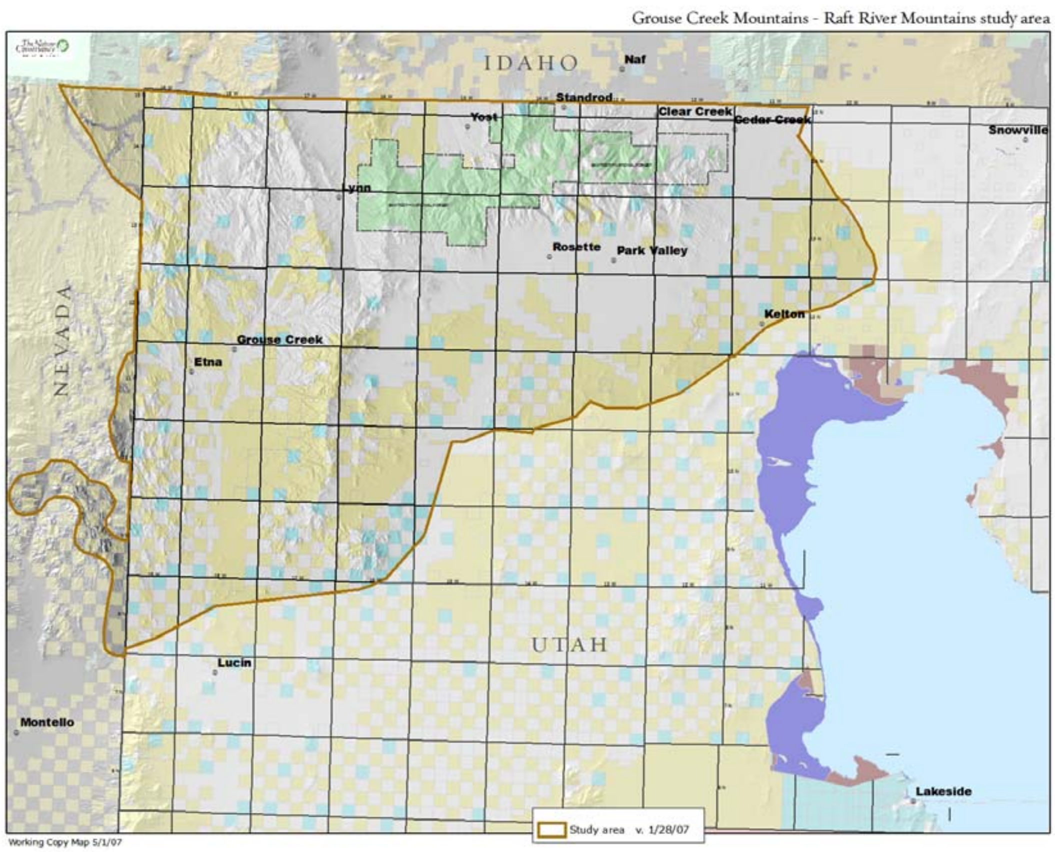


Figure 1. Grouse Creek Mountains-Raft River Mountains project area. Modeled landscape is approximately 1.1 million acres and located almost entirely in Utah.

The Grouse Creek Mountains and Raft River Mountains landscape is considered a conservation priority for The Nature Conservancy and a management priority for the Utah Partners for Conservation and Development. The landscape supports both common and rare species of special management interest: mule deer, pronghorn, pygmy rabbit, greater sage-grouse, ferruginous hawk, northern goshawk, Yellowstone cutthroat trout, Crittenden's springsnail, Cottam's cinquefoil and more. The landscape is home to the third largest historic population of greater sage-grouse in Utah and overlaps with an important raptor migration flyway.

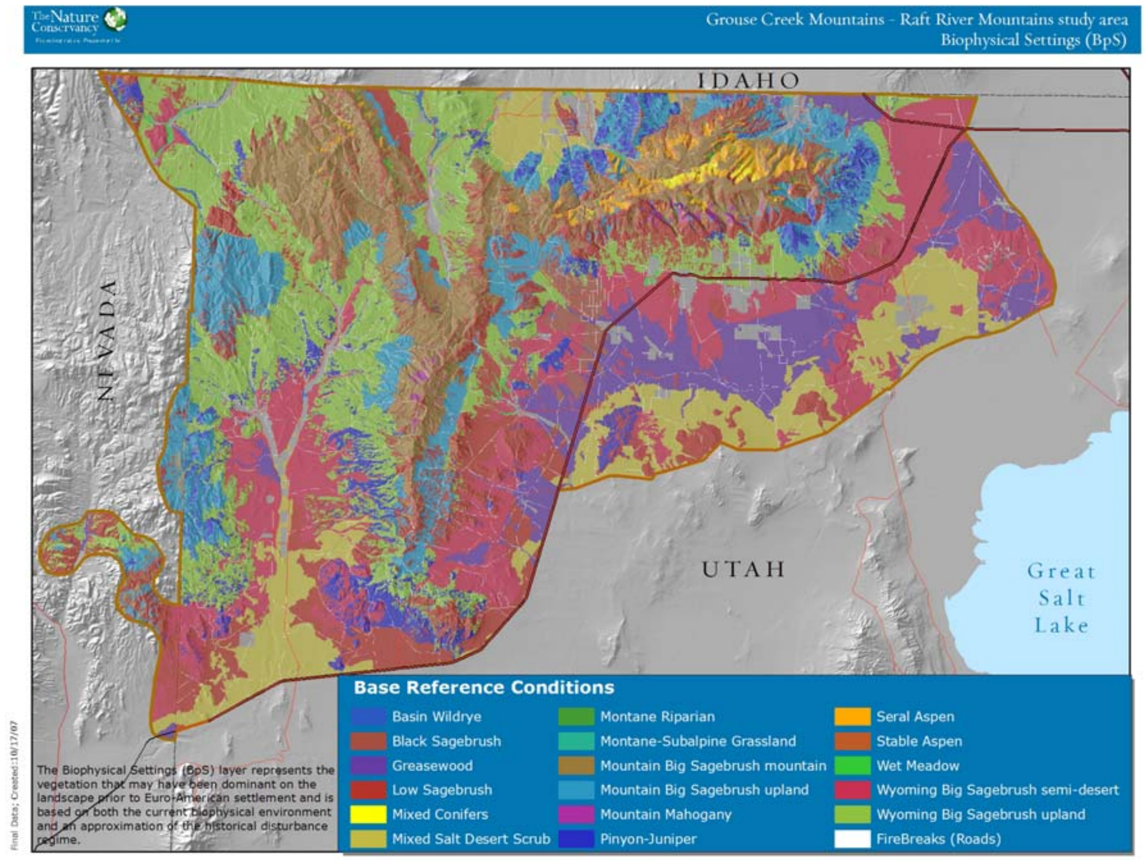


Figure 2. Biophysical settings of the Grouse Creek Mountains-Raft River Mountains project area. A biophysical setting is one type of biophysical classification based on dominant and upper-layer plant species that are indicators of the natural disturbance regime, local climate, and topo-edaphic relationships.

The economy of the Grouse Creek Mountains and Raft River Mountains landscape is rural and dominated by ranching. Hunting, fishing, camping, other recreational activities, and hard rock mining are also important economic activities. Several lower and middle elevation shrublands found on private lands were converted to pastures, alfalfa fields, and dry farming. Higher elevations are generally used as growing season sheep or cattle allotments. Private ownership represents 49.4% of the landscape, whereas the Salt Lake BLM Field Office manages 39.01% of the area and the USFS Sawtooth National Forest is responsible for 4.3%.

The fire regime in many systems of the Grouse Creek Mountains and Raft River Mountains landscape may be outside their range of natural variability due to past land management practices, cheatgrass invasion, or exotic forb invasion. As a consequence, species of special interest and ranching are predicted to be harmed, and state and federal agencies have funded restoration of affected ecological systems or conversion of land to more profitable agriculture uses. Key partners showing concern about natural resource management include Utah Partners for Conservation and Development, The Nature Conservancy, Bureau of Land Management, U.S. Forest Service Sawtooth National Forest, U.S. Department of Agriculture Natural Resources Conservation Services, Utah Division of Wildlife Resources, and private landowners.

2.2. Objectives

Fuels and vegetation management are important tools that can be used as restorative actions on the landscape, but future planning and assessment steps require a process to quantify the cumulative effects of these restoration efforts and their capacity to increase ecological integrity and restore wildlife habitat. Assessing the ability, or inability, of collective restorative processes to meet desired future conditions would result in the capacity to provide adaptive, project specific recommendations with regard to size, geographic distribution, and methods of future restoration projects. Because ecological systems are variable and stakeholders have different beliefs about natural resources management, predictions are inherently uncertain, and uncertainty increases with the size of landscapes being assessed.

Adaptive management theory proposes that stakeholders may reduce the uncertainty of management dilemmas by comparing the effects of alternative, sometime novel 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 while field data are being collected and interpreted.

Utah Partners for Conservation and Development, The Nature Conservancy, Bureau of Land Management, U.S. Forest Service Sawtooth National Forest, U.S. Department of Agriculture Natural Resources Conservation Services (NRCS), Utah Division of Wildlife Resources, and Intermountain West and the Mojave Desert Sky Islands Regional Fire Learning Network (a partnership facilitated by The Nature Conservancy) shared a mutual interest in quantitatively modeling the cumulative impact of past land management projects and exploring alternative future management scenarios on the integrity of ecological systems of the Grouse Creek Mountains and Raft River Mountains landscape.

2.3. Products

Although the main outcome of ecological modeling was the comparison of management scenarios, several necessary and useful by-products were generated. Products developed during the spatial modeling effort included:

1. Two multi-partners collaborative workshops to define objectives and develop models;
2. One multi-partners workshop to report on general results;
3. A digital map of potential vegetation types, hereafter called biophysical settings as used by U.S. Interagency and The Nature Conservancy LANDFIRE project (www.landfire.gov);
4. Descriptions of biophysical settings (similar to Ecological Site Descriptions);
5. A database containing a-spatial boxes-and-arrows (i.e., state-and-transition models; Figure 3) for each of 17 biophysical settings (Westoby et al., 1989; McIver and Starr, 2001; Bestelmeyer et al., 2004);
6. Digital maps of current vegetation condition labeled by the states and phases of the a-spatial models;
7. General description of the state/phases (recognizable discrete representation of vegetation condition) and parameters for each a-spatial biophysical settings model;
8. Estimates of the temporal variability in fire probabilities;
9. Estimates of the fire size distribution for the landscape;
10. Spatially explicit estimates of the natural range of variability by biophysical setting;
11. Description of each spatial modeling scenario;
12. Digital maps of modeled vegetation states and phases per spatial management scenario;
13. Results comparing measures of success among spatial management scenarios and to the natural range of variability defined for the reference condition; and
14. Draft and final reports of recommendations.

3. METHODOLOGY

There were five major methodological components to this project (Figure 4):

1. Synthesizing the ecological knowledge and management information needed for a-spatial and spatial modeling of biophysical settings;
2. Setting ecological and management objectives and creating models using community-based workshops;
3. Mapping biophysical settings and current vegetation condition to support spatial modeling;
4. Setting up and running computer simulations; and
5. Data analysis and reporting.

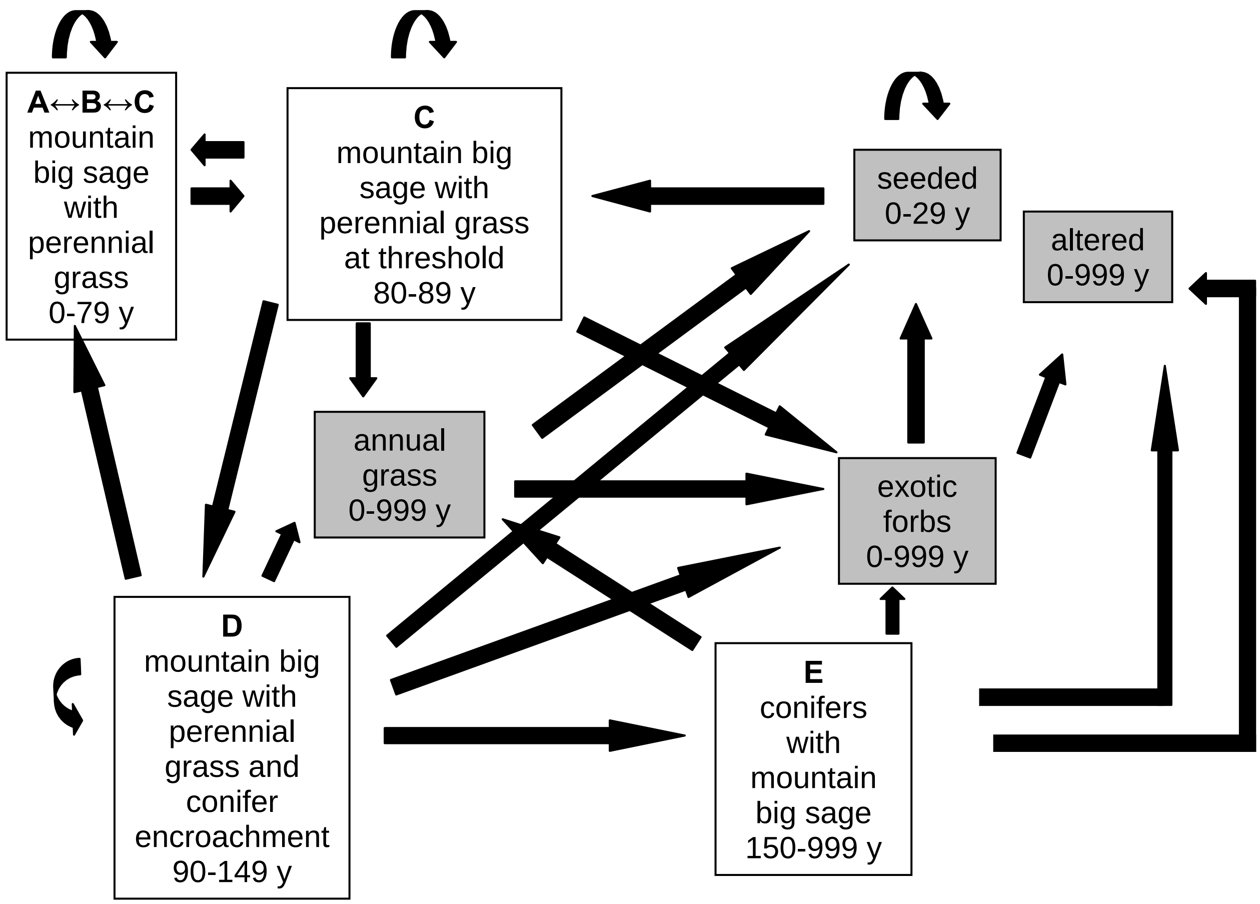


Figure 3. Example of state-and-transition models for mountain big sagebrush based on a VDDT model used for the revision of the Ely Bureau of Land Management's Resource Management Plan from Forbis et al. (2006).

3.1. Ecological and management synthesis

The bulk of the information incorporated in both the a-spatial and spatial management models were obtained from NRCS soil surveys of Utah (mainly from West Box Elder County) and Nevada, draft biophysical settings descriptions and models from LANDFIRE, and from partners and workshop participants. NRCS third order soil surveys were the foundation of modeling and mapping efforts because they described to an appropriate level of precision the biophysical settings in the landscape. As used by LANDFIRE, biophysical settings essentially represent pre-settlement vegetation or current reference conditions, and disturbance regimes. Soils take centuries to form as an interaction of climate, geology, and vegetation. Therefore, they can be used to approximate the pre-settlement or current natural, long-term ecological potential for soil-vegetation interactions (Haines-Young, 1991; Franklin, 1995). Given that the pre-settlement period ended approximately 150 years ago in the Great Basin, current

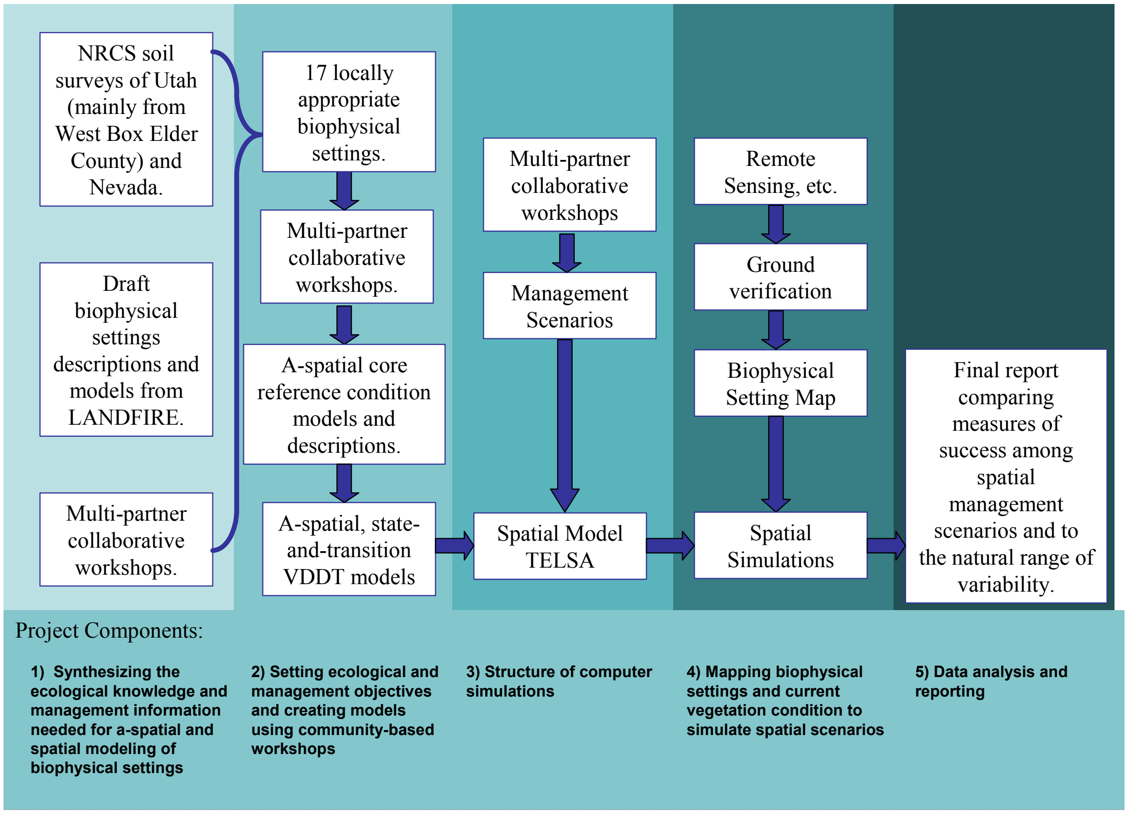


Figure 4. Methodology for spatial model development supported by remote sensing.

soils should be reliable predictors of biophysical settings unless soil horizons were mechanically removed or severely eroded due to post-settlement land management practices. We used the NRCS soil surveys to map biophysical settings by pooling different ecological sites with the same dominant upper-layer species (Figure 2). Seventeen biophysical settings were created based on interpretation of soil surveys and input from NRCS scientists and partners (Table 1). Four biophysical settings were the result of splitting Wyoming big sagebrush (*Artemisia tridentata* spp. *wyomingensis*) into semi-desert (8 to 10 inches of precipitation) and upland (10 to 12 inches of precipitation) ecological sites, and mountain big sagebrush into upland (12 to 14 inches of precipitation) and mountain (14+ inches of precipitation) ecological sites.

3.2. A-spatial core reference models and descriptions

Once the soil surveys had been interpreted into 17 biophysical settings appropriate to the Grouse Creek Mountains-Raft River Mountains study area, descriptions and core reference models were needed for each setting. For the purposes of this study, the states of pre-settlement vegetation classes were considered synonymous with each biophysical setting's core reference condition. As such, the reference condition does not describe

Table 1. Biophysical settings of the 1.1 million-acre Grouse Creek Mountains-Raft River Mountains project area.

Biophysical Settings
WOODLANDS
Mixed Conifers
Mountain Mahogany
Pinyon-Juniper
Seral Aspen
Stable Aspen
RIPARIAN, MOIST, AND MESIC UPLANDS
Basin Wildrye
Montane Riparian
Montane-Subalpine Grassland
Mountain Big Sagebrush: mountain
Mountain Big Sagebrush: upland
Wet Meadow
Wyoming Big Sagebrush: upland
SUB-XERIC AND ROOT LIMITING SHRUBLANDS
Black Sagebrush
Greasewood
Low Sagebrush
Mixed Salt Desert Scrub
Wyoming Big Sagebrush:semi-desert

vegetation condition caused by post-settlement management or unintentional actions (for example, release of cheatgrass). LANDFIRE biophysical setting descriptions include sections on the geographic distribution, biophysical setting, vegetation composition, disturbance regimes, comments by experts, structural vegetation classes (i.e., early, mid-development & closed, mid-development & open, late-development & open, and late-development & closed) and their dynamics, and the mean fire return intervals for surface, mixed severity, and replacement fire. LANDFIRE models were designed for a specific region and incorporated the most recent ecological knowledge on estimated succession transition times, fire frequency and severity, and disturbance probabilities for structural vegetation classes expected to occur during pre-settlement.

LANDFIRE biophysical setting descriptions and core a-spatial models were adapted to the local conditions and flora as a result of on-going projects of the Fire Learning Network and LANDFIRE projects at Great Basin National Park in eastern Nevada and the Wassuk Range in western Nevada. Building on the experience with these projects, draft biophysical settings were modified by Louis Provencher to conform with the definitions of replacement, mixed severity, and surface fire proposed by LANDFIRE (Louis Provencher was the LANDFIRE lead for vegetation modeling of the Great Basin region). New a-spatial core reference condition models for the Grouse Creek Mountains-Raft River Mountains landscape were simpler as a result of using standard definitions of fire severity. Therefore, the current descriptions and models used here generally differed from LANDFIRE's data products. The 17 biophysical settings descriptions based on the LANDFIRE format are presented in Appendix I.

3.3. A-spatial state-and-transitions management models

A-spatial state-and-transition management models were developed for each biophysical setting in three phases to describe as simply as possible the current condition of vegetation. During the first workshop from 23-25 January 2007, five "generic" computer models were developed by adding to the core reference condition models for the following biophysical settings: black sagebrush (*Artemisia nova*), montane riparian, mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana*), basin wildrye (*Elymus cinereus*), and seral aspen (*Populus tremuloides-Abies concolor*). Between the first and second workshops, 12 additional models were created by Louis Provencher using ecologically equivalent reference condition models from elsewhere and adding to them the relevant information from the first 5 models of workshop #1. Furthermore, the mountain big sagebrush core model was split into upland and mountain versions. Before workshop #2, all 17 state-and-transition models except mountain riparian, stable and seral aspen, and wet meadow, were reviewed in detail by Shane Green from NRCS. Participants spent considerable time on the four systems that were not reviewed by Shane Green, during the first workshop. Vegetation condition of each biophysical setting was represented by states (vegetation categories separated by at least one ecological threshold) and phases (different condition of vegetation within the same state) that are succinctly described in Table 2). The phases and states of all biophysical settings are shown in Figure 5.

Table 2. Descriptions of 17 biophysical settings' vegetation classes for the Grouse Creek Mountains-Raft River Mountains, Utah.

Class Code[1]	Class abbreviation and brief description
STABLE ASPEN 1011[2]	
A	*Early*; 0-100% cover of aspen <5m tall
B	*Mid*1*-closed*; 40-99% cover of aspen <5-10m
C	Na
D	*Late*1*-open*; 0-39% cover of aspen 10-25 m, 0-25% conifer cover 10-25 m
E	*Late*1*-closed*; 40-99% cover of aspen 10-25m; few conifers in mid-story
U	*NAS-early*: No-Aspen-early; 0-10% canopy of mountain sage/mountain brush, >50% grass/forb cover
U	*NAS-Mid--open*: No-Aspen-mid-open; 11-30% cover of mountain sage/mountain shrub, >50% herbaceous cover
U	*NAS-Mid--closed*: No-Aspen-mid-closed; 31-50% cover of mountain sage/mountain brush, 25-50% herbaceous cover, <10% conifer sapling cover

U	*NAS-Late-open*: No-Aspen-late-open; 10-30% cover of conifer <10m, 25-40% cover of mountain sage/mountain brush, <30% herbaceous cover,
U	*NAS-Late-closed*: No-Aspen-late-closed; 31-80% conifer cover 10-25m, 6-20% shrub cover, <20% herbaceous cover
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
PINYON-JUNIPER 1019	
A	*Early-open*: 0-20% herbaceous cover
B	*Mid1-open*: 11-20% cover big sage or black sage <1.0m, 10-40% herbaceous cover
C	*Mid2-open*: 11-30% cover of pinyon and/or juniper <5m, 10-40% shrub cover, <20% herbaceous cover
D	*Late1-open*: old growth, 31-50% cover of pinyon and/or juniper <5m-9m, 10-40% shrub cover, <20% herbaceous cover
E	Na
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	*SENN*: Seeded-Non-Native; native or non-native (crested wheatgrass, forage kochia) seed mix cover 5-20%
MONTANE-SUBALPINE MIXED CONIFERS 1052	
A	*Early*: 0-29yrs; 0-15% cover of tree/shrub/grass; <5m
B	*Mid1-closed*: 30-99yrs; 35-100% cover of conifers <24m
C	*Mid1-open*: 31-99yrs; 0-35% cover of conifers <24m
D	*Late1-open*: 100-999yrs; 0-35% cover of conifers 25-49m
E	*Late1-closed*: 100-999yrs; 35-100% cover of conifers 25-49m
SERAL ASPEN 1061	
A	*Early*:0-100% cover aspen <5m
B	*Mid1-closed*: 40-99% cover aspen <5-10m
C	*Mid2-closed*: 40-99% cover aspen 10-24m
D	*Late1-open*: 0-39% cover aspen 10-25 m, 0-25% conifer cover 5-10 m
E	*Late1-closed*: 40-80% cover of conifer 10-50m; <40% cover of aspen 10-25m
U	*NAS-Early*: No-Aspen-early; 0-29yrs; 0-15% cover of tree/shrub/grass; <5m
U	*NAS-Mid1-closed*: No-Aspen-mid-closed; 30-99yrs; 35-100% cover of conifers <24m
U	*NAS-Mid1-open*: No-Aspen-mid1-closed; 31-99yrs; 0-35% cover of conifers <24m

U	*NAS-Late*1*-open*: No-Aspen-late1-open; 100-999yrs; 0-35% cover of conifers 25-49m
U	*NAS-Late*1*-closed*: No-Aspen-late1-closed; 100-999yrs; 35-100% cover of conifers 25-49m
MOUNTAIN MAHOGANY 1062	
A	*Early*: 30-45% cover of mountain mahogany, <3m
B	*Mid*1*-Closed*: 30-45% cover of mountain mahogany, 5-10m
C	*Mid*1*-Open*: 10-30% cover mountain mahogany, 0-5m
D	*Late*1*-Open*: 0-30% cover of mountain mahogany, 5-25m
E	*Late*1*-Closed*: 30-55% cover of mountain mahogany, 5-25m
U	*TrAG*: Tree-Annual-Grass; 0-30% cover of mountain mahogany, 5-25m, 5-20% cheatgrass cover
U	*AG*: Annual-Grasses; 5-30% cheatgrass cover
U	*SENN*: Seeded-Non-Native; native or non-native (crested wheatgrass, forage kochia) seed mix cover 5-20%
MIXED SALT DESERT SCRUB 1081	
A	*Early*: 0-5% cover of shadscale or other shrubs <0.5m
B	*Mid*1-open: 5-20% cover shadscale or other shrubs <0.5m
C	*Mid*2-open: 5-20% cover budsage <0.25m
D	Na
E	Na
U	*ShAG*: Shrub-Annual-Grass; 5-20% cover of shadscale or other shrubs <0.5m, 0-20% cheatgrass cover
U	*AG*: Annual-Grasses; 5-30% cheatgrass cover
U	*SENN*: Seeded-Non-Native; Seeded-Non-Native; native or non-native (crested wheatgrass, forage kochia) seed mix cover 5-20%
MONTANE-SUBALPINE GRASSLAND 1146	
A	*Early*: 0-10% cover of graminoids
B	*Mid--closed*: 11-30% cover of graminoids
C	*Late-closed*: 31-50% cover of graminoids; shrub and tree cover 10-30%
D	Na
E	Na
U	*HVG-open*: Heavily-Grazed-Grassland; 0-10% cover of less palatable graminoids; bareground cover 10-30%; 10-30% tree cover
U	*HVG-closed*: Heavily-Grazed-Grassland; 10-20% cover of less palatable graminoids; bareground cover 10-30%; 10-30% tree cover
U	*TrEnc*: Tree-Encroached; 30-60% cover of shrubs and trees
GREASEWOOD 1153	
A	*Early*: 0-15% herbaceous cover

B	*Mid--closed*: 15-25% greasewood cover
C	Na
D	Na
E	Na
U	Sh*AG*: Shrub-Annual-Grass; 5-20% cover of greasewood <0.5m, 0-20% cheatgrass cover
U	*AG*: Annual-Grasses; 5-30% cheatgrass cover
U	*SENN*: Seeded-Non-Native; Seeded-Non-Native; native or non-native (crested wheatgrass, forage kochia) seed mix cover 5-20%
MONTANE RIPARIAN 1154	
A	*Early*: 0-4 yrs; 0-50% cover of riparian shrubs (willow, cottonwood, buffaloberry); <3m
B	Na
C	*Mid*1*-open*: 5-19yrs; 31-100% cover of riparian trees <10m
D	Na
E	*Late*1*-closed*: 20-999yrs; 31-100% cover of riparian trees 10-24m
U	*HVG*: Heavily-Grazed; 0-30% cover of shrubs and trees >3m
U	*EXF*: Exotic-Forbs; 20-100% cover of exotic forbs (knapweed, tall whitetop, purple loosestrife), salt cedar, or Russian olive
U	*DRY*: Dry-Channel; Dewatered channel; <10% cover riparian trees; <50% cover shrubs
U	*PAS*: Pasture; Floodplain pasture; might be irrigated; 30-100% cover of perennial grasses
U	*DES*: Desertification; Entrenched river/creek with 10-50% cover of upland shrubs (e.g., big sage)
LOW SAGEBRUSH 1079AA	
A	*Early*: 0-10% cover of rabbitbrush and grasses
B	*Mid*1*-open*: 11-20% cover of low sage <0.5m, 5-20% herbaceous cover
C	Na
D	Na
E	*Late*1*-open*: cover of trees 0-10% <5m; 10-25% cover of low sage, 5-20% herbaceous cover
U	*ShAG*: Shrub-Annual-Grass; 5-20% cover of low sage <0.5m, 0-15% cheatgrass cover
U	*AG*: Annual-Grasses; 5-20% cheatgrass cover
U	*TrEnc*: Tree-Encroached; 10-30% cover of trees; <5% herbaceous cover
U	*CWG*: Crested-Wheatgrass-Monoculture; 10-40% cover of crested wheatgrass
BLACK SAGEBRUSH 1079AN	
A	*Early*: 0-10% herbaceous cover, 5% cover of rabbitbrush
B	*Mid--open*: 11-30% black sage <0.5m, 10-30% cover of grasses

C	Na
D	*Late-open*: 0-10% tree cover <5m, 10-25% cover low sage
E	*Late-closed*: 11-40% cover of trees 5-9m, <5% herbaceous cover
U	*ShAG*: Shrub-Annual-Grass; 10-30% black sage <0.5m, 10-30% cover of cheatgrass
U	*AG*: Annual-Grasses; 20-30% cheatgrass cover
U	*TrAG*: Tree-Annual-Grass; 11-40% cover of trees 5-9m, <10% cheatgrass cover
U	*SENN*: Seeded-Non-Native; 10-40% cover of crested wheatgrass or forage kochia
Basin Wildrye 1080BW	
A	*Early*: 0-20% cover of basin wildrye
B	*Mid--Closed*: 21-80% cover of basin wildrye
C	Na
D	*Late-open*: 11-20% cover of big sage; <75% cover of basin wildrye
E	Na
U	*ShAG*: Shrub-Annual-Grass; 11-20% cover of big sage; 11-30% basin wildrye; <30% cover of cheatgrass
U	*AG*: Annual-Grass; 10-40% cover of cheatgrass
U	*TrEnc*: Tree-Encroached; 10-40% cover of conifers
U	*EXF*: Exotic-Forbs; 20-100% exotic forbs (knapweed, tall whitetop, purple loosestrife)
U	*SENN*: Seeded-Non-Native; 10-40% cover of native grasses (basin wildrye), crested wheatgrass, or forage kochia
U	*ESH*: *Early*-Shrub; 0-40% cover of rabbitbrush species
Wyoming Big Sagebrush semi-desert 1080SD	
A	*Early*: 10-25% herbaceous cover, <10% cover of rabbitbrush species and Wyoming big sage
B	Na
C	*Mid-open*: 11-20% cover Wyoming big sagebrush, 10-25% herbaceous cover
D	Na
E	*Late-closed*: 20-40% cover of Wyoming big sage; <15% native herbaceous cover
U	*ShAG*" Shrub-Annual-Grass; 20-40% cover of Wyoming big sage; <20% cheatgrass cover
U	*AG*: Annual-Grass; 10-40% cover of cheatgrass
U	*TrEnc*: Tree-Encroached; 10-40% cover of pinyon or juniper
U	*SENN*: Seeded-Non-Native; 10-40% cover of crested wheatgrass or forage kochia
U	*ShCWG*: Shrub-Crested-Wheatgrass; 10-30% cover of Wyoming big sage, <20% crested wheatgrass cover

WYOMING BIG SAGEBRUSH UPLAND 1080UP	
A	*Early*: 20-40% herbaceous cover, <10% cover of rabbitbrush species and Wyoming big sage
B	*Mid*1-*open*: 11-20% cover Wyoming big sagebrush, 10-40% herbaceous cover
C	*Late*1-*closed:* 20-40% cover of Wyoming big sage; <20% native herbaceous cover
D	*Late*2-*open*: 0-10% pinyon or juniper <5m tall, 20-30% cover of Wyoming big sage; <10% native herbaceous cover
E	*Late*2-*closed*: 11-60% pinyon or juniper <10m tall, 10% cover of Wyoming big sage; <10% native herbaceous cover
U	*ShAG*: Shrub-Annual-Grass; 10-30% Wyoming big sage <0.5m, 10-30% cover cheatgrass
U	*AG*: Annual-Grass; 10-40% cover of cheatgrass
U	*TrAG*: Tree-Annual-Grass; 11-60% cover of trees 5-9m, <20% cheatgrass cover
U	*SENN*: Seeded-Non-Native; 10-40% cover of native grasses, crested wheatgrass, or forage kochia
U	*CWG*: Crested-Wheatgrass-Monoculture; 10-40% cover of crested wheatgrass or forage kochia
MOUNTAIN BIG SAGEBRUSH MOUNTAIN 1126MT	
A	*Early*: 0-10% canopy of mountain sage/mountain brush, >50% grass/forb cover
B	*Mid--open*: 11-30% cover of mountain sage/mountain shrub, >50% herbaceous cover
C	*Mid—closed*: 31-50% cover of mountain sage/mountain brush, 25-50% herbaceous cover, <10% conifer sapling cover
D	*Late-open*: 10-30% cover conifer <10m, 25-40% cover of mountain sage/mountain brush, <30% herbaceous cover,
E	*Late-closed*: 31-80% conifer cover 10-25m, 6-20% shrub cover, <20% herbaceous cover
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
MOUNTAIN BIG SAGEBRUSH UPLAND 1126UP	
A	*Early*: 0-10% canopy of mountain sage/mountain brush, >50% grass/forb cover
B	*Mid--open*: 11-30% cover of mountain sage/mountain shrub, >50% herbaceous cover

C	*Mid—closed*: 31-50% cover of mountain sage/mountain brush, 25-50% herbaceous cover, <10% conifer sapling cover
D	*Late-open*: 10-30% cover conifer <10m, 25-40% cover of mountain sage/mountain brush, <30% herbaceous cover,
E	*Late-closed*: 31-80% conifer cover 10-25m, 6-20% shrub cover, <20% herbaceous cover
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
U	*DPL*: Depleted; 31-50% cover of mountain sage/mountain brush, <5% herbaceous cover, <10% conifer sapling cover
U	*ShAG*: Shrub-Annual-Grass; 31-50% cover of mountain sage/mountain brush, 5-40% cheatgrass cover, <10% conifer sapling cover
WET MEADOW 1145WM	
A	*Early*-open: 0-60% herbaceous cover
B	*Mid*--closed: 61-100% herbaceous cover
C	Na
D	*Late*-open: 0-10% tree-shrub cover, 60-80% herbaceous cover
E	Na
U	*HVG*-open: Heavily-Grazed-Meadow; 0-10% cover of less palatable grasses and forbs; bareground 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

[1]: *LANDFIRE codes generally defined as A = early-development, B = mid-development & closed canopy, C = mid-development & open canopy, D = late-development & open canopy, E = late-development & closed canopy, and U = uncharacteristic of the reference condition due to non-native or native species.*
[2]: *LANDFIRE or project code of the biophysical settings without the map zone code. The code is used in the computer modeling software.*

A-spatial state-and-transition models of biophysical settings were created with the software Vegetation Dynamics Development Tool (VDDT from ESSA Technologies, Ltd.; Barrett, 2001; Beukema et al., 2003b; Forbis et al., 2006). VDDT is the interagency software used by the Fire Regime Condition Class group (www.frcc.gov) and LANDFIRE. VDDT was also applied to BLM management projects (Forbis et al. 2006, Provencher et al. 2007). 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 polygon 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, wildfire). Model parameters (succession duration and disturbance rates) are presented in Appendix II and the VDDT database is available at http://www.tncfire.org/UPCD_report.doc.

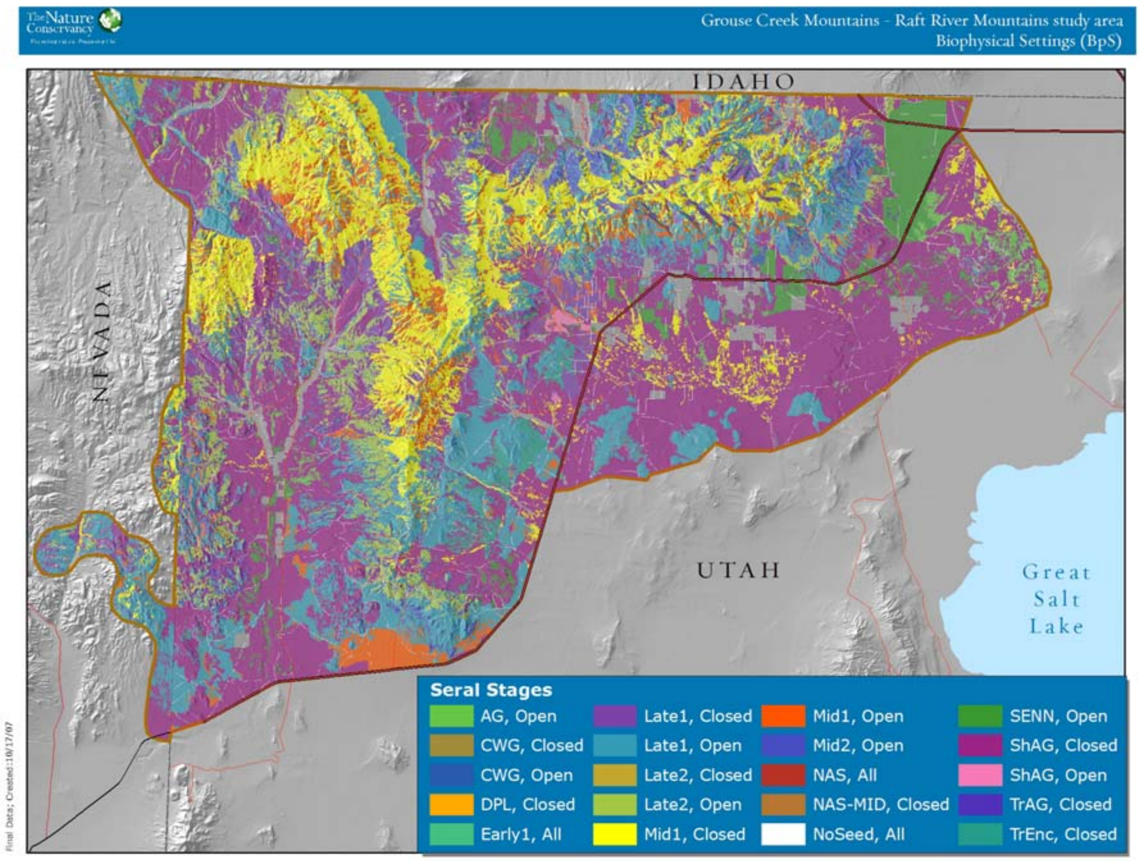


Figure 5. States and phases of biophysical settings for the Grouse Creek Mountains-Raft River Mountains, Utah.

3.4. Spatial scenario modeling

Ten spatially defined management scenarios each encompassing dozens of management actions (for example, prescribed burning) were created during the second workshop from 14-16 March 2007. A management scenario consists of a set of many potential management actions and constraints similar to alternatives proposed in BLM Resource Management Plans and USFS Forest Plans. Additionally, one other pre-requisite scenario was run to estimate benchmarks against which to measure the success of the cumulative impacts and the 10 management scenarios (BENCHMARK SCENARIO A, Table

3). To support scenario development, agency budgets per action and agency constraints/priorities were fleshed out in detail. Without these budgets and constraints information, it is not possible to spatially simulate scenarios. All scenarios are briefly summarized in Table 3.

Table 3. Brief descriptions of the spatial management scenarios for the Grouse Creek Mountains – Raft River Mountains, Utah.

BENCHMARK SCENARIOS

A. SPATIAL REFERENCE CONDITION

A fundamental scenario that was needed to spatially redefine the natural range of variability and measure success of other scenarios in moving the landscape towards this reference or baseline condition. The natural range of variability is the distribution of vegetation development classes per potential natural vegetation type and the distribution of fire types and return intervals in the *pre-settlement* or *naturally functioning* landscape. Partners initially chose non-spatial definitions of the natural range of variability because they were readily obtained from the non-spatial models, which were closely based on LANDFIRE models for the reference condition. Because the spread of fire changes with vegetation composition and position, it is expected that the natural range of variability will differ when fire can move among biophysical settings versus fire not being allowed to influence neighboring cells (for example, a 100-acre patch of mountain big sagebrush surrounded by extensive low sagebrush should burn less often than the same patch surrounded by more mountain big sagebrush). Therefore, all non-spatial models were simulated in the Grouse Creek Mountains – Raft River Mountains landscape using pre-settlement conditions (no European management or disturbances).

MANAGEMENT ALTERNATIVES

1. OWNERSHIP BOUNDARIES

The purpose of this scenario was to test whether or not the boundaries between BLM, USFS and private lands affect the ability of managers to reach the natural range of variability. The baseline version of this scenario used the management actions defined and budgeted by partners during the second workshop (for example, the BLM treats Y acres with herbicide at $X/acre whereas private landowners use half as much for $Z/acre) and respected the frequency of management actions and budgets by agency land ownership. The alternative version of this scenario was to ignore all political boundaries and apply an average budget (for example, this might be a Division of Wildlife Resources project funded with public monies and subject to public constraints) to all landscapes.

2. BIOPHYSICAL SETTINGS MANAGEMENT PRIORITIES

This scenario assumed that different biophysical settings do not have equal priorities for managers. The scenario allocated funds only to biophysical settings with the highest management priority. Three criteria were used to establish joint priorities (Table 4). The first level of decision placed greater priority on biophysical settings that have the greatest ability to successfully respond to plant seeding (1 is highest and 3 is lowest priority). In this case, only biophysical settings with priority 1 and 2 receive treatment. The second level of decision determined whether or not treating late-succession phases of vegetation to early- or mid-succession phases was possible or desirable, based mostly on avoiding a release of cheatgrass. For this level, only biophysical settings with priority 1 receive treatment. The third decision level is binary and assigns a greater priority to managing biophysical settings susceptible to exotic forbs invasion (wet to moist systems).

3. FUEL BREAKS

This scenario created 30-meter fire breaks for every paved and mapped dirt road to contain cheatgrass-driven fires. Fire breaks consisted of a non-native mix of forage kochia and crested wheatgrass. In this landscape, the amount of fire occurring on the landscape was limited by the number of ignitions.

4. ADJACENCY TO DESIRABLE TYPES

The purpose of this scenario was to strategically increase the size of habitat that is desirable because it belongs to the vegetation phases of the reference condition or benefits animal species of special concern (for example, a wildlife seed mix). The scenario preferentially selected polygons for treatment that were in proximity to vegetation phases or states deemed desirable.

For scenarios #5-#7, we selected the best scenario from the previous ones, based on the similarity to the natural range of variability, as the baseline with its management actions. We selected the best scenario to minimize the number of computer simulations while focusing on the variation among the most different scenarios. Therefore, the following scenarios were considered fine-tuning of previous scenarios.

5. INCREASING SERAL COMPLEXITY

The goal of this scenario was to create habitat that might more closely resemble the spatial natural range of variability and increase the suitability of vegetation for greater sage-grouse, mule deer, and perhaps other species. The scenario was implemented by preferentially placing adjacent treatments whose successional “outcome” (for example, early-succession phases) differ from the succession “outcomes” of past treatments already in place. In other words, this scenario sought to reduce homogeneous habitats.

6. REDUCTION OF BUDGET LINE ITEMS

This scenario sought to examine the effects of reducing the cost of three management actions that contribute a large proportion to the total budget. These budget items were: cost of archeological surveys, cost of seed mix, and cost of mechanical woody canopy reduction. Current cost estimates were obtained from partners based on real estimates from public and private lands, and cost of management actions obtained from NRCS’s website. Reduced cost estimates were derived from private lands costs: (a) Predictive GIS modeling and expert knowledge were used to focus archeological surveys in areas of higher probability of finding artifacts; (b) Native and introduced species seed were purchased on the private market and in bulk, and required a lower seed weight per acre because a more efficient seeder was used; and (c) Chaining replaced more expensive mechanical methods.

7. ADJACENCY TO COMMUNITIES AT RISK

The scenario focused resources on restoring the biophysical settings within 2 kilometers of a human community considered at risk. Because most of these settlements are at lower elevation, restoration implies treatment of tree encroachment and cheatgrass invasion.

SENSITIVITY ANALYSES
8. Exotic Dispersal
This scenario simulated variation in the short-distance and long-distance dispersal of exotic forb seeds because uncertainty existed about these parameters. The short-distance dispersal is represented by a negative exponential decay curve with different shapes, whereas the long-distance spread consists of a random number of inoculations at a certain distance from the point of origin. The scenario is modeled through sensitivity analysis where the shape of the short-distance shape parameter and the number of random inoculations are determined by selecting values with a random number generator.
9. Annual Grass Invasion
This scenario was conducted exactly as the Exotic Dispersal scenario, except that annual grass dispersal was modeled. Dr. Susan Meyer from the USDA Shrub Sciences Laboratory provided critical values for short-distance and long-distance dispersal. Cheatgrass seed dispersal is more long distance than for exotic forb seed dispersal.
10. Excessive Herbivory
The purpose of this scenario was to measure the contribution of excessive herbivory to the landscape's departure from the natural range of variability. An underlying assumption of all scenarios, except the *Spatial Reference Condition*, was that livestock grazing followed best management practices and did not generally cause a change of vegetation phases or states. For this scenario, excessive herbivory only is defined as livestock grazing that did not follow best management practices and caused a change in vegetation phases and states. Excessive herbivory was controlled by its frequency of occurrence and its effect on accelerating woody succession. We assumed that excessive herbivory was uncommon in the landscape; therefore we used sensitivity analysis to vary the parameter accelerating woody succession.

The core and most important to partners scenarios were #1 to #4. Scenarios #5 to #7 could be labeled fine-tuning or secondary scenarios. They were designed either because partners (a) thought it would be good to know more about their particular outcomes but did not view them as core strategies or (b) the information behind the new scenarios was plausible but not well established. As such, these fine-tuning scenarios were run on the best performing combinations of scenarios #1 to #4. Scenarios #8-#10 were sensitivity analyses applied only to scenarios #1-#4 for uncertain parameter values, namely those for cheatgrass invasion rates, exotic forb invasion rates, and excessive livestock herbivory intensity. Whether or not results of the main scenarios (#1 to #4) varied with variation in these uncertain parameters did not involve new budgets or management constraints to be defined because we simply added their variation to the main scenarios. This variation was simply modeled by one low and one high value (see section 3.6 for values).

Perhaps the most fundamental pieces of information used to create management scenarios were the budgets from the BLM, USFS, and private landowners reported as the cost per acre and the average area treated for each major activity (for example, prescribed fire). Budget information expressed as area limits to management activities were implemented in TELSA (also in VDDT during workshops). Budget information was obtained from partners between the first and second workshops and further developed during the second workshop. Table 5 is a summary of budget information. We assumed that the cost of management actions for the BLM and USFS were sufficiently similar that we did not need to create two distinct public lands budgets.

Table 4. Biophysical settings and management priority ranks for the 1.1 million-acre Grouse Creek Mountains-Raft River Mountains project area. Priority ranks reflect three different measures of return on the investment from applying management actions. Priorities A and B should be viewed as potential responses following different types of management, whereas priority C was strictly about action to abate an urgent threat.

Biophysical Settings	Priority A: Successful response to seeding[1]	Priority B: Low risk of cheatgrass release after treatment not requiring seeding	Priority C: High urgency to control exotic forbs and trees
Mixed Conifers	na	1	na
Montane Riparian	na	na	1
Montane-Subalpine Grassland	na	1	na
Mountain Big Sagebrush-mountain	na	1	na
Seral Aspen	na	1	na
Stable Aspen	na	1	na
Wet Meadow	na	1	1
Basin Wildrye	1	1	1
Mountain Big Sagebrush-upland	2	1	na
Mountain Mahogany	2	na	na
Wyoming Big Sagebrush-upland	2	1	na
Mixed Salt Desert Scrub	2	na	na
Wyoming Big Sagebrush-semi-desert	2	2	na
Black Sagebrush	3	2	na
Greasewood	3	na	na
Low Sagebrush	3	2	na
Pinyon-Juniper	3	na	na

[1] The smaller the number, the higher the priority. *na* means that management of the potential natural vegetation type is not expected to happen or be significant.

All simulations that were run respecting land ownership boundaries used the first budget (CURRENT MANAGEMENT) of Table 5. For simulations that ignored ownership boundaries, we used the sum of the private and public lands budgets throughout the landscape. Partners did not develop this budget during the second workshop; although an example simulation was conducted using the public lands budget. Experts provided cost reduction estimates for archeological surveys, seed mixtures, and mechanical thinning operations used in the REDUCED COSTS budget (Table 5). Partners did not participate in the creation of the SERAL COMPLEXITy and SERAL COMPLEXITY × REDUCED COSTS budgets (Table 5) as these were created after the workshops. An important consequence of imposing budget limits was that if VDDT or TELSA simulations reached an activity's annual area limit, the rate of that management activity became null (i.e., the money was spent and implementation of that activity stopped for the remainder of the year).

3.5. Mapping biophysical settings and current vegetation condition

TELSA simulations were run on a map of current vegetation condition whose polygons correspond exactly to the states and phases described in the VDDT state-and-transition models (Table 2). An initial map representing the current vegetation polygons of the Grouse Creek Mountains-Raft River Mountains was uploaded into TELSA and was then segmented into smaller "tessellated" polygons (segmentation of polygons into smaller, approximately regular ones that are used for simulations). TELSA modified the initial map as a result of succession and disturbances.

Remote sensing contractor Spatial Solutions created maps of biophysical settings and current vegetation condition from LANDSAT Thematic Mapper imagery (resolution of 25-30m) from 13 June 2006. The Nature Conservancy helped Spatial Solutions with interpretation of vegetation classes as defined in Table 2. The interpreted NRCS soil surveys (described previously) were used as the draft stratification to map biophysical settings mapping and current vegetation condition. An unsupervised classification of the LANDSAT satellite imagery resulted in mapping clusters of spectral classes (combinations of red-blue-green reflectance, defined in Lilles and Kiefer 2000) obtained by thematic stratification that were evaluated against field-based data, existing GIS data, or any other available ancillary data to determine the relationship between the spectral classes from the satellite imagery and current structural vegetation classes per biophysical setting listed in Table 2. As clusters of spectral classes were assigned their appropriate vegetation classes, the unsupervised classification was repeated for the remaining undefined spectral classes. Ancillary data used to help link spectral signatures with their vegetation classes included the U.S. Geological Survey's Digital Elevation Model and U.S. Environmental Protection Agency's ReGAP classification data. GIS models included the use of elevation and aspect zones to correctly assign a structural vegetation class depending on whether or not a biophysical setting was correctly defined. Also, for areas exhibiting spectral anomalies or known errors that could not be efficiently and effectively corrected through further automated image processing techniques, manual editing was infrequently employed after field visits to enhance the thematic accuracy of the final maps.

The most important step of the unsupervised classification was the collection of field data from June 20-23, 2007 for 87 pre-selected sites corresponding to spectral classes of interest that could not be classified or that were tentatively identified to a combination of biophysical settings and structural vegetation classes. These sites are usually small polygons that were used to "train" the software interpreting the imagery. At each field

Table 5. Cost per acre and area treated of restoration actions in public and private ownership categories.

	BUDGET Current Management[1]			
	Public Lands with Archeological Surveys	Private Lands without Archeological Surveys	Total area	Total area

Management Action[2]	(acre)	(cost/acre)	(acre)	(cost/acre)	(acres)	(Ha)
AG-Restoration	1,300.0	$139.00	0.0	$52.00	1,300.0	526.3
Conversion-To-Pasture			50.0	$35.00	50.0	20.2
CWG-Maintenance			500.0	$5.00	500.0	202.4
CWG-Restoration	400.0	$139.00			400.0	161.9
CWG-Seed			100.0	$52.00	100.0	40.5
DPL-Restoration (only 1126up)	500.0	$69.30			500.0	202.4
Exotic-Control	50.0	unk[3]			50.0	20.2
Floodplain-Enlargement					0.0	0.0
Floodplain-Restoration	1.0	unk			1.0	0.4
HVG-Restoration	2.0	unk			2.0	0.8
Canopy-Thinning	100.0	$35.00			100.0	40.5
Riparian-Reclamation					0.0	0.0
RxFire	80.0	$15.00			80.0	32.4
SENN-Maintenance			10.0	$5.00	10.0	4.0
ShAG-Restoration	0.0	$139.00			0.0	0.0
Thin-Mech-Chem-Seed	500.0	$312.00			500.0	202.4
Thin-Sheep					0.0	0.0
Water-Diversion			1.0	unk	1.0	0.4
Weed-Inventory	1,000.0	unk			1,000.0	404.9
	Reduced Costs for Archeological Surveys, Native Seed, and Canopy Thinning[1]					
	Public Lands with Archeological Surveys		Private Lands without Archeological Surveys		Total area	Total area
AG-Restoration	500.0	$79.80	0.0	$52.00	500.0	202.4
Conversion-To-Pasture			50.0	$35.00	50.0	20.2
CWG-Maintenance			500.0	$5.00	500.0	202.4
CWG-Restoration	400.0	$79.80			400.0	161.9
CWG-Seed			100.0	$52.00	100.0	40.5
DPL-Restoration (only 1126up)	400.0	$67.46			400.0	161.9
Exotic-Control	50.0	unk			50.0	20.2
Floodplain-Enlargement					0.0	0.0
Floodplain-Restoration	1.0	unk			1.0	0.4
HVG-Restoration	2.0	unk			2.0	0.8
Canopy-Thinning	5,794.5	$49.50			5,794.5	2,346.0
Riparian-Reclamation					0.0	0.0
RxFire	0.0	$15.00			0.0	0.0
SENN-Maintenance			10.0	$5.00	10.0	4.0
ShAG-Restoration	200.0	$79.80			200.0	81.0
Thin-Mech-Chem-Seed	400.0	$136.50			400.0	161.9
Thin-Sheep					0.0	0.0
Water-Diversion			1.0	unk	1.0	0.4
Weed-Inventory	1,000.0	unk			1,000	404.9
	Seral Complexity[1]					
	Public Lands with Archeological Surveys		Private Lands without Archeological Surveys		Total area	Total area
AG-Restoration	750.0	$139.00	0.0	$52.00	750.0	303.6
Conversion-To-Pasture			50.0	$35.00	50.0	20.2
CWG-Maintenance			500.0	$5.00	500.0	202.4
CWG-Restoration	400.0	$139.00			400.0	161.9

CWG-Seed			100.0	$52.00	100.0	40.5
DPL-Restoration (only 1126up)	500.0	$69.30			500.0	202.4
Exotic-Control	50.0	unk[3]			50.0	20.2
Floodplain-Enlargement					0.0	0.0
Floodplain-Restoration	1.0	unk			1.0	0.4
HVG-Restoration	2.0	unk			2.0	0.8
Canopy-Thinning	2,700.0	$35.00			2,700.0	1,093.1
Riparian-Reclamation					0.0	0.0
RxFire	650.0	$15.00			2,680.0	1,085.1
SENN-Maintenance			10.0	$5.00	10.0	4.0
ShAG-Restoration	0.0	$139.00			0.0	0.0
Thin-Mech-Chem-Seed	250.0	$312.00			250.0	101.2
Thin-Sheep					0.0	0.0
Water-Diversion			1.0	unk	1.0	0.4
Weed-Inventory	1000.0	unk			1000.0	404.9
	Seral Complexity × Reduced Costs[1]					
	Public Lands with Archeological Surveys		Private Lands without Archeological Surveys		Total area	Total area
AG-Restoration	500.0	$139.00	0.0	$52.00	500.0	202.4
Conversion-To-Pasture			50.0	$35.00	50.0	20.2
CWG-Maintenance			500.0	$5.00	500.0	202.4
CWG-Restoration	400.0	$139.00			400.0	161.9
CWG-Seed			100.0	$52.00	100.0	40.5
DPL-Restoration (only 1126up)	400.0	$69.30			400.0	161.9
Exotic-Control	50.0	unk[3]			50.0	20.2
Floodplain-Enlargement					0.0	0.0
Floodplain-Restoration	1.0	unk			1.0	0.4
HVG-Restoration	2.0	unk			2.0	0.8
Canopy-Thinning	4.520.8	$35.00			4,520.0	1,830.3
Riparian-Reclamation					0.0	0.0
RxFire	1,820.0	$15.00			1,820.0	736.8
SENN-Maintenance			10.0	$5.00	10.0	4.0
ShAG-Restoration	0.0	$139.00			0.0	0.0
Thin-Mech-Chem-Seed	250.0	$312.00			200.0	81.0
Thin-Sheep					0.0	0.0
Water-Diversion			1.0	unk	1.0	0.4
Weed-Inventory	1000.0	unk			1000.0	404.9

[1] a) *Current Management* budget reflects current operations for different land managers. BLM and USFS lands were assumed to have similar costs per management actions and archeological surveys. Private lands did not use archeological surveys and were not assumed to use native seed. b) The *Reduced Costs for Archeological Surveys, Native Seed, and Canopy Thinning* budget assumed that the cost of archeological surveys, native seed, and mechanical thinning cost be reduced using estimates from the private sector and chaining, where more expensive mechanical methods are currently used (e.g., hydroaxe). c) The *Seral Complexity* budget focused on increasing canopy thinning and prescribed fire at the expense of intensive mechanical and seeding activities to create reference vegetation classes. Therefore, half of the cost of *Thin-Mech-Chem-Seed* was converted in 50% new acres treated by *RxFire* and 50% more by *Canopy-Thinning*. d) The *Seral Complexity* × *Reduced Costs* budget combined both shifting funds from *Thin-Mech-Chem-Seed* to *RxFire* and *Canopy-Thinning* and reducing the cost of line items described above.

[2] Legend: AG-Restoration = application of herbicide ($17/acre) and mechanical methods ($5/acre with Dixie harrow) preceded by an archeological survey ($35/acre) to convert annual grasslands to either a

seeding made of non-native and native species or relatively pure crested wheatgrass (12 lbs/acre @ $5/acre); Conversion-To-Pasture = private land action to convert riparian floodplain habitat to pasture using non-native pasture seed ($35/acre); CWG-Maintenance = private land action to maintain crested wheatgrass pastures in herbaceous condition by removing shrub ($5/acre); CWG-Restoration = public land action to convert crested wheatgrass pasture to a more native composition (same cost as AG-Restoration); CWG-Seed = private land action to convert shrublands in different condition to crested wheatgrass pasture ($52/acre = $35/acre for seed + $17/acre for either herbicide or mechanical methods); DPL-Restoration = public land action used only in upland mountain big sagebrush to restore mechanically depleted sagebrush to different succession classes of the reference condition ($34.3/acre for seeding with equipment) following an archeological survey ($35/acre); Exotic-Control = public and private lands action to control exotic forb species and saltcedar with herbicide (50 acres completed per year but cost unknown); Floodplain-Enlargement = public and private lands action to restore entrenched riparian floodplain by accelerating formation of lower terraces and wet meadows by mechanically destabilizing entrenched banks (zero acres treated and cost unknown); Floodplain-Restoration = public and private lands action to restore entrenched riparian floodplain using reconstruction of sinuosity, pool and riffle systems, and armoring of headcuts (1 acre treated and cost unknown); HVG-Restoration = public land action to restore heavily grazed riparian floodplain and wet meadows to different succession classes of the reference condition (2 acres per year and cost unknown); Canopy-Thinning = public land action to thin the late-succession canopy of shrublands from the reference condition using various methods requiring no seeding ($35/acre for mowing and brush-beating methods or $49.50/acre for chaining); Riparian-Reclamation = private land action to convert pasture to native riparian habitat (0 acres treated and cost unknown); RxFire = public land action of prescribed fire ignited by hand ($15/acre); SENN-Maintenance = private land action to prevent shrub lands seeded with a mixture of species favorable to wildlife from succeeding to more native shrub cover ($5/acre); ShAG-Restoration = public land action to restore shrublands with an understory of annual grass to either the early successional phase of the reference condition or a seeded non-native/native state (same cost as AG-Restoration); Thin-Mech-Chem-Seed = public land action with archeological survey ($35/acre) to restore either the tree-encroached or tree-with-annual-grass states to a seeded non-native/native mixture using mechanical thinning of trees (lop and scatter for $200/acre), herbicide application ($17/acre),and seeding ($60/acre); Thin-Sheep = public land action to selectively use dormant season sheep browsing to reduce woody canopy cover (0 acres treated and cost unknown); Water-Diversion = private land action permitted by a water right to divert water from a natural streambed (1 acre per year and cost unknown); and Weed-Inventory = public and private land action to detect exotic forb and saltcedar invasion (1,000 acres per year and cost unknown).

site, a set of digital photographs were taken and visual estimates of existing vegetative cover were made to fully characterize the current vegetation type, current structural vegetation class from Table 2, and current vegetative canopy cover (e.g. open or closed). In addition, hundreds of geographically positioned remote sensing notes taken while driving throughout the landscape were entered directly on the imagery. These notes described the biophysical setting and state or phase of the polygon observed on the imagery. When errors were found in NRCS soil surveys, a critical tool for mapping biophysical settings and providing accurate interpretation of current condition was to assign biophysical settings according to the decreasing order of known correlation between soils and dominant species. Biophysical settings that are closely correlated to soil characteristics are low sagebrush, black sagebrush, curlleaf mountain mahogany, and mixed salt desert scrub. It could be safely assumed that these ecological communities were present during pre-settlement if they are present today at the same locations because they are dependent on stable soil characteristics that are generally unfavorable to other species. All other major vegetation types, such as mountain big sagebrush, mountain shrubland, Wyoming big sagebrush, pinyon-juniper woodlands, aspen woodlands, basin wildrye loamy bottoms, wet meadows, mixed conifers, and riparian corridors were harder to map by remote sensing because significant alterations to disturbance regimes might "hide" or "exaggerate" them (for example, pinyon and juniper can overtake many ecological systems that are true shrublands). Therefore, additional care was applied to these later types. The greatest challenge in Great Basin shrublands was determining whether or not pinyon and juniper are invading shrublands or represent true pinyon-juniper woodlands. Our main diagnostic tools were to determine if a) trees were conical, therefore less than 100 years old and perhaps encroaching shrublands, b) the understory contained several skeletons of dead sagebrush (indicator of encroached shrubland), and c) the herbaceous understory was absent or very reduced (indicator of encroached shrubland).

The field data, other data, and remote sensing analysis created two maps of biophysical settings and current structural vegetation classes. These maps in grid format (i.e., pixels) were delivered to The Nature Conservancy at 25-meter resolution and then processed for use in TELSA. Processing was a complex set of clean-up and overlay GIS operations. Steps for image processing were:

1. Converting the grid map to a polygon map;
2. Translating the vegetation class names and codes used by Spatial Solutions to the numeric codes required by TELSA;
3. Carving out of the landscape the non-modeled areas, which were agricultural lands, towns, and water bodies;
4. Eliminating all polygons <1ha by merging them with the polygon of vegetation condition that borders them most;
5. Bordering every mapped paved and dirt roads with a polygon of 30 meters called "fuel break" in the non-seeded state; and
6. Eliminating all polygons <1ha created by the overlay of fuel break polygons by merging them with the polygon of vegetation condition that borders them.

The resulting map of current vegetation condition was the foundation to simulate the 10 management scenarios. For the cumulative impact analysis, additional map preparation was required. We converted polygons observed in the GIS-processed current vegetation condition map of 2006 that overlapped with vegetation management projects from the last 5 years to the state or phase that they would most likely have been before they were treated. Polygons representing past fires, fire rehabilitation projects, and vegetation or fuels treatment projects were supplied by partners. Unfortunately, the determination of pre-treatment vegetation condition, which was required for our analysis, was not included in the partner's GIS data. Therefore, subjectivity and personal communications were used to assign pre-treatment vegetation condition to agency and private projects. One important assumption we made was that all fires in the lower and mid-elevation biophysical settings became annual grasslands (AG) the year during or after the fire but before treatment. Pre-fire classification of vegetation condition was therefore always annual grassland. In all other cases that were not wildfires at those elevations, we assigned the state of vegetation remembered by partners. When partner information was unavailable, we assigned the vegetation condition of the same biophysical setting that currently bordered most the treated area, thereby assuming that the surrounding vegetation did not change in 5 years. In some cases, the new treatment polygons created areas <1ha. These were eliminated using the same step as above.

Using TELSA and GIS software, the processed current vegetation map was tessellated, priority and planning zones overlaid on it, and simulated.

3.6. Setting up and running computer simulations

Table 3 provides a brief narrative of each scenario. Scenarios were tested with two experimental designs. We used a fractional design (Wu and Hamada 2000) to structure the four core scenarios and three sensitivity scenarios as 16 runs. The fractional design was chosen because it allowed us to conduct a feasible number of computer simulations in a timely fashion. Fractional designs test a subset of main and interaction effects while confounding them with a large number of two-way, three-way, and N-way interactions. These confounded interactions called aliases provide the error terms to conduct statistical significance tests, but also pose a risk that the alias might have more influence than the factor apparently tested. The main and interaction effects chosen for testing are obtain by conducting ad hoc alternative statistical models and choosing the most credible one. This most credible model then becomes the final model. The main factors were Ownership Boundaries, Biophysical Settings Priorities, Fuel Breaks, Adjacency to Desirable Types, Exotic Forb Dispersal, Cheatgrass Dispersal, and Excessive Herbivory (Table 6a). Each row of Table 6b represents a simulation type (a combination of presence/low or absence/high for factors) that was replicated once for this report. Statistics were applied to simulations results to test for the effects of each factor and the interactions of all two-factor combinations. All three-factor interactions were used for the error term to test the main and two-faction interactions.

Secondary scenarios were structured as a factorial design (Steel and Torrie 1980) to test only main factors, which were Increasing Seral Complexity, Reduction of Budget Items, and Adjacency to Communities at Risk (Table 7). These simulations were run using as baseline the best simulation from past factorial simulation results of the core scenarios as defined by being closest to the natural range of variability (smallest ecological departure). The best run from past factorial results was the NO-NB-F-A scenario combination, which means that funding was not maintained within ownership, no management priorities were assigned to biophysical settings, fuel breaks were implement along roads, and treatments were placed adjacent to desirable vegetation classes. Therefore, a total of eight runs were conducted for the factorial design.

Table 6a. Levels of core and sensitivity scenarios.

Scenarios	Decision Values

CORE		
Funding by Ownership Boundaries	yes	no
Biophysical Settings Priorities	yes	no
Fuel Breaks	yes	no
Adjacency to Desirable Types	yes	no
SENSITIVITY	LOW	HIGH
Cheatgrass Dispersal[&]	100 starts/year	1,000 starts/year
Exotic Forb Dispersal[#]	0.5	2.0
Excessive Herbivory[#]	0.5	2.0

[&] Number of long distance starts.
[#] Multiplier of the probability/year value found in both VDDT and TELSA versions of models.

Table 6b. Fractional design structure of core and sensitivity scenarios.

Run ID	Fractional Treatment Combination	Scenario Decision						
		Funding by Ownership Boundaries A[&]	Biophysical Settings Priorities B	Fuel Breaks C	Adjacency to Desirable Types D	Cheatgrass Dispersal E= ABC	Exotic Forb Dispersal F = DCD	Excessive Herbivory G =ACD
1	-	no	no	no	no	low	low	low
2	AEG	yes	no	no	no	high	low	high
3	BEF	no	yes	no	no	high	high	low
4	ABFG	yes	yes	no	no	low	high	high
5	CEFG	no	no	yes	no	high	high	high
6	ACF	yes	no	yes	no	low	high	low
7	BCG	no	yes	yes	no	low	low	high
8	ABCE	yes	yes	yes	no	high	low	low
9	DFG	no	no	no	yes	low	high	high
10	ADEF	yes	no	no	yes	high	high	low
11	BDEG	no	yes	no	yes	high	low	high
12	ABD	yes	yes	no	yes	low	low	low
13	CDE	no	no	yes	yes	high	low	low
14	ACDG	yes	no	yes	yes	low	low	high
15	BCDF	no	yes	yes	yes	low	high	low
16	ABCDEFG	yes	yes	yes	yes	high	high	high

[&] Alias structure:

Main effects	**Two-factor interactions**	**Three-factor interactions**
A=BCE=DEF=CDG=BFG	AB=CE=FG	ABD=CDE=ACF=BEF=BCG=AEG=DFG
B=ACE=CDF=DEG=AFG	AC=BE=DG	
C=ABE=BDF=ADG=EFG	AD=EF=CG	
D=BCF=AEF=ACG=BEG	AE=BC=DF	
E=ABC=ADF=BDG=CFG	AF=DE=BG	
F=BCD=ADE=ABG=CEG	AG=CD=BF	
G=ACD=BDE=ABF=CEF	BD=CF=EG	

Table 7. Factorial design structure of secondary scenarios. Values for Exotic Forb Dispersal = 1.0, Cheatgrass Dispersal = 35 starts/year, and Excessive Herbivory =1.0.

	Decisions		
Run ID	Increasing Seral Complexity	Reduction of Budget Line Items	Adjacency to Communities at Risk
1	yes	yes	yes
2	yes	yes	no
3	yes	no	yes
4	yes	no	no
5	no	yes	yes
6	no	yes	no
7	no	no	yes
8	no	no	no

Two key landscape-scale response variables were ecological departure and structural vegetation complexity. Ecological departure, which was our primary measure of management success, is a dissimilarity index (i.e., a form of comparison) between the current range of variability and the natural range of variability. This is also the definition of Fire Regime Condition, the continuous version of the inter-agency metric Fire Regime Condition Class (FRCC) (Provencher et al. *in press*). The current range of variability is the proportions of reference and uncharacteristic vegetation classes in the landscape. Ecological departure is calculated as:

$$\text{Ecological Departure} = 100\% - \sum_{i=1}^{n} \min\{Current_i, NRV_i\},$$

where $Current_i$ is the current range of variability for vegetation class $i=\{1,\ldots, n)$ and NRV_i is the natural range of variability for vegetation class i.

The complexity of structural vegetation classes was defined by the different number and diversity of combinations of biophysical settings and succession classes in an area. Division of Wildlife resources staff decided that every combination of *biophysical setting* × *succession vegetation class* was unique and, therefore, counted as a distinct patch. Allowable succession vegetation classes were any *early-development*, *mid-development*, *late-development*, and *seeded non-native (SENN)* classes. This last measure views vegetation from the perspective of both short-ranging and wide-ranging wildlife species such as greater sage-grouse, mule deer, and antelope. The current indices of structural vegetation complexity were compared among simulation runs and to values calculated for the initial map (2006) and the reference map. Structural vegetation complexity was calculated with the software FragStat (McGarigal and Marks 1995) using two robust indices: patch richness index and Shannon diversity index. Indices were calculated for a

156-acre (63-ha) moving window applied to a 30×30-m raster map (converted from the simulated shape files of the landscape), thus allowing calculation of the mean and standard deviation of each index. Patch richness measures the number of different patches in an area, whereas the Shannon diversity index also takes into account their relative abundance.

3.7. Incorporating variability in fire probabilities over time and historic fire size distributions

It is well known that fire probabilities for different biophysical settings, vegetation states and phases are not constant over time but vary according to external drivers such as temperatures and moisture conditions. Thus during some years that are hot and dry, landscapes are prone to experience a greater number of much larger fires than are normally experienced during most years. This variation could have important implications for the derived benefits from alternative management actions and needs to be considered when simulating these alternatives. To estimate the variability in fire probability over time for the study area we used a fire history obtained from Jeff Kline, BLM, Salt Lake Field Office. The fire history consists of a record for all identified fires in Box Elder County including the date of their occurrence and size. From this record, we derived the total recorded area burned for each year from 1974 to 2006 (Figure 6).

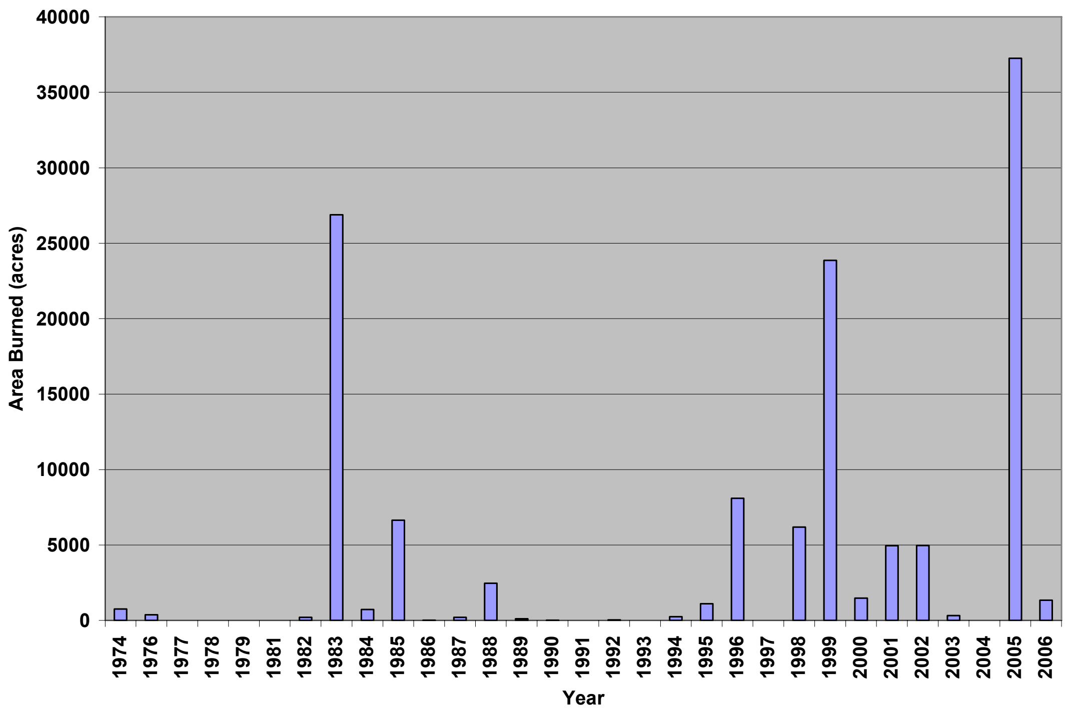


Figure 6. Total area burned in West Box Elder County from 1974 to 2006. Data from Jeff Kline, BLM, Salt Lake Field Office.

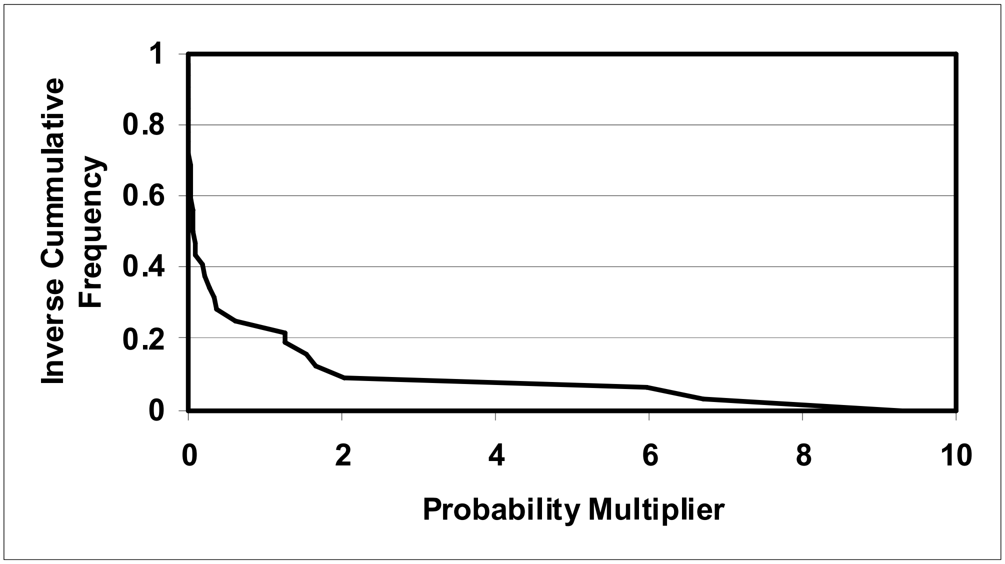


Figure 7. Inverse cumulative frequency for fire probability multiplier based on data from West Box Elder County from 1974 to 2006. Data from Jeff Kline, BLM, Salt Lake Field Office.

We normalized each of these areas in order to represent the amount of fire relative to the average (essentially a fire probability multiplier) and created an inverse cumulative distribution of these multipliers (Figure 7).

From this distribution we can see that over the 32 year period a vast majority of years (>70%) experience less than the average amount of fire (a probability multiplier of less than one; Figure 7), but rarely we see years in which the amount of fire exceeds the average across the entire time period by as much as an order of magnitude. Using this cumulative distribution and a random number generator we created a time series of multipliers to use against our fire probabilities in TELSA (Figure 8).

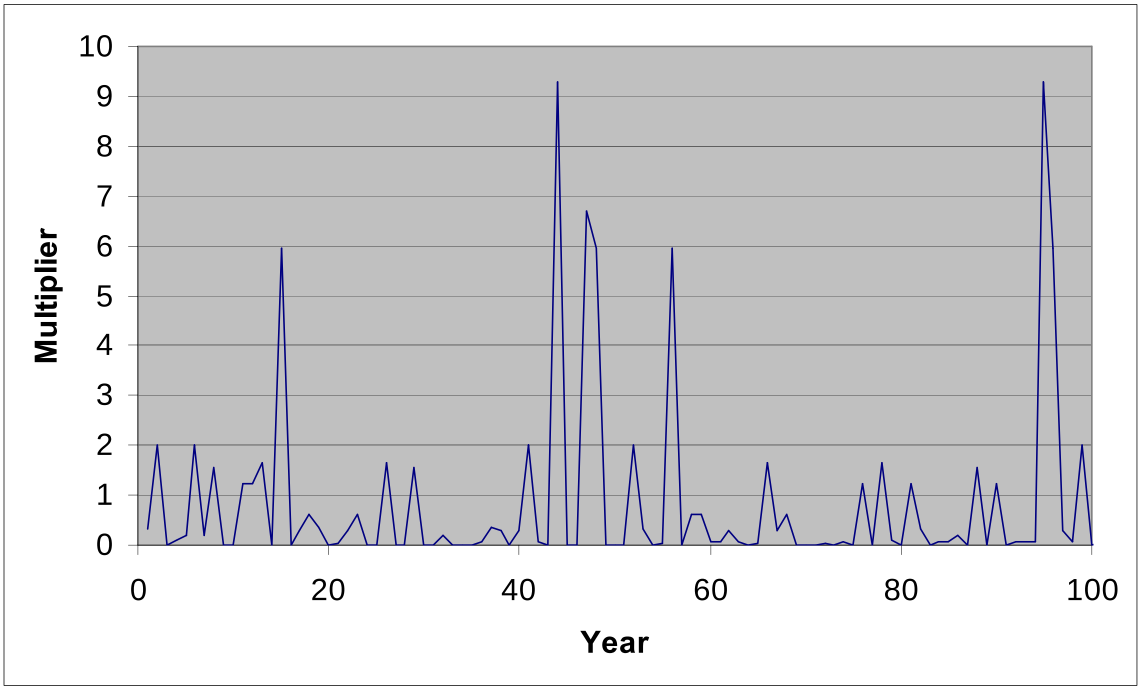


Figure 8. One hundred-year time series of fire probability multipliers generated from extracting the statistical properties of a West Box Elder County data set from 1974 to 2006. Data from Jeff Kline, BLM, Salt Lake Field Office. A different sequence of multipliers can be generated for each replicate (Monte-Carlo) simulation.

In addition to incorporating temporal variation in fire probabilities, our TELSA simulations explicitly simulated fire events including ignition and spread, which requires a fire size distribution as an input. This fire size distribution was obtained from the same data as the probability multipliers for fire by simply counting the frequency of fire sizes in each of 6 classes (<1ha, <10ha, <100ha, <1000ha, <10000ha and >10000ha).

Target fire sizes in TELSA are drawn at random from this distribution but the actual fire sizes experienced (and the total area burned) may be reduced by the occurrence of natural or anthropogenic fuel breaks in the landscape.

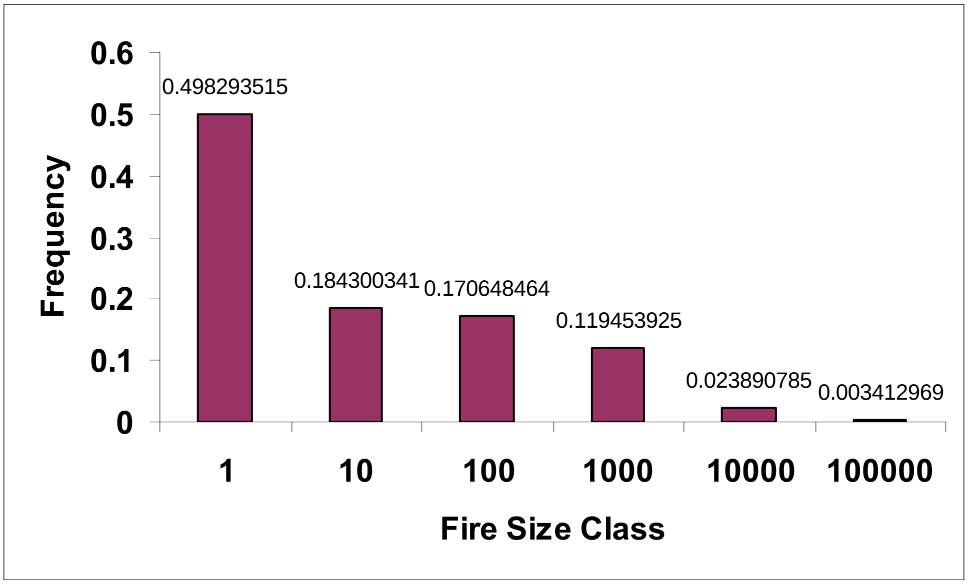


Figure 9. Fire size distribution (ha) obtained from a West Box Elder County data set from 1974 to 2006. Data from Jeff Kline, BLM, Salt Lake Field Office.

4. Results & Discussion

4.1. A-spatial versus spatial natural ranges of variability

One measure of success chosen by partners was ecological departure, which is the dissimilarity between the current condition of the vegetation and the natural range of variability per biophysical setting. As a reminder, the natural range of variability is expressed by the proportions of reference vegetation classes. The natural range of variability, therefore, is of interest to managers because it might be one of many alternative desired future conditions that could guide restoration efforts. The natural range of variability can be calculated from a-spatial VDDT simulations and spatial TELSA simulations with differences expected between the two sets of values. Therefore, ecological departure measured from the same "map" might vary entirely due to spatial effects. The purpose of this section is to describe both the distribution of vegetation classes that form the natural range of variability by biophysical setting and differences between the a-spatial and spatial derivations.

4.1.1. Pattern of natural ranges of variability

Figures 10a-c show the average a-spatial proportion of each reference vegetation class A to E (described in Table 2) represented by a star (no error bars) and the spatial median proportion of each reference vegetation class represented by a box plot (median, 25% and 75% quartiles, and minimum and maximum values). The dominant results describing the natural ranges of variability were (Figures 10 a-c):

- The general distribution of vegetation development classes for most shrublands and seral aspen was consistent: mid-development classes dominated over early and late-development classes for basin wildrye, Wyoming big sagebrush semi-desert and upland sites, mountain big sagebrush upland and mountain sites, and black sagebrush.
- Biophysical settings with long fire return intervals, such as pinyon-juniper and mountain mahogany woodlands, and shrublands of low sagebrush, greasewood, and mixed salt desert scrub were represented more by late-development classes than mid- or early development classes when fire did not spread across biophysical settings (i.e., the purple star).
- With the exception of greasewood and mixed salt desert scrub, this pattern changed, however, when fire was allowed to spread in spatial simulations; indeed, late-development classes were less abundant than mid-development classes because fire spreading from mountain big sagebrush to these fire-infrequent biophysical settings caused a transition from older vegetation classes to early-development classes.
- Stable aspen and montane-subalpine grassland were dominated by closed-canopy vegetation classes.
- The three vegetation classes of the montane-subalpine riparian biophysical setting were equally represented in the landscape.

4.1.2. Comparisons of a-spatial and spatial natural ranges of variability

We found that a-spatial and spatial values for the natural range of variability for each of 16 biophysical settings in the landscape were generally similar with a few notable exceptions (Figures 10a-c). (The 17th biophysical setting, which was montane-subalpine grassland, could not be detected with LANDSAT's 25-meter resolution.) Spatial effects on the natural range of variability were small for stable aspen, seral aspen, black sagebrush, basin wildrye, montane wet meadow, Wyoming big sagebrush–semi-desert, Wyoming big sagebrush–upland, mountain big sagebrush–upland and mountain sites, mixed salt desert, and greasewood because the a-spatial average (star) was very close to the spatial median. Spatial effects were more pronounced for pinyon-juniper, curlleaf mountain mahogany, low sagebrush, montane-subalpine grassland, and montane-subalpine riparian. With the exception of the riparian systems, it appeared that fire spreading from the dominant mountain big sagebrush communities caused a strong reduction of late-development vegetation classes in adjacent communities with longer fire return intervals. The spatial influence had the opposite, but weaker effect on the riparian community; the late-development class represented by trees was more frequent than expected by the a-spatial simulations. Random events impinging on this small and linear system were perhaps the best explanation for the opposite spatial effect observed in riparian communities.

Woodlands

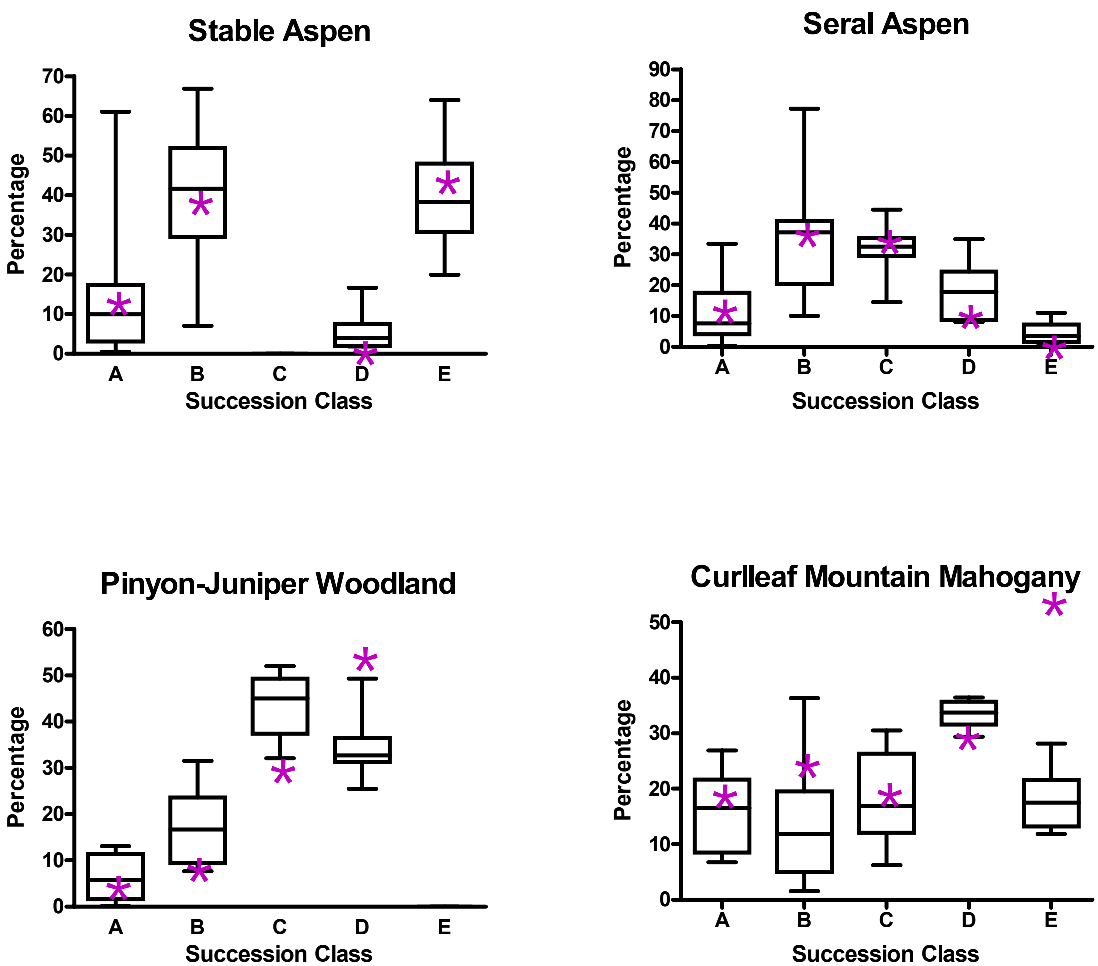


Figure 10a. A-spatial and spatial natural ranges of variability for woodland biophysical settings from the Grouse Creek Mountains-Raft River Mountains, Utah. The purple star represents the a-spatial average (n = 10 replicates) proportion of the vegetation class in the landscape. The box plot contains the spatial median within the box with the lower and upper edges, respectively being the 25% and 75% quartiles, and the error bars are the minimum and maximum values. Vegetation succession classes A-E are described in Table 2.

Riparian, Moist, and Mesic Uplands

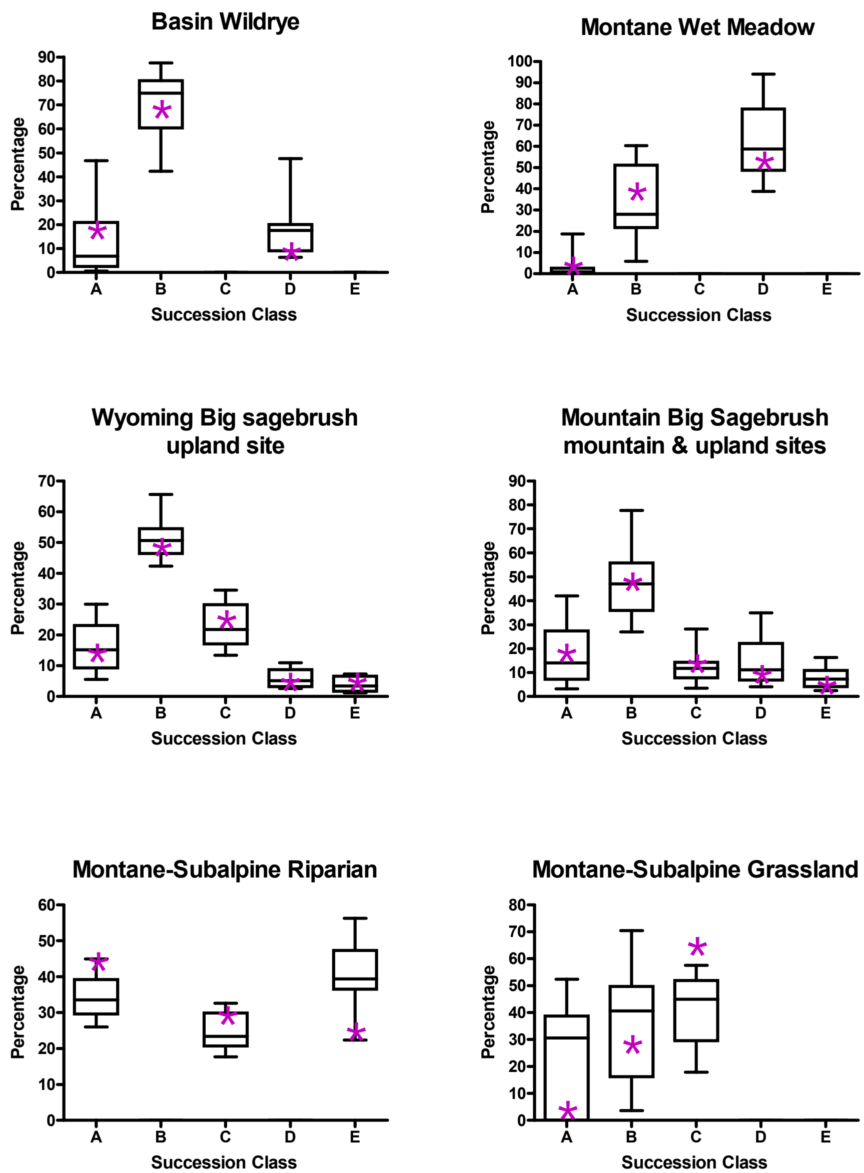


Figure 10b. A-spatial and spatial natural ranges of variability for riparian, moist, and mesic upland biophysical settings from the Grouse Creek Mountains-Raft River Mountains, Utah. The purple star represents the a-spatial average (n = 10 replicates) proportion of the vegetation class in the landscape. The box plot contains the spatial median within the box with the lower and upper edges, respectively being the 25% and 75% quartiles, and the error bars are the minimum and maximum values. Vegetation succession classes A-E are described in Table 2.

Sub-Xeric & Root-Limiting Shrublands

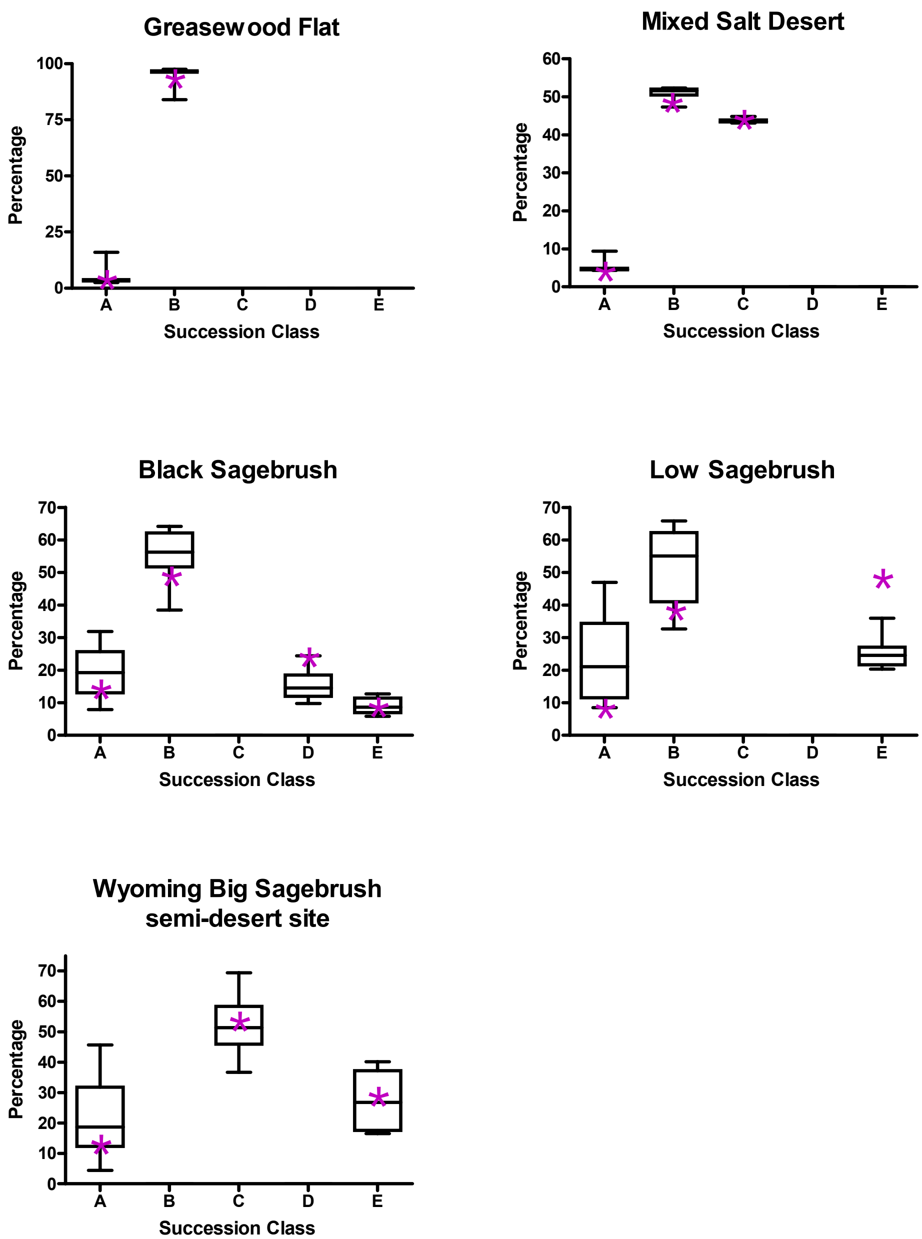


Figure 10c. A-spatial and spatial natural ranges of variability for sub-xeric and root-limiting biophysical settings from the Grouse Creek Mountains-Raft River Mountains, Utah. The purple star represents the a-spatial average (n = 10 replicates) proportion of the vegetation class in the landscape. The box plot contains the spatial median within the box with the lower and upper edges, respectively being the 25% and 75% quartiles, and the error bars are the minimum and maximum values. Vegetation succession classes A-E are described in Table 2.

Overall, these results signify that one could interchangeably use the a-spatial or spatial natural ranges of variability for most biophysical settings; however, choosing the spatial natural range of variability will generally cause greater departure because the current vegetation state of the Grouse Creek Mountains-Raft River Mountains was often dominated by late-development vegetation classes for many woodlands and shrublands, both of which were least abundant with spatial reference simulations. For our analyses, we will use both the a-spatial and spatial natural ranges of variability for the 5-year cumulative impact analysis and only the a-spatial natural range of variability for management scenarios.

Table 8. Cumulative Impact Analysis comparing a-spatial ecological departure between the current vegetation condition and 5 years prior.

	Percent Departure (%) [&]	
Biophysical Setting	5yrs Prior	Current-2006
Stable Aspen	56.10	59.00
Pinyon-Juniper Woodland	7.88	7.79
Mixed Conifers [%]	76.89	62.42
Seral Aspen	78.40	79.26
Curlleaf Mountain Mahogany	27.55	26.88
Low Sagebrush	38.35	31.72
Black Sagebrush	71.85	74.55
Basin Wildrye-Basin Big Sagebrush	80.19	80.09
Wyoming Big Sagebrush-semi-desert	98.59	98.81
Wyoming Big Sagebrush-upland	72.66	70.82
Mixed Salt Desert	100.00	100.00
Mountain Big Sagebrush-mountain	59.62	59.88
Mountain Big Sagebrush-upland	59.57	68.80
Montane Wet Meadow	28.55	22.32
Greasewood Flat	80.84	80.00
Montane-Subalpine Riparian	53.42	53.42

[&] Ecological departure

[%] The natural range of variability for mixed conifers, which is not shown in Figures 10a-c, is 10%, 30%, 30%, 20%, 10% for, respectively, early-development, mid-development closed, mid-development open, late-development open, and late-development closed classes of the reference condition.

4.2. 5-year cumulative impact analysis

Since its inception 2 years ago, the Utah Partners for Conservation and Development received both public and private funding for vegetation management projects implemented in the Grouse Creek Mountains-Raft River Mountains landscape. Moreover, state and federal agencies were also expending funds for vegetation and fire management prior to joining the organization. Therefore, we measured the change in ecological departure for the whole landscape per biophysical settings during 5 years of management. The choice of the 5-year period was made by partners.

Tables 8 and 9 confirmed that very little change occurred to ecological departure from 2001 to 2006 (year of LANDSAT imagery), regardless that the natural range of variability was obtained from a-spatial or spatial simulations (values shown in Appendix III). In fact, the small changes that did occur were often towards greater ecological departure. We were not totally surprised that 5 years of vegetation management projects did not improve ecological departure at the landscape level for several reasons:

- A 5-year period is really too short to change ecological departure of sub-xeric biophysical settings for a landscape (Hemstrom et al. 2001; West and Yorks 2002; Wisdom et al., 2002; Provencher et al. 2007);
- Most projects were small and widely distributed mechanical operations, therefore they were unlikely to modify the proportions of the current vegetation development classes across a whole biophysical setting even if they accomplished a more immediate objective (for example, improve mule deer habitat). The proportions of under-represented reference classes were increased as the expense of over-represented vegetation classes, but the changes were too small to be detected against other sources contributing to greater ecological departure. Ecological departure was most likely to decrease in small systems with a higher return on the investment (i.e., biophysical settings with the highest restoration priorities described in Table 4).
- Vegetation management projects maintained the vegetation class they were meant to improve;
- Treatment areas became infested with cheatgrass as a result of management disturbances. In the case of public lands, native seedings are given higher priority by regulation and introduced species are used when native species are unavailable or when it can be shown that it is not feasible or appropriate to use native species seed. Therefore, public lands fire rehabilitation, wildland-urban interface fuels reduction projects, and wildland restoration projects are often seeded with native species mixtures. Many experts that participated in this project's workshops have concluded that native seedings at lower and middle elevations that are not sprayed with herbicides to inhibit cheatgrass germination will become annual grasslands. The majority of the projects in the study area were for fire rehabilitating; indeed, field visits to remote sensing training polygons confirmed that cheatgrass dominated these areas on public lands;
- Many vegetation treatments used at lower elevations converted degraded rangelands to seedings of introduced species (crested wheatgrass and forage

kochia) or a mixture of introduced and native species. In either case, the resulting vegetation classes were uncharacteristic, sometimes with significant amounts of cheatgrass present. Uncharacteristic vegetation classes completely contribute to ecological departure.

Table 9. Ecological departure based on spatial natural ranges of variability. Ecological departure calculated as described in section 3.6.

	Percent Departure (%)			
Biophysical Settings	5yrs Prior	1 Standard Deviation	Current-2006	1 Standard Deviation
Stable Aspen	55	±17	58	±17
Pinyon-Juniper Woodland	25	±6	25	±6
Seral Aspen	67	±12	68	±11
Curlleaf Mountain Mahogany	59	±6	57	±6
Low Sagebrush	63	±4	57	±4
Black Sagebrush	73	±2	70	±8
Basin Wildrye-Basin Big Sagebrush	71	±11	71	±11
Wyoming Big Sagebrush-semi-desert	99	±0	99	±0
Wyoming Big Sagebrush-upland	73	±4	72	±4
Mixed Salt Desert	100	±0	100	±0
Mountain Big Sagebrush-mountain	62	±7	62	±7
Mountain Big Sagebrush-upland	56	±14	67	±11
Montane Wet Meadow	36	±17	29	±17
Greasewood Flat	81	±0	80	±0
Montane-Subalpine Riparian	59	±5	59	±5

Perhaps a lesson learned from measuring success during 5 years was that the natural range of variability is unforgiving as a benchmark of success because it did not allow for seedings of introduced species that may play a beneficial role in restoring shrublands. In future work, it would be possible to calculate an *acceptable range of variability* analogous to a desired future condition by modeling the use of introduced species seedings in management models (not reference models) to enhance the probability of successful restoration to the reference condition, perhaps through the process of assisted succession (Cox and Anderson 2004: Assisted succession is the process of seeding altered shrublands with introduced species, then seeding these areas to native species years later after cheatgrass has been displaced). Although such an approach might appeal to managers, serious guidelines would be required to ensure that desired conditions are not manipulated to the point of becoming meaningless. For example, seedings of introduced species for the purpose of restoration implies that uncharacteristic vegetation is or was present in the landscape; therefore, the desired range of variability might need to contain "acceptable" areas of annual grasslands or tree-encroached shrublands.

4.3. Core and sensitivity management scenario comparisons

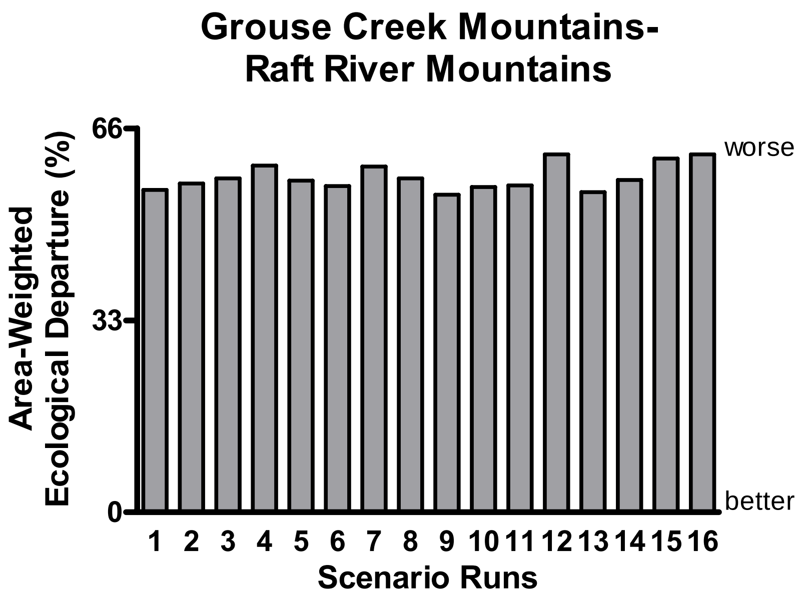
Scenarios are entirely about the future expressed as "what-if" ideas. Partners were asked to think differently about general themes of land management that could potentially be implemented. The first four scenarios that were considered the most substantial by partners are again described here (Table 3):

1. OWNERSHIP BOUNDARIES: The purpose of this scenario was to test whether or not the boundaries between BLM, USFS and private lands affect the ability of managers to reach the natural range of variability and greater structural vegetation complexity;
2. BIOPHYSICAL SETTINGS MANAGEMENT PRIORITIES: The scenario allocated funds only to biophysical settings with the highest management priority using three criteria described in Table 4.
3. FUEL BREAKS: This scenario created 30-meter fire breaks for every paved and mapped dirt road to stop fires. Fire breaks consisted of a non-native mix of forage kochia and crested wheatgrass.
4. ADJACENCY TO DESIRABLE TYPES: This scenario preferentially selected polygons for treatment that were in proximity to vegetation phases or states deemed desirable, thus creating ever increasing desirable habitat.

In addition, we measured the effects of these scenarios while varying the rates of cheatgrass long-distance dispersal, exotic forb short-distance dispersal, and excessive herbivory between low and high values; indeed, there is no guarantee that a core scenario will have consistent desirable results under different conditions. Three analyses were completed to measure the success of scenarios. We measured ecological departure at (a) the landscape level by weighing ecological departure proportional to the area of each biophysical setting in the landscape and (b) for each biophysical setting. The Shannon diversity index measured structural vegetation complexity of the full landscape with the software FragStat (McGarigal and Marks 1995). These measures are always spatially defined.

4.3.1. Landscape-level ecological departure

Differences among scenario combinations for area-weighted ecological departure were small (Figure 11) because lower elevation biophysical settings dominated in area and were highly departed due to cheatgrass invasion (but see later for statistics). The lowest ecological departure was observed in the NO-NB-NF-A-LA-HE-HH (run #9) and NO-NB-F-A-HA-LE-LH (run #13) simulations, which consist of scenarios where funding did not respect ownership boundaries (NO), vegetation treatments were applied to all biophysical settings without priorities (NB), and treatments were implemented adjacent to desirable vegetation classes (A), and where fuel breaks were or not placed along roads (respectively, F or NF). The two scenarios with the equally highest ecological departure were O-B-NF-A-LA-LE-LH (run #12) and O-B-F-A-HA-HE-HH (run #16), both having funding distributed according to ownership (O), management priorities assigned to biophysical settings (B), and treatments were implemented adjacent to desirable vegetation classes (A).



1-NO-NB-NF-NA-LA-LE-LH
2-O-NB-NF-NA-HA-LE-HH
3-NO-B-NF-NA-HA-HE-LH
4-O-B-NF-NA-LA-HE-HH
5-NO-NB-F-NA-HA-HE-HH
6-O-NB-F-NA-LA-HE-LH
7-NO-B-F-NA-LA-LE-HH
8-O-B-F-NA-HA-LE-LH
9-NO-NB-NF-A-LA-HE-HH
10-O-NB-NF-A-HA-HE-LH
11-NO-B-NF-A-HA-LE-HH
12-O-B-NF-A-LA-LE-LH
13-NO-NB-F-A-HA-LE-LH
14-O-NB-F-A-LA-LE-HH
15-NO-B-F-A-LA-HE-LH
16-O-B-F-A-HA-HE-HH

Figure 11. Landscape level a-spatial ecological departures weighted proportional to the area of each biophysical setting in the Grouse Creek Mountains-Raft River Mountains, Utah. Ecological departure of each biophysical setting is presented in Figures 20a-c. Legend: O for Ownership boundaries respected *versus* NO for No Ownership boundaries respected; B for Biophysical Settings priorities used *versus* NB for No Biophysical Settings priorities; F for Fuel Break used *versus* NF for No Fuel Break; and A for Adjacency implemented used *versus* NA for No Adjacency constraint; LA for 100 starts/yr (Low) of long-distance cheatgrass (Annual grass) invasion events vs. HA for 1,000 starts/yr (High); LE for 0.5 (Low) × probability/year for Exotic Forb dispersal vs. HE for 2.0 (High) × probability/year for Exotic Forb dispersal; and LH for 0.5 (Low) × probability/year for excessive Herbivory vs. HH for 2.0 (High) × probability/year for excessive Herbivory.

Visual differences between the scenario with the lowest (NO-NB-F-A; Figure 12) and the highest area-weighted ecological departures (NO-B-NF-NA; Figure 13) were evident, especially for higher elevations (these images are from previous simulations for the same core scenario combinations). The greatest differences between Figures 12 and 13 were that the former showed a greater variety of early (light green) to later (darker green) succession classes in mountain big sagebrush, smaller areas of cheatgrass-infested classes at lower to middle elevations, and less loss of aspen clones (NAS = No-Aspen). The key point for managers appears to be a trade-off between implementing vegetation treatments according to biophysical settings priorities and fuel breaks. These scenarios might be working against each other.

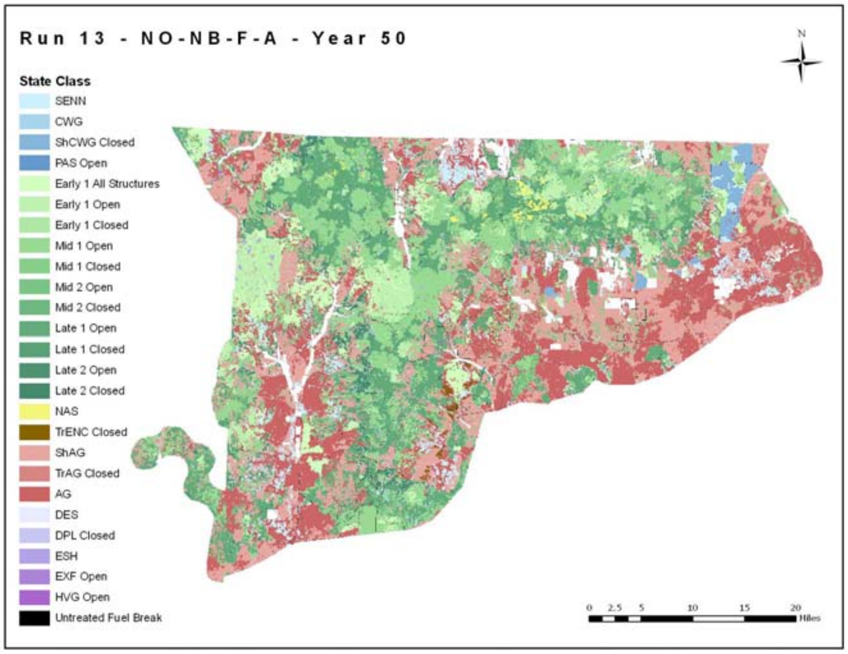


Figure 12. Final current vegetation map of vegetation classes for the No Ownership-No Biophysical Setting Priority-Fuel Break-Adjacency simulation after 50 years. This scenario had the lowest ecological departure for the landscape level and for many biophysical settings for both the fractional design and a previous factorial design. Legend as in Figure 11.

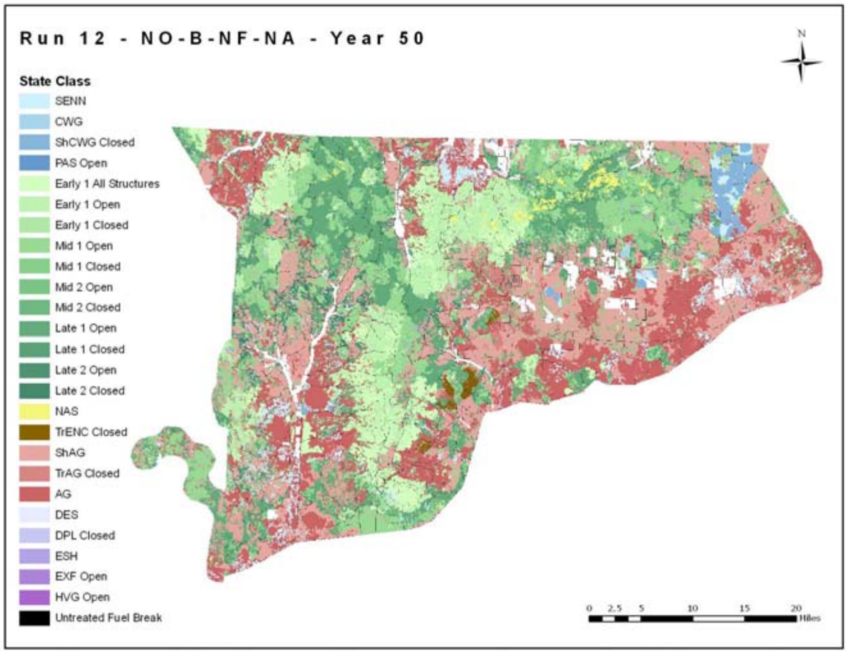


Figure 13. Final current vegetation map of vegetation classes for the No Ownership- Biophysical Setting Priority-No Fuel Break-No Adjacency simulation after 50 years. This scenario had the highest ecological departure for the landscape level and for many biophysical settings for both the fractional design and a previous factorial design. Legend as in Figure 11.

Despite the apparent importance of the ownership factor, area-weighted ecological departure was only significantly lower when priorities were not assigned to biophysical settings ($p = 0.008$; Figure 14). This effect made only a few percentage points of difference, but, due to the low variability, the effect was significant. No other main effects or interactions were significant.

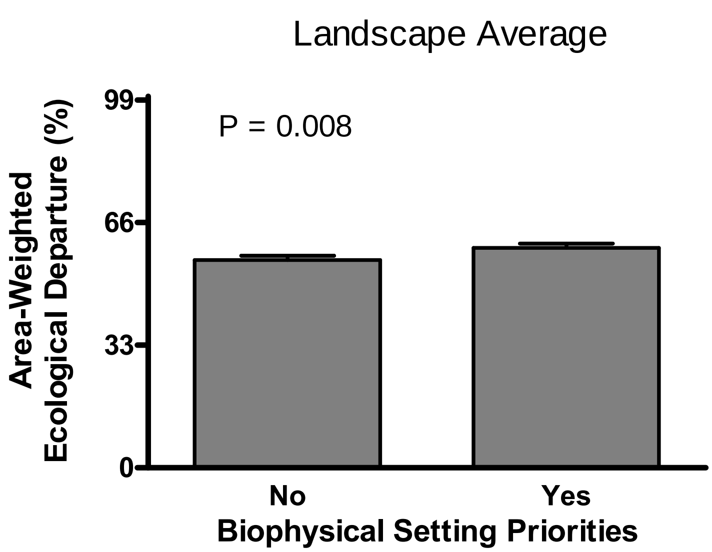


Figure 14. Average area-weighted a-spatial ecological departure (%) for the BIOPHYSICAL SETTINGS PRIORITIES main effect after 50 years of simulated management. Fractional ANOVA:

DF = 1, MS = 0.004346, F = 17.93. Error bars are 95% confidence intervals based on least-square means.

4.3.2. Structural vegetation complexity

Differences among scenario combinations for the index of structural vegetation complexity (Shannon's diversity indices) were of comparable magnitude to those for ecological departure (Figures 16 vs. Figure 11). The highest measure of structural vegetation complexity was observed in the NO-NB-F-A-HA-LE-LH (run #13) scenario combination, which was also one of the two scenario combinations with the lowest ecological departure (above). Scenario combination #9, which was also one with the lowest ecological departure, was average for vegetation complexity. Two combinations of scenarios yielded the least complex vegetation patterns, namely O-B-NF-NA-LA-HE-HH (run #4) and O-B-NF-A-LA-LE-LH (run #12). Run #12 was also one with the greatest ecological departure for area-weighted ecological departure.

Two general differences observed between the scenario combinations with the highest (Figure 17) and the lowest structural vegetation complexity (Figure 18) were that the NO-NB-F-A-HA-LE-LH (run #13) scenario combination had more lower elevation area that could be assessed by the software FragStat (the black background carved out of the landscape are areas that cannot be assessed by FragStat because they are not desirable classes), thus contributing more to overall complexity, and greater amount of darker blue values (more complex vegetation) at higher elevations. Scenario combinations from Figures 17-18 represented extremes, whether other scenarios are shown in Appendix IV.

Shannon's diversity index (vegetation complexity) was significantly higher when fuel breaks were placed along roads ($p = 0.0001$; Figure 19A) and when funding did not respect ownership boundaries ($p = 0.018$; Figure 19B). The fuel break effect was stronger and more variable than the ownership one, which represented a small difference in vegetation complexity. No other effects were significant. After all, the two scenarios runs with the highest vegetation complexity had fuel breaks implemented (Figure 16). The goal of fuel breaks was to stop the spread of homogeneous cheatgrass-infested lower elevations flowing wildfires.

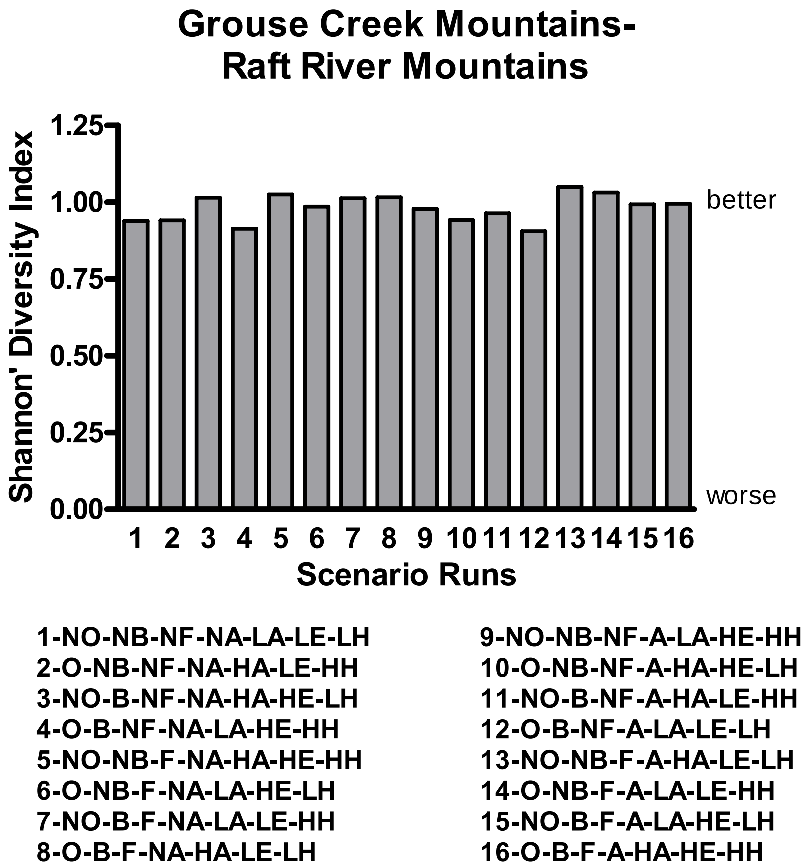


Figure 16. Mean Shannon's diversity index for different scenarios of the Grouse Creek Mountains-Raft River Mountains, Utah. Shannon's diversity index measures both the number of different vegetation patches and the relative abundance of each vegetation patch in a moving window of 200 ha (494 acres) based on a pixel resolution of 30-m. Vegetation patches were considered different if they belonged to different combinations of biophysical settings × succession class (early-development, mid-development open or closed, late-development open or closed, and seeded-nonnative). Legend: O for Ownership boundaries respected *versus* NO for No Ownership boundaries respected; B for Biophysical Settings priorities used *versus* NB for No Biophysical Settings priorities; F for Fuel Break used *versus* NF for No Fuel Break; and A for Adjacency implemented used *versus* NA for No Adjacency constraint; LA for 100 starts/yr (Low) of long-distance cheatgrass (Annual grass) invasion events vs. HA for 1,000 starts/yr (High); LE for 0.5 (Low) × probability/year for Exotic Forb dispersal vs. HE for 2.0 (High) × probability/year for Exotic Forb dispersal; and LH for 0.5 (Low) × probability/year for excessive Herbivory vs. HH for 2.0 (High) × probability/year for excessive Herbivory.

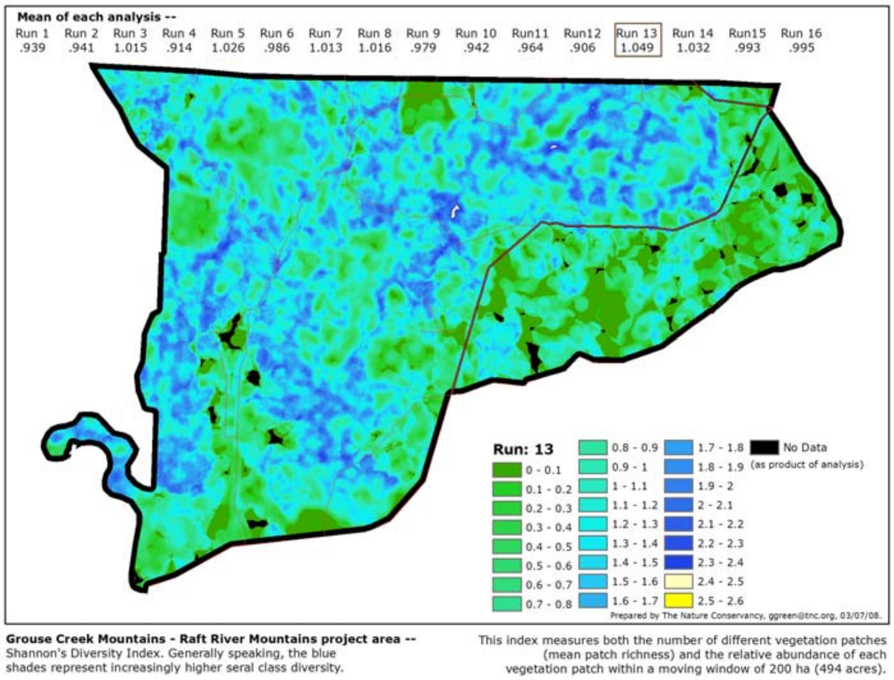
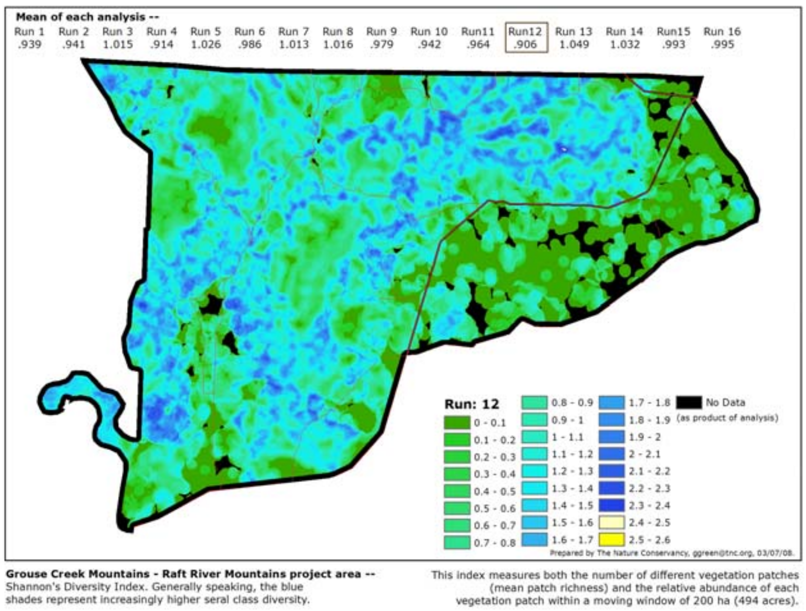


Figure 17. Shannon's diversity index for the NO-NB-F-A-HA-LE-LH (run #13) combination of scenarios after 50 years of simulation. Legend: O for Ownership boundaries respected *versus* NO for No Ownership boundaries respected; B for Biophysical Settings priorities used *versus* NB for No Biophysical Settings priorities; F for Fuel Break used *versus* NF for No Fuel Break; and A for Adjacency implemented used *versus* NA for No Adjacency constraint; LA for 100 starts/yr (Low) of long-distance cheatgrass (Annual grass) invasion events vs. HA for 1,000 starts/yr (High); LE for 0.5 (Low) × probability/year for Exotic Forb dispersal vs. HE for 2.0 (High) × probability/year for Exotic Forb dispersal; and LH for 0.5 (Low) × probability/year for excessive Herbivory vs. HH for 2.0 (High) × probability/year for excessive Herbivory.

A.



B.

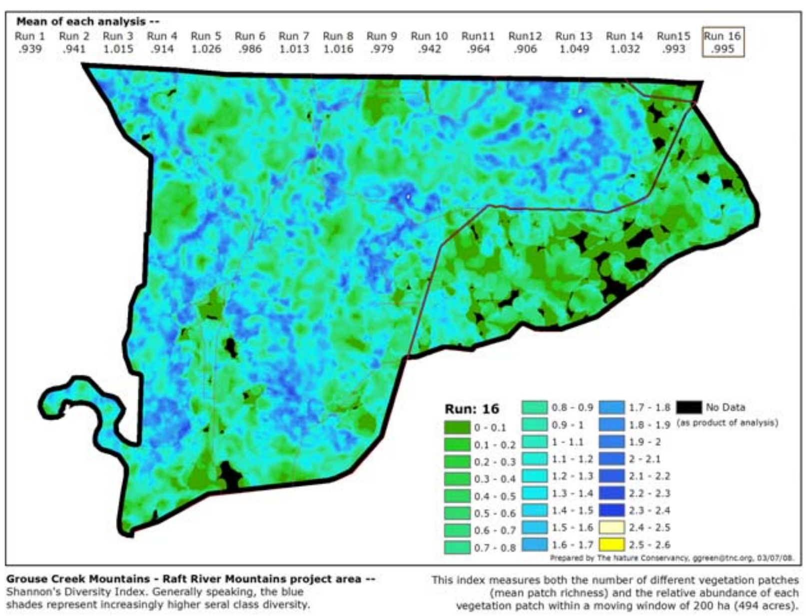


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Figure 18. Shannon's diversity index for the (a) O-B-NF-NA-LA-HE-HH (run #4) and O-B-NF-A-LA-LE-LH (run #12) combination of scenarios after 50 years of simulation. Legend: O for Ownership boundaries respected *versus* NO for No Ownership boundaries respected; B for Biophysical Settings priorities used *versus* NB for No Biophysical Settings priorities; F for Fuel Break used *versus* NF for No Fuel Break; and A for Adjacency implemented used *versus* NA for No Adjacency constraint; LA for 100 starts/yr (Low) of long-distance cheatgrass (Annual grass) invasion events vs. HA for 1,000 starts/yr (High); LE for 0.5 (Low) × probability/year for Exotic Forb dispersal vs. HE for 2.0 (High) × probability/year for Exotic Forb dispersal; and LH for 0.5 (Low) × probability/year for excessive Herbivory vs. HH for 2.0 (High) × probability/year for excessive Herbivory.

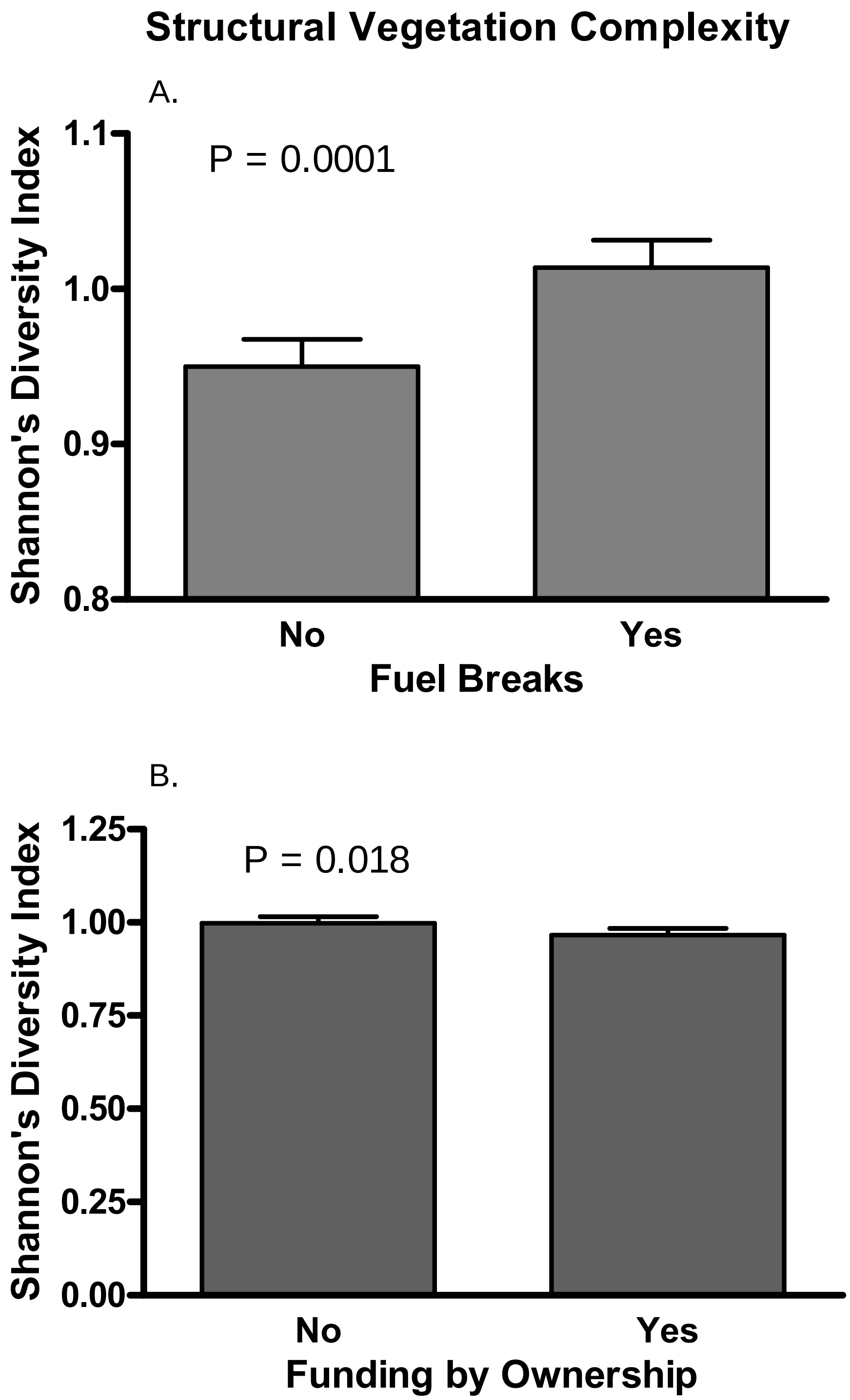


Figure 19. Main effects of (A) fuel breaks and (B) funding by ownership for Shannon's diversity index for different scenarios of the Grouse Creek Mountains-Raft River Mountains, Utah. Fractional ANOVA is: Source = Fuel Breaks, DF = 1, MS = 0.016256, F = 31.98, P = 0.0001; Source = Funding by Ownership, DF = 1, MS = 0.003782, F = 7.44, P = 0.018; and Source = Cheatgrass Dispersal Rate, DF = 1, MS = 0.002162, F = 4.25, P = 0.061. Error bars are 95% confidence intervals based on least-square means.

4.3.3. Ecological departure by biophysical setting

Ecological departure by biophysical setting showed much more variation than the area-weighted analysis. The results for biophysical settings were also more interesting. A few general results emerged across all scenarios and biophysical settings:

1. Only low sagebrush was less than 33% departed (i.e., FRCC 1 or not departed) after 50 years of any combination of management scenarios (Figures 20b). However, ecological departure for stable aspen and pinyon-juniper were generally <33% with the exception of two scenario combinations (Figure 20a). Differences among scenario combinations were clear despite this overall desirable outcome;
2. Sub-xeric (greasewood, mixed salt desert scrub, and Wyoming big sagebrush semi-desert) and montane-subalpine riparian biophysical settings were highly departed and remained so under any management scenario (Figures 20b & c);
3. Five biophysical settings showed small levels of departure (i.e., close to 33%) with different scenario combinations yielding either no departure or weak departure (<50% dissimilarity from the natural range of variability) after 50 years of management: mixed conifers, mountain big sagebrush – mountain site, mountain big sagebrush – upland site, basin wildrye, and montane-subalpine wet meadow (Figures 20a & c);
4. Four biophysical settings were moderately departed and close to being highly departed (>66% departed) with some scenario combinations yielding great improvements: seral aspen, curlleaf mountain mahogany, black sagebrush, and Wyoming big sagebrush – upland site (Figures 20a-c);

Woodlands

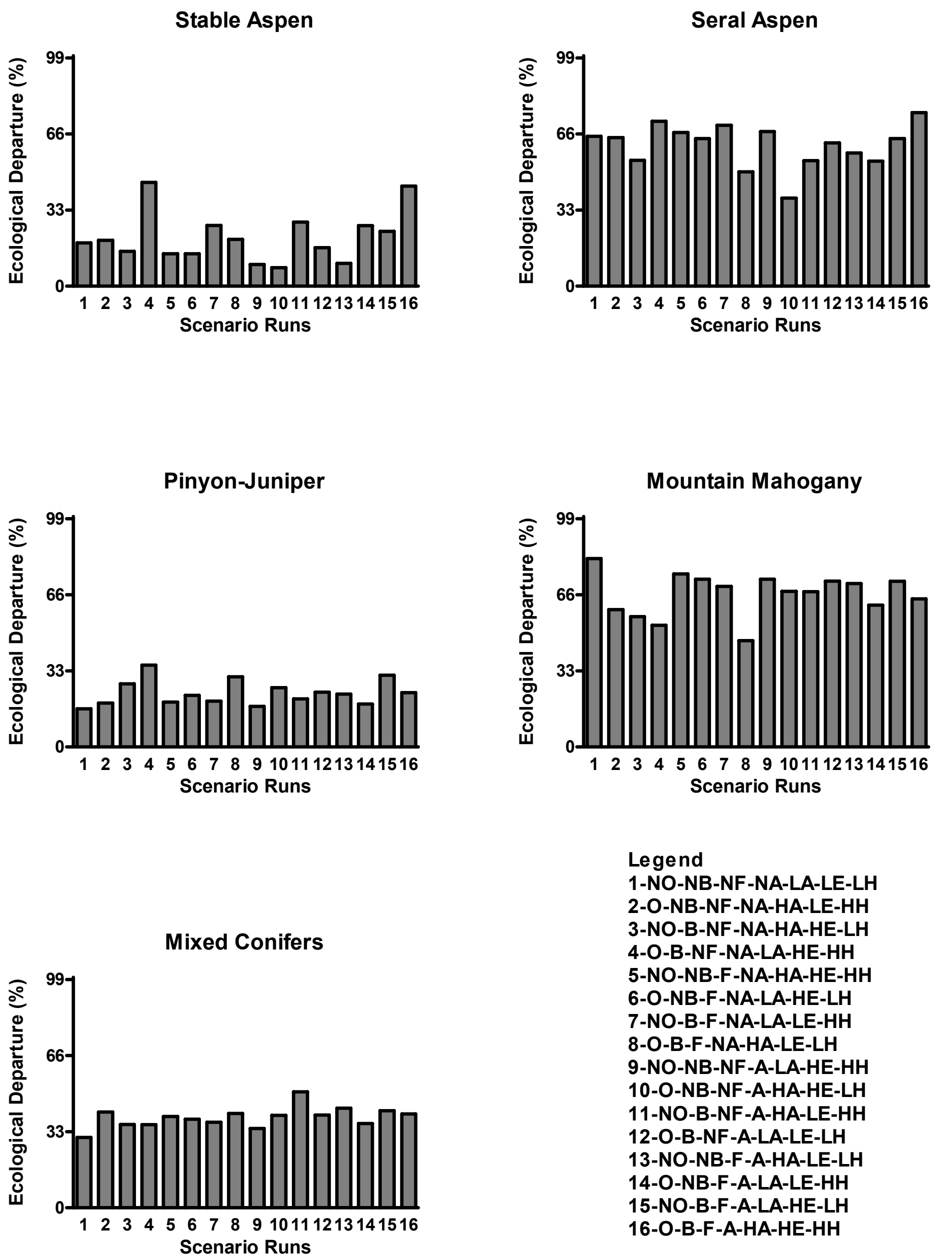


Figure 20a. A-spatial ecological departures for woodlands in the Grouse Creek Mountains-Raft River Mountains, Utah. Legend: O for Ownership boundaries respected *versus* NO for No Ownership boundaries respected; B for Biophysical Settings priorities used *versus* NB for No Biophysical Settings priorities; F for Fuel Break used *versus* NF for No Fuel Break; and A for Adjacency implemented used *versus* NA for No Adjacency constraint; LA for 100 starts/yr (Low) of long-distance cheatgrass (Annual grass) invasion events vs. HA for 1,000 starts/yr (High); LE for 0.5 (Low) × probability/year for Exotic Forb dispersal vs. HE for 2.0 (High) × probability/year for Exotic Forb dispersal; and LH for 0.5 (Low) × probability/year for excessive Herbivory vs. HH for 2.0 (High) × probability/year for excessive Herbivory.

Subxeric & Root Limiting Shrublands

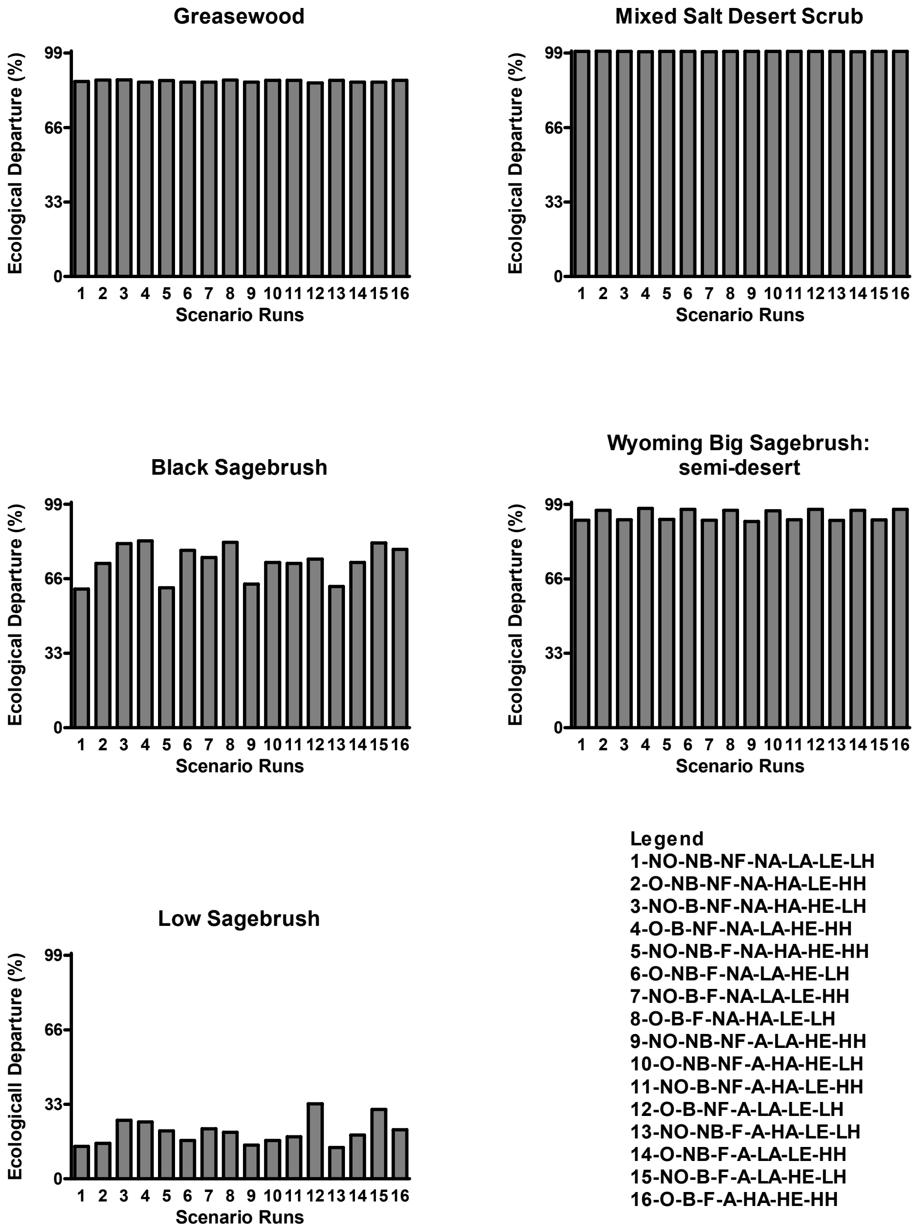
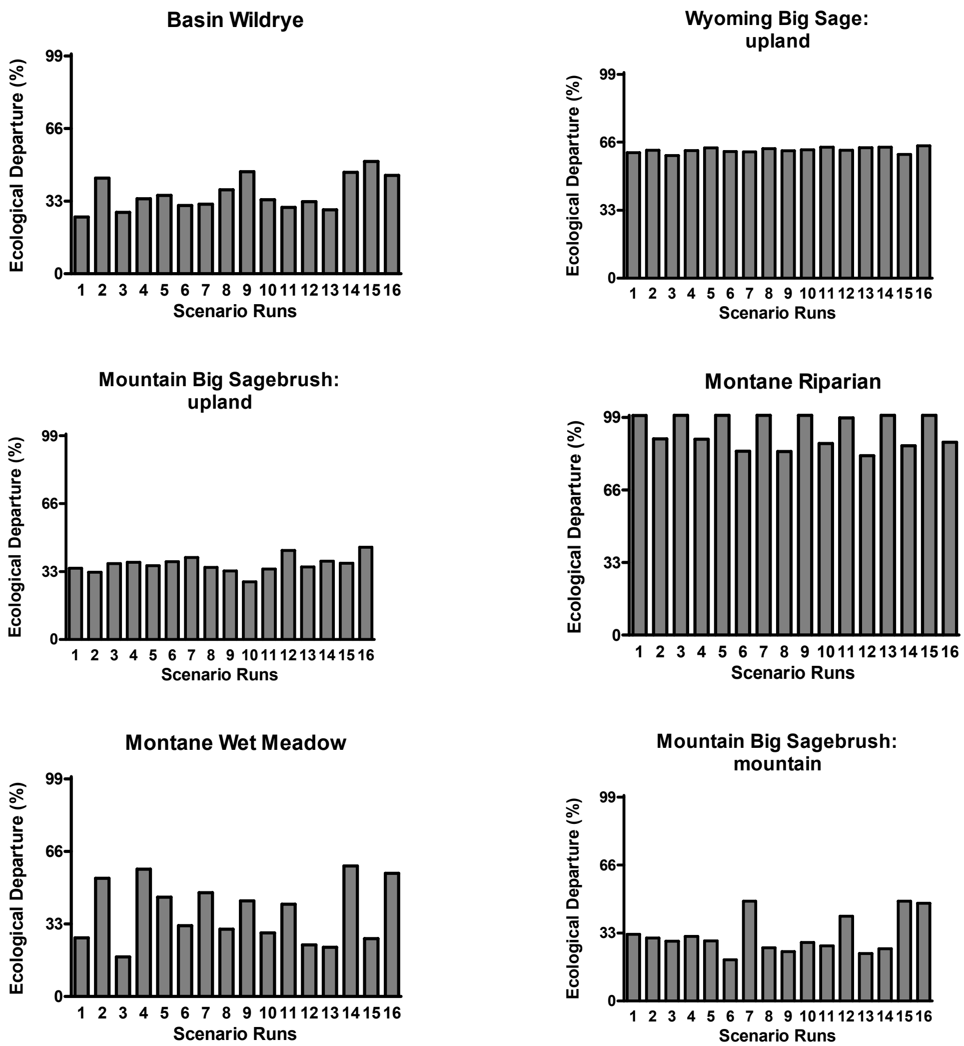


Figure 20b. A-spatial ecological departures per sub-xeric and root-limiting biophysical settings in the Grouse Creek Mountains-Raft River Mountains, Utah. Legend: O for Ownership boundaries respected *versus* NO for No Ownership boundaries respected; B for Biophysical Settings priorities used *versus* NB for No Biophysical Settings priorities; F for Fuel Break used *versus* NF for No Fuel Break; and A for Adjacency implemented used *versus* NA for No Adjacency constraint; LA for 100 starts/yr (Low) of long-distance cheatgrass (Annual grass) invasion events vs. HA for 1,000 starts/yr (High); LE for 0.5 (Low) × probability/year for Exotic Forb dispersal vs. HE for 2.0 (High) × probability/year for Exotic Forb dispersal; and LH for 0.5 (Low) × probability/year for excessive Herbivory vs. HH for 2.0 (High) × probability/year for excessive Herbivory.

Riparian, Moist, & Mesic Uplands



Legend:

1-NO-NB-NF-NA-LA-LE-LH
2-O-NB-NF-NA-HA-LE-HH
3-NO-B-NF-NA-HA-HE-LH
4-O-B-NF-NA-LA-HE-HH
5-NO-NB-F-NA-HA-HE-HH
6-O-NB-F-NA-LA-HE-LH
7-NO-B-F-NA-LA-LE-HH
8-O-B-F-NA-HA-LE-LH
9-NO-NB-NF-A-LA-HE-HH
10-O-NB-NF-A-HA-HE-LH
11-NO-B-NF-A-HA-LE-HH
12-O-B-NF-A-LA-LE-LH
13-NO-NB-F-A-HA-LE-LH
14-O-NB-F-A-LA-LE-HH
15-NO-B-F-A-LA-HE-LH
16-O-B-F-A-HA-HE-HH

Figure 20c. A-spatial ecological departures per riparian, moist, and mesic upland biophysical settings in the Grouse Creek Mountains-Raft River Mountains, Utah. Legend: O for Ownership boundaries respected *versus* NO for No Ownership boundaries respected; B for Biophysical Settings priorities used *versus* NB for No Biophysical Settings priorities; F for Fuel Break used *versus* NF for No Fuel Break; and A for Adjacency implemented used *versus* NA for No Adjacency constraint; LA for 100 starts/yr (Low) of long-distance cheatgrass (Annual grass) invasion events vs. HA for 1,000 starts/yr (High); LE for 0.5 (Low) × probability/year for Exotic Forb dispersal vs. HE for 2.0 (High) × probability/year for Exotic Forb dispersal; and LH for 0.5 (Low) × probability/year for excessive Herbivory vs. HH for 2.0 (High) × probability/year for excessive Herbivory.

The salient statistically significant ($P < 0.055$) results by biophysical setting were relatively straightforward with a few oddities:

1. Whether or not management priorities were assigned to biophysical settings was the most frequent (8 cases) significant ($P \leq 0.055$) scenario effect on ecological departure among all biophysical settings. Although ecological departure of mountain mahogany decreased with management priorities assigned to biophysical settings (Figure 25), the opposite result was observed for stable aspen, pinyon-juniper, black sagebrush, Wyoming big sagebrush–semi-desert (weak effect), low sagebrush, and both mountain big sagebrush (Figures 21, 22, 27-31);
2. Whether or not funding respected ownership was the second most frequent (5 cases) significant ($P \leq 0.055$) scenario effect on ecological departure among all biophysical settings. Ecological departure decreased when funding did not respect ownership boundaries for black sagebrush, Wyoming big sagebrush–semi-desert, and montane wet meadows (Figures 27-28, 32) because funding was distributed to private lands whose managers would not normally engage in ecological restoration. In the case of Wyoming big sagebrush–semi-desert, ownership had a strong statistical effect because variation was very low. On the other hand, ecological departure of curlleaf mountain mahogany and montane riparian decreased with funding restricted to original ownership (Figures 25, 33);
3. Increased excessive herbivory always increased ($P < 0.055$) the ecological departure of stable and seral aspen, montane wet meadows, and montane riparian (weak effect) (Figures 21, 32-33). This was not surprising as the disturbance is more pronounced in these biophysical settings than in other upland vegetation types;
4. An increased rate of long-distance dispersal for cheatgrass had interesting direct and indirect effects on two biophysical settings. As expected, the ecological departure of greasewood (Figure 26) increased with greater cheatgrass dispersal, although marginally so for the much infested greasewood rangelands. Counter-intuitively, montane mixed conifers were also affected by cheatgrass dispersal (Figure 23), although it did not contain cheatgrass invasion as a disturbance. We suspect that greater infestation in upland mountain big sagebrush and Wyoming big sagebrush caused greater fire activity that spread to montane mixed conifers, which would burn readily and a large proportion of early succession classes would be created; thus, the greater departure from a natural range of variability that weighs more heavily towards late-succession classes.
5. As anticipated from results for landscape-level ecological departure, fuel breaks had very little effect on biophysical setting ecological departure, except for montane wet meadows (Figure 32). Because the natural range of variability of wet meadows depends on fire importation maintaining early and mid-succession vegetation classes, fire breaks along roads, which are often adjacent to meadows, would cause greater ecological departure.
6. The oddest result was the significant increased of ecological departure of black sagebrush in response to an increased rate of exotic forb dispersal ($P = 0.028$; Figure 27). The result is odd because the model for black sagebrush does not

contain a pathway for exotic forb invasion; however, this main effect is aliased (confounded) with three-way interaction involving funding by ownership, biophysical setting priorities, fuel breaks, and adjacency of treatments. These interactions could be carrying the effect, which is not strong.

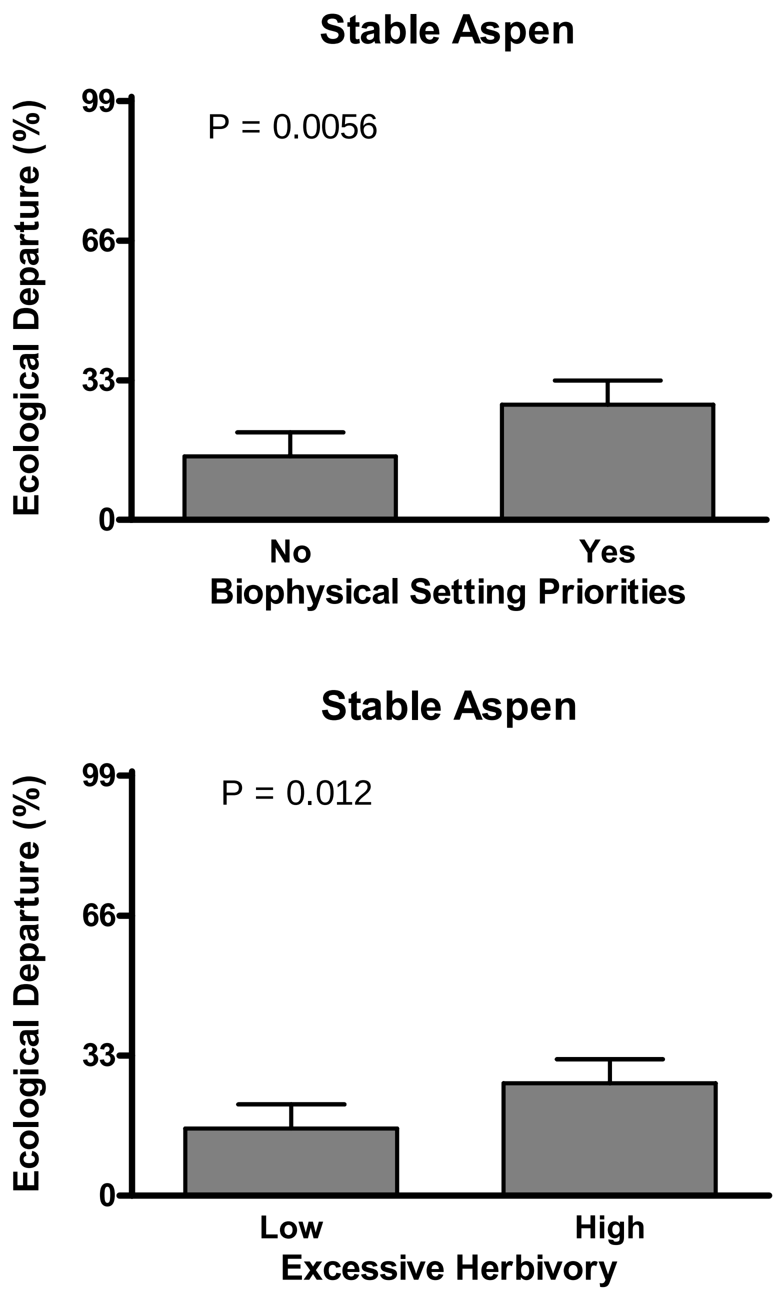


Figure 21. Ecological departure (%) of stable aspen for BIOPHYSICAL SETTING PRIORITIES and EXCESSIVE HERBIVORY effects after 50 years of simulated management. Fractional ANOVA: BIOPHYSICAL SETTING PRIORITIES, DF = 1, MS = 0.060011, F = 10.96; EXCESSIVE HERBIVORY, DF = 1, MS = 0.045889, F = 8.38.

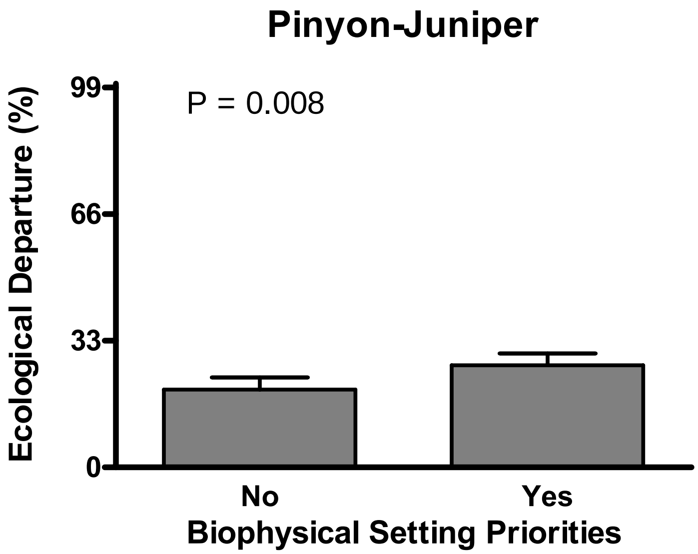


Figure 22. Ecological departure (%) of pinyon-juniper for the BIOPHYSICAL SETTING PRIORITIES effect after 50 years of simulated management. Fractional ANOVA: BIOPHYSICAL SETTING PRIORITIES, DF = 1, MS = 0.015799, F = 9.37.

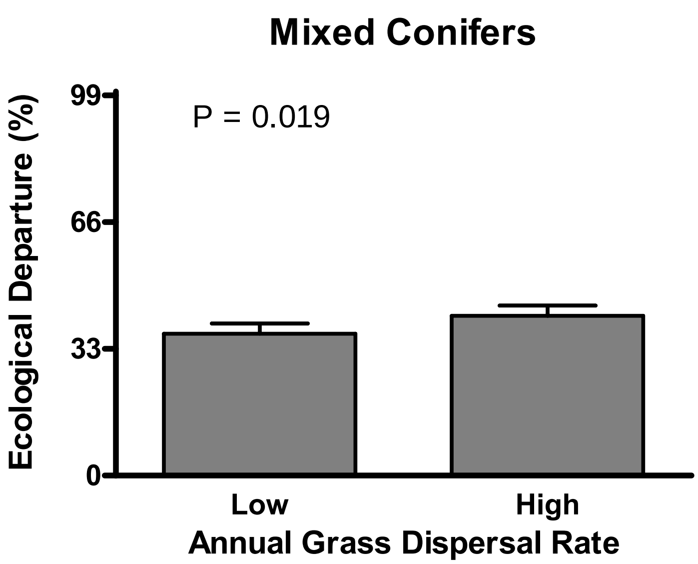


Figure 23. Ecological departure (%) of mixed conifers for the ANNUAL GRASS DISPERSAL RATE EFFECT after 50 years of simulated management. Fractional ANOVA: ANNUAL GRASS DISPERSAL RATE, DF = 1, MS = 0.008688, F = 7.1.

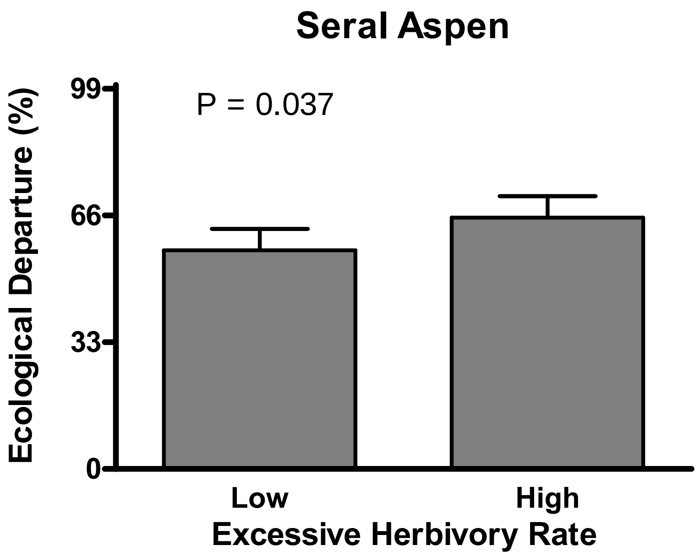


Figure 24. Ecological departure (%) of seral aspen for the EXCESSIVE HERBIVORY RATE effect after 50 years of simulated management. Fractional ANOVA: EXCESSIVE HERBIVORY RATE, DF = 1, MS = 0.028928, F = 5.5.

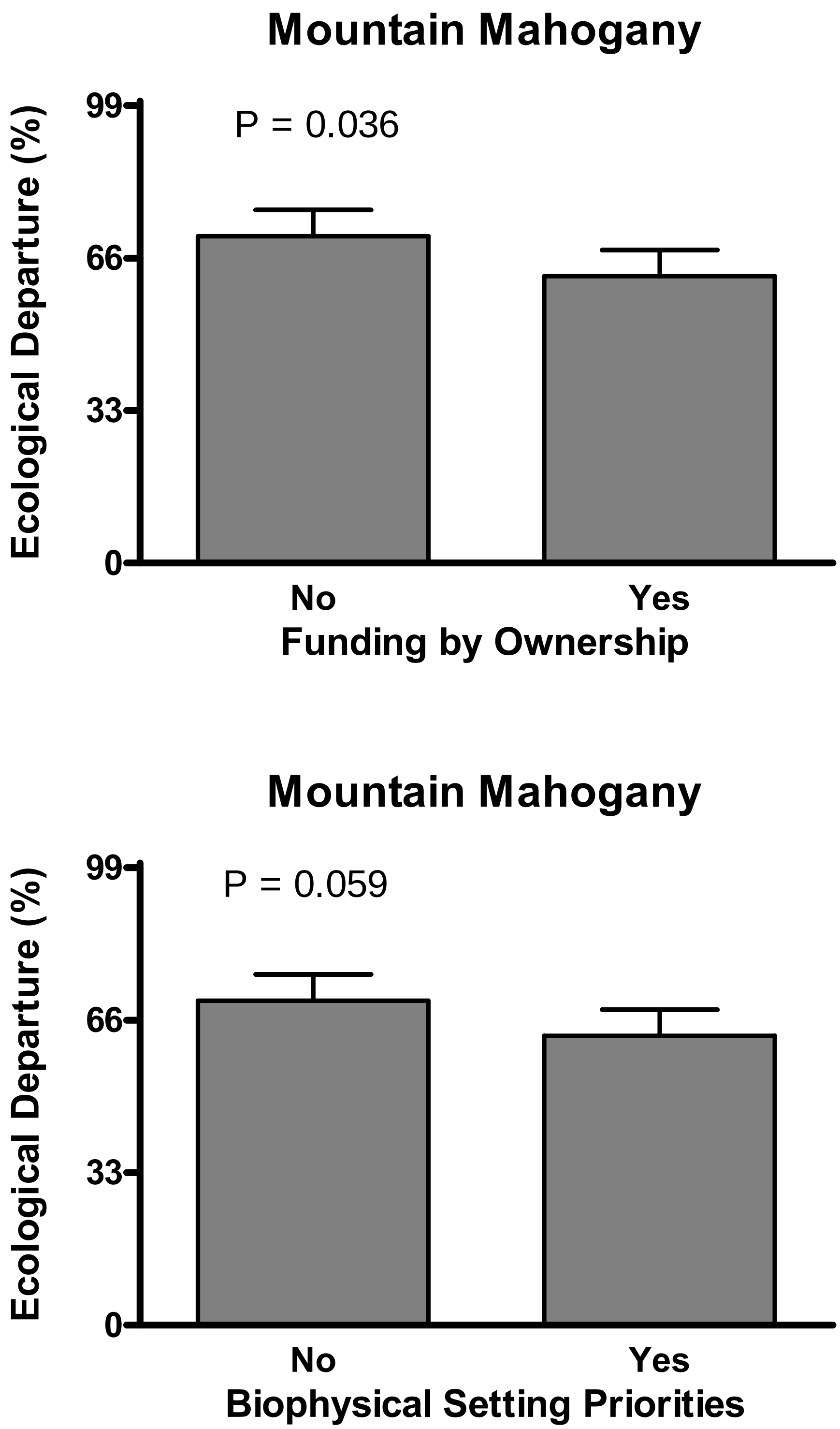


Figure 25. Ecological departure (%) of curlleaf mountain mahogany for OWNERSHIP FUNDING and BIOPHYSICAL SETTING PRIORITIES after 50 years of simulated management. Fractional ANOVA: FUNDING BY OWNERSHIP, DF = 1, MS = 0.030099, F = 5.44 ; BIOPHYSICAL SETTING PRIORITIES, DF = 1, MS = 0.023488, F = 4.25.

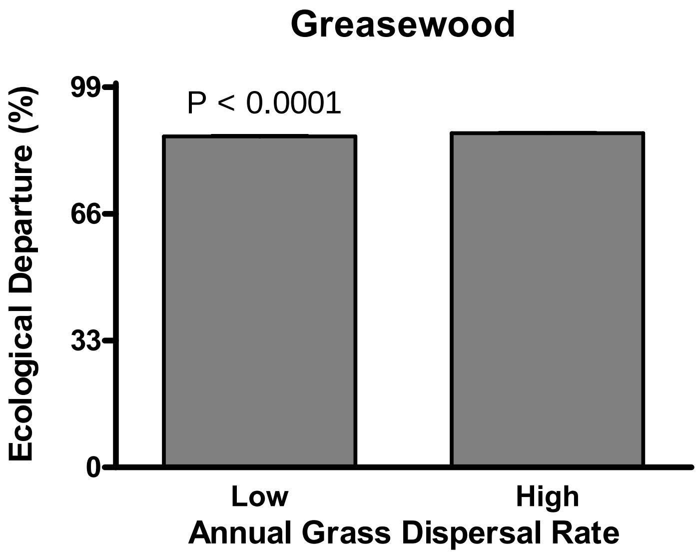
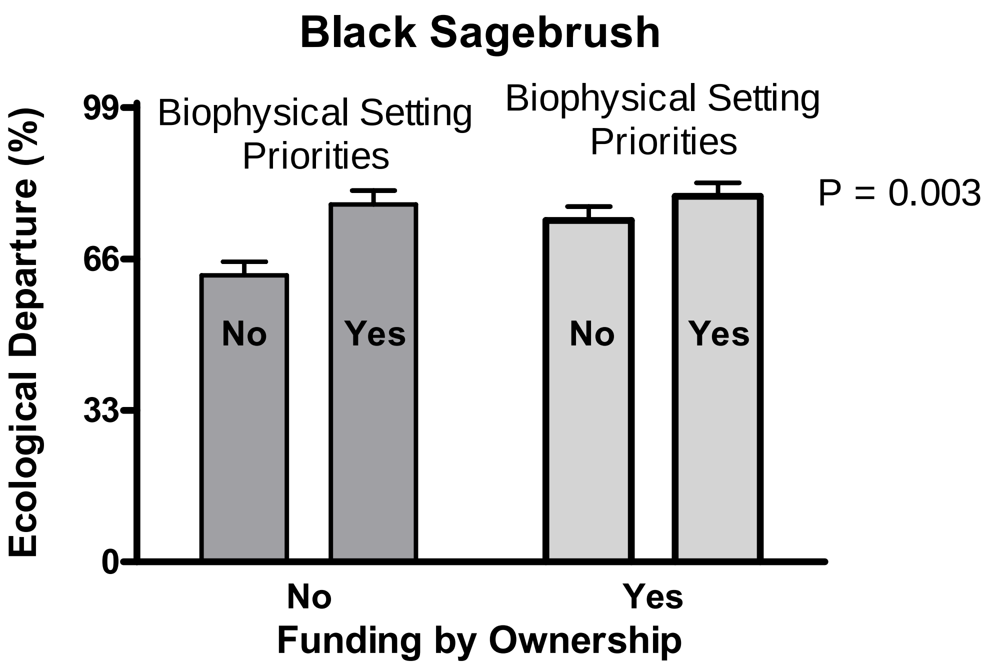


Figure 26. Ecological departure (%) of greasewood for the ANNUAL GRASS DISPERSAL RATE effect after 50 years of simulated management. Fractional ANOVA: ANNUAL GRASS DISPERSAL RATE, DF = 1, MS = 0.000304, F =140.09.



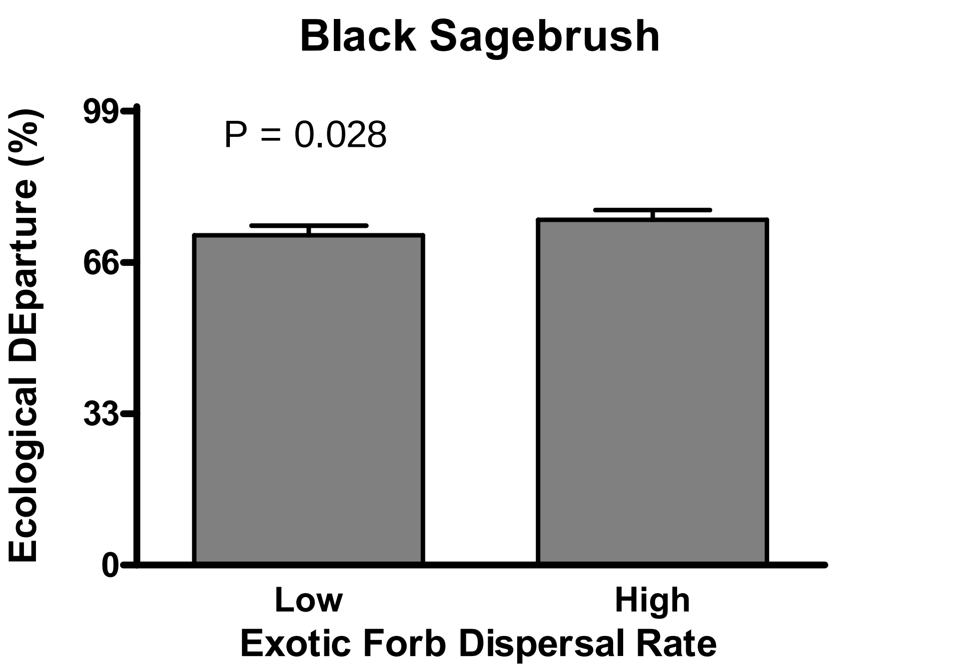


Figure 27. Ecological departure (%) of black sagebrush for the interaction of BIOPHYSICAL SETTING PRIORITIES × OWNERSHIP FUNDING and the effect of EXOTIC FORB DISPERSAL after 50 years of simulated management. Fractional ANOVA; BIOPHYSICAL SETTING PRIORITIES × OWNERSHIP FUNDING, DF = 1, MS = 0.010579, F = 14.45; EXOTIC FORB DISPERSAL , DF = 1, MS = 0.004708, 6.43.

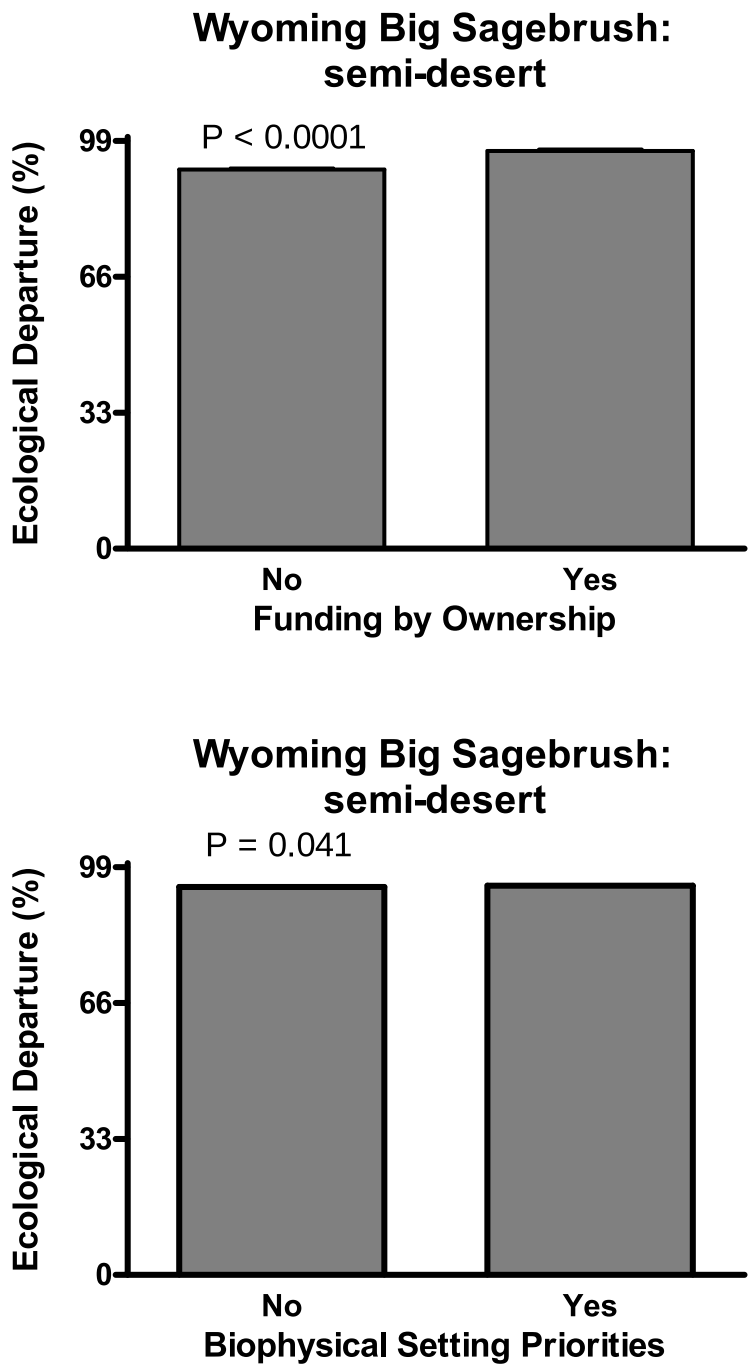


Figure 28. Ecological departure (%) of Wyoming big sagebrush–semi-desert site for the effects of FUNDING BY OWNERSHIP and BIOPHYSICAL SETTING PRIORITIES after 50 years of simulated management. Fractional ANOVA: FUNDING BY OWNERSHIP, DF = 1, MS = 0.008387, F = 1131.03; BIOPHYSICAL SETTING PRIORITIES, DF = 1, MS = 3.79E-05, F = 5.11.

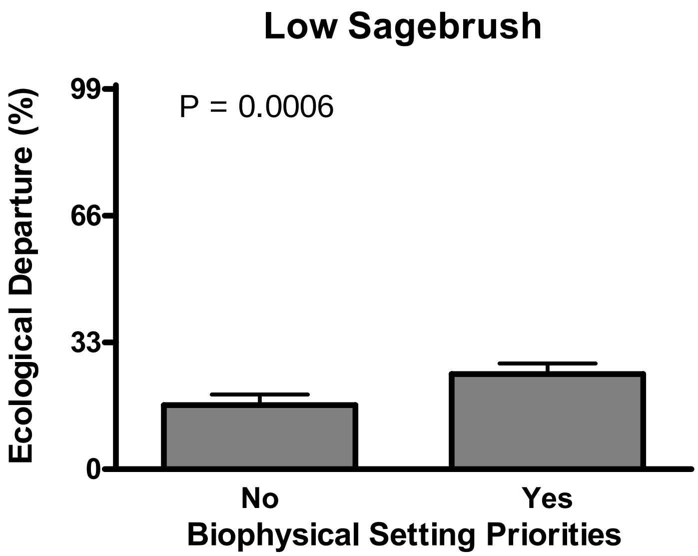


Figure 29. Ecological departure (%) of low sagebrush for the effect of BIOPHYSICAL SETTING PRIORITIES after 50 years of simulated management. Fractional ANOVA: BIOPHYSICAL SETTING PRIORITIES, DF = 1, MS = 0.026408, F = 20.92.

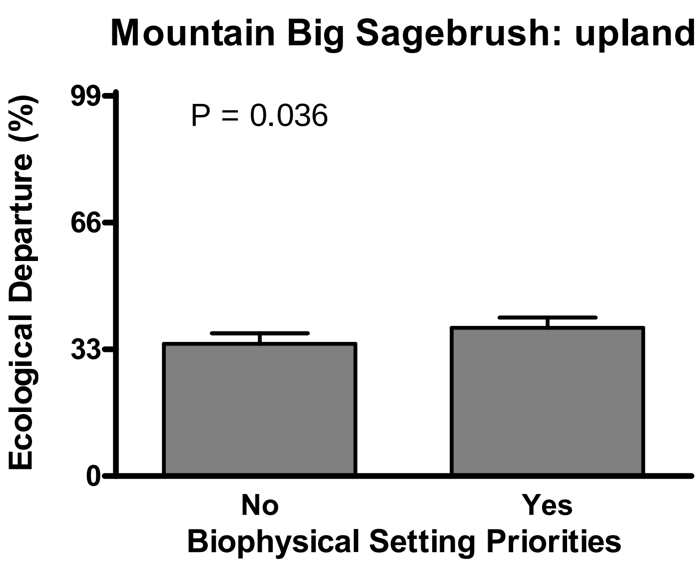


Figure 30. Ecological departure (%) of mountain big sagebrush–upland site for the effect of BIOPHYSICAL SETTING PRIORITIES after 50 years of simulated management. Fractional ANOVA: BIOPHYSICAL SETTING PRIORITIES, DF = 1, MS = 0.006739, F = 5.39.

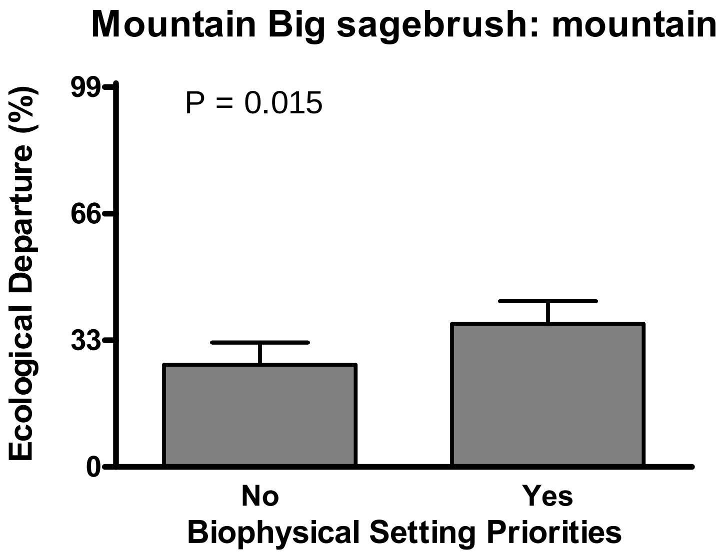


Figure 31. Ecological departure (%) of mountain big sagebrush–mountain site for the effect of BIOPHYSICAL SETTING PRIORITIES after 50 years of simulated management. Fractional ANOVA: BIOPHYSICAL SETTING PRIORITIES, DF = 1, MS = 0.045884, F =7.63.

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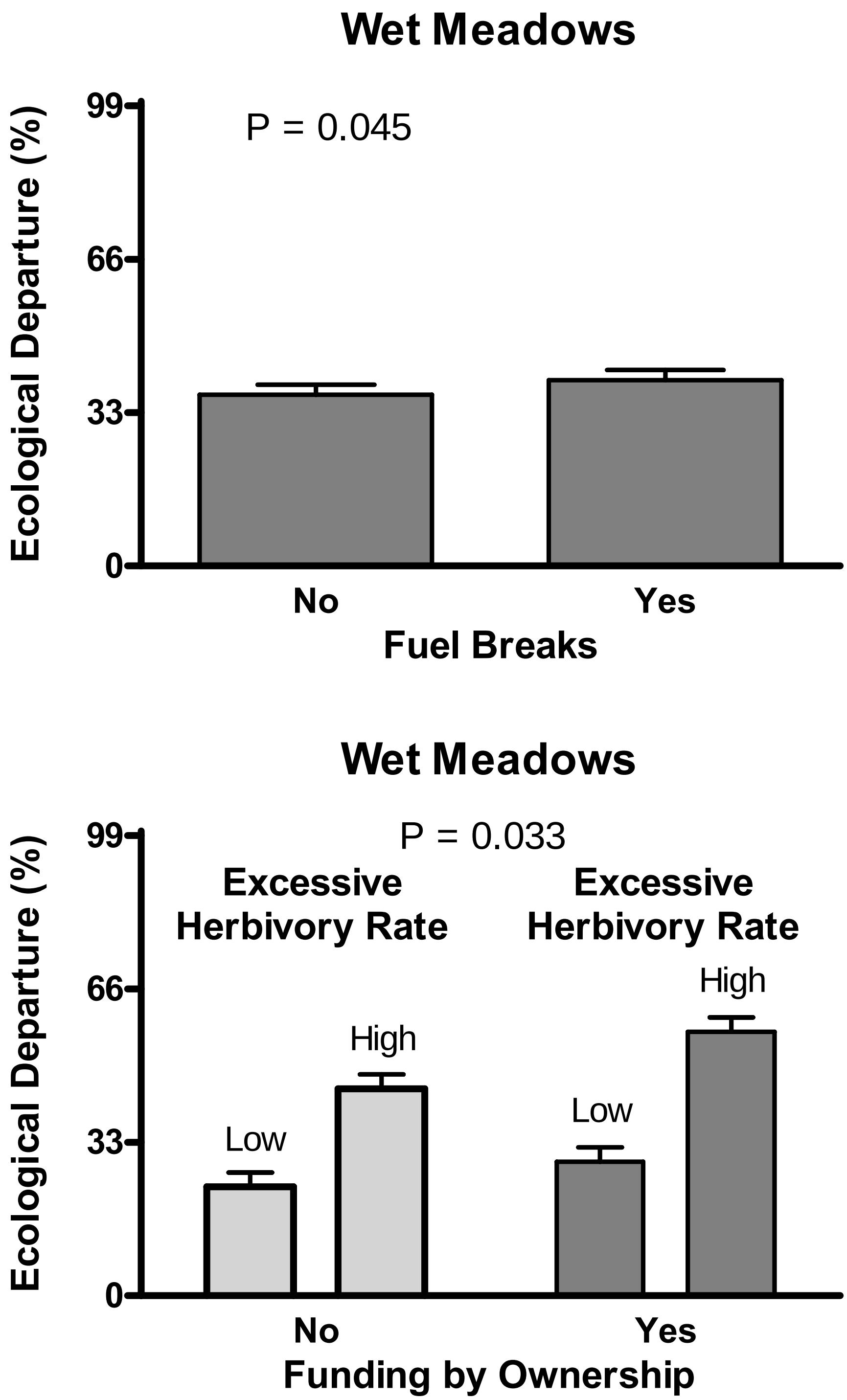

Figure 32. Ecological departure (%) of montane-subalpine wet meadow for the effect of FUEL BREAKS, and the interaction of EXCESSIVE HERBIVORY RATE × FUNDING BY OWNERSHIP after 50 years of simulated management. The main effects of EXCESSIVE HERBIVORY RATE and FUNDING BY OWNERSHIP are both $P < 0.0001$. Fractional ANOVA: EXCESSIVE HERBIVORY RATE, DF = 1, MS = 0.004696, F = 5.96; FUNDING BY OWNERSHIP, DF = 1, MS = 0.004001, F = 5.08.

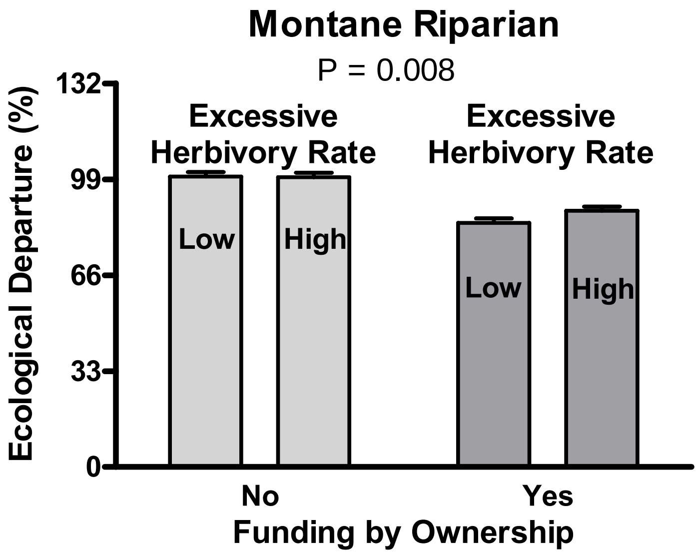

Figure 33. Ecological departure (%) of montane riparian for the interaction of EXCESSIVE HERBIVORY RATE × FUNDING BY OWNERSHIP after 50 years of simulated management. The main effects of EXCESSIVE HERBIVORY RATE and FUNDING BY OWNERSHIP are, respectively, P = 0.017 and P < 0.0001. Fractional ANOVA: EXCESSIVE HERBIVORY RATE × FUNDING BY OWNERSHIP, DF = 1, MS = 0.001904, F = 9.95.

4.4. Secondary management scenario comparisons

Secondary management scenarios were fine-tuning scenarios that used the No-Ownership-No Biophysical Settings Priorities-Fuel Breaks-Adjacency (NO-NB-F-A) core scenario as a baseline. The NO-NB-F-A scenario combination had the lowest landscape-weighted ecological departure and highest vegetation complexity for past factorial testing of core scenarios. As it happens, the NO-NB-F-A-HA-LF-HH scenario combination was also the best performing run for fractional design. Secondary management scenario descriptions are briefly repeated here (Table 3):

1. INCREASING SERAL COMPLEXITY: The scenario was implemented by preferentially placing adjacent treatments whose successional "outcome" (for example, early-succession phases) differ from the succession "outcomes" of past treatments already in place.
2. REDUCTION OF BUDGET LINE ITEMS: This scenario examined the effects of reducing the costs of archeological surveys, seed mix, and mechanical woody canopy reduction.
3. ADJACENCY TO COMMUNITIES AT RISK: The scenario focused resources on restoring the biophysical settings within 2 kilometers of a human community considered at risk.

4.4.1. Ecological departure and vegetation complexity

None of the secondary management scenarios had an effect on landscape-level ecological departure as weighted by the area of each biophysical setting or structural vegetation complexity using Shannon's diversity index (Table 10). Mean ecological departure varied between 55% and 57%, whereas Shannon's diversity index ranged between 0.69 and 0.76 (maps shown in Appendices V-VI).

Table 10. Multivariate analysis of variance (MANOVA) of the area-weighted ecological departure and Shannon's diversity Index for fine-tuning management scenarios using the sum of the three-way interaction mean squares as the error term. Legend: S for increasing Succession complexity of vegetation during treatment application; R for budget Reduction of archeological surveys, seed, and mechanical thinning; and C for application of vegetation treatments only around human Communities at risk

Source	Wilk's λ	F	Effect DF	Error DF	P
S	0.95	0.05	1	1	0.857
R	0.69	0.46	1	1	0.622
C	0.71	0.40	1	1	0.640
S*R	0.45	1.21	1	1	0.469
S*C	0.43	1.33	1	1	0.455
R*C	0.99	0.01	1	1	0.932

Statistical differences for ecological departure by biophysical settings were only seen for 3 of 14 (vegetation complexity was not calculated at the level of biophysical settings): montane-subalpine riparian, basin wildrye, and Wyoming big sagebrush semi-desert. Several of the statistical effects were weak, but the strongest results suggested the following:

- The communities at risk scenario had stronger effects than the seral complexity scenario;
- Vegetation management that increased seral complexity only slightly increased ecological departure for the montane-subalpine riparian biophysical setting, but decreased it for basin wildrye (Table 11; Figure 34a and c);
- Placing vegetation management treatments only around communities at risk moderately increased ecological departure of basin wildrye and Wyoming big sagebrush semi-desert biophysical settings (Table 11; Figures 35 and 36), but greatly decreased ecological departure in the montane-subalpine riparian biophysical setting (Table 11; Figure 34).

These results are relatively easy to explain. Placing vegetation treatments only adjacent to communities at risk resulted in the neglect of several biophysical settings that were not adjacent to towns or were much larger that the footprint of restoration around towns. Furthermore, Wyoming big sagebrush semi-desert was more susceptible to the effect of communities at risk because it was susceptible to cheatgrass invasion and experienced high failure rates of restoration to the seeded-nonnative state from annual grasslands or shrublands with an understory of annual grasses. Therefore, (a) if Wyoming big sagebrush semi-desert was not in the footprint of communities at risk, it would become more departed due to fires and cheatgrass invasion or (b) if it was within the restoration footprint, few restoration improvements to ecological departure would be simulated.

The case of basin wildrye is probably one of neglect coupled with annual grass and exotic forb invasions, or pinyon-juniper encroachment. The rate of exotic forb invasion and trees encroachment in basin wildrye are faster than in other terrestrial systems. Most basin wildrye ecological sites that were close to communities at risk have been converted to permanent agriculture (not simulated), therefore leaving patches of basin wildrye that were not managed because they were away from towns.

The montane-subalpine riparian biophysical settings responded the opposite to other systems. Interestingly, funding to treat communities at risk is usually not used to treat riparian corridors, but we did not discard this possibility here. As a result of many towns being close to significant creeks and springs, this biophysical setting received disproportionally more restoration activity than other biophysical settings. Moreover, riparian systems respond successfully and fast to restoration treatments, thus the reduction in ecological departure.

Table 11. Factorial analysis of variance (ANOVA) of ecological departure by biophysical settings for secondary management scenarios using the sum of the three-way interaction mean squares as the error term. Legend: S for increasing Succession complexity of vegetation during treatment application; R for budget Reduction of archeological surveys, seed, and mechanical thinning; and C for application of vegetation treatments only around human communities at risk.

Source	DF	MS	F	P
Stable Aspen				
S	1	0.0130	4.2	0.289
R	1	0.0660	21.7	0.134
C	1	0.0760	24.8	0.126
S*R	1	0.0480	15.6	0.158
S*C	1	0.0140	4.5	0.279
R*C	1	0.0030	1.1	0.487
Error	1	0.0030		
Pinyon-Juniper Woodland				
S	1	0.0000	0.16	0.759
R	1	0.0020	2.39	0.366
C	1	0.0000	0.00	0.971
S*R	1	0.0020	2.81	0.342
S*C	1	0.0000	0.33	0.669
R*C	1	0.0010	1.06	0.491
Error	1	0.0007		
Mixed Conifers				
S	1	0.0040	0.83	0.529
R	1	0.0030	0.53	0.601
C	1	0.0050	0.93	0.512
S*R	1	0.0020	0.39	0.644
S*C	1	0.0020	0.33	0.667

R*C	1	0.0110	2.07	0.386
Error	1	0.0052		
Seral Aspen				
S	1	0.0230	0.889	0.519
R	1	0.0260	0.994	0.501
C	1	0.0000	0.000	0.996
S*R	1	0.0040	0.163	0.756
S*C	1	0.0000	0.009	0.938
R*C	1	0.0260	0.996	0.501
Error	1	0.0259		
Curlleaf Mountain Mahogany				
S	1	0.0010	0.4	0.652
R	1	0.0010	0.4	0.645
C	1	0.0010	0.5	0.594
S*R	1	0.0000	0.0	0.884
S*C	1	0.0250	15.7	0.157
R*C	1	0.0050	2.9	0.338
Error	1	0.0016		
Montane-Subalpine Riparian				
S	1	0.0020	170.0	0.049
R	1	0.0000	1.0	0.603
C	1	0.6720	49000.0	0.003
S*R	1	0.0000	1.0	0.500
S*C	1	0.0020	170.0	0.049
R*C	1	0.0000	1.0	0.603
Error	1	0.0000		
Low Sagebrush				
S	1	0.0000	0.040	0.875
R	1	0.0050	0.615	0.577
C	1	0.0000	0.034	0.885
S*R	1	0.0070	0.830	0.530
S*C	1	0.0060	0.633	0.572
R*C	1	0.0000	0.000	0.993
Error	1	0.0088		
Black Sagebrush				
S	1	0.0000	0.7	0.561
R	1	0.0020	4.1	0.292
C	1	0.0330	87.4	0.068
S*R	1	0.0000	0.4	0.630
S*C	1	0.0020	4.9	0.269
R*C	1	0.0000	0.1	0.788
Error	1	0.0004		
Basin Wildrye				
S	1	0.0110	1402.0	0.017
R	1	0.0000	34.0	0.109
C	1	0.0220	2833.0	0.012
S*R	1	0.0000	48.0	0.091
S*C	1	0.0150	1911.0	0.015
R*C	1	0.0020	262.0	0.039

Error	1	0.0000		
Wyoming Big Sagebrush: semi-desert				
S	1	0.0000	0.0	0.882
R	1	0.0000	0.5	0.617
C	1	0.0130	327.4	0.035
S*R	1	0.0000	0.6	0.577
S*C	1	0.0000	0.0	0.951
R*C	1	0.0000	0.4	0.652
Error	1	0.0000		
Wyoming Big Sagebrush: upland				
S	1	0.0000	0.32	0.670
R	1	0.0010	2.12	0.383
C	1	0.0010	3.23	0.323
S*R	1	0.0000	0.08	0.829
S*C	1	0.0000	0.01	0.951
R*C	1	0.0000	0.04	0.872
Error	1	0.0004		
Mountain Big Sagebrush: mountain				
S	1	0.0020	1.12	0.482
R	1	0.0000	0.01	0.925
C	1	0.0040	2.04	0.389
S*R	1	0.0000	0.04	0.880
S*C	1	0.0060	3.49	0.313
R*C	1	0.0020	0.87	0.523
Error	1	0.0018		
Mountain Big Sagebrush: upland				
S	1	0.0010	1.40	0.446
R	1	0.0020	3.32	0.319
C	1	0.0040	5.50	0.257
S*R	1	0.0050	6.97	0.230
S*C	1	0.0000	0.69	0.559
R*C	1	0.0020	2.58	0.354
Error	1	0.0007		
Wet Meadow				
S	1	0.0060	16.9	0.152
R	1	0.0090	24.8	0.126
C	1	0.0010	2.2	0.375
S*R	1	0.0080	21.8	0.134
S*C	1	0.0010	2.0	0.394
R*C	1	0.0000	0.8	0.530
Error	1	0.0004		

The deliberate attempt to increase succession complexity through vegetation treatments worked in interaction with the communities at risk scenario with opposite trends for montane-subalpine riparian and basin wildrye biophysical settings (Figures 28c and 29). Ecological departure in riparian corridors probably increased because, being nearly 100% pasture, could not accommodate easily treatments that created early succession classes (most treatments) because pasture was by definition an early succession class. Therefore, treatments were sometimes not done even when needed. Basin wildrye did not respond to communities at risk because most of this biophysical setting was outside the footprint of towns; however, when communities at risk were not considered, ecological departure decreased because restoration created a distribution of succession vegetation classes closer to the natural range variability. Restoration was not constrained by pastures in basin wildrye; therefore greater flexibility to management activities was possible.

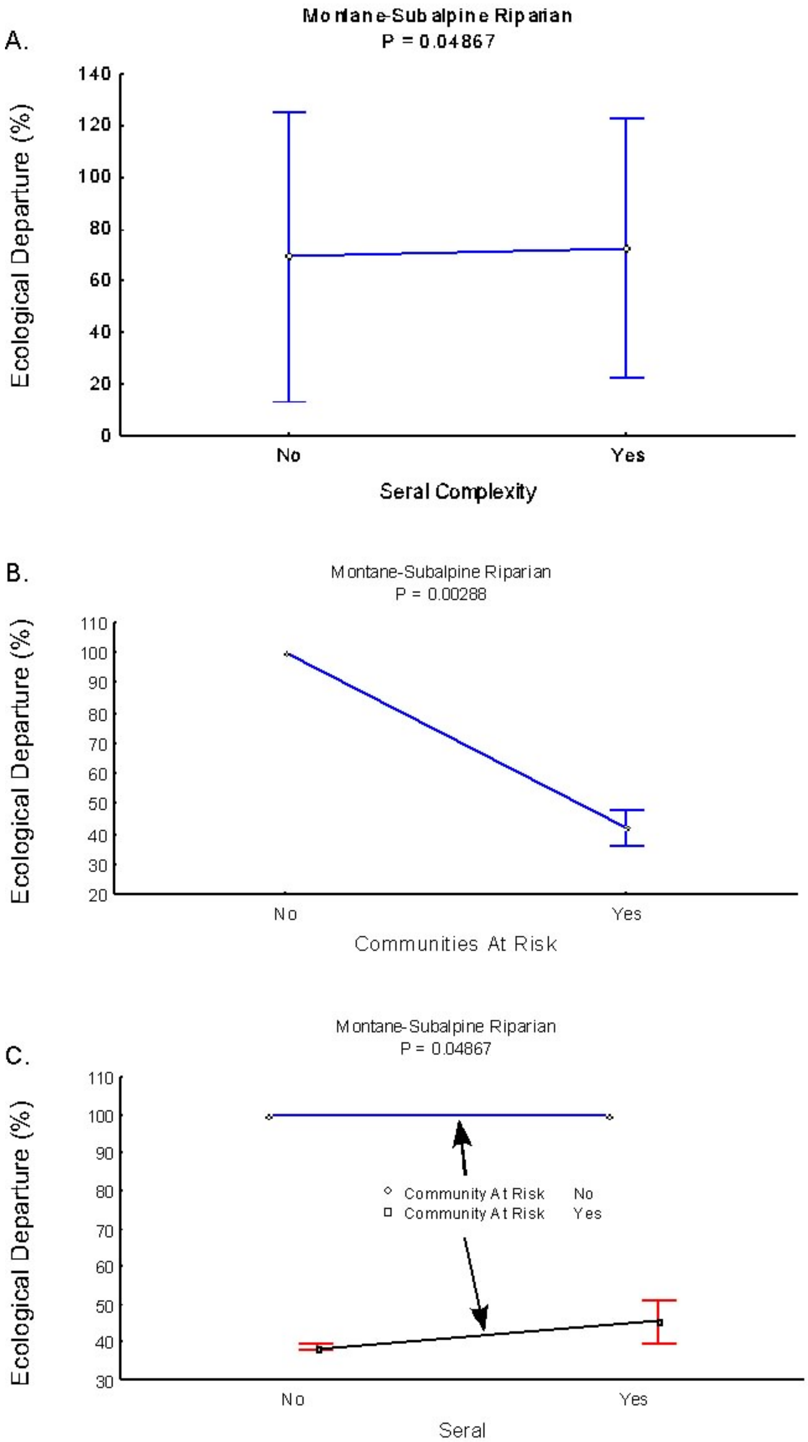

Figure 34. Ecological departure (%) of montane-subalpine riparian biophysical setting for the effect of SERAL COMPLEXITY (A), COMMUNITIES AT RISK (B), and their interaction after 50 years of simulated management.

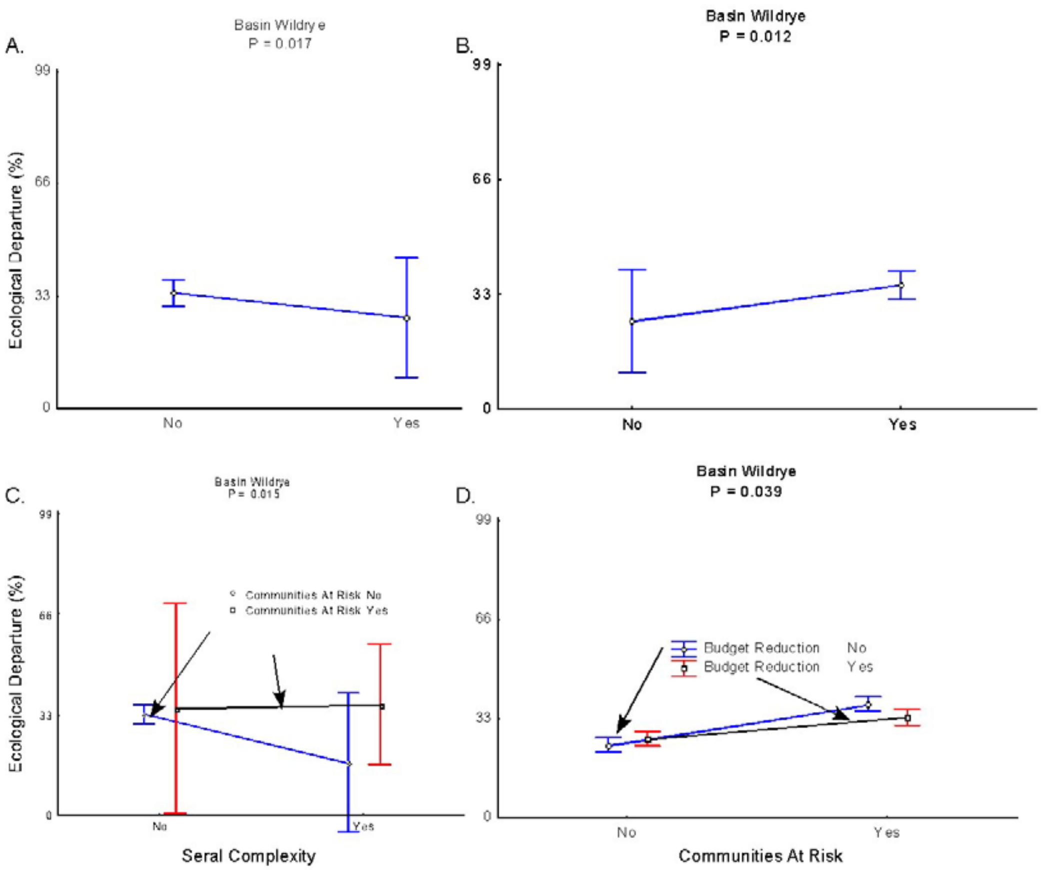

Figure 35. Ecological departure (%) of basin wildrye for the effect of SERAL COMPLEXITY (a), COMMUNITIES AT RISK (b), and interactions (c-d) after 50 years of simulated management.

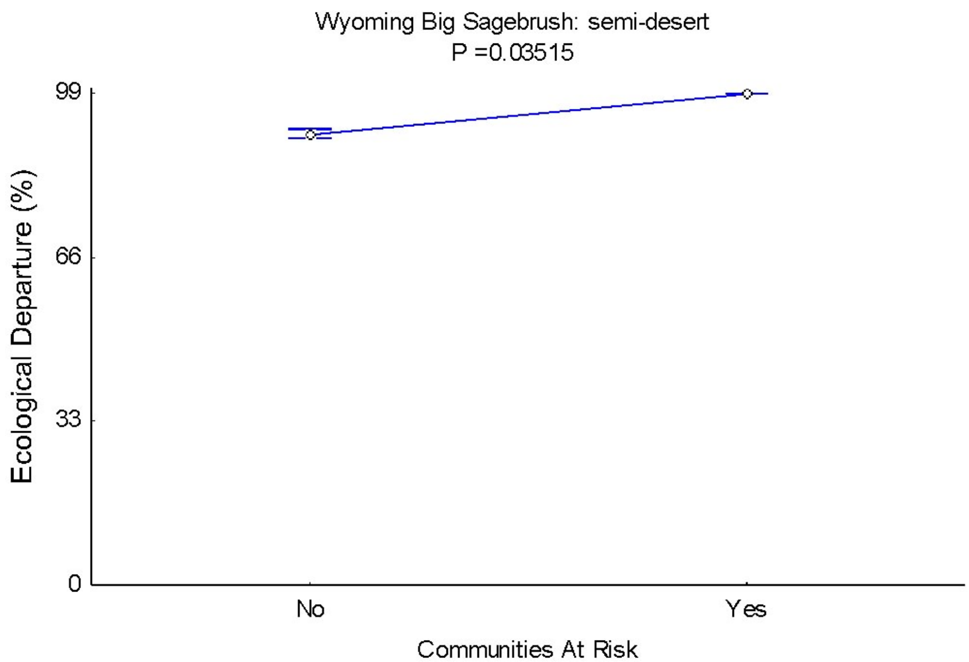

Figure 36. Ecological departure (%) of Wyoming big sagebrush semi-desert for the effect of COMMUNITIES AT RISK after 50 years of simulated management.

4.5. Management implications

Management implications were divided in two groups: "what we should do given what we learned" and "what we should consider given what we did not learn."

4.5.1. What we should do given what we learned

The overall management conclusions for all scenarios based on patterns in ecological departure and structural vegetation complexity were:

1. **Small projects do not affect landscape-level ecological condition**. Vegetation management projects, including fire rehabilitation, distributed across the landscape from 2001 to 2006 had no detectable landscape-level effects on ecological departure because they were too small, created outcomes that were either no different or worse than the condition they attempted to fix, converted degraded range to pasture, or realized improvements to ecological departure were masked by continued deterioration of the landscape due to mainly cheatgrass invasion. Local vegetation management projects that were not in response to post-fire rehabilitation might have achieved local objectives.

2. **Prioritizing biophysical settings for management can backfire**. Biophysical settings with a higher return on the investment usually occupy a smaller area and higher elevations in the landscape; therefore, concentrating limited resources means that biophysical settings with lower returns on the investment, which are generally at middle to lower elevations and more widespread, will be neglected while also being more susceptible to cheatgrass invasion. This scenario often had the strongest and more frequent effect, and managing biophysical settings according to priorities had detrimental effects by increasing ecological departure Biophysical setting priorities had no effect on structural vegetation complexity. Managers should not decide restoration activities based on biophysical setting's ability to respond to treatments.

3. **Funding distributed across ownership boundaries made a difference in a limited number of cases**. Utah Partners for Conservation and Development have the ability to distribute funds for fire and vegetation management across ownership boundaries, including private ownership. Results suggest that this should be encouraged to especially restore black sagebrush and montane wet meadows, and marginally so for Wyoming big sagebrush semi-desert, and to increase structural vegetation complexity. On the other hand, curlleaf mountain mahogany and montane riparian benefit more by keeping funding within their original ownership.

4. **Fuel breaks increased structural vegetation complexity**. Fuel breaks had the strongest effect on increasing structural vegetation complexity, even under high rates of cheatgrass dispersal. Fuel breaks along paved and dirt roads made of introduced species, also called "green strips", should be implemented below the 30.5 centimeter (12 inch) precipitation zone, where this action was most needed, and perhaps from 30.5 to 35.6 centimeter (12 to 14 inches) of precipitation. Although we simulated a 30-meter (98 feet) wide fuel break, 61-meter (200 foot) corridors might be more effective, although more expensive.

5. **Placing vegetation treatments adjacent to desirable habitat had no effect**. Only a few of the more continuous biophysical settings could benefit from this scenario; however, this might have been an added constraint that simply made treatment placement less successful (less area treated or treated less frequently).

6. **Managing vegetation only around communities at risk does not help**. Focusing resources within 2 km of communities at risk will generally have no effect or caused greater ecological departure to Wyoming big sagebrush semi-desert and basin wildrye. Only riparian systems, which are often near towns and generally not the object of National Fire Plan hazardous fuels reduction funding, showed decreased ecological departure.

7. **Increasing seral complexity helped at the margin**. The strategy that increased seral complexity had only small effects, although they generally decreased ecological departure, except for riparian systems.

8. **Reduction of budget items did not have effects**.

9. **Increased rates for excessive herbivory was more consequential than for cheatgrass and exotic forb dispersal.** A two-fold (four-fold relative to the lower tested rate) increase in the rate of excessive herbivory increased ecological departure of stable and seral aspen, wet meadows, and montane riparian although this activity was infrequent in vegetation models. Livestock operators have the ability to reduce detrimental forms of grazing on smaller, more mesic biophysical settings through either passive or active grazing systems.
10. **Greater rates of long-distance cheatgrass dispersal and exotic forb dispersal were detrimental and somewhat indirect.** It appears that management scenarios are fairly resistant to different rates of cheatgrass and exotic forb dispersal.

4.5.2. What we should consider given what we did not learn

The Utah Partners for Conservation and Development need to develop new approaches to both reduce cheatgrass-infested states at lower to middle elevations (15.2 -30.5 centimeter or 6-12 inch precipitation zone) and to restore higher elevation biophysical settings that are or will become highly departed in the next decade: stable and seral aspen, upland and mountain sites of mountain big sagebrush, and upland sites of Wyoming big sagebrush (Table 8). Two exceptions at lower elevation biophysical settings that did respond to scenarios were low sagebrush and black sagebrush (Figure 20b). This situation is not unique to this Intermountain West landscape and our proposed scenarios have not performed well for biophysical settings from lower elevations.

The Nature Conservancy is proposing two approaches as food for thought. These approaches are being considered in Nevada and Idaho, and clearly belong in a Research and Development category. Moreover, both ideas are not exclusive. Partners are encouraged to view them as hypotheses.

4.5.2.1. Incentives to create forage reserves on altered public and private lands

Western ranches typically consist of a base property on deeded land with federal grazing allotments attached to it. Most allotments span lower and higher elevations to allow for both summer and winter ranges, or different and usually adjacent allotments from the BLM and USFS allow livestock access to summer and winter ranges. In the basin and range country, summer pasture is used for approximately four months per year and is often a bottleneck for ranching and restoration because summer range is smaller in area than winter range and therefore removal of livestock following wildfire or restoration has a disproportionally greater effect on the profitability of a ranch. Without access to summer forage, ranchers must move cattle to pasture often situated on private lands and sometimes irrigated and, therefore they must buy forage (or sacrifice their winter hay). Higher elevation rangelands and woodlands are in need of active restoration while it is still feasible to treat them. Ranchers are often reluctant to allow restoration because of purely short-term financial constraints. On the other hand, there is often no shortage of degraded lower elevation rangelands invaded by cheatgrass or lacking native herbaceous cover. Such degraded range is often ungrazable except during the winter and for a few weeks in the early spring. Therefore, in the larger picture of western rangeland restoration, there is a clear need for higher elevation restoration at reasonable costs and to recover cheatgrass infested rangelands at middle to lower elevations.

Recovery of cheatgrass infested rangelands is very difficult with native seed mixes and without the herbicides Plateau or Oust. Plateau has recently been approved for national use on BLM lands; however some states do not allow it (for example, California). BLM is required by regulation to first use native seed mixtures and only deploy introduced species when the former are unavailable. Moreover, native species nurseries strongly recommend 5 years of rest for native species seedings before livestock grazing can be resumed; regulation only allows for 2-3 years. Many BLM seedings become annual grasslands as a result of fire rehabilitation projects where native seed has not survived. Cheatgrass can be successfully displaced from rangelands with seedings of introduced pasture species: crested wheatgrass and forage kochia. These two species are generally non-invasive, although forage kochia is more prone to spread from seedings. Furthermore, native plant species can be seeded into pastures years after cheatgrass has been displaced ("assisted-succession", Cox and Anderson 2004).

The Nature Conservancy is proposing to remove an important barrier to restoration of upper elevation rangelands and woodlands, namely the reluctance of ranchers to allow it, by providing nearby affordable and alternative sources of forage created from converting cheatgrass infested rangelands into either introduced species pastures, which may have varying cover of shrublands. We are seeking to create an incentive program and a market to facilitate the creation of pastures on otherwise degraded rangelands on private and federally managed lands (most likely BLM) with funding from the Utah Partners for Conservation and Development. The incentive would be both for 1) private landowners or agencies to pay for seeding operations on only cheatgrass infested or depleted range and 2) to subsidized ranchers for the transfer of livestock to these pastures during rest of upper elevation rangelands and woodlands. Importantly, one group will need to act as a broker to match up agency needs, permittees, and recipients of livestock, and to establish forage reserves.

4.5.2.2. Implementation of sustainable management systems on public allotments

Detrimental forms of livestock grazing persist in the arid West despite proven benefits of various rest-rotation and seasonal grazing practices to herbaceous productivity and animal weight gains (but see contrary evidence by Briske et al. 2008). Year-long grazing is surprisingly common, especially on federal land allotments. Large portions of the Intermountain West that receive the majority of their precipitation during the winter with no to little monsoonal influence typically support cool-season grasses, which are not adapted to prolonged large ungulate grazing. Year-long grazing is especially harmful to cool season grasses and forbs found in dry shrublands compared to the warm-season grasses that grow in areas of monsoonal influence.

Detrimental forms of grazing often persist in the Great Basin for the one or more of the following reasons: (1) livestock operators do not know about, are not motivated by, or are not willing to take the financial risk of converting to other forms of grazing management; (2) changing BLM or USFS grazing permits is, or is perceived to be, too difficult due to poor operator and agency relationships; (3) operators do not see the benefit of resting pastures that are grazed year-round by unmanaged wild horses and introduced ungulate game species; and (4) there may not be an effective institutional structure in place to allow revisions of the current grazing practices. Partners engaged in this project's modeling effort acknowledged that more profitable and ecologically beneficial grazing systems should be introduced to the Grouse Creek Mountains-Raft River Mountains project area.

We propose the development of negotiated, temporary livestock grazing management contracts that would buy from a livestock operator the rights to detrimental forms of livestock grazing for private lands and for federal allotments for the duration of the life of a federal grazing permit. The compensation of operators would be for the loss of realized livestock productivity due to the transition between grazing systems for a period of five years, while offering to mediate operator-agency interactions associated with permit modifications and to monitor the ecological and financial effectiveness of grazing management contracts. Compensation to operator's federal allotment permit would be conditional on a negotiated change of permit by the BLM or USFS.

We are unaware of any organization, including The Nature Conservancy, using these grazing contracts as a stand alone strategy. Grazing contracts have sometimes been included in conservation easements purchased by The Nature Conservancy. An organization that could implement grazing management contracts would need some expertise at (a) brokering land management contracts, (b) understanding the differences between strictly profit-maximizing grazing management systems and profitable ecological grazing management systems, (c) mediation among diverse stakeholders, and (d) ecological monitoring.

4.6. Transferability of method

The method we used here can be implemented just about anywhere. Difficulty of implementation would increase if partners do not cooperate with modelers, soil surveys are not available, the landscape is not accessible for remote sensing surveys, or site-specific land management budgets are not readily available. Except for the first condition, these limitations greatly increase cost of implementation. The social component of landscape-level modeling is perhaps the most important and interesting. Without local support, modeling land management scenarios is pointless. As we discovered here, the social process of documenting knowledge and beliefs, learning, and building trust among stakeholders of very different backgrounds was the most valuable result.

Landscape-level modeling spanning decades of management is inherently complex, but it does not need to be complicated. A few rules help keep modeling simple:

1. Define clearly objectives and measures of success while keeping both to a minimum.
2. Clearly distinguish potential vegetation (biophysical settings) from current vegetation (succession classes).
3. Accomplish tasks in this general order to minimize costs:
   (a) interpret soil surveys to the smallest acceptable (to partners) number of biophysical settings;
   (b) clearly define a minimum of objectives and measures of success;
   (c) draft the most simple and standardized a-spatial models for each biophysical settings and described phases and states of vegetation that could be detected by remote sensing;
   (d) obtain partner land management budgets before scenario development;
   (e) determine whether or not spatially explicit scenarios and simulations are necessary;
   (f) if spatial modeling is chosen,
      i) conduct remote sensing using a minimum of two field surveys (generally early summer);
      ii) prepare maps for TELSA software;
   (g) develop as few as possible spatial or a-spatial scenario simulations in stakeholder workshops; and
   (h) conduct and organize simulations.

4.7. Collaborative landscape planning – Grouse Creek Mountains/Raft River Mountains and beyond

This project provides tools for partners to answer some of the questions posed in our first collaborative workshop in January 2007. What is the current ecological condition of this landscape? What are the reference conditions for the various vegetation types? What is the current rate of disturbance for threats such as cheatgrass, invasive forbs, and altered fire regime? Will we reach our objectives with current management? Are there alternative management scenarios that would be more successful?

It will be our future partnerships, however, that will provide answers to the questions not yet answered. What is our vision of conservation success for this landscape? How can we strategically plan our restoration efforts on this landscape? How can we work together to achieve this vision and achieve best land health results?

We have the opportunity to continue this partnership, and explore ways to work together. A couple of those opportunities are described in this report – see 4.5 Management Implications for a summary of what our collaborative model suggests we should or should not consider to achieve best ecological health, and possibilities for aiding the local ranching economy and easing pressures on private and public allotments by creating grazing reserves and/or a sustainable management system on public allotments. We can foresee many other options. For example, we – Sawtooth National Forest, Bureau of Land Management and The Nature Conservancy, and others who are interested - can use products from this project and shared resources to develop fire plans and/or aspen restoration projects for northwest Utah. We invite all to continue the conversations about landscape planning and future outcomes for this landscape, and collaborative projects.

Looking beyond this northwest corner of Utah, does this collaborative model process have implications for other parts of Utah and the West? We suggest that it does, and that it can be a process to achieve efficient and effective conservation throughout the state. In a recent white paper, former Utah Division of Wildlife Resources employees, Adam Kozlowski and Janet Sutter, explored the cost and time constraints for statewide habitat restoration. Utah Partner for Conservation and Development habitat categories, they explain, cover 12,570,382 acres or 23 percent of the State of Utah. Estimating restoration at $75 per acre for 50 percent of the habitat, it would cost $471,389,325 and 31 years to treat these lands – assuming no additional habitat degradation or loss of ecological system functions. If 50 percent of the seedings work, the number of acres restored would decline from 200,000 acres/year to 100,000 acres/year, inflating the cost of restoration to $150 per acre, and increasing the cost and time estimates to a price tag of $942,000,000 to treat these same lands! Their conclusion: in many cases we cannot work harder. It is going to become increasingly more important that we work more efficiently. They proposed two solutions to increase that efficiency: 1) Assess landscape conditions with 10-12 smaller focus areas throughout the state and 2) provide individualized, local planning solutions for each of these smaller focus areas. The Grouse Creek Mountains/Raft River Mountains collaborative model, they suggest, is an example of how to provide managers with tools to effectively and efficiently address conservation threats on a landscape scale, and result in millions of dollars savings to Utah Partners for Conservation and Development over the lifetime of this Watershed Initiative.

5. Acknowledgments

The participation and contributions of many were critical to this exploration of answers to partner questions about the Grouse Creek Mountains-Raft River Mountains landscape. We would like to recognize the support, time, data and expertise shared by many partner organizations and certain individuals: Utah Partners for Conservation and Development for their financial support and vision of creating tools to address management at a landscape scale, especially Rory Reynolds and A.J. Martinez; Bureau of Land Management for generously sharing data and time, in particular Brook Chadwick and Jeff Kline for fire expertise; U.S. Forest Service Sawtooth National Forest for generously sharing data and time, especially Scott Nannenga and Dena Santini; U.S. Department of Agriculture Natural Resources Conservation Services (NRCS) and Shane Green for his thorough reviews of the state-and-transition models; Utah Division of Wildlife Resources, in particular Adam Kozlowski for his commitment to addressing wildlife/habitat management at a landscape and statewide level and Ron Greer for his assistance with fieldtrip logistics; Mike Welch, Troy Forrest and Shane Green for important data on private lands management; Dr. Susan Meyer for insights on cheatgrass disturbance; Lynn Decker and Jeremy Bailey for tremendous encouragement from the Fire Learning Network; Jim Smith for financial support from The Nature Conservancy's LANDFIRE project; Spatial Solutions, Inc. for working beyond the call of duty; ESSA Technologies, Ltd. and Leonardo Frid for invaluable modeling expertise; financial support in the form of match to the Fire Learning Network from The Nature Conservancy of Nevada; and significant financial support from The Nature Conservancy of Utah.

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Appendix I. Descriptions of the reference conditions of biophysical settings for the Grouse Creek Mountains-Raft River Mountains, Utah. The following descriptions were generated with LANDFIRE's ModelTracker database.

LANDFIRE Biophysical Setting Model

***Biophysical Setting:* gr1011** **Rocky Mountain Aspen Forest and 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*

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 chilensis), Pteridium aquilinum, Rudbeckia occidentalis, Thalictrum fendleri, Valeriana occidentalis,

*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.

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 interpreted ground fires that scarred trees, probably started by Native Americans, as mixed severity fire that

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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 gr1011 is closely based on BpS gb1011, but with the removal of mixed severity fire in class B as per new LANDFIRE fire type definitions. BpS gb1011 was developed for Great Basin National Park by Neal Darby (Neal_Darby@nps.gov), Ben Roberts (ben_roberts@nps.gov), Bryan Hamilton (Bryan_Hamilton@nps.gov), and Louis Provencher (lprovencher@tnc.org). NRV did not changed, although the total FRI is longer.

BpS gb1011 was based on BpS 171011 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:

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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 **40%**

Mid Development 1 Closed

Description

Aspen over 6' tall dominate. Canopy cover is highly variable. Replacement fire occurs every 60 yrs on average. 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:

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

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:

---

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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.

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.

Class E **0%**

Late Development 1 Closed

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	0%
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 10
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	68	50	300	0.014706	60
Mixed	101	20	60	0.009901	40
Surface					
All Fires	41			0.02462	

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.

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LANDFIRE Biophysical Setting Model

***Biophysical Setting:* gr1019** **Great Basin Pinyon-Juniper Woodland-moist**

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

General Information

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

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Modeler 2	see Comments		**Reviewer**
Modeler 3			**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), Achnatherum hymenoides, and Bouteloua gracilis (higher elevation). Achnatherum hymenoides is absent from or not diagnotic for this BpS in parts of eastern Nevada (NRCS range site descriptions for 028AY075NV and 028AY077NV). Common forbs are Phlox spp., Eriogonum spp., Astragalus spp., and Arabidopsis 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.

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. 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

Inter-Mountain Basins Juniper Savanna (BPS 1115) is generally found at elevations below the physiological tolerance of Pinus monophylla.

Dry types of gr1019 may have cover ranges that do not match the successional age class proposed below and would cause error in remote sensing analysis.

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

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

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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.

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 gr1019 is based on modifications to gb1019-moist designed for Great Basin National Park by Neal Darby (Neal_Darby@nps.gov), Ben Roberts (ben_roberts@nps.gov), Bryan Hamilton (Bryan_Hamilton@nps.gov), and Louis Provencher (lprovencher@tnc.org). To reflect new fire type definitions used in LANDFIRE, it was decided that mixed severity fire does not play a role in fire sensitive pinyon juniper (this type does not underburn), whereas replacement is the dominant fire type. Small surface fires was kept as a rarity in class D occuring only when fine fuel have substantlly increased after wet years.

BpS gb1011 was 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 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.

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 rotation of approximately 500 yrs and cause a transtion to class B by killing older trees.

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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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. 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
- [x] 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:

Disturbances

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Fire Regime Group:** 5

Historical Fire Size (acres)

Avg 10
Min 1
Max 5000

Sources of Fire Regime Data

- ☑ Literature
- ☑ Local Data
- ☑ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	296	10	1000	0.003378	85
Mixed					
Surface	1667	5	1000	0.0006	15
All Fires	251			0.00399	

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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LANDFIRE Biophysical Setting Model

Biophysical Setting: **gr1052** **Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodlands**

☐ *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.

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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

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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

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

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

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

Fuel Model 2

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

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

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

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

Fuel Model 10

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

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

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

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

Fuel Model 8

*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.

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

- [x] Literature
- [ ] Local Data
- [x] 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

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

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LANDFIRE Biophysical Setting Model

***Biophysical Setting:* gr1061** **Inter-Mountain Basins Aspen-Mixed Conifer Forest and 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
Modeler 2
Modeler 3
Reviewer
Reviewer
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	☐ 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 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 gr1011 (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 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

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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 gr1061 is closely based on BpS gb1061 developed by Neal Darby (Neal_Darby@nps.gov) and Bryan Hamilton (Bryan_Hamilton@nps.gov) for Great Basin National Park. The only modification to BpS gb 1061 was to remove mixed severity fire from class B. The NRV did not change but the total FRI is longer.

BpS gb1061 was based on BpS 121061 developed by Julia Richardson (jhrichardson@fs.fed.us) and Louis

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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.

Provencher (lprovencher@tnc.org). Species composition is based on range site descriptions 028AY080NV 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
- [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:

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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 **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. 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
☑ 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
☑ 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:

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

Indicator Species* and Canopy Position

POTR Upper
ABCO Mid-Upper
PSME
PIFL2 Mid-Upper

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ 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:

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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).

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
- ☑ 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

Fire Regime Group:** 2

Historical Fire Size (acres)

Avg 10
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	71	50	300	0.014085	49
Mixed	68	10	50	0.014706	51
Surface					
All Fires	35			0.02880	

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.

LANDFIRE Biophysical Setting Model

Biophysical Setting: **gr1062** **Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland**

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

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 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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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 mixed severity fires (FRI of 200 yrs) in the closed mid-development class, the stand will adopt a savanna-like woodland structure with a grassy understory with mountain big sagebrush. Surface fire every 40 yrs on average originating from adjacent systems (mountain big sagebrush) will maintain the savanna condition. 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.

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 gr1062 is based on BpS gb1062 developed by Neal Darby (Neal_Darby@nps.gov), Bryan Hamilton (Bryan_Hamilton@nps.gov), and .Ben Roberts (ben_roberts@nps.gov). BpS gb1062 was modified by

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removing mixed severity fire acting as maintenance fire from classes C, B, and D following new fire type defintions from LANDFIRE. Mountain mahogany is fire-sensitive and only supports mixed severity fire under special circumstances. Mixed severity fire was retained in class B to cause a transtion to class D. Compared to BpS gb1062, the new NRV varied by only 5% in classes B and C and the total FRI is longer as a decrease of mixed sevrity fire.

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 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

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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behavior, especially if chaparral species are present. Replacement fire (average FRI of 500 yrs) and native herbivory (2 out every 100 seedlings) of seedlings all affect this class. Replacement fire and native herbivory will reset the ecological clock to zero. Succession to class C after 20 years.

Class B **15%**

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 will result in 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 **10%**

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. 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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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, 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. Replacement fire every 500 yrs on average is the only disturbance and

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:

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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.

causes a transition to class A. Class will become old-growth with trees reported to reach 1000+ years.

Disturbances

Fire Regime Group:** 4

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	38
Mixed	1428	50	150	0.000700	8
Surface	200	50	200	0.005	54
All Fires	109			0.00921	

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)

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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.

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LANDFIRE Biophysical Setting Model

Biophysical Setting: gr1079aa **Great Basin Xeric Mixed Sagebrush Shrubland-ARAR**

☐ *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

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mid-lower elevations. Forbs often include buckwheats (Eriogonum spp.), fleabanes (Erigeron spp.), phloxs (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

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experiences fire.

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

Indicator Species* and Canopy Position

CHRYS	Upper
ACLE9	Mid-Upper
ACHY	Mid-Upper
ACTH7	Middle

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 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.

class A. Succession to B after 25 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:* gr1079an** **Great Basin Xeric Mixed Sagebrush Shrubland-ARNO**

☐ *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

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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.

cliffrose (Purshia stansburiana) and Nevada ephedra (Ephedra nevadensis)

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).

*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 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%

*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
☑ 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

☑ Literature
☐ Local Data
☑ 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.

*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

- [ ] Insects/Disease
- [x] 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, 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: gr1080bw   Inter-Mountain Basins Big Sagebrush-LECI4

☐ *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, ARTR, ERTE1, LETR5, PASM, ACHY

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
0	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 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

*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.

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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**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 **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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*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 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

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	%
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%

Late1 Closed

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	%
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

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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)

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LANDFIRE Biophysical Setting Model

Biophysical Setting: gr1080sd — Inter-Mountain Basins Big Sagebrush Shrubland_semi-desert

☐ *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** 1/23/2007

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

Vegetation Type

Upland Shrubland

Dominant Species*

ARTR	HECO
CHVI8	ELEL5
EPVI	ACHY
ARAR	ACSP1

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 ecological system is found in eastern CA, central NV, and UT and is distinct from Wyoming big sagebrush semi-desert in upland soils (more productive but not steppe) 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 4,200 - 6,500 ft, and occurs on well-drained soils on slopes (30-75%). Typical soils are loamy slopes 8-10" precipitation zones (PZ), stony slopes 8-10 PZ, and erodable slopes 8-12 PZ (north facing). It is found on shallow soil with depth to bedrock between 4-14". Elevationally it is found between low elevation salt desert shrub and big sagebrush zones where pinyon and juniper can establish.

Vegetation Description

The BpS consists of xeric Wyoming big sagebrush sites with a minor presence of rabbitbrush and green ephedra, and dominant grasses are Indian ricegrass, desert needlegrass, and needleandthread. Shrub canopy cover generally ranges from 5 to 25%.

Perennial forb cover is usually <10% with perennial grass cover reaching 20 - 25% on the more productive sites. Pinyon and juniper are absent to rare (then moslty Utah juniper) due to low precipitation zone. Wyoming big sagebrush semi-desert is critical habitat for the Greater Sage Grouse and many sagebrush obligates.

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Disturbance Description

The BpS is characterized by replacement fires. Total fire return interval is 136 yrs. Fire return interval decreases from 200 yrs in early development to 125 yrs in mid-development, and 100 yrs in late-development.

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.

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

Identification concerns include instaces of low-statured Wyoming big sagebrush due to reduced effective rooting zone. Low-statured Wyoming big sagebrush can be confused with black sagebrush (BpS gr1079AN) from a distance or satellite.

BpS gr1080s can be confused with gr1080up, which is genrally at higher elvations or on deeper soils.

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, and salt desert shrub at low 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 and other noxious weeds is common and results in change in fire frequency and vegetation dynamics. Lack of disturbance (i.e., fire suppression) can result in pinyon-juniper encroachment where adjacent to pinyon-juniper woodlands, although tree encroachment is less likely than in upland Wyoming big sagebrush sites (BpS gr1080up).

Native Uncharacteristic Conditions

Tree cover is uncharacteristic. More than 40% shrub cover in uncharacteristic.

Scale Description

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

BpS can occupy large areas (>5,000 acres). Historic disturbance (fire) likely ranged from small (< 10 ac) to large (max 5,000 acres) depending on conditions, time since last ignition, and fuel loading. The average patch size is assumed to be 250 acres.

Issues/Problems

Uncertainty exists about fire regimes.

Comments

BpS gr1080s is based on BpS wr1080d (Inter-Mountain Basins Big Sagebrush Shrubland-dry) from the Wassuk Range developed by Louis Provencher (lprovencher@tnc.org). Class D and E from wr1080d were removed (no tree invasion in this type), and mixed severity fire was removed leaving only replacement fire following new LANDFIRE definitions.

BpS 121080 was modified to reflect dry Wyoming big sagebrush and Lahontan sagebrush, respectively, on slopes >30% or shallow claypan (wr1080d) in western Nevada, more specifically the Wassuk Range. Shrub cover in the same development classes to do not overlap between the dry and moist 1080. The BpS was described based on species composition, landform position, and soil type described in NRCS soil survey for

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Lyon (#625) and Mineral (#744) counties, and Hawthorne Army Depot (#799).

BpS 121080 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 200 years on average but has no effect on succession. Succession to class B after 25 years.

Indicator Species* and Canopy Position

CHVI8	Upper
ACHY	Mid-Upper
ELEL5	Mid-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 (10-25% cover) with scattered shrubs representing <5% upper canopy cover.

Fuel Model 1

Class B 55%

Mid Development 1 Open

Description

Shrubs and herbaceous vegetation can be co-dominant, fine fuels bridge the woody fuels, but fuel discontinuities are common on slopes. Replacement fire has a mean FRI of 125 years. Succession to class C after 50 years.

Indicator Species* and Canopy Position

ARTR	Upper
EPVI	Mid-Upper
ACSP12	Mid-Upper
ACHY	Mid-Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11%	20%
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:

Fuel Model 2

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Class C 30%

Late 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. Replacement fire occurs with a mean FRI of 100 years. Prolonged drought (mean return interval of 100 years) and insect/disease (every 75 years on average) cause a transition to class B. Succession stays in this class.

Indicator Species* and Canopy Position

ARTR	Upper
EPVI	Mid-Upper
ACHY	Lower
ACSP12	Lower

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	21 %	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 D 0%

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		

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

Class E 0%

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		

☐ 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 250
Min 10
Max 5000

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	136	30	200	0.007353	100
Mixed					
Surface					
All Fires	136			0.00737	

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)

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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.

30.

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LANDFIRE Biophysical Setting Model

***Biophysical Setting:* gr1080up** **Inter-Mountain Basins Big Sagebrush Shrubland-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

Modeler 1	Louis Provencher	lprovencher@tnc.org	**Reviewer**
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	☐ 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 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

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sites. Bluebunch wheatgrass may be a dominant species following replacement fires and as a co-dominant 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)

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to large (> 10,000 acres) depending on conditions, time since last ignition, and fuel loading. The average 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 papramaters 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
- [x] Shrub
- [ ] Tree

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:

Early development is dominanted by grasses and forbs (>15% cover) with scattered shrubs

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representing <10% upper canopy cover.

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
- [x] 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
- [x] 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:

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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 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.

Indicator Species* and Canopy Position

JUNIP	Upper
PIMO	Upper
ARTR	Mid-Upper
ELEL5	

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 2

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).

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.

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Additional Disturbances Modeled

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

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NRCS. 2003. Major Lannd Resource Area 25 Owyhee High Plateau. Oregon and Nevada Ecological Site

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NRCS. 2003. Major Land Resource Area 27 Fallon-Lovelock Area. Nevada Ecological Site Descriptions. Reno, NV.

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Vale, T. R. 1975. Presettlement vegetation in the sagebrush-grass area of the intermountain west. Journal of Range Management 28(1): 32-36.

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LANDFIRE Biophysical Setting Model

Biophysical Setting: **gr1081** **Inter-Mountain Basins Mixed Salt Desert Scrub**

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

General Information

Contributors (also see the Comments field) **Date** 3/17/2005

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Modeler 3	Don Major	dmajor@tnc.org	**Reviewer**		
			FRCC		

Vegetation Type

Upland Shrubland

Dominant Species*

ATCO SABA1
ARSP5
KRLA
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 often 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 variable becoming finer toward valley bottoms. Many soils are derived from alluvium. 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.

This group generally lies above playas, lakes, and greasewood communities. Both to the north and up slope it is bordered by low elevation big sagebrush groups, commonly ARTRWY, ARAR8, and ARNO4 communities. To the south this group is bordered by Mojave Desert transition communities.

Vegetation Description

This ecological system includes low (<3 ft) and medium-sized shrubs found widely scattered (often 20-30 feet apart) to high density (3-5 plants per sq. m) shrubs interspersed with low to mid-height bunch grasses.

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Common shrubs are shadscale, winterfat, budsage, Nevada ephedra, horsebrush, low rabbitbrush, broom snakeweed, saltbush, and spiny hopsage. Bailey's greasewood (Sarcobatus baileyi) is common in western Nevada and the Wassuk Range. Shrub dominance is highly dependant on the site. Some of these shrubs will be present. 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. The relative abundance of species may vary in a patchwork pattern across the landscape in relation to subtle differences in soils (e.g., sand sheets or other surface textural differences) and reflect variation in disturbance history. Total cover rarely exceeds 25% and annual precipiation is closely linked to prior 12 months precipitation. Stand replacing disturbances (insects, extended wet periods and drought) shift dominance between shrub and grass species. Following drought coupled with insect infestations, the system will tend more toward Class C (bud sagebrush).

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

This ecological system contains the typical Great Basin salt desert shrub communities. Salt desert shrub communities are varied and the current model and description capture the most typical. Salt desert shrub is also common in the Wyoming big sagebrush community and there is some species overlap.

A drier site of mixed salt desert would include fourwing salthbush, which is usually not found within the shadscale community. The same model would apply with perhaps longer recovery times.

NOTE for MZs 12 and 17:
Where BPS 1081community is adjacent to a black sage or Wyoming big sage that has burned, these communities are often replaced by shadscale community at lower elevation. Further, these sites generally don't have budsage and winterfat, however, the temporal nature of this condition is unknown.
In rare occurrences shrub dominance can also shift.

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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.

Indian ricegrass can dominate sites with sandy surface textures, however, the temporal nature of this condition is unknown.

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

BPS 1081 forms vast communities easily >100,000 acres in valley bottoms. 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

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).

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

*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

Dominated by scattered and young shrubs (shadscale). After 5 years, vegetation moves to Class B as the primary successional pathway. Extended wet period (every 55 years) will have a stand replacing effect, with an ecological setback of 5 years.

Indicator Species* and Canopy Position

ACHY	Upper
ATCO	Upper
SABA1	Mid-Upper
ELEL5	Low-Mid

Upper Layer Lifeform

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

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	5%
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 50%

Mid Development 1 Open

Description

Dominated by shadscale. Extended wet periods (every 55 years on average) will cause a stand replacing transition to Class A. During extended drought periods (every 55 years), vegetation will shift to Class C (bud sagebrush dominant). Replacement fire is rare (mean FRI of 1000 years).

Indicator Species* and Canopy Position

SABA1	Mid-Upper
ATCO	Upper
ELEL5	Lower
ARSP5	Low-Mid

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:

Class C 45%

Mid Development 2 Open

Description

Budsage canopy cover is dominant with young shadscale establishing from seed. After 50 years, vegetation moves back to Class B through succession. Drought (mean return interval of 35 years) will maintain vegetation in Class C. Fire would not carry in this class.

Indicator Species* and Canopy Position

ARSP5	Upper
KRLA	Upper
ELEL5	Middle
ATCO	Lower

Upper Layer Lifeform

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

Fuel Model 4

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:

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	

*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 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
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	2000			0.0005	96
Mixed					
Surface					
All Fires	1992			0.00052	

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.

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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.

LANDFIRE Biophysical Setting Model

***Biophysical Setting:* gr1126mt** **Inter-Mountain Basins 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

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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).

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

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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.

(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.

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
☑ 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 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
☑ 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	

☑ 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.

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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 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 D. Otherwise, succession keeps vegetation in class C.

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:

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%.

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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 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:

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)

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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.

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LANDFIRE Biophysical Setting Model

***Biophysical Setting:* gr1126up** **Inter-Mountain Basins Montane Sagebrush Steppe-upland 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** 11/12/2007

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

Lower to mid-montane elevations across the western U.S., specifically from 1,590m to 1,980m (5,200-6,500 ft) in the mountains of northern Nevada, northwestern Utah, southeast Wyoming, and southern Idaho.

Biophysical Site Description

This ecological system occurs in many of the western United States, usually at middle elevations of 1,590m to 1,980m (5,200-6,500 ft) in the northern Great Basin. This BpS is clearly in the 30.5-35.5 cm/yr (12-14 in) precipaitation zone of mountain big sagebrush. Elsewhere, yearly precipitation can start at from 25 cm/year (Mueggler and Stewart 1980, Tart 1996). The climate regime is cool, semi-arid to subhumid. 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). All aspects are represented.

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

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sagebrush and low sagebrush and with mountain mahogany occurring on north-facing slopes.

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.

Some difficulty might be encountered in separating upland and mountain sites of mountain big sagebrush.

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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 gr1126up resulted from splitting BpS gr 1126 into NRCS mountain and upland ecological sites(NRCS soil series: Ant Flat R025XY310UT, Collard R028AY306UT, Hupp R028AY306UT, and Donnardo R028AY306UT).

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 gr1126up was reviewed by Shane Green, Utah NRCS.

BpS gr1126 was taken as is from gb1126 because the only fire type was replacement.

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

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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.

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.

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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 D. Otherwise, succession keeps vegetation in class C.

Indicator Species* and Canopy Position

ARTRV Upper
PUTR2 Upper
SYMPH Low-Mid
CONIF Mid-Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ 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:

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%.

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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:

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)

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LANDFIRE Biophysical Setting Model

Biophysical Setting: gr1145wm Rocky Mountain Alpine-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** 1/18/2007

Modeler 1	Louis Provencher	lprovencher@tnc.org	**Reviewer**
Modeler 2	See Comments		**Reviewer**
Modeler 3			**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). 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 into them.

*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

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 the mid- and late-development classes B and C. 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). 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 montane riparian Systems (1154 or 1160) and early-mid seral mountain big sagebrush dominated by basin wildrye (BpS gr1080bw).

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

BpS gr1145wm was based on BpS gb1145wm developed by Tod Williams (Tod_Williams@nps.gov), Bryan Hamilton (Bryan_Hamilton@nps.gov), Neal Darby (Neal_Darby@nps.gov), and Ben Roberts (ben_roberts@nps.gov) for Great Basin National Park. Two modifications were done to create BpS gr1145wm: 1) removal of mixed severity fire as per new LANDFIRE definitions and 2) applying a FRI of 40 yrs to both calsses B and C. NRV barely changed.

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.
**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

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 40%

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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*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 55%

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. 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
- ☑ 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	

☑ 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

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:

*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:** 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	30	50	0.02381	100
Mixed					
Surface					
All Fires	42			0.02383	

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.

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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.

LANDFIRE Biophysical Setting Model

***Biophysical Setting:* gr1146** **Southern Rocky Mountain Montane-Subalpine Grassland**

☐ *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*

DANT	POFE
POCU	POWH
POGL	RIMO
ELTRT	JUCO6

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

High elevations in the central-eastern Great Basin. Found on a few ranges, such as the Snake Range.

Biophysical Site Description

In Great Basin National Park, this ecological system typically occurs from 2895 m (9500 feet) to 3200 m (10,500 ft) on warm aspects. Soils somewhat resemble prairie soils in that the A-horizon is dark brown, relatively high in organic matter, neutral to slightly acidic, and usually well-drained. Unlike prairie soils, these soils are generally cold and while loamy on the surface, grade to higher in coarse fragments at depth. Lack of soil depth and high soil fragment volume result in a very low water holding capacity favorable to grassland development.

Vegetation Description

This BpS usually consists of a mosaic of two or three plant communities with one of the following dominant bunch grasses: Danthonia intermedia, Danthonia unispicata, Poa cusickii, Poa glauca ssp rupicola, Poa fendleriana, Poa wheeleri, Elymus trachycaulus, Achnatherum lettermanii, or various sedges (Carex rossii and Carex phaeocephala). Shrubs are Ribes montigenum, Juniperus communis, and Erameria suffruticosus. These smallpatch grasslands are intermixed with matrix stands of spruce-fir, limber pine (Pinus flexilis), and aspen (Populus tremuloides) forest.

Disturbance Description

Based on BpS gb1056 (spruce-fir), a fire return interval of 200 years for replacement fire was chosen. Fire spread from adjacent types.

Native herbivory probably maintained the herbaceous condition through a mixture of grazing and browsing.

*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

Montane grasslands are very similar and intergrade with their subalpine counterparts.

With long-term fire suppression, these sites are prone to shrub encroachment.

Fine-grained soils are prone to compaction with heavy grazing use during early season when soils are moist.

Native Uncharacteristic Conditions

Scale Description

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

Type occurs in patches <100 acres.

Issues/Problems

Literature and concept for this system is based on the Rocky Montains. A few examples of montane-subalpine grasslands exist in the Great Basin (e.g., Great Basin National Park), but these are uncommon and small because montane big sagebrush or low sagebrush would usually dominate or surround these sites.

Comments

BpS gr1146 was atken as-is from BpS gb1146 (see modelers above).

Other modeler for BpS gb1146 was Ben Roberts (ben_roberts@nps.gov). BpS gb1146 was based on BpS 121146 developed by Cheri Howell (chowell02@fs.fed.us) and Julia H. Richardson (jhrichardson@fs.fed.us). The FRI was increased to 200 years and herbivory was added, especially browsing in the woody class C.

BPS 1146 for mapping zones 12 and 17 was based on the description and model from zone 16 with edits in species composition, geographic range, and scale. Within the Great Basin dominant graminiod species vary by location and substrate. BPS 1146 for MZ 16 was based on R3MGRA created by Wayne A. Robbie (wrobbie@fs.fed.us) and adopted by Louis Provencher (lprovencher@tnc.org) for MZ 16.

Vegetation Classes

Class A 5%

Early Development 1 All Struc

Description

Low cover of graminoids, forbs and sedges. Replacement fire (Mean FRI of 200 years) setbacks succession to age zero. Native herbivory occurs on 50% of the landscape per year, but does affect succession. Succession to class B after 5 years.

Indicator Species* and Canopy Position

POGLR Upper
POCUE Upper
DANTH Upper
ELTRT Upper

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0%	10%
Height	Herb 0m	Herb 1.0m
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.

Class B 30%

Mid Development 1 Closed

Description

High cover of graminoids, forbs and sedges . Low shrubs start occupying the grasslands at <9% cover. Replacement fire (Mean FRI of 200 years) setbacks succession to age zero. Native herbivory occurs on 50% of the landscape per year, but does affect succession. Succession to class C after 5 years.

Indicator Species* and Canopy Position

POGLR Upper
POCUE Upper
DANTH Upper
ELTRT Upper

Upper Layer Lifeform

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

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	30 %
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 C 65%

Late Development 1 Closed

Description

High cover of graminoids, forbs and sedges . Low shrubs occupying <9-30% cover. Replacement fire (Mean FRI of 200 years) setbacks succession to age zero. Native herbivory occurs on 30%/year of the landscape per year, and browsing causes thnning and transition to class B. Surface fire (mean FRI of 100 years) causes a transition to B by thinning shrubs.

Indicator Species* and Canopy Position

RIMO? Mid-Upper
POGLR Upper
DANTH Upper
ELTRT Upper

Upper Layer Lifeform

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

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	50 %
Height	Herb 0.6m	Herb 1.0m
Tree Size Class	None	

- [ ] 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

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	%
Height		
Tree Size Class		

Upper Layer Lifeform

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

Fuel Model

- [ ] 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 E **0%**

Late Development 1 Closed

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	%
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 10
Max 100

Sources of Fire Regime Data

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

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	200			0.005	43
Mixed					
Surface	151			0.006623	57
All Fires	86			0.01163	

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
- [x] 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.

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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.

LANDFIRE Biophysical Setting Model

***Biophysical Setting:* gr1153** **Inter-Mountain Basins Greasewood Flat**

☐ *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	Sandy Gregory	s50grego@nv.blm.gov	**Reviewer**	Mike Zielinski	mike_zielinski@nv.blm.gov
Modeler 2	Bryan Bracken	Bryan_Bracken@blm.gov	**Reviewer**	Terri Barton	terri_barton@nv.blm.gov
Modeler 3	Jack Sheffey	Jack_Sheffey@blm.gov	**Reviewer FRCC**		

Vegetation Type

Wetlands and Riparian

Dominant Species*

SAVE4
DISTI
LECI4
ATCO

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

Occurs throughout much of the western US in intermountain basins. Common in Nevada and Utah.

Biophysical Site Description

This site occurs on aluvial flats, lake plains, or sodic dunes usually adjacent to playas below the mixed salt desert shrubland zone. Sites typically have sodic soils, shallow water table, and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations. Slope gradients of less than 2 percent are most typical. Elevations are between 3800 and 5800 feet. Average annual precipitation is 5 to 8 inches; mean temperature is 45 to 50 degrees F; average growing season is 100 to 120 days. The surface layer will normally crust inhibiting water infiltration and seedling emergence.

Vegetation Description

This system sometimes occurs as a mosaic of multiple communities, with open to moderately-dense shrublands dominated or co-dominated by Sarcobatus vermiculatus (greasewood). Atriplex confertifolia (shadscale) may be present or co-dominant. Occurences are often surrounded by mixed salt desert scrub. Herbaceous layer, if present, is usually dominated by graminoids. There may be inclusions of Sporobolus airoides (alkali sacaton), and Distichilis spicata (saltgrass). Vegetation on this site is normally restricted to coppice mound areas that are surrounded by playa-like depressions or nearly level, usually barren, inner spaces. Potential vegetative composition is about 15 percent grasses, 5 percent forbes and 80 percent shrubs. As ecological condition declines herbaceous understory is reduced or eliminated and the site becomes a community of halophytic shrub dominated by greasewood.

*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

Historically, fire was extremely infrequent. This type may be killed by standing water that lasts greater than 40 days based on observation of inundations of Lake Bonneville flats in 1983 (pers. observ., Gary Medlyn, Ely BLM) (mean return interval of 150 years). Vigorous resprouter following low to moderate severity fires, although severe fires may result in some mortality. Some re-seeding may occur from nearby remnant plants.

Adjacency or Identification Concerns

Halogeton is likely to invade this site.

Native Uncharacteristic Conditions

Scale Description

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

Scale ranges from tens to 100,000s of acres.

Issues/Problems

Comments

BpS gr1153 and BpS wr1153 were taken as-is from BpS 121153 with minor changes to Biophysical Site Description. Names of modelers and reviewers were retained.

Reviewers recommended extended the MFRI from 200 to 1000 years and adding extended flooding to 150 years return interval. Duration of class A was extended to 5 from 2 years.

Vegetation Classes

Class A 5%

Early Development 1 All Struc

Description

Some grasses and greasewood sprouts are present. Some representation of other sprouting species may also be present (e.g., rabbitbrush). Grass species varies geographically, but include the following for Utah and Nevada: inland saltgrass, bottlebrush squirreltail, and alkali sacaton. Succession to class B after 5 years.

Indicator Species* and Canopy Position

ELEl4	Upper
LECI4	Lower
SPAI	Lower
SAVE4	Middle

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0%	15%
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:

*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 **95%**

Mid Development 1 Closed

Description

Greasewood shrubs are mature. Rabbitbrush may be found in association with greasewood. May occur with various sagebrush species and salt desert shrub vegetation (shadscale, saltbushes, and budsage). Greasewood communities stay in this class indefinitely. Replacement fire is rare (mean FRI of 1000 years). Prolongued flooding events (>40 days) will cause a transition to class A (return interval of 150 years).

Indicator Species* and Canopy Position

SAVE4	Upper
DISTI	Lower
SPAI	Middle
LECI4	Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	15 %	25 %
Height	Shrub Dwarf <0.5m	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 **0%**

Late Development 1 Open

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

☐ 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

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	0 %
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:

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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 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
- ☑ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	1000	500	2000	0.001	98
Mixed					
Surface					
All Fires	998			0.00102	

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.

LANDFIRE Biophysical Setting Model

Biophysical Setting: **gr1154** **Inter-Mountain Basins Montane Riparian Systems**

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

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

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
18	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, 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 ecoregion with 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. iN larger river systems, 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 shrub and 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 present in the Grouse Creek Mountains-Raft River Mountains (Hall 1946; Zeveloff 1988) and crop younger cottonwoods (Populus spp.) and willows (Salix spp.), and frequently influence the hydrologic regime through construction of dams, etc. Beaver will move from areas where tree availability is depleted. Younger stands of cottonwood and willow will be affected by beaver every 5 years, whereas mid-development and late-development trees will be affected, respectively, every 20 years (50% stand replacing and 50% thinning) and 1000 years (strong thinning disturbance).

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 88 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

BpS gr1154 was based on BpS 181154 developed by Louis Provencher (lprovencher@tnc.org) for the Columbia Plateau and BpS gb1154 developed by Tod Williams (Tod_Williams@nps.gov), Bryan Hamilton (Bryan_Hamilton@nps.gov), Neal Darby (Neal_Darby@nps.gov), and Ben Roberts (ben_roberts@nps.gov) for Great Basin National Park. Beaver activity was added to BpS gb1154 using the parameter values of BpS 181154 (Snake River Plains mapzone). Other paramaters were not modified. The resulting NRV was very different with beaver activity, which was expected.

BpS gb1154 was 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.

*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 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.

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 45%

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 1) weather-related stress expressed as 7-year annual flooding events and 2) beaver activity with a return interval of 5 years to young patches of trees and shrubs (option 1). 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:

*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 **30%**

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, 2) 20-yr flooding events (weather-related stress) causing stand replacement, and 3) beaver (Castor canadensis) clear-cutting (Option1). Beaver clearcutting occurs every 20 yrs on average with a total probability partitioned 50/50 causing, respectively, a transition back to Class A (mean return interval = 40 yrs) and class B (mean return interval = 40 yrs). Replacement fire occurs about every 50 yrs on average. Succession to class C after 15 years.

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:

Class C **25%**

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. Beaver activity (option 1) is infrequent and causes a thinning disturbance to class B every 100 yrs on average. 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:

*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:** 4

Historical Fire Size (acres)

Avg 10
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	88	31	112	0.011364	100
Mixed					
Surface					
All Fires	88			0.01138	

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) option 1-beaver herbivory
- ☐ 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.

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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.

Appendix II. Parameters and pathways for natural and management disturbances for each VDDT biophysical settings model. Numbers and codes extracted from VDDT Access database. Cover and structural state abbreviation described in Table 2. Consult VDDT user manual downloadable from www.essa.com to understand use and value of parameters. Models can be viewed with the software VDDT and the GCM-RRM database.

Probabilistic Transition[&]	From Cover Type	From Structural Stage	To Cover Type	To Structural Stage	Min Age	Max Age	Time Since disturbance Min	Time Since disturbance Max*	Disturbance Rate = ProbXProp	Relative Age	Keep Relative Age
STABLE ASPEN - 1011											
AltSuccession	ESH	OPN	NAS-Mid	OPN	0	999	0	9999	0.01	0	FALSE
AltSuccession	Late1	CLS	Late1	OPN	40	1039	100	9999	1	0	FALSE
Canopy-Thinning	Late1	CLS	Early1	CLS	40	1039	0	9999	0.0033	0	FALSE
Canopy-Thinning	Late1	OPN	Early1	CLS	100	200	0	9999	0.0033	0	FALSE
Canopy-Thinning	NAS-Late	OPN	NAS-Mid	CLS	71	114	0	9999	0.001	0	FALSE
Canopy-Thinning	NAS-Mid	CLS	NAS	ALL	50	70	0	9999	0.005	0	FALSE
Canopy-Thinning1	Late1	CLS	Mid1	CLS	40	1039	0	9999	0.0033	0	FALSE
Canopy-Thinning1	Late1	OPN	Mid1	CLS	100	200	0	9999	0.0033	0	FALSE
Canopy-Thinning1	NAS-Late	OPN	NAS	ALL	71	114	0	9999	0.0045	0	FALSE
Canopy-Thinning1	NAS-Mid	CLS	NAS-Mid	OPN	50	70	0	9999	0.005	0	FALSE
Canopy-Thinning2	NAS-Late	OPN	NAS-Mid	OPN	71	114	0	9999	0.0045	0	FALSE
Excessive-Herbivory	Early1	CLS	NAS	ALL	2	9	0	9999	0.001	0	FALSE
Excessive-Herbivory	Late1	OPN	Late1	OPN	100	200	0	9999	0.001	5	FALSE
Excessive-Herbivory	NAS	ALL	ESH	OPN	2	11	0	9999	0.0003	0	FALSE
Excessive-Herbivory	NAS	ALL	NAS	ALL	0	11	0	9999	0.000825	2	FALSE
Excessive-	NAS-Late	OPN	NAS-	OPN	71	114	0	9999	0.001	2	FALSE

Herbivory			Late								
Excessive-Herbivory	NAS-Mid	OPN	ESH	OPN	12	49	0	9999	0.0003	0	FALSE
Excessive-Herbivory	NAS-Mid	CLS	NAS-Mid	CLS	50	70	0	9999	0.001	1	FALSE
Excessive-Herbivory1	NAS-Mid	OPN	NAS-Mid	OPN	12	49	0	9999	0.000825	2	FALSE
Insect/Disease	Late1	CLS	Early1	CLS	40	1039	0	9999	0.001	0	FALSE
Insect/Disease	Late1	OPN	Late1	CLS	100	200	0	9999	0.003	0	FALSE
Insect/Disease	NAS-Late	CLS	NAS-Late	OPN	115	140	0	9999	0.013	0	FALSE
Insect/Disease	NAS-Mid	CLS	NAS-Mid	OPN	50	70	0	9999	0.013	0	FALSE
Insect/Disease1	Late1	CLS	Mid1	CLS	40	1039	0	9999	0.004	0	FALSE
MixedFire	Late1	CLS	Late1	CLS	40	1039	0	9999	0.02	0	FALSE
MixedFire	Late1	OPN	Late1	CLS	100	200	0	9999	0.05	0	FALSE
ReplacementFire	ESH	OPN	NAS	ALL	0	999	0	9999	0.002	0	FALSE
ReplacementFire	Late1	CLS	Early1	CLS	40	1039	0	9999	0.017	0	FALSE
ReplacementFire	Late1	OPN	Early1	CLS	100	200	0	9999	0.017	0	FALSE
ReplacementFire	Mid1	CLS	Early1	CLS	10	39	0	9999	0.017	0	FALSE
ReplacementFire	NAS	ALL	NAS	ALL	0	11	0	9999	0.0125	-12	FALSE
ReplacementFire	NAS-Late	OPN	NAS	ALL	71	114	0	9999	0.025	0	FALSE
ReplacementFire	NAS-Late	CLS	NAS	ALL	115	140	0	9999	0.013	0	FALSE
ReplacementFire	NAS-Mid	OPN	NAS	ALL	12	49	0	9999	0.025	0	FALSE
ReplacementFire	NAS-Mid	CLS	NAS	ALL	50	70	0	9999	0.01	0	FALSE
ReplacementFire	TrEnc	CLS	ESH	OPN	141	999	0	9999	0.0067	0	FALSE
ReplacementFire1	ESH	OPN	ESH	OPN	0	999	0	9999	0.018	0	FALSE
RxFire	Late1	CLS	Early1	CLS	40	1039	0	9999	0.01	0	FALSE
RxFire	Late1	OPN	Early1	CLS	100	200	0	9999	0.01	0	FALSE
RxFire	NAS-Late	OPN	NAS	ALL	71	114	0	9999	0.005	0	FALSE
RxFire	NAS-Late	CLS	NAS	ALL	115	140	0	9999	0.005	0	FALSE
RxFire	NAS-Mid	CLS	NAS	ALL	50	70	0	9999	0.005	0	FALSE
RxFire1	NAS-Late	OPN	NAS-Late	OPN	71	114	0	9999	0.005	0	FALSE

RxFire1	NAS-Late	CLS	NAS-Late	CLS	115	140	0	9999	0.005	0	FALSE
RxFire1	NAS-Mid	CLS	NAS-Mid	CLS	50	70	0	9999	0.005	0	FALSE
Thin-Mech-Chem-Seed	TrEnc	CLS	NAS	ALL	141	999	0	9999	0.01	0	FALSE
PINYON-JUNIPER WOODLAND-1019											
AG-Invasion	Late1	OPN	TrAG	CLS	100	999	0	9999	0.002	0	FALSE
AG-Invasion	Mid2	OPN	TrAG	CLS	30	99	0	9999	0.002	0	FALSE
AG-Restoration	AG	OPN	SENN	OPN	0	1	0	9999	0.25	0	FALSE
AG-Restoration1	AG	OPN	AG	OPN	0	1	0	9999	0.75	0	FALSE
Insect/Disease	Late1	OPN	Mid1	OPN	100	999	0	9999	0.002	0	FALSE
Insect/Disease	Mid2	OPN	Mid1	OPN	30	99	0	9999	0.002	0	FALSE
Insect/Disease1	Late1	OPN	Mid2	OPN	100	999	0	9999	0.002	0	FALSE
ReplacementFire	AG	OPN	AG	OPN	0	999	0	9999	1	-9999	FALSE
ReplacementFire	Early1	OPN	Early1	OPN	0	9	0	9999	0.005	-10	FALSE
ReplacementFire	Late1	OPN	Early1	OPN	100	999	0	9999	0.002	0	FALSE
ReplacementFire	Mid1	OPN	Early1	OPN	10	29	0	9999	0.005	0	FALSE
ReplacementFire	Mid2	OPN	Early1	OPN	30	99	0	9999	0.005	0	FALSE
ReplacementFire	SENN	OPN	SENN	OPN	3	30	0	9999	0.003825	-999	FALSE
ReplacementFire	TrAG	CLS	AG	OPN	30	999	0	9999	0.034	0	FALSE
ReplacementFire1	SENN	OPN	AG	OPN	3	30	0	9999	0.0013	0	FALSE
SurfaceFire	Late1	OPN	Late1	OPN	100	999	0	9999	0.001	0	FALSE
Wind/Weather/Stress	TrAG	CLS	TrAG	CLS	30	999	0	9999	0.002	-1	FALSE
Wind/Weather/Stress1	TrAG	CLS	AG	OPN	30	999	0	9999	0.002	0	FALSE
MIXED CONIFERS-1052											
AltSuccession	Late1	OPN	Late1	CLS	100	999	35	9999	1	0	FALSE
AltSuccession	Mid1	OPN	Mid1	CLS	31	99	35	9999	1	0	FALSE
Insect/Disease	Late1	OPN	Late1	OPN	100	999	0	9999	0.01	0	FALSE
Insect/Disease	Late1	CLS	Late1	OPN	100	999	0	9999	0.012	0	FALSE
Insect/Disease	Mid1	CLS	Mid1	CLS	30	99	0	9999	0.02	0	FALSE

Insect/Disease	Mid1	OPN	Mid1	OPN	31	99	0	9999	0.01	0	FALSE
Insect/Disease1	Late1	CLS	Mid1	OPN	100	999	0	9999	0.008	0	FALSE
MixedFire	Late1	CLS	Late1	OPN	100	999	0	9999	0.021	0	FALSE
MixedFire	Mid1	CLS	Mid1	OPN	30	99	0	9999	0.021	0	FALSE
ReplacementFire	Early1	ALL	Early1	ALL	0	29	0	9999	0.008	-30	FALSE
ReplacementFire	Late1	OPN	Early1	ALL	100	999	0	9999	0.0025	0	FALSE
ReplacementFire	Late1	CLS	Early1	ALL	100	999	0	9999	0.008	0	FALSE
ReplacementFire	Mid1	CLS	Early1	ALL	30	99	0	9999	0.008	0	FALSE
ReplacementFire	Mid1	OPN	Early1	ALL	31	99	0	9999	0.0025	0	FALSE
RxFire	Late1	OPN	Late1	OPN	100	999	0	9999	0.005	0	FALSE
RxFire	Late1	CLS	Early1	ALL	100	999	0	9999	0.005	0	FALSE
RxFire	Mid1	CLS	Early1	ALL	30	99	0	9999	0.005	0	FALSE
RXFire1	Late1	CLS	Late1	OPN	100	999	0	9999	0.005	0	FALSE
RXFire1	Mid1	CLS	Mid1	OPN	30	99	0	9999	0.005	0	FALSE
SurfaceFire	Late1	OPN	Late1	OPN	100	999	0	9999	0.025	0	FALSE
SurfaceFire	Late1	CLS	Late1	CLS	100	999	0	9999	0.021	0	FALSE
SurfaceFire	Mid1	OPN	Mid1	OPN	31	99	0	9999	0.025	0	FALSE
Wind/Weather/Stress	Early1	ALL	Early1	ALL	0	29	0	9999	0.007	0	FALSE
Wind/Weather/Stress	Late1	OPN	Late1	OPN	100	999	0	9999	0.001	0	FALSE
Wind/Weather/Stress	Late1	CLS	Late1	OPN	100	999	0	9999	0.005	0	FALSE
Wind/Weather/Stress	Mid1	CLS	Mid1	OPN	30	99	0	9999	0.005	0	FALSE
Wind/Weather/Stress	Mid1	OPN	Mid1	OPN	31	99	0	9999	0.001	0	FALSE
SERAL ASPEN-1061											
AltSuccession	Late1	OPN	Late1	CLS	80	1079	100	9999	1	0	FALSE
AltSuccession	NAS-Late	OPN	NAS-Late	CLS	101	999	35	9999	1	0	FALSE
AltSuccession	NAS-Mid	OPN	NAS-Mid	CLS	31	100	35	9999	1	0	FALSE
Canopy-Thinning	Late1	OPN	Mid2	CLS	80	1079	0	9999	0.0033	0	FALSE
Canopy-Thinning	Mid2	CLS	Early1	ALL	40	79	0	9999	0.0033	0	FALSE

Canopy-Thinning1	Late1	OPN	Early1	ALL	80	1079	0	9999	0.0033	0	FALSE
Canopy-Thinning1	Mid2	CLS	Mid1	CLS	40	79	0	9999	0.0033	0	FALSE
Canopy-Thinning2	Late1	OPN	Mid1	CLS	80	1079	0	9999	0.0033	0	FALSE
Canopy-Thinning2	Mid2	CLS	Mid2	CLS	40	79	0	9999	0.0033	-40	FALSE
Excessive-Herbivory	Early1	ALL	NAS	ALL	0	9	0	9999	0.01	0	FALSE
Insect/Disease	Late1	CLS	Late1	OPN	100	119	0	9999	0.003	0	FALSE
Insect/Disease	Mid2	CLS	Mid1	CLS	40	79	0	9999	0.004	0	FALSE
Insect/Disease	NAS-Late	CLS	NAS	ALL	101	999	0	9999	0.012	80	FALSE
Insect/Disease	NAS-Late	OPN	NAS-Late	OPN	101	999	0	9999	0.01	0	FALSE
Insect/Disease	NAS-Mid	CLS	NAS-Mid	OPN	31	100	0	9999	0.02	0	FALSE
Insect/Disease	NAS-Mid	OPN	NAS-Mid	OPN	31	100	0	9999	0.01	0	FALSE
Insect/Disease1	Mid2	CLS	Early1	ALL	40	79	0	9999	0.001	0	FALSE
MixedFire	Late1	OPN	Mid2	CLS	80	1079	0	9999	0.05	0	FALSE
MixedFire	Late1	CLS	Late1	OPN	100	119	0	9999	0.05	0	FALSE
MixedFire	Mid2	CLS	Mid2	CLS	40	79	0	9999	0.025	0	FALSE
MixedFire	NAS-Late	CLS	NAS-Late	OPN	101	999	0	9999	0.02	0	FALSE
MixedFire	NAS-Mid	CLS	NAS-Mid	OPN	31	100	0	9999	0.021	0	FALSE
MixedFire	NAS-Mid	OPN	NAS-Mid	OPN	31	100	0	9999	0.025	0	FALSE
ReplacementFire	Late1	OPN	Early1	ALL	80	1079	0	9999	0.017	0	FALSE
ReplacementFire	Late1	CLS	Early1	ALL	100	119	0	9999	0.017	0	FALSE
ReplacementFire	Mid1	CLS	Early1	ALL	10	39	0	9999	0.017	0	FALSE
ReplacementFire	Mid2	CLS	Early1	ALL	40	79	0	9999	0.017	0	FALSE
ReplacementFire	NAS	ALL	NAS	ALL	0	30	0	9999	0.0083	-999	FALSE
ReplacementFire	NAS-Late	CLS	NAS	ALL	101	999	0	9999	0.017	0	FALSE
ReplacementFire	NAS-Late	OPN	NAS	ALL	101	999	0	9999	0.0025	0	FALSE
ReplacementFire	NAS-Mid	CLS	NAS	ALL	31	100	0	9999	0.02	0	FALSE
ReplacementFire	NAS-Mid	OPN	NAS	ALL	31	100	0	9999	0.0025	0	FALSE

RxFire	Late1	OPN	Early1	ALL	80	1079	0	9999	0.008	0	FALSE
RxFire	Late1	CLS	Early1	ALL	100	119	0	9999	0.008	0	FALSE
RxFire	Mid2	CLS	Early1	ALL	40	79	0	9999	0.008	0	FALSE
RxFire	NAS-Late	CLS	NAS	ALL	101	999	0	9999	0.0025	0	FALSE
RxFire	NAS-Late	OPN	NAS-Late	OPN	101	999	0	9999	0.0025	0	FALSE
RxFire	NAS-Mid	CLS	NAS	ALL	31	100	0	9999	0.0025	0	FALSE
RxFire1	Late1	OPN	Late1	OPN	80	1079	0	9999	0.002	0	FALSE
RxFire1	Late1	CLS	Late1	CLS	100	119	0	9999	0.002	0	FALSE
RxFire1	Mid2	CLS	Mid2	CLS	40	79	0	9999	0.002	0	FALSE
RxFire1	NAS-Late	CLS	NAS-Late	OPN	101	999	0	9999	0.0025	0	FALSE
RxFire1	NAS-Mid	CLS	NAS-Mid	OPN	31	100	0	9999	0.0025	0	FALSE
SurfaceFire	NAS-Late	CLS	NAS-Late	CLS	101	999	0	9999	0.02	0	FALSE
SurfaceFire	NAS-Late	OPN	NAS-Late	OPN	101	999	0	9999	0.025	0	FALSE
Wind/Weather/Stress	NAS-Late	CLS	NAS-Late	OPN	101	999	0	9999	0.012	0	FALSE
Wind/Weather/Stress	NAS-Mid	OPN	NAS-Mid	OPN	31	100	0	9999	0.001	0	FALSE
Wind/Weather/Stress1	NAS-Late	CLS	NAS-Late	CLS	101	999	0	9999	0.008	0	FALSE
					CURLLEAF MOUNTAIN MAHOGANY-1062						
AG-Invasion	Late1	OPN	TrAG	CLS	60	999	0	9999	0.001	0	FALSE
AG-Invasion	Late1	CLS	TrAG	CLS	150	999	0	9999	0.001	0	FALSE
AG-Restoration	AG	OPN	SENN	OPN	0	1	0	9999	0.25	0	FALSE
AG-Restoration1	AG	OPN	AG	OPN	0	1	0	9999	0.75	0	FALSE
AltSuccession	Late1	OPN	Late1	CLS	60	999	150	9999	1	0	FALSE
MixedFire	Mid1	CLS	Late1	OPN	60	149	0	9999	0.005	0	FALSE
NativeGrazing	Early1	ALL	Early1	ALL	0	19	0	9999	0.02	-20	FALSE
NativeGrazing	Mid1	CLS	Mid1	CLS	60	149	0	9999	0.001	0	FALSE
NativeGrazing	Mid1	OPN	Mid1	OPN	20	59	0	9999	0.01	0	FALSE
ReplacementFire	AG	OPN	AG	OPN	0	999	0	9999	1	0	FALSE

ReplacementFire	Early1	ALL	Early1	ALL	0	19	0	9999	0.002	-20	FALSE
ReplacementFire	Late1	OPN	Early1	ALL	60	999	0	9999	0.003	0	FALSE
ReplacementFire	Late1	CLS	Early1	ALL	150	999	0	9999	0.002	0	FALSE
ReplacementFire	Mid1	CLS	Early1	ALL	60	149	0	9999	0.007	0	FALSE
ReplacementFire	Mid1	OPN	Early1	ALL	20	59	0	9999	0.007	0	FALSE
ReplacementFire	TrAG	CLS	AG	OPN	60	999	0	9999	0.007	0	FALSE
SurfaceFire	Late1	OPN	Late1	OPN	60	999	0	9999	0.025	0	FALSE
MIXED SALT DESERT-1081											
AG-Invasion	Early1	ALL	AG	CLS	0	4	0	9999	0.005	0	FALSE
AG-Invasion	Mid1	OPN	ShAg	CLS	5	1004	0	9999	0.01	0	FALSE
AG-Invasion	Mid2	OPN	ShAg	CLS	10	59	0	9999	0.005	0	FALSE
AG-Restoration	AG	CLS	SENN	OPN	0	1	0	9999	0.5	0	FALSE
AG-Restoration1	AG	CLS	AG	CLS	0	1	0	9999	0.5	0	FALSE
AltSuccession	SENN	OPN	Mid1	OPN	30	999	0	9999	0.001	0	FALSE
ReplacementFire	AG	CLS	AG	CLS	0	999	0	9999	1	-999	FALSE
ReplacementFire	Mid1	OPN	Early1	ALL	5	1004	0	9999	0.001	0	FALSE
ReplacementFire	ShAg	CLS	AG	CLS	5	999	0	9999	0.25	0	FALSE
ShAG-Restoration	ShAg	CLS	SENN	OPN	5	999	0	9999	0.005	0	FALSE
ShAG-Restoration1	ShAg	CLS	ShAg	CLS	5	999	0	9999	0.005	0	FALSE
Wind/Weather/Stress	Early1	ALL	Early1	ALL	0	4	0	9999	0.018	-10	FALSE
Wind/Weather/Stress	Mid1	OPN	Early1	ALL	5	1004	0	9999	0.018	0	FALSE
Wind/Weather/Stress	Mid2	OPN	Mid2	OPN	10	59	0	9999	0.018	-5	FALSE
Wind/Weather/Stress	ShAg	CLS	AG	CLS	5	999	0	9999	0.018	0	FALSE
Wind/Weather/Stress1	Mid1	OPN	Mid2	OPN	5	1004	0	9999	0.018	0	FALSE
MONTANE-SUBALPINE GRASSLAND-1146											
AltSuccession	HVG	OPN	Mid1	CLS	2	10	0	9999	0.005	0	FALSE
AltSuccession	HVG	CLS	Late1	CLS	13	999	0	9999	0.005	0	FALSE

Excessive-Herbivory	Early1	ALL	HVG	OPN	2	4	0	9999	0.0005	0	FALSE
Excessive-Herbivory	HVG	OPN	HVG	OPN	4	10	0	9999	0.001	2	FALSE
Excessive-Herbivory	HVG	CLS	HVG	CLS	11	999	0	9999	0.001	2	FALSE
Excessive-Herbivory	Late1	CLS	HVG	CLS	10	909	0	9999	0.001	0	TRUE
Excessive-Herbivory	Mid1	CLS	Mid1	CLS	5	9	0	9999	0.000825	2	FALSE
Excessive-Herbivory1	Mid1	CLS	HVG	OPN	5	9	0	9999	0.0003	0	FALSE
NativeGrazing	Early1	ALL	Early1	ALL	0	4	0	9999	0.5	0	FALSE
NativeGrazing	HVG	CLS	HVG	CLS	11	999	0	9999	0.1	0	FALSE
NativeGrazing	Late1	CLS	Mid1	CLS	10	909	0	9999	0.1	0	FALSE
NativeGrazing	Mid1	CLS	Mid1	CLS	5	9	0	9999	0.5	0	FALSE
ReplacementFire	Early1	ALL	Early1	ALL	0	4	0	9999	0.005	-5	FALSE
ReplacementFire	HVG	OPN	Early1	ALL	2	10	0	9999	0.005	0	FALSE
ReplacementFire	HVG	CLS	HVG	OPN	11	999	0	9999	0.005	0	FALSE
ReplacementFire	Late1	CLS	Early1	ALL	10	909	0	9999	0.005	0	FALSE
ReplacementFire	Mid1	CLS	Early1	ALL	5	9	0	9999	0.005	0	FALSE
ReplacementFire	TrEnc	CLS	HVG	OPN	50	999	0	9999	0.017	0	FALSE
RxFire	HVG	OPN	Early1	ALL	10	10	0	9999	0.0025	0	FALSE
RxFire	HVG	CLS	HVG	OPN	11	999	0	9999	0.0025	0	FALSE
RxFire	Late1	CLS	Early1	ALL	10	909	0	9999	0.0025	0	FALSE
RxFire	TrEnc	CLS	HVG	OPN	50	999	0	9999	0.0025	0	FALSE
RxFire1	HVG	OPN	HVG	OPN	2	10	0	9999	0.0025	0	FALSE
RxFire1	HVG	CLS	HVG	CLS	11	999	0	9999	0.0025	0	FALSE
RxFire1	Late1	CLS	Late1	CLS	10	909	0	9999	0.0025	0	FALSE
RxFire1	TrEnc	CLS	TrEnc	CLS	50	999	0	9999	0.0025	0	FALSE
SurfaceFire	Late1	CLS	Mid1	CLS	10	909	0	9999	0.01	0	FALSE
Thin-Mech-Chem-Seed	TrEnc	CLS	HVG	OPN	50	999	0	9999	0.005	0	FALSE
Tree-Invasion	HVG	CLS	TrEnc	CLS	50	999	0	9999	0.005	0	FALSE

Tree-Invasion	Late1	CLS	TrEnc	CLS	50	909	0	9999	0.005	0	FALSE
Wind/Weather/Stress	TrEnc	CLS	HVG	OPN	50	999	0	9999	0.013	0	FALSE
GREASEWOOD-1153											
AG-Invasion	Early1	ALL	AG	OPN	0	4	0	9999	0.005	0	FALSE
AG-Invasion	Mid1	CLS	ShAG	CLS	5	1004	0	9999	0.005	0	FALSE
AG-Restoration	AG	OPN	SENN	OPN	0	1	0	9999	0.25	0	FALSE
AG-Restoration1	AG	OPN	AG	OPN	0	1	0	9999	0.75	0	FALSE
AltSuccession	SENN	OPN	Mid1	CLS	30	999	0	9999	0.001	0	FALSE
ReplacementFire	AG	OPN	AG	OPN	0	999	0	9999	1	-999	FALSE
ReplacementFire	Mid1	CLS	Early1	ALL	5	1004	0	9999	0.001	0	FALSE
ReplacementFire	ShAG	CLS	AG	OPN	5	999	0	9999	0.25	0	FALSE
ShAG-Restoration	ShAG	CLS	SENN	OPN	5	999	0	9999	0.0025	0	FALSE
ShAG-Restoration1	ShAG	CLS	AG	OPN	5	999	0	9999	0.0075	0	FALSE
Wind/Weather/Stress	Mid1	CLS	Early1	ALL	5	1004	0	9999	0.007	0	FALSE
MONTANE RIPARIAN-1154											
Beaver-Herbivory	HVG	OPN	HVG	OPN	5	999	0	9999	0.01	0	FALSE
Beaver-Herbivory	Late1	CLS	Mid1	OPN	20	1019	0	9999	0.001	0	FALSE
Beaver-Herbivory	Mid1	OPN	Mid1	OPN	5	19	0	9999	0.05	0	FALSE
Beaver-Herbivory1	Late1	CLS	Late1	CLS	20	1019	0	9999	0.001	0	FALSE
Conversion-To-Pasture	Early1	ALL	PAS	OPN	0	9999	0	9999	0.002	0	FALSE
Conversion-To-Pasture	HVG	OPN	PAS	OPN	0	9999	0	9999	0.002	0	FALSE
Conversion-To-Pasture	Late1	CLS	PAS	OPN	0	9999	0	9999	0.002	0	FALSE
Conversion-To-Pasture	Mid1	OPN	PAS	OPN	0	9999	0	9999	0.002	0	FALSE
Entrenchment	HVG	OPN	DES	OPN	0	4	0	9999	0.05	0	FALSE
Entrenchment	HVG	OPN	DES	OPN	5	999	0	9999	0.01	0	FALSE

Excessive-Herbivory	Early1	ALL	HVG	OPN	0	9999	0	9999	0.01	0	TRUE
Excessive-Herbivory	Late1	CLS	HVG	OPN	0	9999	0	9999	0.0025	0	TRUE
Excessive-Herbivory	Mid1	OPN	HVG	OPN	0	9999	0	9999	0.005	0	TRUE
Exotic-Control	EXF	OPN	HVG	OPN	0	999	0	20	0.85	0	TRUE
Exotic-Control1	EXF	OPN	EXF	OPN	0	999	0	20	0.15	0	FALSE
Exotic-Invasion	Early1	ALL	EXF	OPN	0	9999	5	9999	0.01	0	FALSE
Exotic-Invasion	HVG	OPN	EXF	OPN	0	999	5	9999	0.33	0	TRUE
Exotic-Invasion	Late1	CLS	EXF	OPN	0	9999	5	9999	0.01	0	FALSE
Exotic-Invasion	Mid1	OPN	EXF	OPN	0	9999	5	9999	0.01	0	FALSE
Flooding	Early1	ALL	Early1	ALL	0	4	0	9999	0.13	-5	FALSE
Flooding	HVG	OPN	HVG	OPN	0	4	0	9999	0.13	-999	FALSE
Flooding	Late1	CLS	Late1	CLS	20	1019	0	9999	0.05	0	FALSE
Flooding	Mid1	OPN	Mid1	OPN	5	19	0	9999	0.17	0	FALSE
Flooding1	Late1	CLS	Early1	ALL	20	1019	5	9999	0.01	0	FALSE
Flooding1	Mid1	OPN	Early1	ALL	5	19	5	9999	0.05	0	FALSE
Floodplain-Enlargement	DES	OPN	Early1	ALL	50	999	0	9999	0.01	0	FALSE
Floodplain-Restoration	DES	OPN	Early1	ALL	0	999	0	9999	0.01	0	FALSE
HVG-Restoration	HVG	OPN	Early1	ALL	0	4	0	9999	0.01	0	TRUE
HVG-Restoration	HVG	OPN	Mid1	OPN	5	19	0	9999	0.01	0	TRUE
HVG-Restoration	HVG	OPN	Late1	CLS	20	999	0	9999	0.01	0	TRUE
ReplacementFire	DES	OPN	DES	OPN	0	999	0	9999	0.02	-999	FALSE
ReplacementFire	EXF	OPN	EXF	OPN	0	999	0	9999*	0.2	-999	FALSE
ReplacementFire	HVG	OPN	HVG	OPN	5	999	0	9999	0.02	-999	FALSE
ReplacementFire	Late1	CLS	Early1	ALL	20	1019	0	9999	0.02	0	FALSE
ReplacementFire	Mid1	OPN	Early1	ALL	5	19	0	9999	0.02	0	FALSE
Riparian-Reclamation	PAS	OPN	Early1	ALL	0	999	0	9999	0.001	0	FALSE
Water-Diversion	DES	OPN	DRY	OPN	0	9999	0	9999	0.001	0	FALSE
Water-Diversion	Early1	ALL	DRY	OPN	0	9999	0	9999	0.001	0	FALSE

Water-Diversion	EXF	OPN	DRY	OPN	0	9999	0	9999	0.001	0	FALSE
Water-Diversion	HVG	OPN	DRY	OPN	0	9999	0	9999	0.001	0	FALSE
Water-Diversion	Late1	CLS	DRY	OPN	0	9999	0	9999	0.001	0	FALSE
Water-Diversion	Mid1	OPN	DRY	OPN	0	9999	0	9999	0.001	0	FALSE
Water-Diversion	PAS	OPN	DRY	OPN	0	9999	0	9999	0.001	0	FALSE
Weed-Inventory	Early1	ALL	Early1	ALL	0	9999	0	9999	0.25	0	FALSE
Weed-Inventory	HVG	OPN	HVG	OPN	0	9999	0	9999	0.25	0	FALSE
Weed-Inventory	Late1	CLS	Late1	CLS	0	9999	0	9999	0.25	0	FALSE
Weed-Inventory	Mid1	OPN	Mid1	OPN	0	9999	0	9999	0.25	0	FALSE
LOW SAGEBRUSH-1079AA											
AG-Invasion	Late1	OPN	ShAG	CLS	120	999	0	9999	0.001	0	FALSE
AG-Invasion	Mid1	OPN	ShAG	CLS	25	119	0	9999	0.001	0	FALSE
AG-Restoration	AG	OPN	Early1	ALL	0	1	0	9999	0.25	0	FALSE
AG-Restoration1	AG	OPN	AG	OPN	0	1	0	9999	0.75	0	FALSE
CWG-SEED	Late1	OPN	CWG	OPN	120	999	0	9999	0.001	0	FALSE
ReplacementFire	AG	OPN	AG	OPN	0	999	0	9999	0.5	0	FALSE
ReplacementFire	CWG	OPN	CWG	OPN	0	120	0	9999	0.002	-999	FALSE
ReplacementFire	Early1	ALL	Early1	ALL	1	24	0	9999	0.004	-24	FALSE
ReplacementFire	Late1	OPN	Early1	ALL	120	999	0	9999	0.004	0	FALSE
ReplacementFire	Mid1	OPN	Early1	ALL	25	119	0	9999	0.004	0	FALSE
ReplacementFire	ShAG	CLS	AG	OPN	25	999	0	9999	0.1	0	FALSE
ReplacementFire	TrEnc	CLS	Early1	ALL	200	999	0	9999	0.004	0	FALSE
ShAG-Restoration	ShAG	CLS	Mid1	OPN	25	999	0	9999	0.0037	0	FALSE
ShAG-Restoration1	ShAG	CLS	Late1	OPN	25	999	0	9999	0.0037	0	FALSE
ShAG-Restoration2	ShAG	CLS	ShAG	CLS	25	999	0	9999	0.0025	0	FALSE
Thin-Mech-Chem-Seed	TrEnc	CLS	Mid1	OPN	300	999	0	9999	0.01	0	FALSE
Thin-Mech-Chem-Seed1	TrEnc	CLS	Late1	OPN	200	300	0	9999	0.01	0	FALSE
Thin-Sheep	Late1	OPN	Late1	OPN	120	999	0	9999	0.01	-5	FALSE

Thin-Sheep	Mid1	OPN	Mid1	OPN	25	119	0	9999	0.01	-5	FALSE
Thin-Sheep	ShAG	CLS	ShAG	CLS	25	999	0	9999	0.01	-7	FALSE
Tree-Invasion	Late1	OPN	TrEnc	CLS	200	999	0	9999	0.001	0	FALSE
Tree-Invasion	ShAG	CLS	TrEnc	CLS	25	999	0	9999	0.005	0	FALSE
Wind/Weather/Stress	Early1	ALL	Early1	ALL	1	24	0	9999	0.002	-1	FALSE
Wind/Weather/Stress	Late1	OPN	Mid1	OPN	120	999	0	9999	0.0025	0	FALSE
Wind/Weather/Stress	Mid1	OPN	Mid1	OPN	25	119	0	9999	0.0025	-1	FALSE
Wind/Weather/Stress	ShAG	CLS	ShAG	CLS	25	999	0	9999	0.0025	-1	FALSE
Wind/Weather/Stress	TrEnc	CLS	Late1	OPN	200	300	0	9999	0.0025	0	FALSE
Wind/Weather/Stress	TrEnc	CLS	Mid1	OPN	301	999	0	9999	0.0025	0	FALSE
Wind/Weather/Stress1	Late1	OPN	Late1	OPN	120	999	0	9999	0.0025	-1	FALSE
Wind/Weather/Stress1	Mid1	OPN	Early1	ALL	25	119	0	9999	0.0025	0	FALSE
Wind/Weather/Stress1	ShAG	CLS	AG	OPN	25	999	0	9999	0.0025	0	FALSE
BLACK SAGEBRUSH-1079AN											
AG-Invasion	Early1	ALL	ShAG	OPN	10	24	0	9999	0.001	0	TRUE
AG-Invasion	Late1	OPN	ShAG	OPN	120	194	0	9999	0.01	0	TRUE
AG-Invasion	Mid1	OPN	ShAG	OPN	25	119	0	9999	0.005	0	TRUE
AG-Restoration	AG	OPN	SENN	OPN	0	1	0	9999	0.25	0	FALSE
AG-Restoration1	AG	OPN	AG	OPN	0	1	0	9999	0.75	0	FALSE
AltSuccession	SENN	OPN	Mid1	OPN	75	999	0	9999	0.5	0	FALSE
Canopy-Thinning	Late1	OPN	Mid1	OPN	120	194	0	9999	0.006	0	FALSE
Canopy-Thinning1	Late1	OPN	Late1	OPN	120	194	0	9999	0.001	-999	FALSE
Canopy-Thinning2	Late1	OPN	Early1	ALL	120	194	0	9999	0.003	0	FALSE

CWG-Restoration	SENN	OPN	Mid1	OPN	0	999	0	9999	0.01	0	FALSE
CWG-SEED	Early1	ALL	SENN	OPN	1	24	0	9999	0.01	0	FALSE
CWG-SEED	Late1	OPN	SENN	OPN	120	194	0	9999	0.01	0	FALSE
CWG-SEED	Late1	CLS	SENN	OPN	195	300	0	9999	0.01	0	FALSE
CWG-SEED	Mid1	OPN	SENN	OPN	25	119	0	9999	0.01	0	FALSE
Excessive-Herbivory	Early1	ALL	ShAG	OPN	2	24	0	9999	0.001	0	FALSE
Excessive-Herbivory	Late1	OPN	Late1	OPN	120	194	0	9999	0.01	7	FALSE
Excessive-Herbivory	Mid1	OPN	Mid1	OPN	25	119	0	9999	0	7	FALSE
Excessive-Herbivory1	Early1	ALL	Early1	ALL	2	24	0	9999	0.01	2	FALSE
ReplacementFire	AG	OPN	AG	OPN	0	999	0	9999	1	-999	FALSE
ReplacementFire	Early1	ALL	Early1	ALL	1	24	0	9999	0.004	-24	FALSE
ReplacementFire	Late1	OPN	Early1	ALL	120	194	0	9999	0.0067	0	FALSE
ReplacementFire	Late1	CLS	Early1	ALL	195	300	0	9999	0.0068	0	FALSE
ReplacementFire	Mid1	OPN	Early1	ALL	25	119	0	9999	0.0067	0	FALSE
ReplacementFire	SENN	OPN	SENN	OPN	0	999	0	9999	0.002	-999	FALSE
ReplacementFire	ShAG	OPN	AG	OPN	0	999	0	9999	0.4	0	FALSE
ReplacementFire	TrAG	CLS	AG	OPN	0	999	0	9999	0.0067	0	FALSE
SENN-Maintenance	SENN	OPN	SENN	OPN	0	999	0	9999	0.01	-999	FALSE
ShAG-Restoration	ShAG	OPN	SENN	OPN	9	999	0	9999	0.00125	0	FALSE
ShAG-Restoration1	ShAG	OPN	ShAG	OPN	0	999	0	9999	0.00375	0	FALSE
Thin-Mech-Chem-Seed	TrAG	CLS	SENN	OPN	0	999	0	9999	0.005	0	FALSE
Thin-Mech-Chem-Seed1	TrAG	CLS	AG	OPN	0	999	0	9999	0.005	0	FALSE
Thin-Sheep	Late1	OPN	Late1	OPN	122	194	0	9999	0.01	-7	FALSE
Thin-Sheep	Late1	OPN	Mid1	OPN	120	121	0	9999	0.01	0	FALSE
Thin-Sheep	ShAG	OPN	ShAG	OPN	0	999	0	9999	0.01	-7	FALSE

Tree-Invasion	ShAG	OPN	TrAG	CLS	0	999	0	9999	0.01	0	FALSE
Wind/Weather/Stress	Early1	ALL	Early1	ALL	1	24	0	9999	0.002	-1	FALSE
Wind/Weather/Stress	Late1	OPN	Late1	OPN	120	194	0	9999	0.0083	-1	FALSE
Wind/Weather/Stress	Late1	CLS	Late1	CLS	195	300	0	9999	0.0083	-1	FALSE
Wind/Weather/Stress	Mid1	OPN	Mid1	OPN	25	119	0	9999	0.0025	-1	FALSE
Wind/Weather/Stress1	Late1	OPN	Mid1	OPN	120	194	0	9999	0.0083	0	FALSE
Wind/Weather/Stress1	Late1	CLS	Late1	OPN	195	300	0	9999	0.0083	0	FALSE
Wind/Weather/Stress1	Mid1	OPN	Early1	ALL	25	119	0	9999	0.0025	0	FALSE
BASIN WILDRYE-1080BW											
AG-Restoration	AG	OPN	SENN	OPN	0	1	0	9999	0.5	0	FALSE
AG-Restoration1	AG	OPN	AG	OPN	0	1	0	9999	0.2	0	FALSE
AG-Restoration2	AG	OPN	Early1	OPN	0	1	0	9999	0.3	0	FALSE
Excessive-Herbivory	Late1	OPN	ShAG	OPN	76	9999	0	9999	0.005	0	FALSE
Excessive-Herbivory	Mid1	OPN	ESH	CLS	11	75	0	9999	0.005	0	FALSE
Excessive-Herbivory1	Late1	OPN	Late1	OPN	76	1000	0	9999	0.01	5	FALSE
Excessive-Herbivory1	Mid1	OPN	Mid1	OPN	11	75	0	9999	0.01	5	FALSE
Exotic-Control	EXF	OPN	Early1	OPN	0	999	0	20	0.55	0	FALSE
Exotic-Control1	EXF	OPN	EXF	OPN	0	999	0	20	0.15	0	FALSE
Exotic-Control2	EXF	OPN	SENN	OPN	0	999	0	20	0.3	0	FALSE
Exotic-Invasion	AG	OPN	EXF	OPN	0	9999	5	9999	0.03	0	FALSE
Exotic-Invasion	Early1	OPN	EXF	OPN	1	9999	5	9999	0.03	0	FALSE
Exotic-Invasion	Late1	OPN	EXF	OPN	76	9999	5	9999	0.01	0	FALSE
Exotic-Invasion	Mid1	OPN	EXF	OPN	11	75	5	9999	0.02	0	FALSE

Exotic-Invasion	ShAG	OPN	EXF	OPN	11	9999	5	9999	0.03	0	FALSE
Insect/Disease	Late1	OPN	Mid1	OPN	76	1000	0	9999	0.01	0	FALSE
Insect/Disease	Mid1	OPN	Mid1	OPN	11	75	0	9999	0.01	0	FALSE
Insect/Disease	ShAG	OPN	ShAG	OPN	11	999	0	9999	0.005	-999	FALSE
Insect/Disease1	ShAG	OPN	AG	OPN	11	999	0	9999	0.005	0	FALSE
ReplacementFire	AG	OPN	Early1	OPN	0	999	0	9999	0.5	0	FALSE
ReplacementFire	Early1	OPN	Early1	OPN	1	999	0	9999	0.02	-10	FALSE
ReplacementFire	EXF	OPN	EXF	OPN	0	999	0	999	0.2	-999	FALSE
ReplacementFire	Late1	OPN	Early1	OPN	76	1000	0	9999	0.015	0	FALSE
ReplacementFire	Mid1	OPN	Early1	OPN	11	75	0	9999	0.025	0	FALSE
ReplacementFire	SENN	OPN	SENN	OPN	0	100	0	9999	0.013	-999	FALSE
ReplacementFire	ShAG	OPN	AG	OPN	11	999	0	9999	0.15	0	FALSE
ReplacementFire	TrEnc	CLS	AG	OPN	76	999	0	9999	0.0034	0	FALSE
ReplacementFire1	TrEnc	CLS	SENN	OPN	76	999	0	9999	0.0034	0	FALSE
RxFire	Late1	OPN	Early1	OPN	76	1000	0	9999	0.005	0	FALSE
RxFire1	Late1	OPN	Late1	OPN	76	1000	0	9999	0.005	0	FALSE
ShAG-Restoration	ShAG	OPN	SENN	OPN	11	999	0	9999	0.003	0	FALSE
ShAG-Restoration1	ShAG	OPN	AG	OPN	11	999	0	9999	0.002	0	FALSE
ShAG-Restoration2	ShAG	OPN	Early1	OPN	11	999	0	9999	0.005	0	FALSE
Thin-Mech-Chem-Seed	ESH	CLS	SENN	OPN	0	200	0	9999	0.005	0	FALSE
Thin-Mech-Chem-Seed	TrEnc	CLS	SENN	OPN	76	999	0	9999	0.01	0	FALSE
Thin-Mech-Chem-Seed1	ESH	CLS	Early1	OPN	0	200	0	9999	0.005	0	FALSE
Tree-Invasion	Late1	OPN	TrEnc	CLS	76	1000	0	9999	0.01	0	FALSE
Tree-Invasion	ShAG	OPN	TrEnc	CLS	11	999	0	9999	0.01	0	FALSE
Weed-Inventory	AG	OPN	AG	OPN	0	9999	0	9999	0.01	0	FALSE
Weed-Inventory	Early1	OPN	Early1	OPN	1	9999	0	9999	0.01	0	FALSE
Weed-Inventory	Late1	OPN	Late1	OPN	76	9999	0	9999	0.01	0	FALSE

Weed-Inventory	Mid1	OPN	Mid1	OPN	11	75	0	9999	0.01	0	FALSE
Weed-Inventory	ShAG	OPN	ShAG	OPN	11	9999	0	9999	0.01	0	FALSE
Wind/Weather/Stress	Late1	OPN	Mid1	OPN	76	1000	0	9999	0.01	0	FALSE
Wind/Weather/Stress	Mid1	OPN	Mid1	OPN	11	75	0	9999	0.01	-1	FALSE
Wind/Weather/Stress	ShAG	OPN	ShAG	OPN	11	999	0	9999	0.005	-1	FALSE
Wind/Weather/Stress1	ShAG	OPN	AG	OPN	11	999	0	9999	0.005	0	FALSE
WYOMING BIG SAGEBRUSH: SEMI-DESERT-1080SD											
AG-Invasion	Early1	ALL	ShAG	CLS	10	24	0	9999	0.005	0	FALSE
AG-Invasion	Late1	CLS	ShAG	CLS	75	999	0	9999	0.01	0	FALSE
AG-Invasion	Mid1	OPN	ShAG	CLS	25	74	0	9999	0.0075	0	FALSE
AG-Restoration	AG	OPN	AG	OPN	0	1	0	9999	0.5	-999	FALSE
AG-Restoration1	AG	OPN	SENN	OPN	0	1	0	9999	0.5	0	FALSE
AltSuccession	ShCWG	CLS	Mid1	OPN	70	999	0	9999	0.5	0	FALSE
Canopy-Thinning	Late1	CLS	Mid1	OPN	75	999	0	9999	0.01	0	FALSE
Canopy-Thinning1	Late1	CLS	Early1	ALL	75	999	0	9999	0.01	-9999	FALSE
CWG-Maintenance	SENN	OPN	SENN	OPN	0	999	0	9999	0.01	-999	FALSE
CWG-Maintenance	ShCWG	CLS	SENN	OPN	41	999	0	9999	0.01	0	FALSE
CWG-Restoration	SENN	OPN	Mid1	OPN	0	40	0	9999	0.01	0	FALSE
CWG-Restoration	ShCWG	CLS	Early1	ALL	41	999	0	9999	0.01	0	FALSE
CWG-SEED	Early1	ALL	SENN	OPN	0	24	0	9999	0.01	0	FALSE
CWG-SEED	Late1	CLS	SENN	OPN	75	999	0	9999	0.01	0	FALSE
CWG-SEED	Mid1	OPN	SENN	OPN	25	74	0	9999	0.01	0	FALSE
CWG-SEED	TrEnc	CLS	SENN	OPN	75	999	0	9999	0.01	0	FALSE
Excessive-Herbivory	Early1	ALL	Early1	ALL	2	24	0	9999	0.01	2	FALSE
Excessive-Herbivory	Late1	CLS	Late1	CLS	75	999	0	9999	0.01	7	FALSE

Excessive-Herbivory1	Early1	ALL	ShAG	CLS	2	24	0	9999	0.001	0	FALSE
Insect/Disease	Late1	CLS	Mid1	OPN	75	999	0	9999	0.013	0	FALSE
ReplacementFire	AG	OPN	AG	OPN	0	999	0	9999	1	-9999	FALSE
ReplacementFire	Early1	ALL	Early1	ALL	0	24	0	9999	0.005	-24	FALSE
ReplacementFire	Late1	CLS	Early1	ALL	75	999	0	9999	0.01	0	FALSE
ReplacementFire	Mid1	OPN	Early1	ALL	25	74	0	9999	0.008	0	FALSE
ReplacementFire	SENN	OPN	SENN	OPN	0	999	0	9999	0.002	-999	FALSE
ReplacementFire	ShAG	CLS	AG	OPN	10	999	0	9999	0.4	0	FALSE
ReplacementFire	TrEnc	CLS	AG	OPN	75	999	0	9999	0.0034	0	FALSE
ReplacementFire1	TrEnc	CLS	SENN	OPN	75	999	0	9999	0.0034	0	FALSE
ShAG-Restoration	ShAG	CLS	SENN	OPN	10	24	0	9999	0.0075	0	FALSE
ShAG-Restoration1	ShAG	CLS	ShAG	CLS	10	999	0	9999	0.0025	0	FALSE
Thin-Mech-Chem-Seed	TrEnc	CLS	SENN	OPN	75	999	0	9999	0.005	0	FALSE
Thin-Mech-Chem-Seed1	TrEnc	CLS	AG	OPN	75	999	0	9999	0.005	0	FALSE
Thin-Sheep	Late1	CLS	Mid1	OPN	75	76	0	9999	0.01	0	FALSE
Thin-Sheep	Late1	CLS	Late1	CLS	77	999	0	9999	0.01	-7	FALSE
Thin-Sheep	ShAG	CLS	ShAG	CLS	10	999	0	9999	0.01	-7	FALSE
Tree-Invasion	Late1	CLS	TrEnc	CLS	75	999	0	9999	0.01	0	FALSE
Tree-Invasion	ShAG	CLS	TrEnc	CLS	10	999	0	9999	0.01	0	FALSE
Wind/Weather/Stress	Early1	ALL	Early1	ALL	0	24	0	9999	0.01	-1	FALSE
Wind/Weather/Stress	Late1	CLS	Mid1	OPN	75	999	0	9999	0.005	0	FALSE
Wind/Weather/Stress	Mid1	OPN	Mid1	OPN	25	74	0	9999	0.005	-1	FALSE
Wind/Weather/Stress1	Late1	CLS	Late1	CLS	75	999	0	9999	0.005	-1	FALSE
Wind/Weather/Str	Mid1	OPN	Early1	ALL	25	74	0	9999	0.005	0	FALSE

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WYOMING BIG SAGEBRUSH: UPLAND-1080UP											
AG-Invasion	Early1	ALL	ShAG	CLS	10	19	0	9999	0.001	0	FALSE
AG-Invasion	Late1	CLS	ShAG	CLS	60	99	0	9999	0.005	0	FALSE
AG-Invasion	Late2	OPN	ShAG	CLS	100	124	0	9999	0.005	0	FALSE
AG-Invasion	Late2	CLS	TrAG	CLS	150	1149	0	9999	0.005	0	FALSE
AG-Invasion	Mid1	OPN	ShAG	CLS	20	59	0	9999	0.005	0	FALSE
AG-Invasion1	Late2	OPN	TrAG	CLS	125	149	0	9999	0.005	0	FALSE
AG-Restoration	AG	OPN	SENN	OPN	0	1	0	9999	0.75	0	FALSE
AG-Restoration1	AG	OPN	AG	OPN	0	1	0	9999	0.25	-999	FALSE
AltSuccession	CWG	CLS	SENN	OPN	40	999	0	9999	0.5	0	FALSE
AltSuccession	SENN	OPN	Mid1	OPN	40	999	0	9999	0.25	0	FALSE
Canopy-Thinning	Late1	CLS	Mid1	OPN	60	99	0	9999	0.01	0	FALSE
Canopy-Thinning	Late2	OPN	Mid1	OPN	100	149	0	9999	0.005	0	FALSE
Canopy-Thinning	Late2	CLS	Early1	ALL	150	1149	0	9999	0.01	0	FALSE
Canopy-Thinning1	Late2	OPN	Late1	CLS	100	149	0	9999	0.005	0	FALSE
CWG-Maintenance	CWG	CLS	CWG	CLS	0	999	0	9999	0.01	-999	FALSE
CWG-Restoration	CWG	CLS	Early1	ALL	0	999	0	9999	0.001	0	FALSE
CWG-SEED	Early1	ALL	CWG	CLS	0	19	0	9999	0.01	0	FALSE
CWG-SEED	Late1	CLS	CWG	CLS	60	99	0	9999	0.01	0	FALSE
CWG-SEED	Late2	OPN	CWG	CLS	100	149	0	9999	0.01	0	FALSE
CWG-SEED	Late2	CLS	CWG	CLS	150	1149	0	9999	0.01	0	FALSE
CWG-SEED	Mid1	OPN	CWG	CLS	20	59	0	9999	0.01	0	FALSE
CWG-SEED	TrAG	CLS	CWG	CLS	125	999	0	9999	0.01	0	FALSE
Excessive-Herbivory	Early1	ALL	Early1	ALL	2	19	0	9999	0.01	1	FALSE
Excessive-Herbivory	Late1	CLS	Late1	CLS	60	99	0	9999	0.01	5	FALSE
Excessive-Herbivory	Late2	OPN	Late2	OPN	100	149	0	9999	0.01	5	FALSE
Excessive-Herbivory1	Early1	ALL	ShAG	CLS	2	19	0	9999	0.001	0	FALSE

Insect/Disease	Late1	CLS	Mid1	OPN	60	99	0	9999	0.013	0	FALSE
Insect/Disease	Late2	OPN	Late1	CLS	100	149	0	9999	0.013	0	FALSE
ReplacementFire	AG	OPN	AG	OPN	0	999	0	9999	1	-999	FALSE
ReplacementFire	CWG	CLS	CWG	CLS	0	999	0	9999	0.001	-999	FALSE
ReplacementFire	Early1	ALL	Early1	ALL	0	19	0	9999	0.008	-20	FALSE
ReplacementFire	Late1	CLS	Early1	ALL	60	99	0	9999	0.013	0	FALSE
ReplacementFire	Late2	OPN	Early1	ALL	100	1031	0	9999	0.01	0	FALSE
ReplacementFire	Late2	CLS	Early1	ALL	150	1149	0	9999	0.008	0	FALSE
ReplacementFire	Mid1	OPN	Early1	ALL	20	59	0	9999	0.01	0	FALSE
ReplacementFire	SENN	OPN	SENN	OPN	0	999	0	9999	0.002	-999	FALSE
ReplacementFire	ShAG	CLS	AG	OPN	10	999	0	9999	0.4	0	FALSE
ReplacementFire	TrAG	CLS	AG	OPN	125	999	0	9999	0.002	0	FALSE
ReplacementFire 1	TrAG	CLS	SENN	OPN	125	999	0	9999	0.006	0	FALSE
RxFire	Late1	CLS	Early1	ALL	60	99	0	9999	0.005	0	FALSE
RxFire	Late2	OPN	Early1	ALL	100	149	0	9999	0.005	0	FALSE
RxFire	Late2	CLS	Early1	ALL	150	1149	0	9999	0.004	0	FALSE
RxFire1	Late1	CLS	Late1	CLS	60	99	0	9999	0.005	0	FALSE
RxFire1	Late2	OPN	Late2	OPN	100	149	0	9999	0.005	0	FALSE
RxFire1	Late2	CLS	Late2	CLS	150	1149	0	9999	0.004	0	FALSE
SENN-Maintenance	SENN	OPN	SENN	OPN	0	999	0	9999	0.01	-999	FALSE
ShAG-Restoration	ShAG	CLS	Early1	ALL	10	999	0	9999	0.003	0	FALSE
ShAG-Restoration1	ShAG	CLS	ShAG	CLS	10	999	0	9999	0.001	0	FALSE
ShAG-Restoration2	ShAG	CLS	SENN	OPN	10	999	0	9999	0.006	0	FALSE
Thin-Mech-Chem-Seed	TrAG	CLS	SENN	OPN	125	999	0	9999	0.01	0	FALSE
Thin-Sheep	Late1	CLS	Mid1	OPN	60	61	0	9999	0.01	0	FALSE
Thin-Sheep	ShAG	CLS	ShAG	CLS	10	999	0	9999	0.01	-7	FALSE
Thin-Sheep1	Late1	CLS	Late1	CLS	62	99	0	9999	0.01	-7	FALSE
Tree-Invasion	ShAG	CLS	TrAG	CLS	10	999	0	9999	0.01	0	FALSE

Wind/Weather/Stress	Late1	CLS	Early1	ALL	60	99	0	9999	0.003	0	FALSE
Wind/Weather/Stress	Late2	OPN	Late1	CLS	100	149	0	9999	0.01	0	FALSE
Wind/Weather/Stress	Late2	CLS	Mid1	OPN	150	1149	0	9999	0.01	0	FALSE
Wind/Weather/Stress	TrAG	CLS	ShAG	CLS	125	999	0	9999	0.013	0	FALSE
Wind/Weather/Stress1	Late1	CLS	Mid1	OPN	60	99	0	9999	0.01	0	FALSE
MOUNTAIN BIG SAGEBRUSH: MOUNTAIN-1126MT											
AltSuccession	ESH	OPN	Mid1	OPN	0	999	0	9999	0.01	0	FALSE
Canopy-Thinning	Late1	CLS	Early1	OPN	50	999	0	9999	0.005	0	FALSE
Canopy-Thinning	Late1	OPN	Late1	CLS	71	114	0	9999	0.001	0	FALSE
Canopy-Thinning1	Late1	CLS	Mid1	OPN	50	999	0	9999	0.005	0	FALSE
Canopy-Thinning1	Late1	OPN	Early1	OPN	71	114	0	9999	0.0045	0	FALSE
Canopy-Thinning2	Late1	OPN	Mid1	OPN	71	114	0	9999	0.0045	0	FALSE
Excessive-Herbivory	Early1	OPN	ESH	OPN	0	11	0	9999	0.0003	0	FALSE
Excessive-Herbivory	Late1	CLS	Late1	CLS	50	70	0	9999	0.001	1	FALSE
Excessive-Herbivory	Late1	OPN	Late1	OPN	71	114	0	9999	0.001	2	FALSE
Excessive-Herbivory	Mid1	OPN	Mid1	OPN	0	9999	0	9999	0.000825	2	FALSE
Excessive-Herbivory1	Early1	OPN	Early1	OPN	0	11	0	9999	0.000825	2	FALSE
Excessive-Herbivory1	Mid1	OPN	ESH	OPN	0	9999	0	9999	0.0003	0	FALSE
Insect/Disease	Late1	CLS	Mid1	OPN	50	999	0	9999	0.013	0	FALSE
Insect/Disease	Late2	CLS	Late1	OPN	115	140	0	9999	0.013	0	FALSE

ReplacementFire	Early1	OPN	Early1	OPN	0	11	0	9999	0.0125	-12	FALSE
ReplacementFire	ESH	OPN	ESH	OPN	0	999	0	9999	0.018	-999	FALSE
ReplacementFire	Late1	CLS	Early1	OPN	50	999	0	9999	0.025	0	FALSE
ReplacementFire	Late1	OPN	Early1	OPN	71	114	0	9999	0.025	0	FALSE
ReplacementFire	Late2	CLS	Early1	OPN	80	1079	0	9999	0.013	0	FALSE
ReplacementFire	Mid1	OPN	Early1	OPN	12	49	0	9999	0.025	0	FALSE
ReplacementFire	TrEnc	CLS	ESH	OPN	141	999	0	9999	0.0067	0	FALSE
ReplacementFire1	ESH	OPN	Early1	OPN	0	999	0	9999	0.002	0	FALSE
RxFire	Late1	CLS	Early1	OPN	50	999	0	9999	0.005	0	FALSE
RxFire	Late1	OPN	Early1	OPN	71	114	0	9999	0.005	0	FALSE
RxFire	Late2	CLS	Early1	OPN	115	140	0	9999	0.005	0	FALSE
RxFire1	Late1	CLS	Late1	CLS	50	70	0	9999	0.005	0	FALSE
RxFire1	Late1	OPN	Late1	OPN	71	114	0	9999	0.005	0	FALSE
RxFire1	Late2	CLS	Late2	CLS	115	140	0	9999	0.005	0	FALSE
Thin-Mech-Chem-Seed	TrEnc	CLS	Early1	OPN	141	999	0	9999	0.01	0	FALSE
MOUNTAIN BIG SAGEBRUSH: UPLAND-1126UP											
AG-Invasion	DPL	CLS	ShAG	CLS	50	999	0	9999	0.005	0	FALSE
AltSuccession	ESH	OPN	Mid1	OPN	0	999	0	9999	0.01	0	FALSE
Canopy-Thinning	Late1	CLS	Early1	OPN	50	999	0	9999	0.005	0	FALSE
Canopy-Thinning	Late1	OPN	Late1	CLS	71	114	0	9999	0.001	0	FALSE
Canopy-Thinning1	Late1	CLS	Mid1	OPN	50	999	0	9999	0.005	0	FALSE
Canopy-Thinning1	Late1	OPN	Early1	OPN	71	114	0	9999	0.0045	0	FALSE
Canopy-Thinning2	Late1	OPN	Mid1	OPN	71	114	0	9999	0.0045	0	FALSE
DPL-Restoration	DPL	CLS	ESH	OPN	50	999	0	9999	0.004	0	FALSE
DPL-Restoration1	DPL	CLS	Mid1	OPN	50	999	0	9999	0.004	0	FALSE
DPL-Restoration2	DPL	CLS	Late1	CLS	50	999	0	9999	0.001	0	FALSE
DPL-Restoration3	DPL	CLS	Early1	OPN	50	999	0	9999	0.0001	0	FALSE
Excessive-Herbivory	Early1	OPN	ESH	OPN	0	11	0	9999	0.001	0	FALSE

Excessive-Herbivory	Late1	CLS	DPL	CLS	50	9999	0	9999	0.001	0	FALSE
Excessive-Herbivory	Late1	OPN	Late1	OPN	0	9999	0	9999	0.001	2	FALSE
Excessive-Herbivory	Mid1	OPN	Mid1	OPN	0	9999	0	9999	0.000825	3	FALSE
Excessive-Herbivory1	Mid1	OPN	ESH	OPN	0	9999	0	9999	0.0003	0	FALSE
Insect/Disease	Late1	CLS	Mid1	OPN	50	999	0	9999	0.013	0	FALSE
ReplacementFire	DPL	CLS	ESH	OPN	50	999	0	9999	0.02	0	FALSE
ReplacementFire	Early1	OPN	Early1	OPN	0	11	0	9999	0.0125	-12	FALSE
ReplacementFire	ESH	OPN	ESH	OPN	0	999	0	9999	0.018	-999	FALSE
ReplacementFire	Late1	CLS	Early1	OPN	50	999	0	9999	0.02	0	FALSE
ReplacementFire	Late1	OPN	Early1	OPN	71	114	0	9999	0.02	0	FALSE
ReplacementFire	Late2	CLS	Early1	OPN	80	1079	0	9999	0.013	0	FALSE
ReplacementFire	Mid1	OPN	Early1	OPN	12	49	0	9999	0.025	0	FALSE
ReplacementFire	ShAG	CLS	ShAG	CLS	50	999	0	9999	0.25	-999	FALSE
ReplacementFire1	ESH	OPN	Early1	OPN	0	999	0	9999	0.002	0	FALSE
RxFire	Late1	CLS	Early1	OPN	50	999	0	9999	0.005	0	FALSE
RxFire	Late1	OPN	Early1	OPN	71	114	0	9999	0.005	0	FALSE
RxFire	Late2	CLS	Early1	OPN	115	140	0	9999	0.005	0	FALSE
RxFire1	Late1	CLS	Late1	CLS	50	70	0	9999	0.005	0	FALSE
RxFire1	Late1	OPN	Late1	OPN	71	114	0	9999	0.005	0	FALSE
RxFire1	Late2	CLS	Late2	CLS	115	140	0	9999	0.005	0	FALSE
ShAG-Restoration	ShAG	CLS	Early1	OPN	50	999	0	9999	0.009	0	FALSE
ShAG-Restoration1	ShAG	CLS	ShAG	CLS	50	999	0	9999	0.001	0	FALSE
Thin-Mech-Chem-Seed	TrEnc	CLS	Early1	OPN	141	999	0	9999	0.01	0	FALSE
Thin-Sheep	ESH	OPN	Early1	OPN	0	999	0	9999	0.01	0	FALSE
Tree-Invasion	DPL	CLS	TrEnc	CLS	50	999	0	9999	0.01	0	FALSE
Tree-Invasion	ShAG	CLS	TrEnc	CLS	50	999	0	9999	0.01	0	FALSE

Wind/Weather/Stress	Early1	OPN	Early1	OPN	0	11	0	9999	0.013	-12	FALSE
Wind/Weather/Stress	Late1	CLS	Early1	OPN	50	70	0	9999	0.013	0	FALSE
Wind/Weather/Stress	Late1	OPN	Late1	OPN	71	114	0	9999	0.013	-1	FALSE
Wind/Weather/Stress	Late2	CLS	Late1	OPN	115	140	0	9999	0.013	0	FALSE
Wind/Weather/Stress	Mid1	OPN	Early1	OPN	12	49	0	9999	0.013	0	FALSE
MONTANE-SUBALPINE WET MEADOW-1145WM											
AG-Restoration	AG	OPN	DES	CLS	0	1	0	999	0.75	0	FALSE
AG-Restoration1	AG	OPN	AG	OPN	0	1	0	999	0.25	0	FALSE
Entrenchment	HVG	OPN	DES	CLS	1	2	0	9999	0.05	0	FALSE
Entrenchment	HVG	OPN	DES	CLS	3	999	0	9999	0.01	0	FALSE
Excessive-Herbivory	Early1	OPN	HVG	OPN	0	2	0	9999	0.01	0	FALSE
Excessive-Herbivory	Late1	OPN	HVG	OPN	23	999	0	9999	0.005	0	FALSE
Excessive-Herbivory	Mid1	CLS	HVG	OPN	3	22	0	9999	0.01	0	FALSE
Exotic-Control	EXF	OPN	Early1	OPN	1	999	0	20	0.85	0	FALSE
Exotic-Control1	EXF	OPN	EXF	OPN	1	999	0	20	0.15	0	FALSE
Exotic-Invasion	HVG	OPN	EXF	OPN	1	999	0	9999	0.33	0	FALSE
Exotic-Invasion	Late1	OPN	EXF	OPN	23	999	5	9999	0.005	0	FALSE
Exotic-Invasion	Mid1	CLS	EXF	OPN	3	22	5	9999	0.005	0	FALSE
Floodplain-Enlargement	DES	CLS	HVG	OPN	50	999	0	9999	0.01	0	FALSE
Floodplain-Restoration	DES	CLS	HVG	OPN	2	999	0	9999	0.01	0	FALSE
HVG-Restoration	HVG	OPN	Early1	OPN	1	2	0	9999	0.01	0	FALSE
HVG-Restoration1	HVG	OPN	Mid1	CLS	3	22	0	9999	0.01	0	FALSE
HVG-	HVG	OPN	Late1	OPN	23	999	0	9999	0.01	0	FALSE

Restoration2											
Insect/Disease	TrEnc	CLS	DES	CLS	75	999	0	9999	0.013	0	FALSE
ReplacementFire	AG	OPN	AG	OPN	0	999	0	9999	1	-999	FALSE
ReplacementFire	DES	CLS	DES	CLS	2	999	0	9999	0.005	-999	FALSE
ReplacementFire	EXF	OPN	EXF	OPN	1	999	0	9999	0.025	-9999	FALSE
ReplacementFire	HVG	OPN	HVG	OPN	1	999	0	9999	0.025	-999	FALSE
ReplacementFire	Late1	OPN	Early1	OPN	23	999	0	9999	0.025	0	FALSE
ReplacementFire	Mid1	CLS	Early1	OPN	3	22	0	9999	0.025	0	FALSE
ReplacementFire	TrEnc	CLS	DES	CLS	75	999	0	9999	0.009825	0	FALSE
ReplacementFire 1	DES	CLS	AG	OPN	2	999	0	9999	0.005	0	FALSE
ReplacementFire 1	TrEnc	CLS	AG	OPN	75	999	0	9999	0.0033	0	FALSE
RxFire	TrEnc	CLS	DES	CLS	75	999	0	9999	0.009825	0	FALSE
RxFire1	TrEnc	CLS	AG	OPN	75	999	0	9999	0.0033	0	FALSE
Thin-Mech-Chem-Seed	TrEnc	CLS	DES	CLS	75	999	0	9999	0.01	0	FALSE
Tree-Invasion	DES	CLS	TrEnc	CLS	75	999	0	9999	0.005	0	FALSE
Weed-Inventory	DES	CLS	DES	CLS	2	999	0	9999	0.25	0	FALSE
Weed-Inventory	Early1	OPN	Early1	OPN	0	2	0	9999	0.25	0	FALSE
Weed-Inventory	HVG	OPN	HVG	OPN	1	999	0	9999	0.25	0	FALSE
Weed-Inventory	Late1	OPN	Late1	OPN	23	999	0	9999	0.25	0	FALSE
Weed-Inventory	Mid1	CLS	Mid1	CLS	3	22	0	9999	0.25	0	FALSE
Wind/Weather/Stress	Early1	OPN	Early1	OPN	0	2	0	9999	0.0167	-2	FALSE
ROAD-FUEL-BREAK											
AltSuccession	SENN	CLS	NoSeed	ALL	25	999	0	9999	0.1	0	FALSE
Fuel-Break-Maintenance	SENN	CLS	SENN	CLS	0	999	0	9999	0.1	-25	FALSE
Fuel-Break-Seed	NoSeed	ALL	SENN	CLS	0	999	0	9999	0.375	0	FALSE
Fuel-Break-Seed1	NoSeed	ALL	NoSeed	ALL	0	999	0	9999	0.125	0	FALSE
ReplacementFire	NoSeed	ALL	NoSeed	ALL	0	999	0	9999	0.01	-999	FALSE

ReplacementFire	SENN	CLS	SENN	CLS	0	999	0	9999	0.001	-999	FALSE

* Relative TSD (Time Since Disturbance) was 5. All other values were -9999.

& Disturbance codes: AG-Invasion, annual rate of annual grass invasion; AG-Restoration, annual rate of conversion of annual grassland to other classes; AG-Restoration1, annual rate of failure of conversion of annual grassland to either the SENN or other reference class; AG-Restoration2, annual rate of failure conversion of annual grassland to either reference class or SENN; AltSuccession, stochastic alternative succession pathway; Beaver-Herbivory, annual rate of beaver herbivory to an early development class; Beaver-Herbivory1, annual rate of beaver herbivory to a mid-development class; Canopy-Thinning, annual rate of mechanical canopy thinning without seeding creating an early development class; Canopy-Thinning1, annual rate of mechanical canopy thinning without seeding creating an mid-development class; Canopy-Thinning2, annual rate of mechanical canopy thinning without seeding creating an late-development class; Conversion-To-Pasture, annual rate of conversion of riparian floodplain to pasture of introduced species; CWG-Maintenance, annual rate of maintaining crested wheatgrass pasture in an early development class; CWG-Restoration annual rate of converting crested wheatgrass or introduced species pasture to a class dominated by native herbaceous and woody plant species; CWG-SEED annual rate of seeding crested wheatgrass and/or forage kochia; DPL-Restoration, annual rate of converting depleted or cheatgrass-infested shrublands to either SENN or native classes class; DPL-Restoration1, annual rate of failure from converting depleted or cheatgrass-infested shrublands to SENN; DPL-Restoration2, annual rate of failure converting annual grasslands to native vegetation classes; DPL-Restoration3, annual rate of failure converting the shrub-annual grass class to either SENN or native classes; Entrenchment, , annual rate of entrenchment of streams causing transition of riparian vegetation to drier vegetation; Excessive-Herbivory, annual rate of excessive livestock grazing operating outside best management practices and causing accelerated woody succession or loss of aspen; Excessive-Herbivory1, annual rate of excessive livestock grazing operating outside best management practices and causing conversion to the shrub-annual grass class; Exotic-Control, annual rate of successful application of herbicide to control exotic forb and tree species in riparian and moist biophysical settings resulting in native vegetation; Exotic-Control1 annual rate of failure from application of herbicide to control exotic forb and tree species in riparian and moist biophysical settings; Exotic-Control2, annual rate of successful application of herbicide to control exotic forb and tree species in riparian and moist biophysical settings resulting in SENN; Exotic-Invasion, annual rate of invasion of exotic forb and tree species in riparian and moist biophysical settings; Flooding, annual rate of high-frequency flood events; Flooding1, annual rate of low-frequency flood events; Floodplain-Enlargement, annual rate of restoration activities that deliberately destabilize entrenched stream walls to accelerate recovery of lower riparian terraces; Floodplain-Restoration, annual rate of restoration activities that reconnect the stream to its floodplain; Fuel-Break-Maintenance, annual rate of maintaining 30-m introduced species fuel breaks along paved and dirt roads; Fuel-Break-Seed, annual rate of seeding 30-m introduced species fuel breaks along paved and dirt roads; Fuel-Break-Seed1, annual rate of failure of seeding 30-m introduced species fuel breaks along paved and dirt roads that results in no change in vegetation; HVG-Restoration, annual rate of restoration activities to convert heavily grazed vegetation class to an early development class; HVG-Restoration1, annual rate of restoration activities to convert heavily grazed vegetation class to a mid-development class; HVG-Restoration2, annual rate of restoration activities to convert heavily grazed vegetation class to a late-development class; Insect/Disease, , annual rate of insect or disease outbreaks causing a transition to an early-development class; Insect/Disease1, annual rate of restoration activities to convert heavily grazed vegetation class to a later development class; MixedFire, annual rate of mixed severity fire; NativeGrazing, annual rate of native herbivory; ReplacementFire, annual rate of replacement fire;ReplacementFire1, annual rate of replacement fire in early succession shrublands causing a transition to early-development reference classes; Riparian-Reclamation, annual rate of restoration activities returning water flow to dewatered riparian corridors; RxFire, annual rate of successful prescribed fire; RxFire1, annual rate of unsuccessful prescribed fire causing transition to annual grassland; SENN-Maintenance, annual rate of activities used to prevent succession in an introduced species and native plant species mix; ShAG-Restoration, annual rate of converting cheatgrass-infested shrublands to either SENN or native classes; ShAG-Restoration1, annual rate of failure of converting cheatgrass-infested shrublands to SENN; ShAG-Restoration2, annual rate of converting cheatgrass-infested shrublands to native vegetation classes; SurfaceFire, annual rate of surface fire; Thin-Mech-Chem-Seed, annual rate of a suite of activities that use mechanical, chemical, and seeding methods to restored either tree encroached shrublands that might contain cheatgrass; Thin-Mech-Chem-Seed1, annual rate of failure of a suite of activities resulting in annual grasslands that use mechanical, chemical, and seeding methods to restored either tree encroached shrublands that might contain cheatgrass; Thin-Sheep, annual rate of prescriptive sheep grazing to reverse woody succession; Thin-Sheep1 Thin-Sheep, annual rate of failure of prescriptive sheep grazing to reverse woody succession; Tree-Invasion, annual rate of tree invasion in shrublands causing a change in vegetation class; Water-Diversion, annual rate of diverting water out of a stream as allowed by water rights; Weed-Inventory, annual rate of exotic forb and tree species inventories; Wind/Weather/Stress, annual rate of weather related events such as flooding and drought resulting in early development vegetation; Wind/Weather/Stress1, annual rate of weather related events such as flooding and drought resulting in mid-development vegetation.

Appendix III. Average Natural Range of Variability from a-spatial VDDT and spatial TELSA simulations for the Grouse Creek Mountains-Raft River Mountains, Utah.

	*	Reference Condition			
Biophysical Setting	Early-Development (% ± 1 StDev)	Mid-Development Closed (% ± 1 Stdev)	Mid-Development or Late1-Development Open (% ± 1 Stdev)	Late1-Development or Late2-Development Open (% ± 1 Stdev)	Late1-Development or Late2-Development Closed (% ± 1 Stdev)
Stable Aspen-VDDT	14.0	40.0	0.0	1.0	45.0
Stable Aspen-TELSA	14.9 ± 17.6	39.3 ± 18.1	0.0 ± 0.0	5.7 ± 5.7	40.1 ± 11.1
Pinyon-Juniper Woodland-VDDT	5.0	10.0	30.0	55.0	0.0
Pinyon-Juniper Woodland-TELSA	6.0 ± 4.4	17.3 ± 7.5	43.0 ± 6.3	33.7 ± 6.5	0.0 ± 0.0
Seral Aspen-VDDT	14.0	40.0	35.0	10.0	1.0
Seral Aspen-TELSA	11.1 ± 10.0	34.3 ± 19.5	32.3 ± 8.3	18.0 ± 8.7	4.3 ± 4.0
Curlleaf Mountain Mahogany-VDDT	10.0	15.0	10.0	20.0	45.0
Curlleaf Mountain Mahogany-TELSA	16.3 ± 6.4	13.7 ± 11.4	17.9 ± 8.0	33.5 ± 2.1	18.7 ± 5.7
Low Sagebrush-VDDT	10.0	40.0	0.0	0.0	50.0
Low Sagebrush-TELSA	23.1 ± 10.1	51.7 ± 9.7	0.0 ± 0.0	0.0 ± 0.0	25.2 ± 4.3
Black Sagebrush-VDDT	15.0	50.0	0.0	25.0	10.0
Black Sagebrush-TELSA	20.4 ± 7.4	55.1 ± 5.9	0.0 ± 0.0	15.5 ± 4.5	9.0 ± 2.0
Basin Wildrye-Basin Big Sagebrush-VDDT	20.0	70.0	0.0	10.0	0.0
Basin Wildrye-Basin Big Sagebrush-TELSA	11.5 ± 14.0	69.6 ± 16.1	0.0 ± 0.0	18.8 ± 11.1	0.0 ± 0.0
Wyoming Big Sagebrush-semi-desert-VDDT	15.0	0.0	55.0	0.0	30.0
Wyoming Big Sagebrush-semi-desert-TELSA	20.1 ± 9.7	0.0 ± 0.0	52.1 ± 7.8	0.0 ± 0.0	27.8 ± 8.9
Wyoming Big Sagebrush-upland-VDDT	15.0	50.0	25.0	5.0	5.0
Wyoming Big Sagebrush-upland-TELSA	16.2 ± 6.6	51.5 ± 7.4	22.8 ± 6.1	5.8 ± 3.0	3.7 ± 2.4

Mixed Salt Desert-VDDT	5.0			50.0			45.0			0.0			0.0		
Mixed Salt Desert-TELSA	5.3	±	1.7	51.0	±	1.6	43.7	±	0.6	0.0	±	0.0	0.0	±	0.0
Mountain Big Sagebrush-mountain-VDDT	20.0			50.0			15.0			10.0			5.0		
Mountain Big Sagebrush-mountain-TELSA	17.3	±	11.5	47.8	±	15.0	12.5	±	7.3	14.7	±	9.5	7.8	±	4.3
Mountain Big Sagebrush-upland-VDDT	20.0			50.0			15.0			10.0			5.0		
Mountain Big Sagebrush-upland-TELSA	17.3	±	11.5	47.8	±	15.0	12.5	±	7.3	14.7	±	9.5	7.8	±	4.3
Montane Wet Meadow-VDDT	5.0			40.0			0.0			55.0			0.0		
Montane Wet Meadow-TELSA	2.8	±	5.7	32.9	±	14.7	0.0	±	0.0	64.3	±	15.7	0.0	±	0.0
Montane-Subalpine Grasslands-VDDT	5.0			30.0			65.0			0.0			0.0		
Montane-Subalpine Grasslands-TELSA	22.0	±	20.2	35.8	±	21.0	42.1	±	13.7	0.0	±	0.0	0.0	±	0.0
Greasewood Flat-VDDT	5.0			95.0			0.0			0.0			0.0		
Greasewood Flat-TELSA	4.6	±	4.0	95.4	±	4.0	0.0	±	0.0	0.0	±	0.0	0.0	±	0.0
Montane-Subalpine Riparian-VDDT	45.0			0.0			30.0			0.0			25.0		
Montane-Subalpine Riparian-TELSA	34.3	±	4.7	0.0	±	0.0	24.9	±	4.9	0.0	±	0.0	40.9	±	7.1

Appendix IV. Maps of final vegetation complexity as shown by Shannon's diversity index for each core scenario combination. Legend: O for Ownership boundaries respected *versus* NO for No Ownership boundaries respected; B for Biophysical Settings priorities used *versus* NB for No Biophysical Settings priorities; F for Fuel Break used *versus* NF for No Fuel Break; and A for Adjacency implemented used *versus* NA for No Adjacency constraint; LA for 100 starts/yr (Low) of long-distance cheatgrass (Annual grass) invasion events vs. HA for 1,000 starts/yr (High); LE for 0.5 (Low) × probability/year for Exotic Forb dispersal vs. HE for 2.0 (High) × probability/year for Exotic Forb dispersal; and LH for 0.5 (Low) × probability/year for excessive Herbivory vs. HH for 2.0 (High) × probability/year for excessive Herbivory.

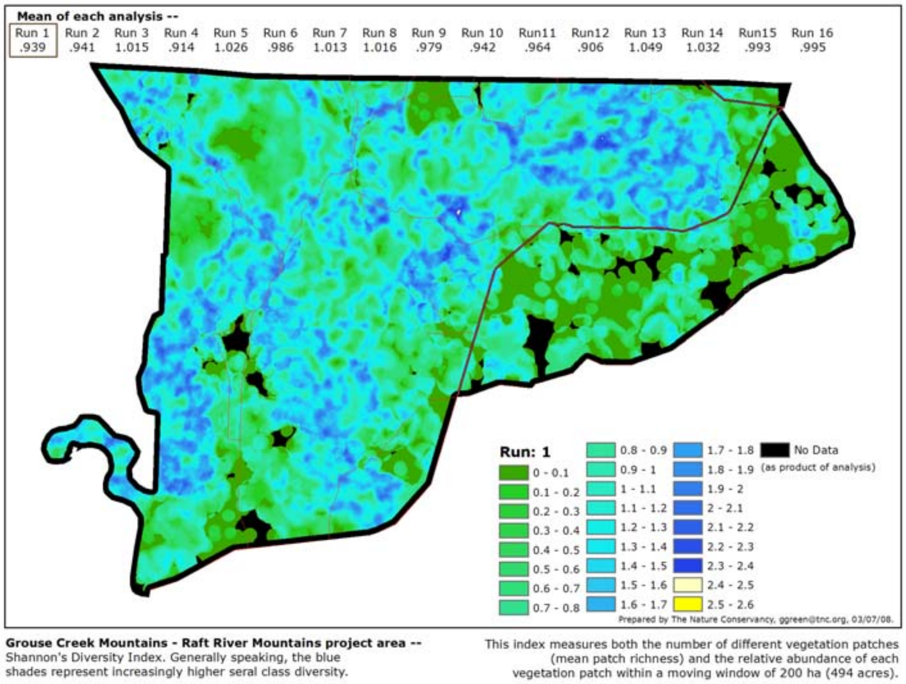

Figure IV-1. Final current vegetation complexity map expressed by Shannon's diversity index for the NO-NB-NF-NA-LA-LE-LH simulation after 50 years.

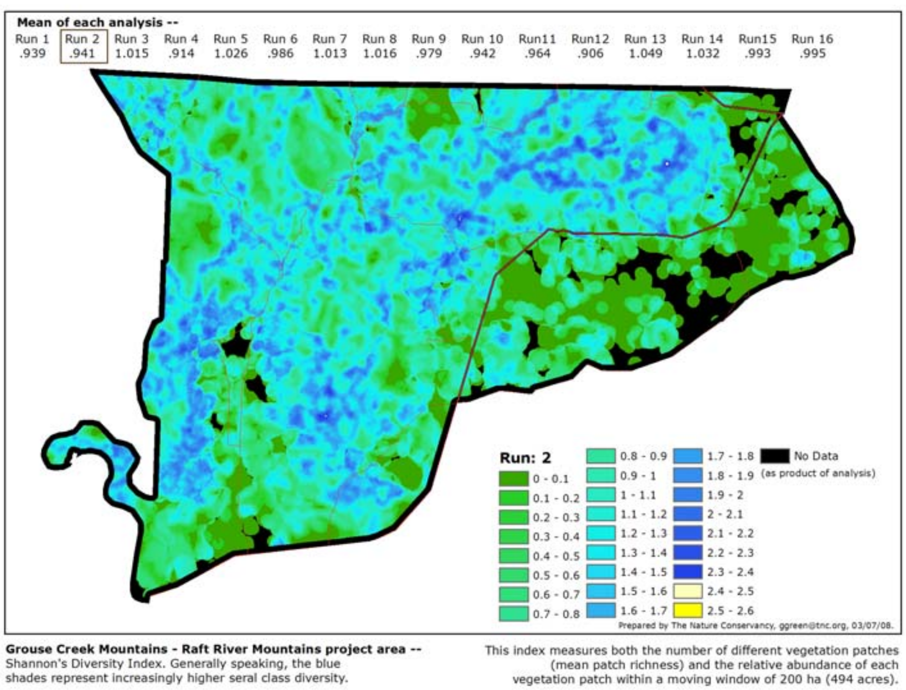

Figure IV-2. Final current vegetation complexity map expressed by Shannon's diversity index for the O-NB-NF-NA-HA-LE-HH simulation after 50 years.

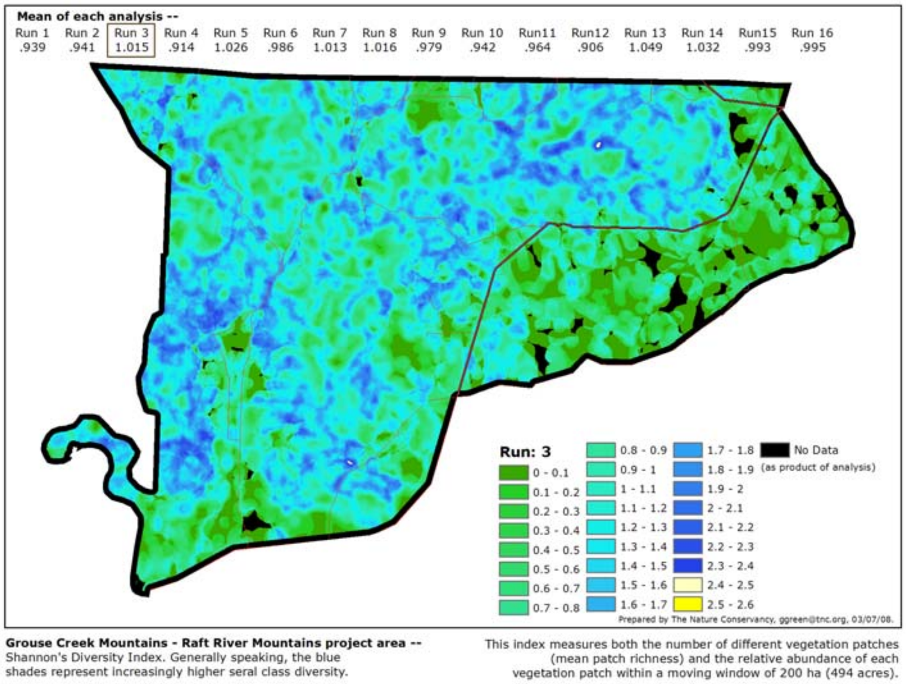

Figure IV-3. Final current vegetation complexity map expressed by Shannon's diversity index for the NO-B-NF-NA-HA-HE-HH simulation after 50 years.

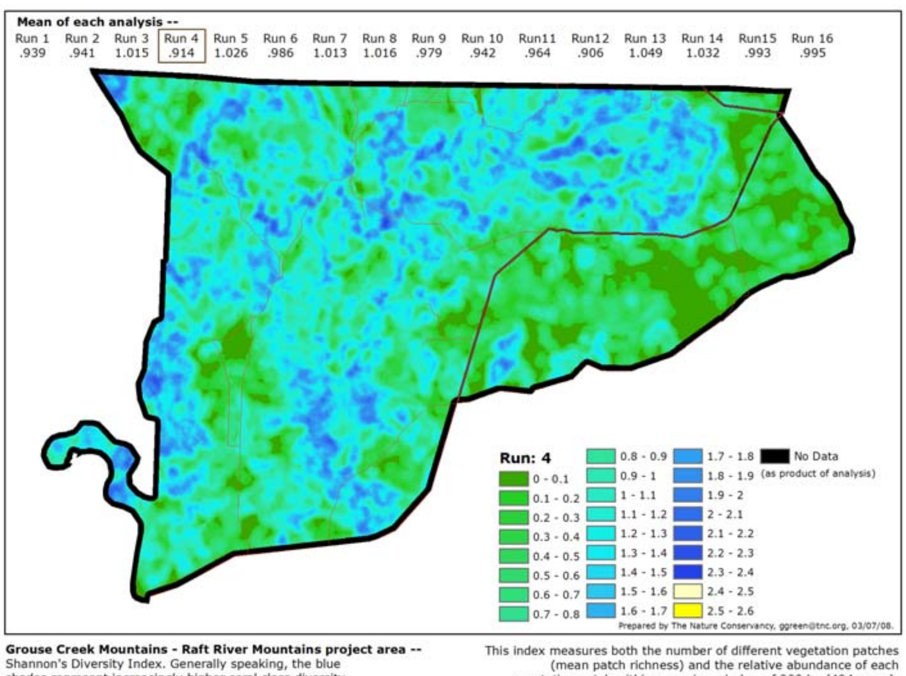

Figure IV-4. Final current vegetation complexity map expressed by Shannon's diversity index for the O-B-NF-NA-LA-HE-HH simulation after 50 years.

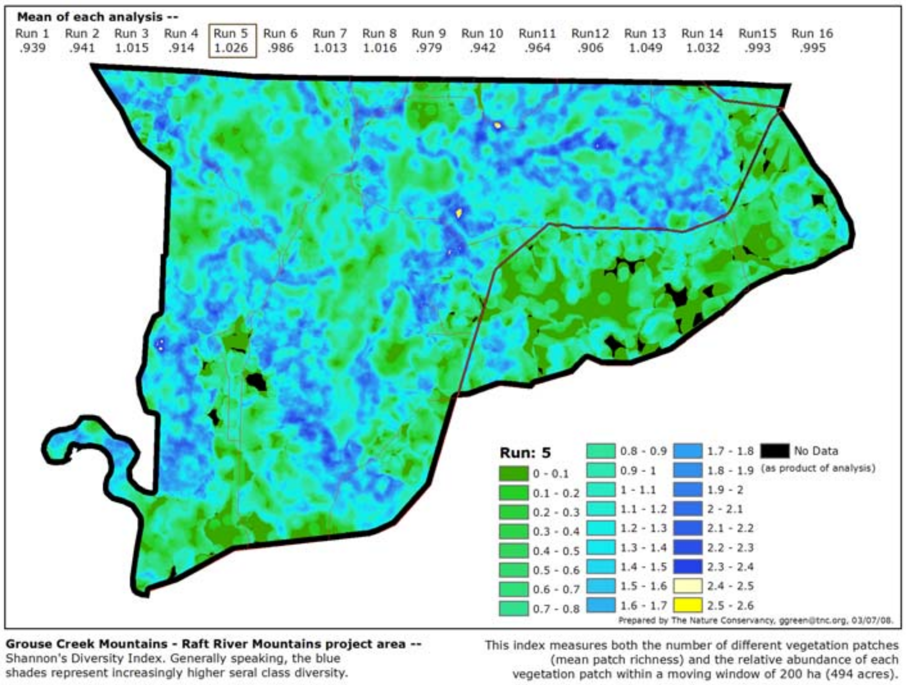

Figure IV-5. Final current vegetation complexity map expressed by Shannon's diversity index for the NO-NB-F-NA-HA-HE-HH simulation after 50 years.

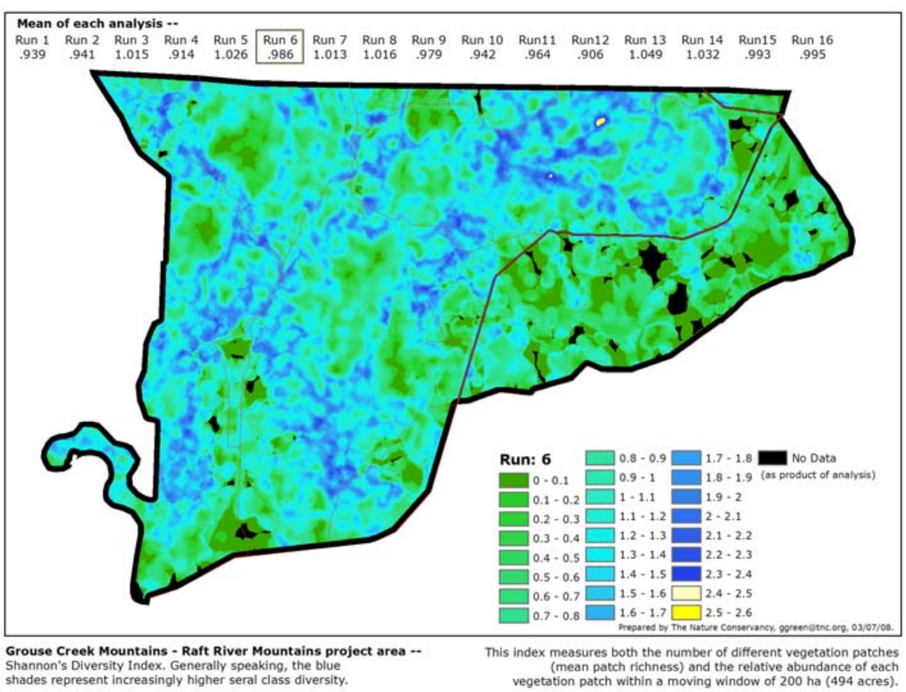

Figure IV-6. Final current vegetation complexity map expressed by Shannon's diversity index for the O-NB-F-NA-LA-HE-LH simulation after 50 years.

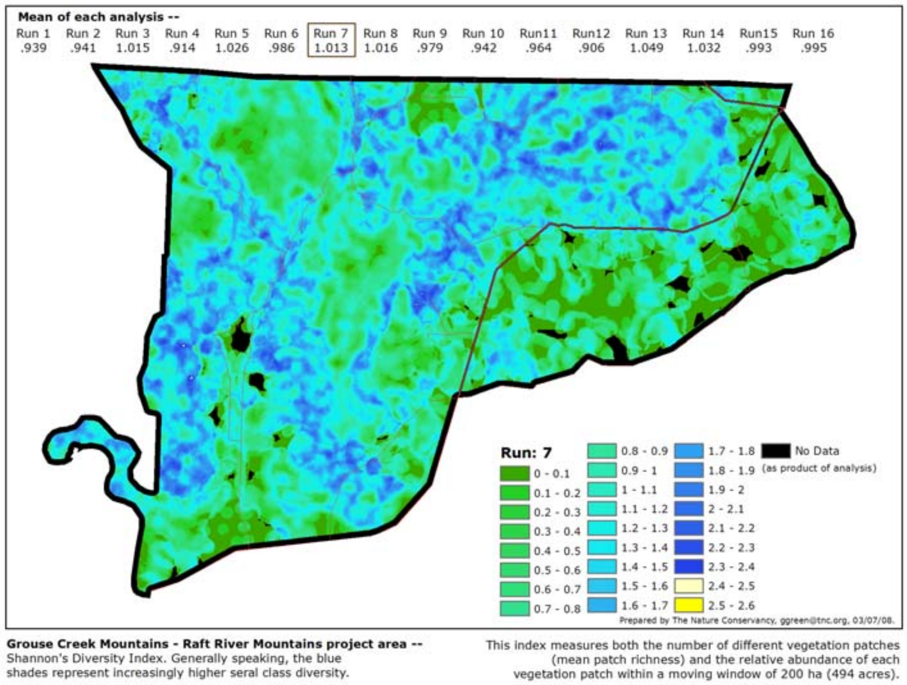

Figure IV-7. Final current vegetation complexity map expressed by Shannon's diversity index for the NO-B-F-NA-LA-LE-HH simulation after 50 years.

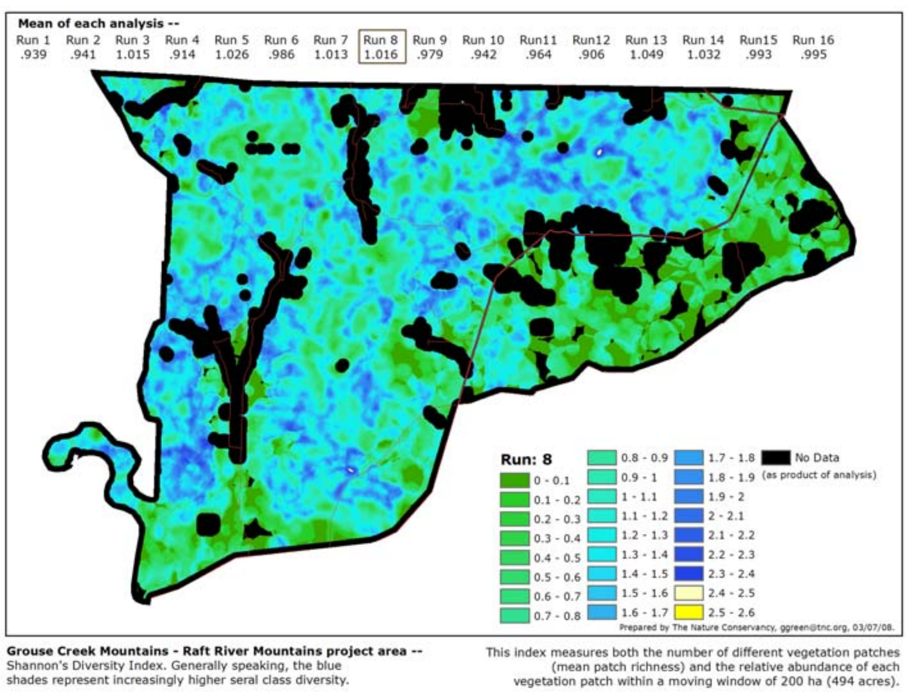

Figure IV-8. Final current vegetation complexity map expressed by Shannon's diversity index for the O-B-F-NA-HA-LE-LH simulation after 50 years.

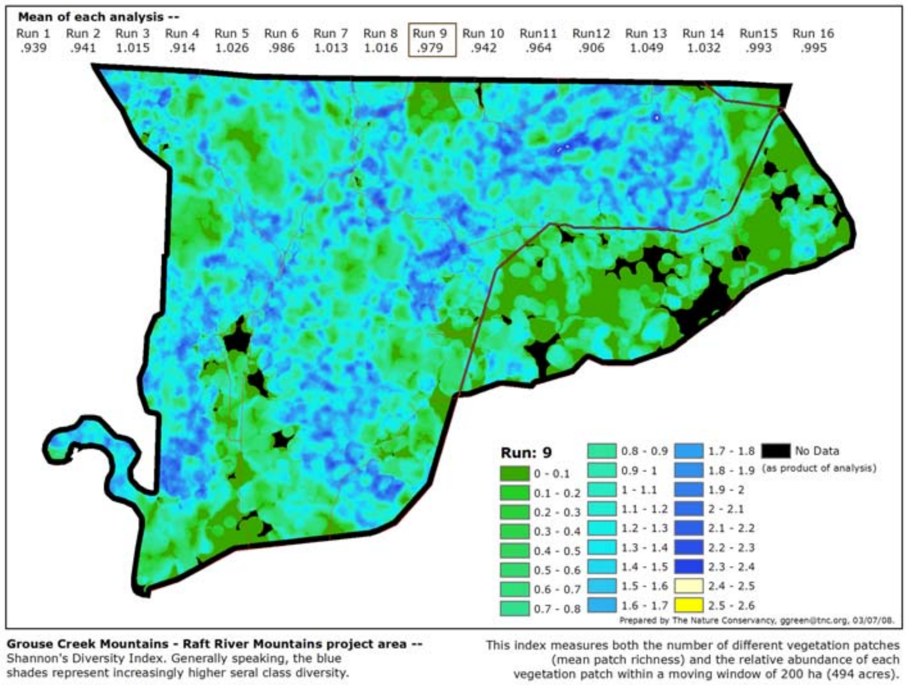

Figure IV-9. Final current vegetation complexity map expressed by Shannon's diversity index for the NO-NB-NF-A-LA-HE-HH simulation after 50 years.

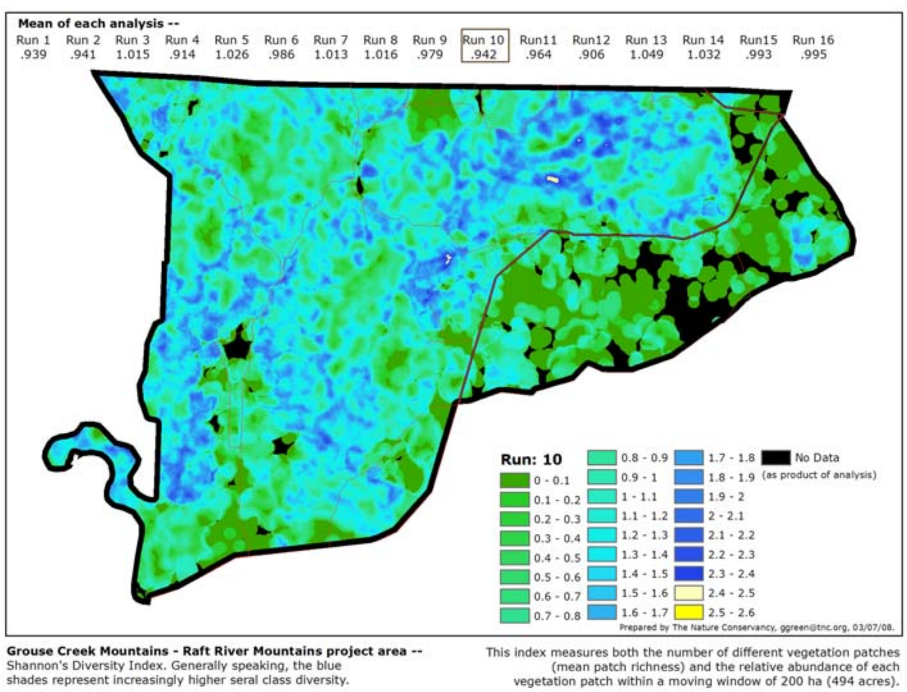

Figure IV-10. Final current vegetation complexity map expressed by Shannon's diversity index for the O-NB-NF-A-HA-HE-LH simulation after 50 years.

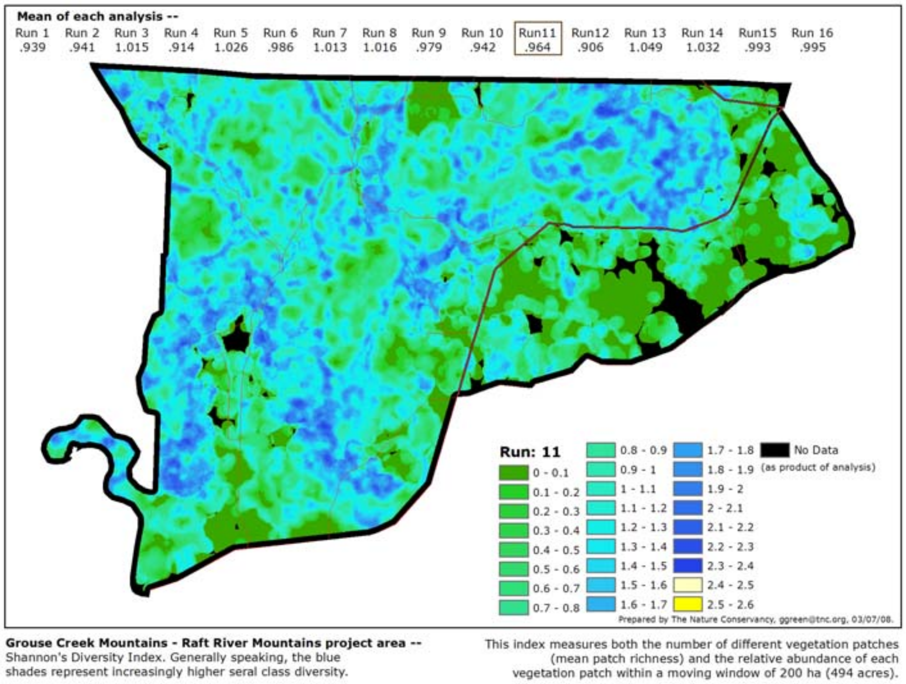

Figure IV-11. Final current vegetation complexity map expressed by Shannon's diversity index for the NO-B-NF-A-HA-LE-HH simulation after 50 years.

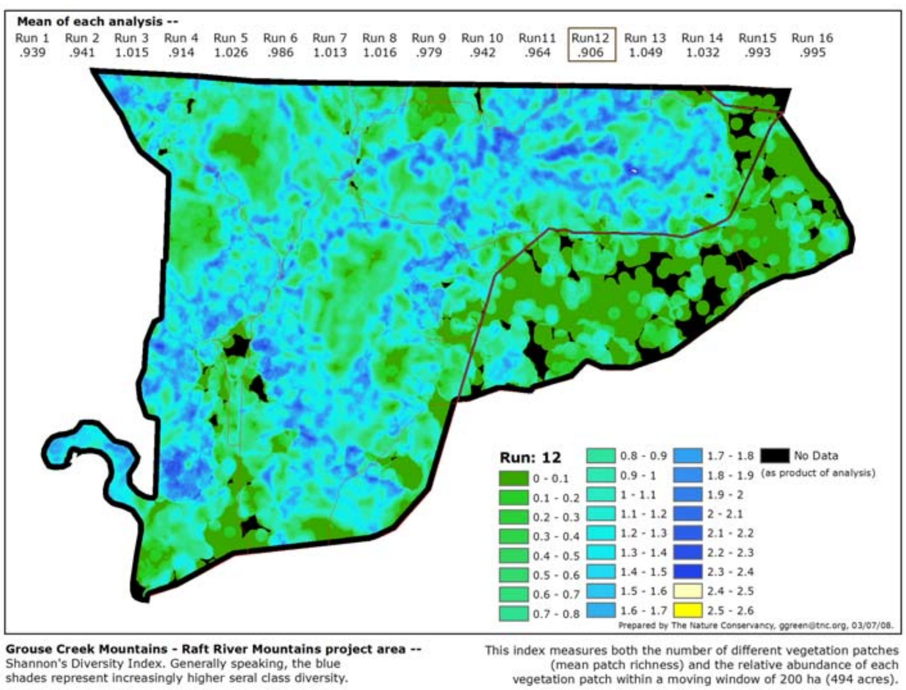

Figure IV-12. Final current vegetation complexity map expressed by Shannon's diversity index for the O-B-NF-A-LA-LE-LH simulation after 50 years.

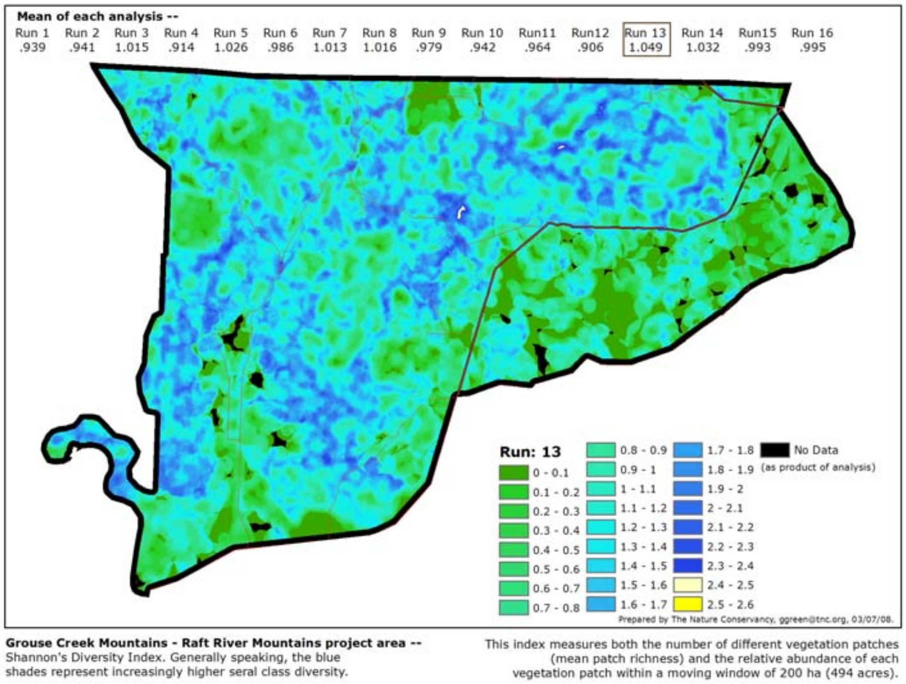

Figure IV-13. Final current vegetation complexity map expressed by Shannon's diversity index for the NO-NB-F-A-HA-LE-LH simulation after 50 years.

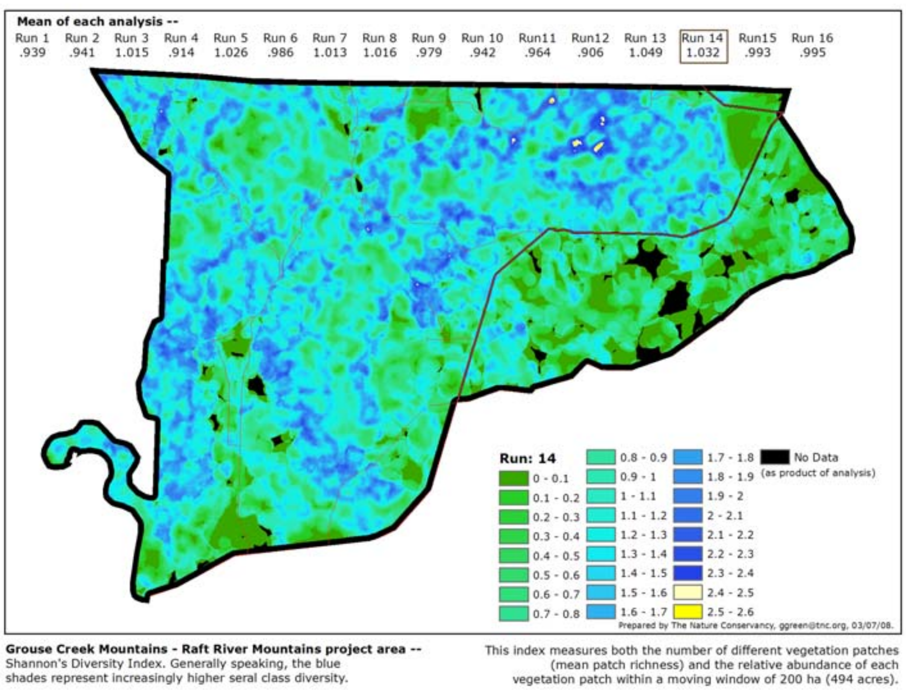

Figure IV-14. Final current vegetation complexity map expressed by Shannon's diversity index for the O-NB-F-A-LA-LE-HH simulation after 50 years.

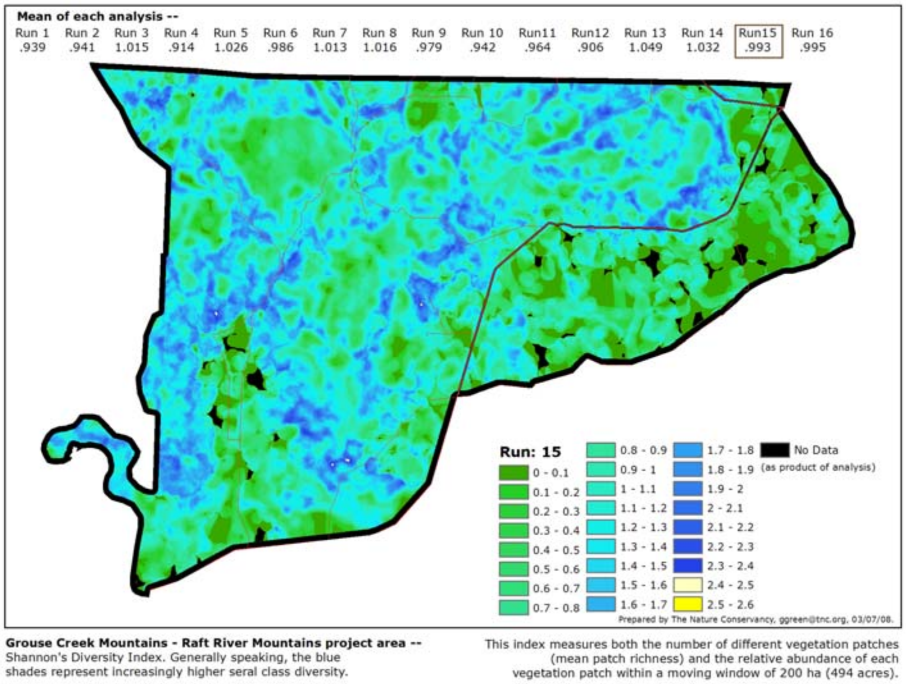

Figure IV-15. Final current vegetation complexity map expressed by Shannon's diversity index for the NO-B-F-A-LA-HE-LH simulation after 50 years.

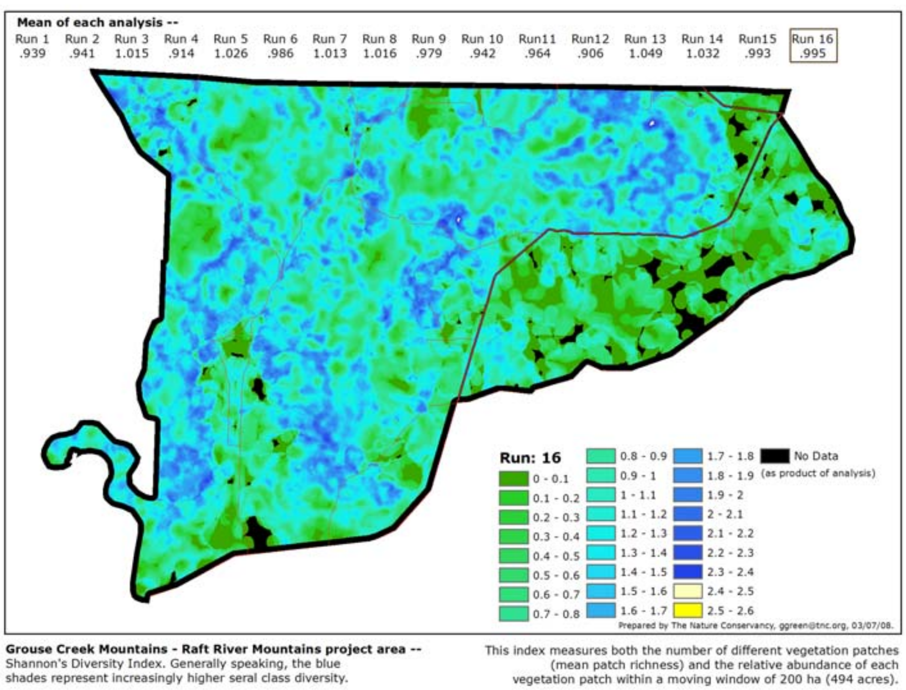

Figure IV-16. Final current vegetation complexity map expressed by Shannon's diversity index for the O-B-F-A_HA-HE-HH simulation after 50 years.

Appendix V. Maps of final vegetation classes for each secondary management scenario combinations. All scenarios from 17 to 23 have as a baseline the scenario combination No Ownership-No Biophysical Setting Priority-Fuel Break-No Adjacency, which is combination #24. Legend: S for increasing Succession complexity of vegetation during treatment application; R for budget Reduction of archeological surveys, seed, and mechanical thinning; and C for application of vegetation treatments only around human Communities at risk.

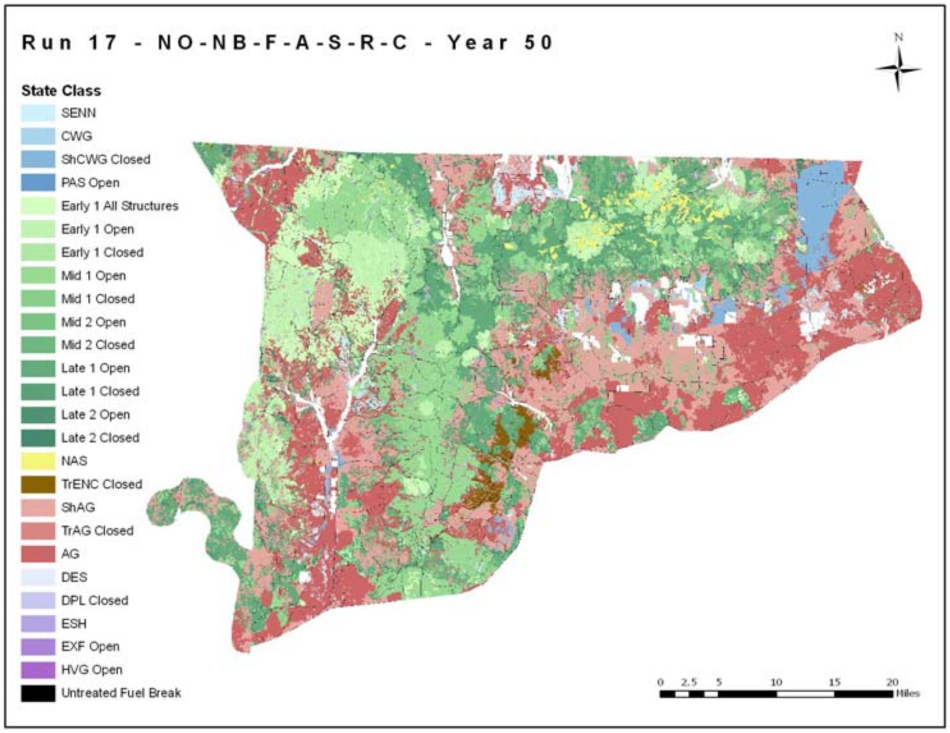

Figure V-1. Final current vegetation map of vegetation classes for the Seral Complexity-Budget Reduction-Communities at Risk simulation after 50 years.

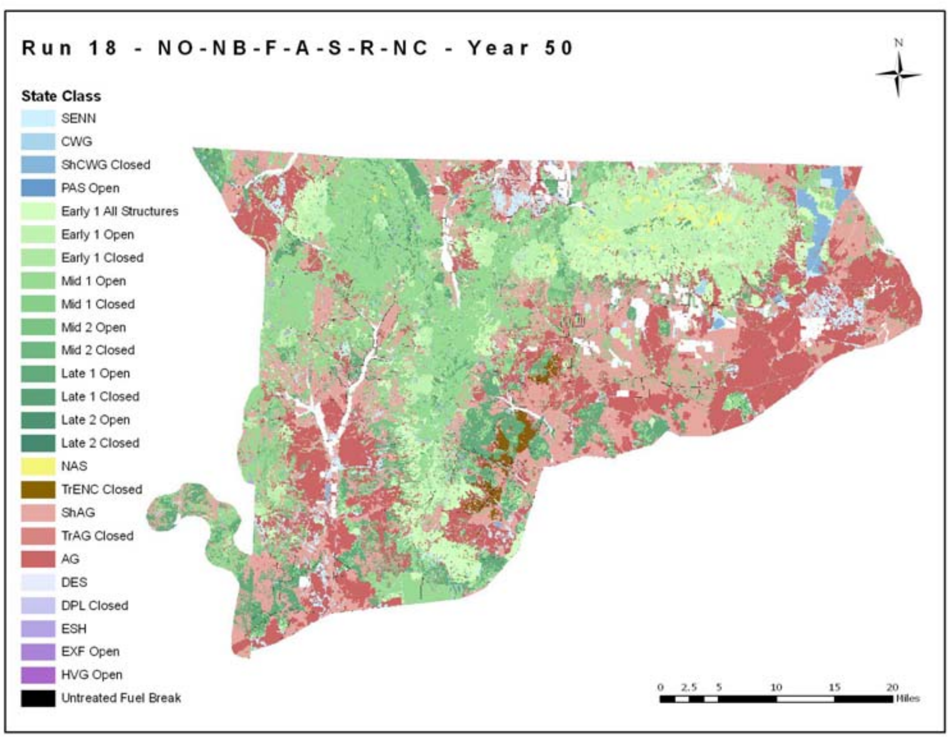

Figure V-2. Final current vegetation map of vegetation classes for the Seral Complexity-Budget Reduction-No Communities at Risk simulation after 50 years.

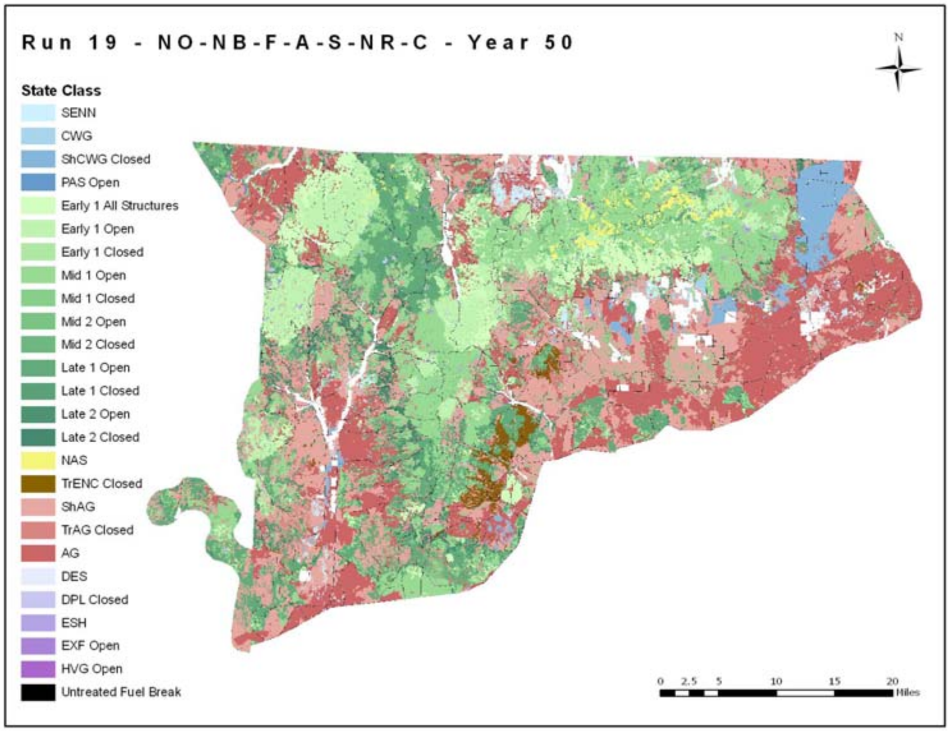

Figure V-3. Final current vegetation map of vegetation classes for the Seral Complexity-No Budget Reduction-Communities at Risk simulation after 50 years.

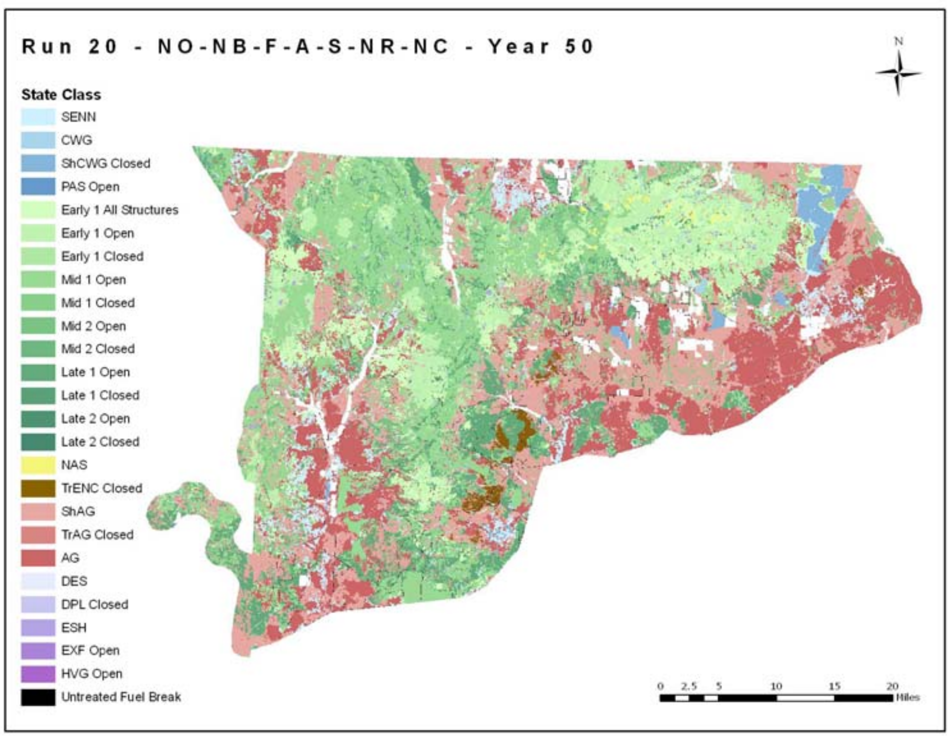

Figure V-4. Final current vegetation map of vegetation classes for the Seral Complexity-No Budget Reduction-No Communities at Risk simulation after 50 years.

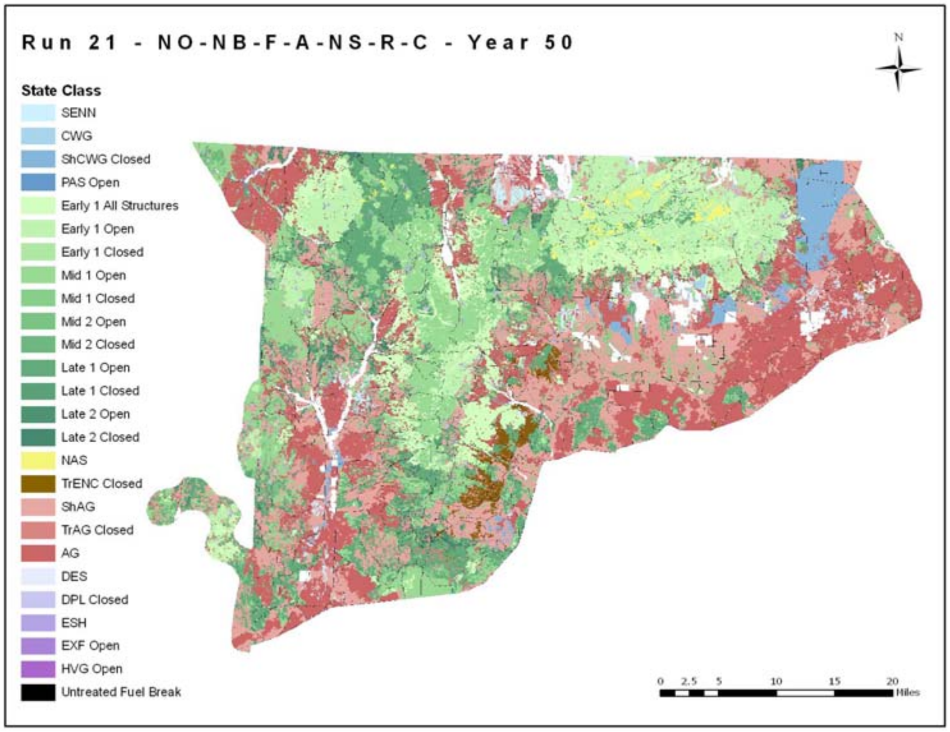

Figure V-5. Final current vegetation map of vegetation classes for the No Seral Complexity-Budget Reduction-Communities at Risk simulation after 50 years.

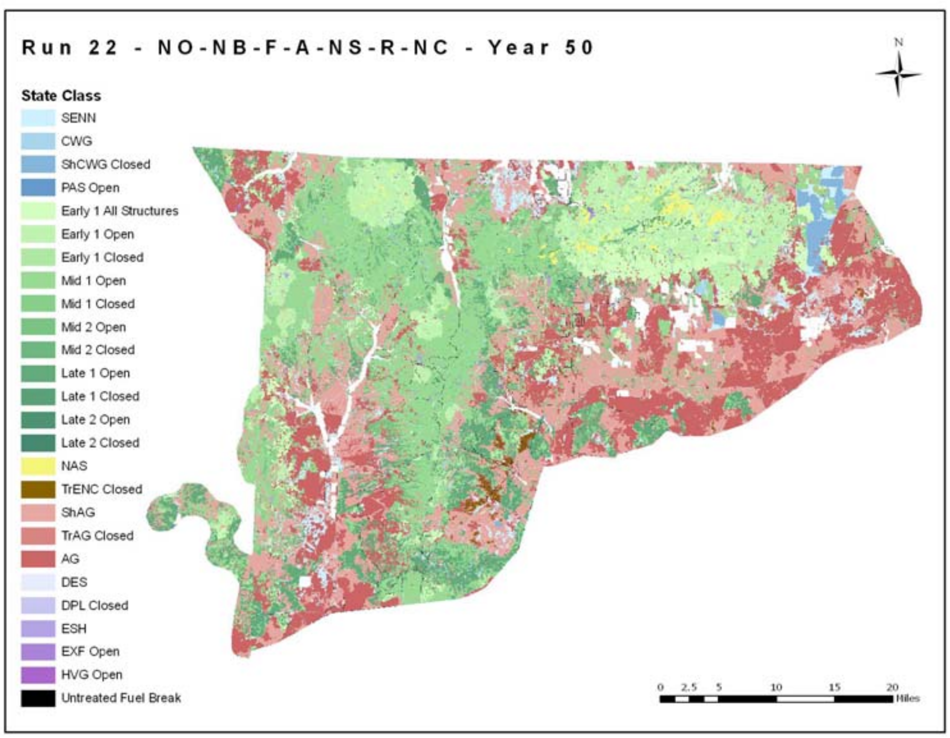

Figure V-6. Final current vegetation map of vegetation classes for the No Seral Complexity-Budget Reduction-No Communities at Risk simulation after 50 years.

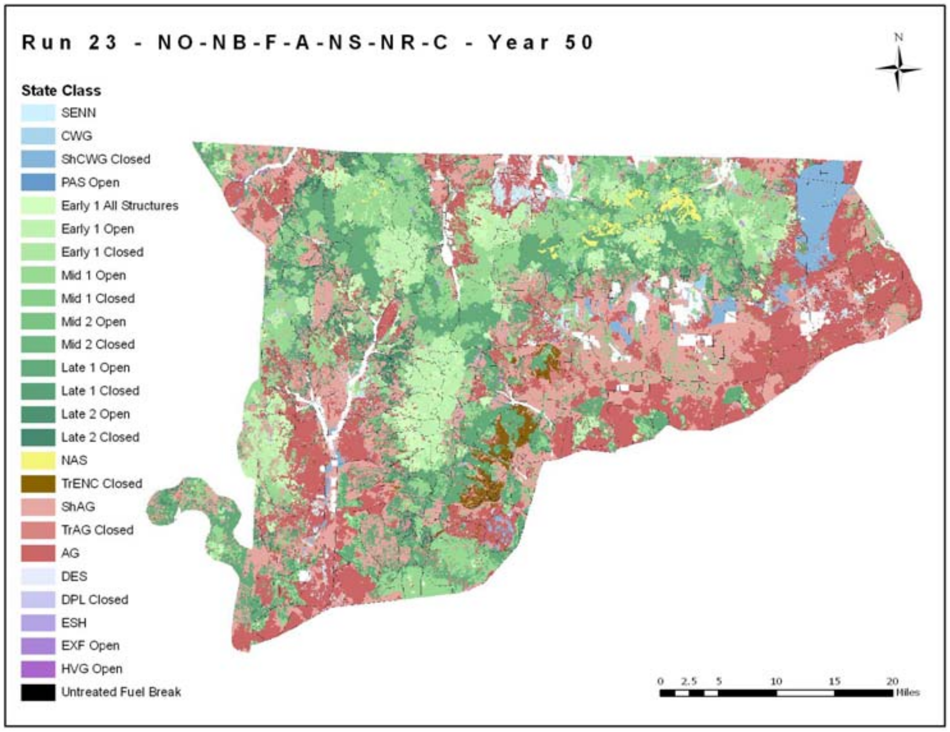

Figure V-7. Final current vegetation map of vegetation classes for the No Seral Complexity-No Budget Reduction-Communities at Risk simulation after 50 years.

Appendix VI. Maps of final vegetation complexity as expressed by Shannon's diversity index for each secondary management scenario combination. Legend: S for increasing Succession complexity of vegetation during treatment application; R for budget Reduction of archeological surveys, seed, and mechanical thinning; and C for application of vegetation treatments only around human Communities at risk.

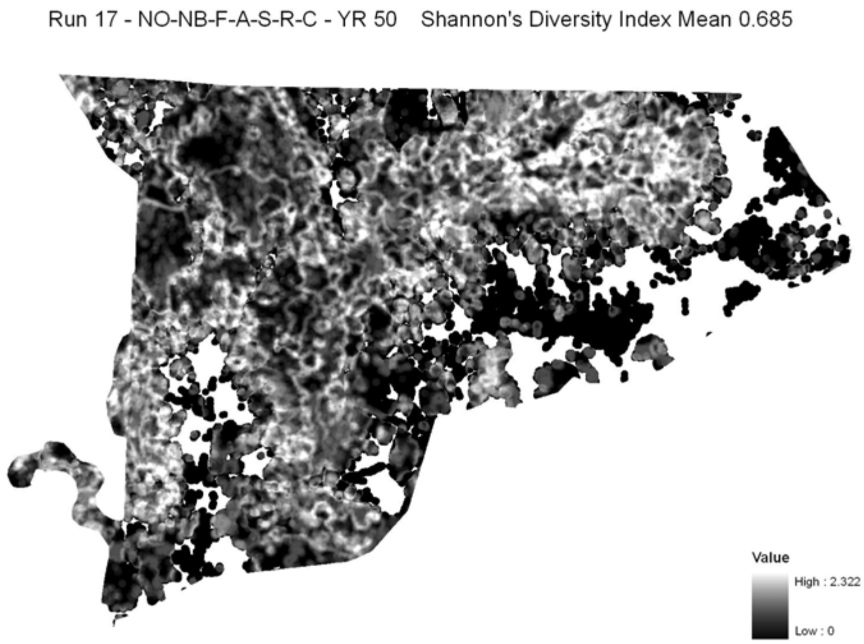

Figure VI-1. Final current vegetation map of vegetation complexity based on Shannon's diversity index for the Seral Complexity-Budget Reduction-Communities at Risk simulation after 50 years.

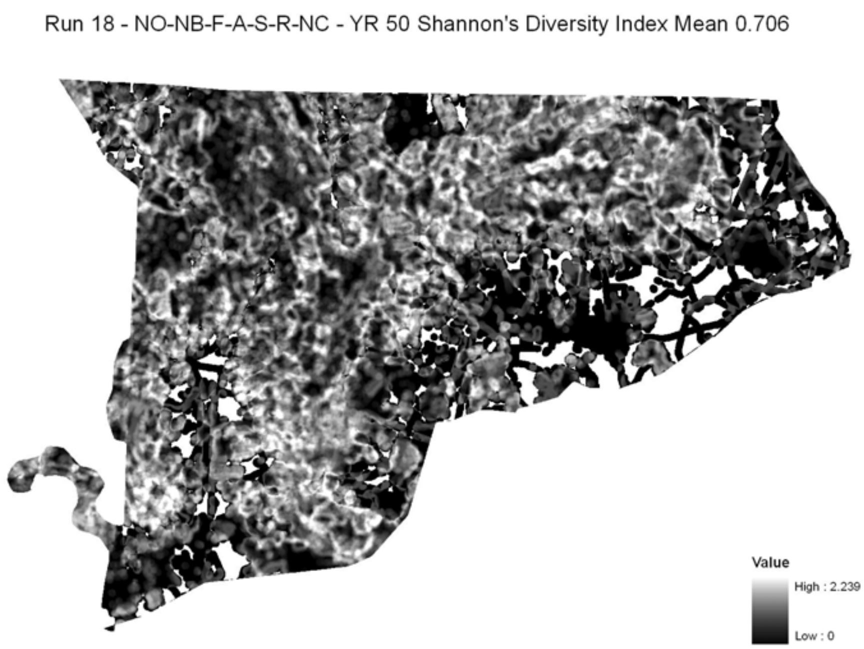

Figure VI-2. Final current vegetation map of vegetation complexity based on Shannon's diversity index for the Seral Complexity-Budget Reduction-No Communities at Risk simulation after 50 years.

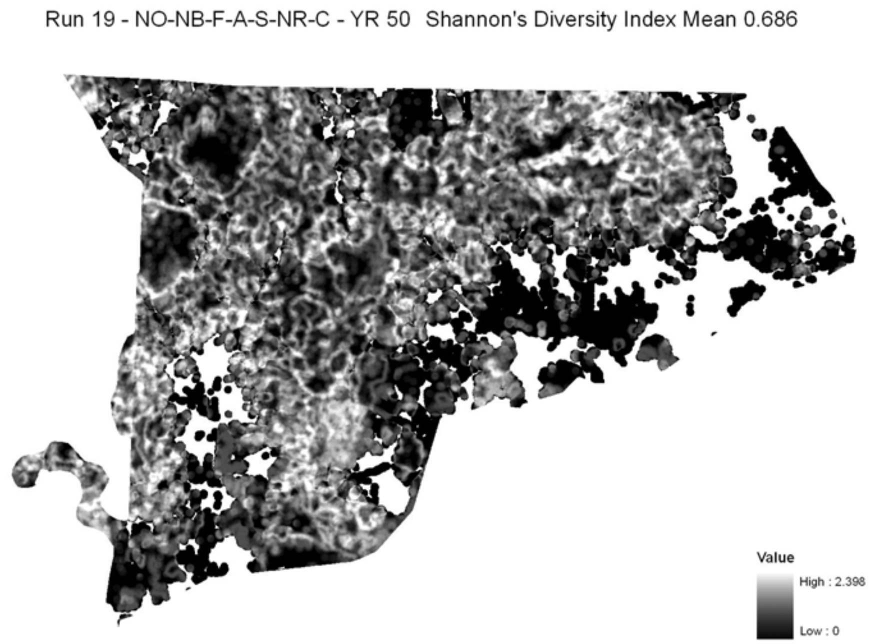

Figure VI-3. Final current vegetation map of vegetation complexity based on Shannon's diversity index for the Seral Complexity-No Budget Reduction-Communities at Risk simulation after 50 years.

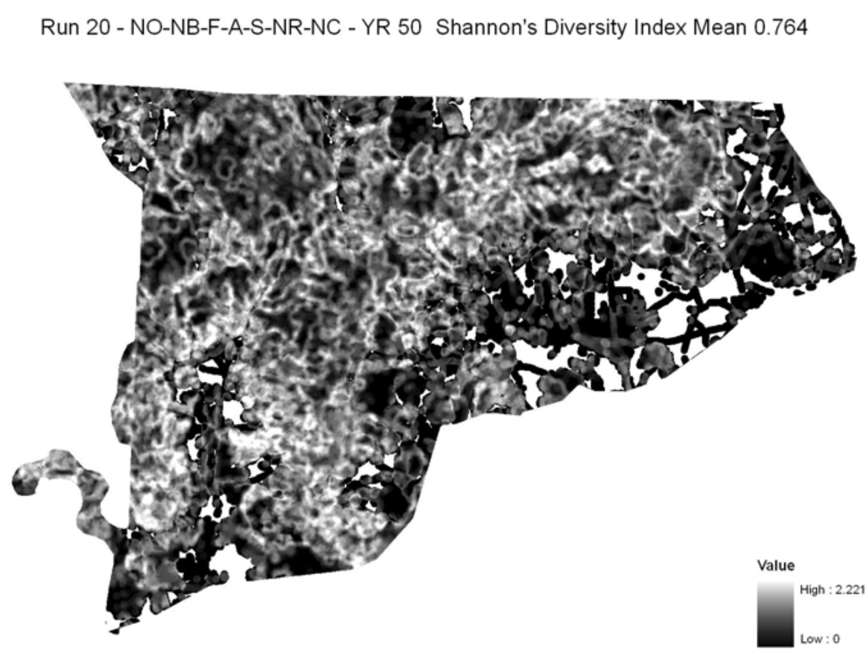

Figure VI-4. Final current vegetation map of vegetation complexity based on Shannon's diversity index for the Seral Complexity-No Budget Reduction-No Communities at Risk simulation after 50 years.

Run 21 - NO-NB-F-A-NS-R-C - YR 50   Shannon's Diversity Index Mean 0.679

Figure VI-5. Final current vegetation map of vegetation complexity based on Shannon’s diversity index for the No Seral Complexity-Budget Reduction-Communities at Risk simulation after 50 years.

Run 22 - NO-NB-F-A-NS-R-NC - YR 50 Shannon's Diversity Index Mean 0.709

Figure VI-6. Final current vegetation map of vegetation complexity based on Shannon’s diversity index for the No Seral Complexity-Budget Reduction-No Communities at Risk simulation after 50 years.

Run 23 - NO-NB-F-A-NS-NR-C - YR 50 Shannon's Diversity Index Mean 0.712

Figure VI-7. Final current vegetation map of vegetation complexity based on Shannon's diversity index for the No Seral Complexity-No Budget Reduction-Communities at Risk simulation after 50 years.