Draft Report to the U.S. Forest Service Spring Mountains National Recreation Area
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R--Fire Regime Condition Class Mapping for the Spring Mountains Southern Nevada
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Photo: Alkali sacaton-mesquite loamy bottom, south Spring Mountains; Louis Provencher, 2008

By

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Table of Contents

Executive Summary

The Nature Conservancy was contracted to map Fire Regime Condition Classes (FRCC) and associated products for approximately 1.25 million acres of the Spring Mountains in U.S. Forest Service (USFS), Bureau of Land Management (BLM), and private land management. FRCC is a measure of departure of vegetation structure-composition, and fire regimes between current and reference condition. The Nature Conservancy interpreted ecological site associations from three USDA Natural Resource Conservation Service soil surveys to 20 major vegetation types representing LANDFIRE biophysical settings (potential vegetation types) typical of Mojave Desert high elevation ranges. The natural range of variability (percentage of each succession class per biophysical setting) was either obtained from LANDFIRE or recalculated after adapting LANDFIRE computer models. Biophysical settings are the fundamental stratification of FRCC mapping. Subcontractor Spatial Solutions conducted remote sensing with field help from Conservancy staff from April to August 2008. Spatial Solutions refined associations of biophysical settings to unique ones and mapped succession and uncharacteristic vegetation classes per biophysical settings. The Nature Conservancy processed biophysical settings and current vegetation class geodata, and natural ranges of variability with the inter-agency software FRCC Mapping Tool. Four biophysical settings, including the very extensive creosotebush-white bursage and blackbrush systems, were in FRCC 3, 5 biophysical settings were in FRCC 2, and 11 in FRCC 1. Higher elevation and the lowest elevation biophysical settings (below creosotebush-white bursage) were generally less departed from the natural range of variability. A summary output table was also produced that identified vegetation classes per biophysical settings that were over-represented, similar, or under-represented compared to the natural range of variability. The summary output table is directly relevant to land management decisions.

Introduction

Recent western fires have shown that the alteration of natural fire regimes have dire human and ecological costs. Although much media attention has been devoted to the human cost of fires in the wildland-urban interface, the ecological costs of wildland fires burning fuels in amounts and composition outside the natural range of variability have been devastating to the ecological integrity of landscapes and to the management of sensitive and listed species. Wildland fires with catastrophic effects can be prevented by strategically treating landscapes with various combinations of prescribed fire, mechanical and chemical methods, and grazing management. Fire Regime Condition Class (FRCC) mapping of a project area is required to seek funding from the National Fire Plan Operations and Reporting System for implementation of fuels management projects (as per Healthy Forest Restoration Act). Fire Regime Condition is also a landscape-level measure of ecological departure between the pre-settlement and current distributions of vegetation succession classes and fire regimes for a given area that is either reported from 0% (not departed) to 100% (completely departed) or in three equal classes as FRCC I (not departed), II (moderately departed) or III (highly departed) (Hann *et al*. 2004). The FRCC map is not the only product of FRCC analysis; indeed, the Relative Amount geodata is perhaps more interesting to land managers because it can be used to identify problem areas with higher priority for fuels management (treatable areas). Yet, accurately mapping FRCC on remote, large, and rugged landscapes is challenging and requires at least the application of mid-scale project methodology (Shlisky and Hann 2003).

The Nature Conservancy of Nevada (TNC) and Spatial Solutions, Inc. (Provencher *et al*. 2008) recently adapted Shlisky and Hann's (2003) mid-scale methodology by combining it with soil survey interpretation, mid- and high-resolution satellite imagery, and field verification. These improvements to the methodology are needed for landscapes where (1) fuels managers require greater accuracy and precision for mapping treatable areas, (2) steep topography or patchy or linear vegetation patterns necessitate higher resolution imagery or more field verification, (3) and LANDFIRE geodata products are not supported by sufficient remote sensing training plots, as is the case for the Mojave and Sonora Deserts (the project lead, Dr. Provencher, was TNC's regional lead for the Great Basin region of LANDFIRE that includes the Mojave Desert).

FRCC mapping of the Spring Mountains is important to many stakeholders, including TNC, because these mountains have globally significant biodiversity maintained within fire-adapted and sensitive ecological systems. TNC of Nevada identified the Spring Mountains as one of its 12 most important landscapes in the Mojave Desert and Great Basin ecoregions (The Nature Conservancy 2000, Nachlinger *et al*. 2001). The landscape is home to many rare species of plants and animals, some that are found nowhere else in the world. The U.S. Fish and Wildlife Service approximately tracks 50+ species of special concern on the Spring Mountains. Moreover, ponderosa pine stands, which are uncommon in the Mojave Desert and Great Basin, are an important community type in the Spring Mountains National Recreation Area. The fire regime in many of these systems may be outside the natural range of variability due to past land management practices and the invasion of non-native annual grasses at lower elevations. Current land uses include heavy recreational activity, mainly from Las Vegas residents, and management of non-native elk, wild horses, and wild burros. The wildland-urban interface is also a significant aspect of fire management in the Spring Mountains due to communities around and within public lands supporting heavy fuels accumulation (for examples, Kyle and Lee Canyons).

The objective of this contract was to map FRCC and associated products of major ecological systems for approximately 1.25 million acres of the Spring Mountains in U.S. Forest Service (USFS), Bureau of Land Management (BLM), and private management.

Methods

TNC used the FRCC mapping methodology initially implemented in the 45,000 acres of Mount Grant on Hawthorne Army Depot described in Provencher *et al.* (2008; Appendix I), and more recently used for the 350,000 acres of the Wassuk Range (western Nevada), and the 200,000 acres of the Bodie Hills-Mono Lake Basin landscape (eastern California). Provencher *et al.* (2008) adapted the mid-scale methodology described by Shlisky and Hann (2003). TNC staff of Nevada worked with the remote sensing subcontractor Spatial Solutions, Inc., which has coordinated acquisition dates of QuickBird imagery for all of Clark County in 2006. The method has four major steps:

(1) interpret soil surveys to map biophysical settings, which are static polygons representing pre-settlement vegetation types; (2) describe biophysical settings and, if necessary, calculate their natural ranges of variability with computer simulation software; (3) refine mapping of biophysical settings and interpret current vegetation to succession and uncharacteristic classes described in biophysical settings using remote sensing analysis and field surveys to establish training plots and verify draft maps; and (4) process the biophysical settings and current vegetation class maps, and natural ranges of variability with the inter-agency FRCC Mapping Tool software to create FRCC and Relative Amount geodata layers.

Interpreting soil surveys to biophysical settings

The foundation of FRCC mapping is the stratification of a landscape by biophysical settings. We obtained biophysical settings by interpreting USDA Natural Resource Conservation Service (NRCS) order III soil surveys from www.soildatamart.gov to groups of ecological sites dominated by the same upper-layer species into the same biophysical setting. The NRCS defines ecological site as "A distinctive kind of land with specific physical characteristics that differs from other kinds on land in its ability to produce a distinctive kind and amount of vegetation." (*National Forestry Manual*, www.nrcs.usda.gov/technical/ECS/forest/2002_nfm_complete.pdf). Three soil surveys from Nevada were used: #775, #785, and #788. Soil survey geodata were clipped to the project area (Fig. 1). Each polygon per soil survey was coded to one or more biophysical settings using two tables from soil surveys: Rangeland Productivity & Plant Composition and Forestland Productivity. The dominant upper-layer species listed in the soil survey tables dictated which biophysical setting was assigned to each polygon. For example, if blackbrush was the most abundant shrub listed, the biophysical setting became "blackbrush." In the older soil survey for the Las Vegas Valley, the lists of reference species in the Rangeland Productivity & Plant Composition table were limited to forage species and often did not include the dominant shrubs or trees. We visited with the state office of NRCS to obtain the additional information from the ecological site descriptions that allowed us to correctly assign a biophysical setting label to the polygon. All adjacent polygons with the same biophysical setting identity were merged.

Remote sensing analysis of biophysical settings based on soil surveys is always complicated by soil associations, which are polygons containing >1 ecological site or >1 biophysical setting. The soil surveys of order III, which are the norm in Nevada, typically do not map ecological sites <10 acres or representing <1% of a mapped polygon, and often do not resolve each soil polygon (a "map unit" in NRCS jargon) to unique vegetation types. Soil surveys do, however, indicate the presence and proportion of the polygon occupied by each ecological site. As a result, one map unit polygon might contain 2-7 biophysical settings whose exact positions are not described. These biophysical settings must be split to unique biophysical settings by remote sensing to complete FRCC analysis.

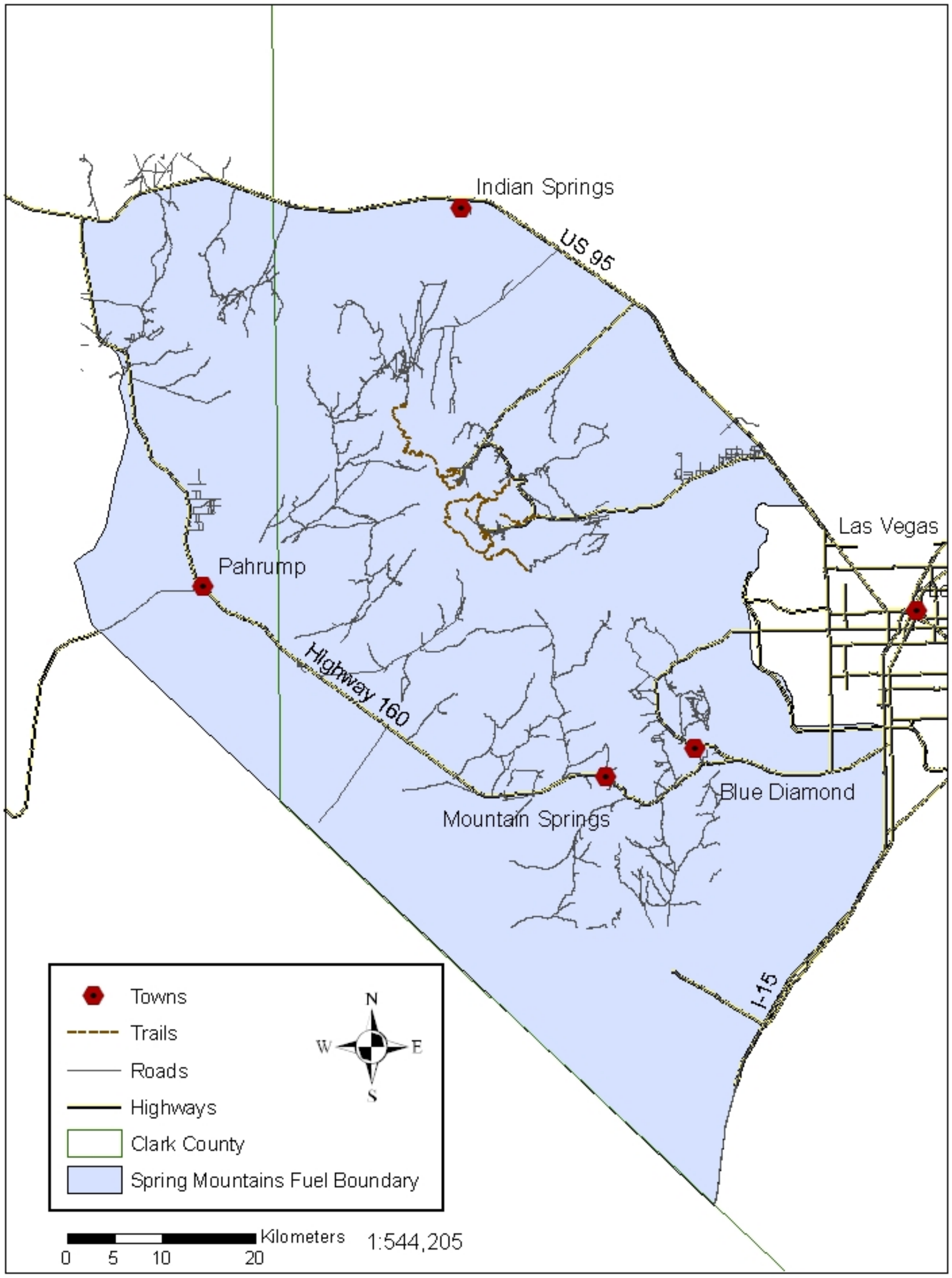

Fig. 1. The Spring Mountains project area (shaded). The boundary of the project is approximately the California-Nevada border, Pahrump, Highway 160, Highway 95, Highway 215, and Interstate 15.

Identifying biophysical settings from the same map unit polygon proved difficult, especially at lower elevations.

- Digital Elevation Models were used to separate creosotebush-white bursage from blackbrush because both biophysical settings were sparsely vegetated and had comparable spectral signatures at their transition zone. We determined from field observations that a transition elevation of 4,000 ft adequately separated these two biophysical settings. This elevation was used in most cases, but the transition zone was locally adjusted when field observations indicated a different elevation.
- We frequently encountered polygons that had very similar vegetation classes at the same elevations: pinyon-juniper woodlands, black sagebrush with > 20% pinyon-juniper cover, blackbrush with >20% pinyon-juniper cover, and montane sagebrush steppe with >20% tree cover. Because the midstory vegetation under the trees was not readily visible to the satellite, these different biophysical settings could not be easily separated using spectral classes. Differences among them were mostly edaphic. Moreover, the NRCS often labeled these systems and adjacent shrublands without trees as pinyon-juniper woodland. We know from the Great Basin that pinyon and juniper can overtake many ecological systems that are true shrublands because significant alterations to disturbance regimes might "hide" or "exaggerate" them (Blackburn and Tuller 1970, Miller and Rose 1999, Provencher *et al*. 2008). In the Mojave Desert, this relationship is more nuanced, sometimes incorrect, because blackbrush and black sagebrush have mean fire return interval comparable to those of pinyon-juniper woodlands and fires do not "climb up the hill" from desert scrub (creosotebush-white bursage and blackbrush), which does not have an evolutionary history with fire. These observations about fire return intervals suggest a larger proportion of the biophysical setting in later succession stages, although encroachment by trees with suppression of the understory was commonly found. Our main diagnostic tools to separate late-development shrublands with trees from true woodlands were a) trees were conical, therefore less than 100 years old and perhaps encroaching shrublands, b) the understory contained several skeletons of dead shrubs (indicator of encroached shrubland), and c) the herbaceous understory was absent or very reduced (indicator of encroached shrubland).

Biophysical setting descriptions and natural range of variability

The description of each biophysical setting for the Mojave Desert was initially downloaded from www.LANDFIRE.gov (Hann *et al*. 2004). Nearly all descriptions from LANDFIRE were acceptable and needed no revisions, especially since many were written by local experts for the Spring Mountains area. A few biophysical settings were revised or remodeled because they contained parameters for surface and mixed severity fires that have been redefined by LANDFIRE since the Mojave Desert was processed in 2005-2006. State-and-transition models for these biophysical settings were revised by eliminating these fire types were appropriate and recalculating their natural ranges of variability, which is included in the description, using standard LANDFIRE methodology (Hann *et al*. 2004, Provencher *et al*. 2008). The natural range of variability was calculated with the state-and-transition modeling software Vegetation Dynamics Development Tool (VDDT, ESSA Technologies; Beukema *et al.* 3002, Forbis *et al*. 2006, Provencher *et al*. 2007; Provencher *et al*. 2008). Finally, new biophysical settings not identified by LANDFIRE were split from existing ones or were newly created. These were mostly small or linear vegetation types. New descriptions and models adapted from the Great Basin ecoregion were created again following LANDFIRE methodology. All descriptions are presented in Appendix II. The natural range of variability per biophysical setting is shown in Table 1 and included in Appendix II's descriptions.

Table 1. The natural range of variability for biophysical settings of the Spring Mountains.

Biophysical Setting		Natural Range of Variability					
Code[@]	Name	A[&]	B	C	D	E	U
1019	Pinyon-Juniper Woodland	5	5	25	65	0	0
1020	Subalpine Limber-Bristlecone Pine Woodland	15	15	70	0	0	0
1052	Mesic Montane Mixed Conifers	10	30	15	35	10	0
1054	Ponderosa Pine Woodland	10	9	20	60	1	0
1061	Seral Aspen	25	50	15	9	1	0
1062	Curlleaf Mountain Mahogany Woodland	10	15	10	20	45	0
1079	Black Sagebrush	15	40	20	25	0	0
1080bw[#]	Basin Wildrye	20	60	20	0	0	0
1081	Mixed Salt Desert Scrub	5	50	45	0	0	0
1082	Blackbrush	25	75	0	0	0	0
1087	Creosotebush-White Bursage	15	85	0	0	0	0
1104	Mogollon Chaparral	10	90	0	0	0	0
1126	Montane Sagebrush Steppe	20	50	15	10	5	0
1135	Semi-Desert Grassland	30	70	0	0	0	0
1143[#,&]	Alpine Fell-Field	5	95	0	0	0	0
1145	Subalpine-Montane Mesic Meadow	5	40	55	0	0	0
1145wm[#]	Subalpine-Montane Wet Meadow	5	40	55	0	0	0
1154	Montane Riparian	25	55	20	0	0	0
1155mesquite[#]	Mesquite Dunes and Loamy Bottom	30	20	50	0	0	0
1155washes	Warm Desert Riparian Systems-Washes	25	75	0	0	0	0

[@] LANDFIRE core code that is not preceded by the two-digit map zone identification.
[&] Standard LANDFIRE coding for the 5-box vegetation model: A = early-development; B = mid-development, open; C = mid-development, closed; D = late-development, open; E = late-development, closed; and U = uncharacteristic. This terminology was sometimes modified for biophysical settings with <5 boxes (Appendix II).
[#]Legend: Biophysical settings not in the original map zone 13 of LANDFIRE.
[&] Initially coded as 1144, alpine tundra, by Spatial Solutions. Alpine fell-field (1143) was initially identified by NatureServe and LANDFIRE, but not included in the last biophysical setting maps by LANDFIRE.

Remote sensing analysis of biophysical settings and current vegetation classes

Spatial Solutions was subcontracted to conduct remote sensing analysis of the Spring Mountains. Spatial Solutions used the software Imagine® from Leica Geosystems to conduct the unsupervised classification of seven images of QuickBird each captured on different dates and one image of LandSat 5 Thematic Mapper for the northern portion in Nye County outside of USFS lands. Different capture dates of imagery each required a different unsupervised classification (i.e., the same vegetation type may present varying spectral responses on different dates of imagery). QuickBird imagery was captured from west to east on May 23, 2006, May 28, 2006, June 5, 2006, June 10, 2006, June 23, 2006, and September 23, 2006. LandSat TM imagery for Nye County was from late May, 2006. Imagery was cloud free. The imagery was clipped to the project area.

The unsupervised classification of the satellite imagery is described in Provencher *et al*. (2008; Appendix I) and details are not repeated here. To support interpretation of spectral classes (defined in Lilles and Kiefer 2000), we conducted a first field trip to establish training plots from May 25 - June 2, 2008. We modified the protocol for establishing training plots described in Provencher *et al*. (2008) because the Spring Mountains was a large, very rugged area with multiple unsupervised classifications that needed to be assessed in a short period of time. Therefore, the previous method of spending 10-15 minutes per plot and visually estimating the cover of dominant plant species and abiotic groups was simply not feasible. We opted to rapidly assign a biophysical setting and current vegetation class labels, and take ancillary notes, while both driving along hundreds of miles of paved and dirt roads and visiting a series of pre-selected plots. “Road observations” were geo-referenced and noted directly with the software Imagine on the imagery. Spatial solutions collected 3,073 geo-referenced road observations. In addition, we visited remote plots by helicopter for six hours on June 2 where we made the same biophysical setting and current vegetation class determinations as conducted on the ground. Digital photographs were taken at each geo-referenced field plots and “helicopter” plots (Appendix III).

The field data and geo-referenced road and helicopter notes were combined, when necessary, with the U.S. Geological Survey’s Digital Elevation Model, USFS-BLM fire history map, and USFS-BLM drainage map to create a draft map of biophysical settings. The penultimate draft of biophysical settings was verified and improved during a second field trip from 21-24 July, including a 4-hour helicopter survey. In addition, staff hiked the Griffith Peak Trail of USFS to obtain observations on curlleaf mountain mahogany, aspen, montane mixed conifers, subalpine conifers, and subalpine meadows. At each pre-selected field or helicopter location, we determined whether or not the mapped biophysical setting and current vegetation class were correct and digital photographs were taken (Appendix III). The same verification process was conducted for “road observations.” Many new observations were also added, especially in areas not previously visited. This final field trip allowed Spatial Solutions to complete the biophysical setting map, which proved the most difficult to complete, and the current vegetation class map. The last iteration in the final draft map of current vegetation classes was used to calculate the FRCC.

A normal accuracy assessment of remote sensing efforts was generally not possible for the project area because we disproportionally depended on road observations and the volume of observations were both used to verify portions of the draft map and define spectral classes “on-the-fly.” Therefore, verification and map building were concurrent processes for 1.25 million acres. As a general rule, no map is ever 100% accurate and a 70% success rate is considered good. General statements about accuracy are listed below by biophysical setting and vegetation classes.

1. Biophysical setting:

(a) The greatest challenge and source of error was the "coarseness" of soil surveys for characterizing biophysical settings because the whole FRCC analysis was stratified by biophysical settings; therefore uncertainty at the strata levels can create errors everywhere else. The mosaics of biophysical settings described in NRCS map unit polygons as well as the all-encompassing large number of potential biophysical setting vegetation class mosaics presented in the surveys left a myriad of biophysical setting characterizations possible for each identified soil polygon. Numerous errors were also found throughout the soil survey's ecological descriptions throughout the study area;

(b) Overall accuracy measures for the biophysical setting layers likely resided in the range of 85-90+% if calculated on the basis of percentage of total land area (i.e. 85-90+% of the actual land area is classified/mapped correctly). For areas of potential mis-classification, the following statements applied;

   i) Within-class accuracies certainly varied. Individual biophysical setting classes were mapped using varying techniques deemed to be most appropriate for each specific biophysical setting. For instance, due to the widely varying spectral patterns associated with desert washes, primarily manual delineation of washes from the QuickBird imagery was employed. This approach probably resulted in increased errors of omission (*versus* errors of commission) as smaller, less significant and less visually apparent washes could have been missed. Conversely, due to the strong and relatively consistent spectral response of chaparral, primarily spectral analysis directly from the QuickBird imagery was used to identify and characterize regions of chaparral. This technique *could* have resulted in increased errors of commission as other biophysical settings, such as very dense pinyon-juniper woodland with an occurrence of light chaparral species may present similar spectral response to chaparral. Each biophysical setting class may have contained their own set of specific similar circumstances related to errors of commission and errors of omission;

   ii) Regions of classification/mapping errors were the most prominent along transition boundaries between biophysical settings;

   iii) The biophysical setting map was a combination of potential and existing vegetation characterization that impacted the empirical accuracy of the biophysical setting layer. This was best seen in the characterization of chaparral. Extensive fire regeneration on the southern slopes of the Spring Mountains presented dense consistent cover of chaparral species adjacent to unburned stands of pinyon and juniper. The chaparral species were primarily limited to the burned regeneration vegetation. However, one would assume that if the moderate slopes of pinyon and juniper adjacent to the existing fire scar were to burn, the chaparral species would, too, return to these current pinyon-juniper dominated sites. This indicated that the true chaparral distribution would likely be wider than presented through an examination of the existing vegetation. Accurately characterizing the extent of chaparral in these instances was difficult;

iv) Since refinements of the basic soil survey descriptions were required for many biophysical settings to be derived directly from the imagery, the specific extent of the biophysical setting (potential vegetation) *versus* the actual extent of that type (existing vegetation) may have resulted in additional biophysical setting errors. A good example was seral aspen. Very non-specific and extremely limited delineations of aspen were found in the soil survey descriptions. Given that the true extent of an aspen biophysical setting may have vary widely from the observed current extent of aspen, discrepancies could have resulted in the characterization of aspen in the final biophysical setting layer;

v) Another specific source of potential error may have been in the precise delineation of pinyon-juniper woodlands. Given that pinyon-juniper woodland was widely ranging throughout the study area, and coupled with the fact that the soil descriptions provide no real effective clue to the exact distribution of true pinyon-juniper woodland, spatial modeling based on a combination of spectral reflectance, landform, and slope were utilized to delineate pinyon-juniper woodland. Potential for mischaracterization was possible anytime spatial models, which were inherently based on a combination of research, field observations, assumptions and generalizations, were employed;

vi) Limited access to many of the more remote wilderness areas absolutely impacted the accuracy of the biophysical setting layer. Validation data within these regions were extremely limited and resulted in increased potential for inaccuracy in the classification of biophysical setting for these areas;

vii) Black sagebrush presented a greater challenge for distinction since this class can occur in very many different types of conditions ranging from heavily tree covered (which “looked” like a pinyon-juniper woodland) to an open shrub community (which may have “looked” like surrounding blackbrush); and

viii) In terms of individual class accuracy, the User’s Accuracy measures for individual biophysical setting were strong (likely 80 – 90%). Producer’s Accuracy measures likely fell in the 70 – 85% range.

2. Vegetation classes:

(a) The overall accuracy measure for the vegetation class map likely fell in the 70-85% range;

(b) The vegetation class classification was based on the assumption that the biophysical setting layer was accurate. Since vegetation classes varied from one biophysical setting to another, accurate characterization of vegetation classes was directly linked to the biophysical setting classification. Given this fact, the potential for accumulating errors was present. In other words, if a region(s) of a specific biophysical setting was mis-classified, the chances were high that the vegetation class map would also be mis-classified. For example, if an area is mapped as pinyon-juniper woodland when actually the correct biophysical setting for that area was chaparral, the associated vegetation class classification based on the incorrect pinyon-juniper woodland designation would also likely be incorrect because only two vegetation classes existed for chaparral compared to the >6 vegetation classes for pinyon-juniper woodland;

(c) The full detailed characterization of vegetation classes, which included *both* a designation of vegetation classes as well as the indication, if any, of uncharacteristic condition, likely contained more potential classification error than a version where all uncharacteristic classes are consolidated. Uncharacteristic classes were split to increase the management value of the FRCC analysis. However, the more detail contained in any map, the greater the likelihood for mis-classification of the individual detailed classes;

(d) Due to the very low vegetation cover of many of the lower elevation shrub communities (e.g. mixed salt desert, creosotebush-white bursage, blackbrush), detection and characterization of the uncharacteristic vegetation classes consisting of shrub with an understory containing annual grass were challenging because so much of the spectral reflectance from these sites was dominated by bare ground and minimum annual grass cover. Because annual grass cover was detected in virtually all field occurrences of creosotebush-white bursage and blackbrush, the extrapolation of field observations to the entire study area resulted in extensive characterization of shrubs with annual grass for these biophysical settings. This extrapolation may have resulted in more errors of commission of the shrubs with annual grass vegetation class; and

(e) Inherently, biophysical settings that have a great number of potential vegetation classes (e.g. montane sagebrush steppe) had greater potential for mis-classification than biophysical settings made only a few vegetation classes, such as chaparral.

Calculating FRCC with the FRCC Mapping Tool

FRCC was calculated by TNC staff using the FRCC Mapping Tool (Hutter et al. 2007) supported by ARC GIS 9.2 (ESRI, Redlands, CA). Input files were the biophysical and current vegetation class grid layers, and the natural ranges of variability. The FRCC Mapping Tool essentially compares percentages from the natural range of variability (Table 1) to those observed in the current imagery. The comparison is calculated with an index of dissimilarity (Fire Regime Condition; shown in Provencher *et al*. [2008]; Table 2).

We retained the "Strata FRCC" layer, which shows FRCC across all biophysical settings (strata), the relative amount layer, and the relative amount summary output table. The relative amount layer is simply a geodata layer that codes each pixel into one of five groups depending on the degree of departure of its succession class compared to the natural range of variability: trace, underrepresented, similar, over-represented, and abundant. The summary output table breaks down in tabular form the relative amount by biophysical setting and provides estimates of acres differences per vegetation class needed to be changed to reach the natural range of variability. This last table is the most important to land managers.

Table 2. Example of FRCC calculation using mountain big sagebrush from the north Schell Creek Range, USFS Ely Ranger District.

	Current Vegetation Class						
	A[&]	B	C	D	E	U	Total
Natural range of variability (%)	20	50	15	10	5	0	100
Current acres by class in project area from remote sensing	0	43	10285	959	4929	2008	18223
Current percentage of classes	0	<1	56	5	27	11	
Fire Regime Condition[@] (%)	0	0	15	5	5	0	75
Fire Regime Condition Class[#]							3

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

[@] Fire Regime condition = $100\% - \sum_{i=1}^{n} \min\{Current_i, NRV_i\}$

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

Results and Discussion

Biophysical settings

Twenty biophysical settings were mapped based on refinements of NRCS soil surveys (Fig. 2). Dominant systems were creosotebush-white bursage, blackbrush, and pinyon-juniper woodlands accounting for 80% of the vegetation (Table 3). A few biophysical settings offered surprises.

- Montane sagebrush steppe is dominated by mountain big sagebrush. Examples of this biophysical setting on some high elevation slopes of the Spring Mountains resembled typical Great Basin occurrences. However, mountain big sagebrush was more consistently found in washes at lower than expected elevations (<6,500 ft). We assumed that cold air drafting allowed mountain big sagebrush to persist as a wash species. One training plot at 5,800 ft in Kyle Canyon was visited the previous year by Dr. Rick Miller from Oregon State University who identified mountain big sagebrush as the dominant shrub.
- We frequently found pinyon and juniper in varying cover in upper elevation blackbrush, which is not surprising given that blackbrush, pinyon, and juniper are fire-sensitive species persisting in communities with long fire return intervals. The LANDFIRE description mentions "Scattered *Juniperus osteosperma* or desert scrub species may also be present", whereas we clearly observed as much as 10-40% pinyon-juniper cover on gentle slopes that were not typical pinyon-juniper

woodlands and were surrounded by pure occurrences of blackbrush. Therefore, future blackbrush mapping should separate the LANDFIRE biophysical setting into thermic (no trees, lower elevation) and mesic (trees possible, higher elevation) blackbrush biophysical settings where the mesic type is composed of three succession classes. The current description has only two succession classes. The late-development class should include pinyon-juniper cover up to 20%.

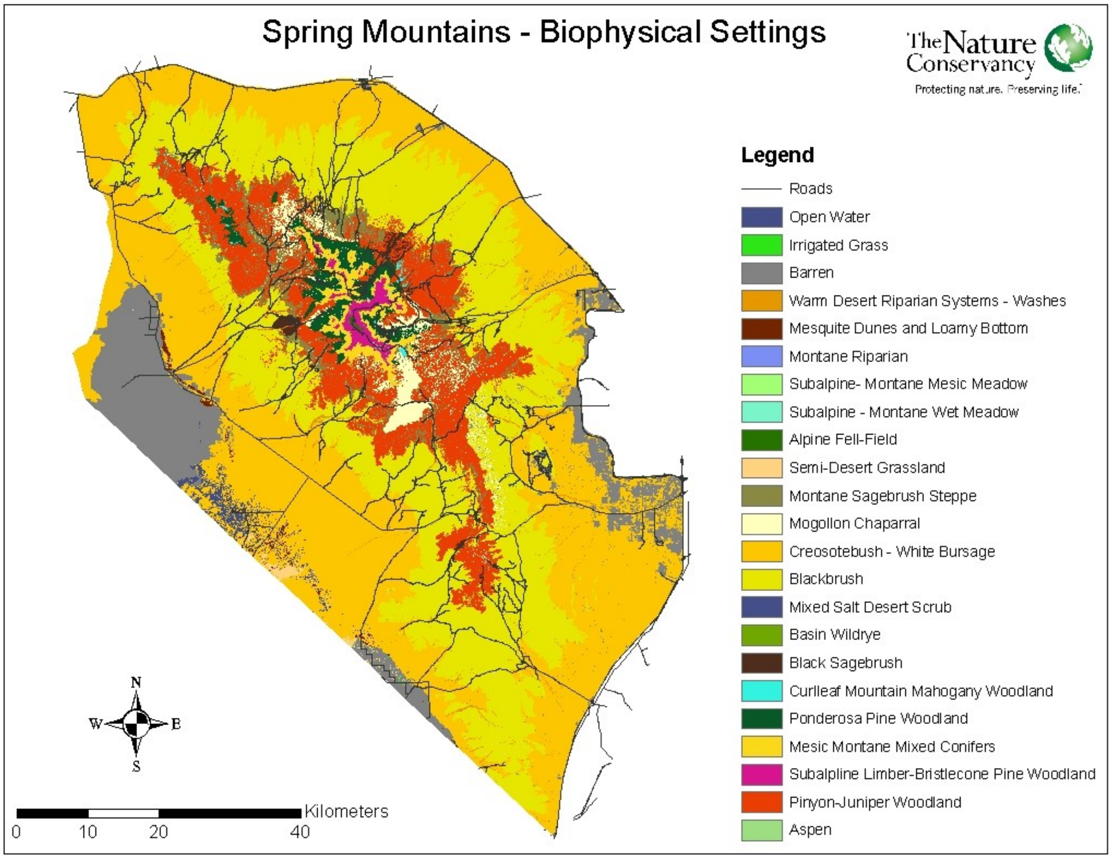

Fig. 2. Biophysical settings of the Spring Mountains, Nevada.

- Two distinct types of ponderosa pine biophysical settings might be present on the Spring Mountains. Most creeks and washes support the classic ponderosa pine with a mixed, abundant herbaceous and shrub understory, as in Kyle, Lee, Clark, and Carpenter Canyons. The high and dry calcareous slopes and ridges often found north of Mount Charleston did not fit this description: the understory vegetation was very sparse (frequently non-existent), mineral soil, litter, and rock were the dominant cover, ponderosa pine regeneration was lacking, and trees appeared to be very old. We contacted Dr. Stanley Kitchen of USFS in Utah who found similar ponderosa pine types in western Utah where tree ring analysis showed that fire regimes dramatically changed (mean fire return interval became distinctly longer) a few decades *before* European settlement. He hypothesized that the stands of ponderosa pine might be calcareous relicts from the Little Ice Age; they burned during the colder and wetter Little Ice Age when fine fuels were more abundant, but have since dried up and loss their understory component and fine fuels that carried frequent surface fires to droughty soil. In one of these Utah stands, he found the oldest recorded ponderosa pine in America. Further research on this hypothetical relict type is warranted for the Spring Mountains.

- Chaparral was widespread on the high slopes of the Spring Mountains. Many areas that burned in the last decades were today fully dominated by chaparral species. Pinyon and juniper were abundant species prior to fire given the number of dead and standing snags found in the old burns. Many of these slopes were labeled as pinyon-juniper woodlands in NRCS soil surveys, which appears improbable given that chaparral has a mean fire return interval ranging from 50-75 years that is shorter than the 322-year mean fire return interval of pinyon-juniper woodland. We labeled these occurrences as chaparral, not pinyon-juniper woodlands (Appendix II). We also labeled as chaparral apparent pinyon-juniper woodlands that had significant chaparral midstories.

Table 3. Percentage of area occupied by biophysical settings and unassessed areas in the 1.25 million acre Spring Mountains, Nevada.

Biophysical Setting	Percentage of Landscape
Pinyon-Juniper Woodland	10.89
Subalpine Limber-Bristlecone Pine Woodland	0.61
Mesic Montane Mixed Conifers	1.31
Ponderosa Pine Woodland	1.75
Seral Aspen	0.04
Curlleaf Mountain Mahogany Woodland	0.08
Black Sagebrush	0.31
Basin Wildrye	0.00
Mixed Salt Desert Scrub	0.69
Blackbrush	31.44
Creosotebush-White Bursage	38.17
Mogollon Chaparral	2.11
Montane Sagebrush Steppe	2.55
Semi-Desert Grassland	0.28
Alpine Fell-Field	0.03
Subalpine-Montane Mesic Meadow	0.01
Subalpine-Montane Wet Meadow	0.00
Montane Riparian	0.01
Mesquite Dunes and Loamy Bottom	0.23
Warm Desert Riparian Systems-Washes	0.88
Developed/Roads	7.97
Rock/Gravel/Soil	0.64
Open Water	0.00
Irrigated Grass	0.01

- The NRCS soil surveys listed several map unit polygons as containing Wyoming big sagebrush and big sagebrush ecological sites. We tentatively labeled these as Inter-Mountain Basins Big Sagebrush Shrubland (as per LANDFIRE), which would be commonly termed Wyoming big sagebrush semi-desert and upland sites. Many soil scientists warned us that Wyoming big sagebrush was absent or rare in the Mojave Desert and replaced by basin big sagebrush. Despite extensive field surveys and dedicated helicopter time to find these types in the map unit polygons, they were never detected. Therefore, we dropped Wyoming big sagebrush as a biophysical setting. We did, however, find sizable patches of big sagebrush, mostly likely mountain big sagebrush, mixed with snakeweed and a minor component of blackbrush in early-development upland blackbrush where the surrounding unburned area was mature blackbrush with a small component of big sagebrush.

Current vegetation classes

Current vegetation classes included succession and uncharacteristic classes. Uncharacteristic classes are all classes that are not succession classes and resulted from post-settlement human management or accidents related to post-settlement human actions (for example, release of non-native species). FRCC analysis only requires that grid files be labeled as classes A-E and U (defined in Table 1). It should be noted that The Nature Conservancy and Spatial Solutions went one step further by splitting uncharacteristic classes into different forms that specify, for examples, i) the level of non-native annual grass invasion (from annual grasslands to shrublands or woodlands of different succession age with an understory of non-native annual grass), ii) shrublands that lack any herbaceous understory, and iii) tree-encroached shrublands. This data is only available in the electronic original GIS raster files provided with this report (attached DVD). These data are the most practical to plan management actions, which was not the purpose of this contract.

Notable observations about current vegetation classes were:

- The most important result was the widespread uncharacteristic class that covered nearly all of the creosotebush-white bursage and blackbrush biophysical settings (Fig. 3). The uncharacteristic class was primarily due to non-native annual grasses. Red brome and cheatgrass were found in 100% of the blackbrush plots visited, including road observations, and all creosotebush-white bursage plots except those closest to the California-Nevada border. Moreover, a significant portion of lower elevations pinyon-juniper woodlands contained cheatgrass in the understories (Fig. 3).
- Small biophysical settings at the lowest elevations near the California-Nevada border were generally not invaded by non-native species and appeared in good condition. These included mesquite growing on dunes and loamy bottoms (silty soil), semi-desert grasslands, and mixed salt desert scrub.

- Late-development vegetation classes dominated most biophysical settings regardless of the degree of non-native species infestation. Notable exceptions were annual grasslands in burned areas.
- Non-native annual grass species were not observed in the upper montane and subalpine zones, however cheatgrass was observed up to 8,000 ft in pinyon-juniper woodlands and blackbrush.

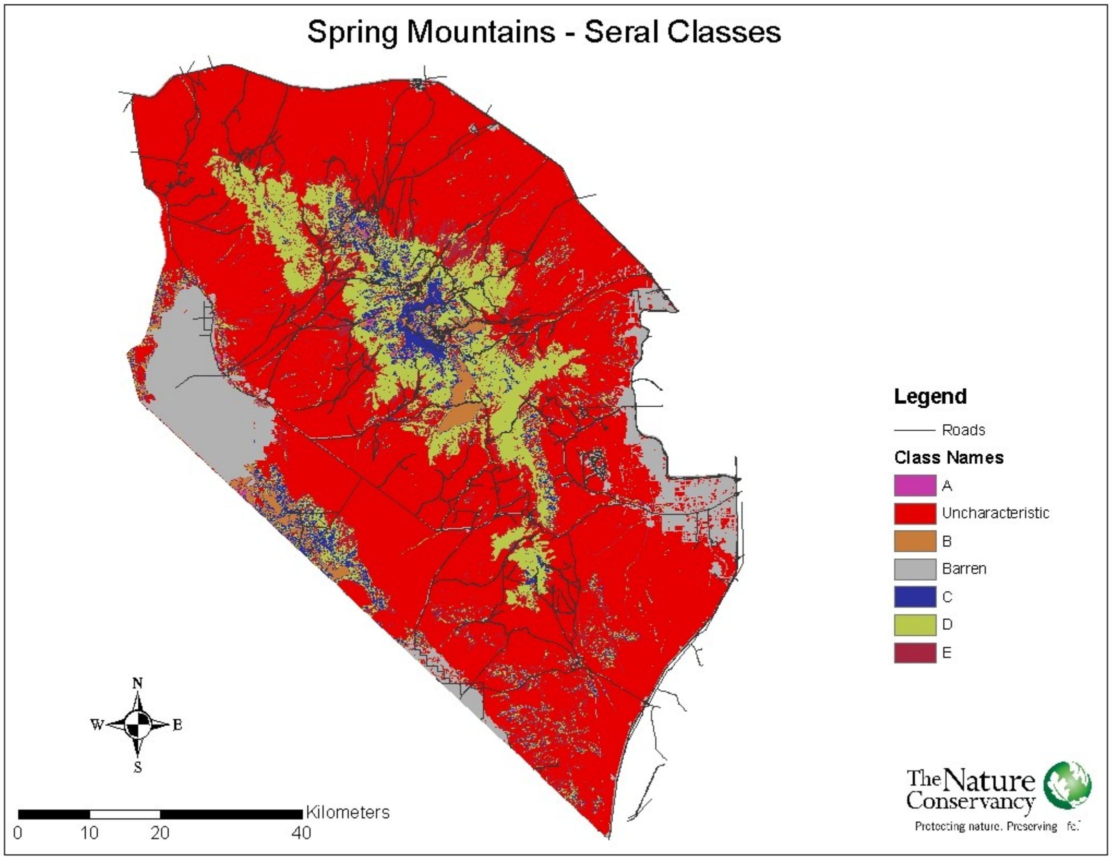

Fig. 3. Current vegetation classes of biophysical settings of the Spring Mountains, Nevada. Legend: Classes A-E are explained in Table 1 and more precisely described in Appendix II. Barren pixels were not assessed.

Fire Regime Condition Classes

Following U.S. interagency protocols and publications on FRCC (Hann and Bunnell 2001; Schmidt *et al*. 2002; Hann and Strom 2003), dissimilarity measures ranging from 0 to 33% per biophysical setting were classified as 'intact' or unaltered (FRCC 1). Departures ranging from 34 to 66% and 67 to 100% were, respectively, classified as 'moderate' (FRCC 2) or 'high' (FRCC 3) departure. Given the widespread uncharacteristic classes of Fig. 3, it came as no surprise that the creosotebush-white bursage and blackbrush biophysical settings were in FRCC III, therefore highly departed from the natural range of variability (Fig. 4). Table 4 lists the FRCC value by biophysical setting, which was not obvious from Fig. 4.

Four biophysical settings were in FRCC 3, 5 biophysical settings were in FRCC 2, and 11 in FRCC 1. Biophysical settings in FRCC 3 represented 70+% of the landscape, and include creosotebush-white bursage, blackbrush, montane sagebrush steppe, and basin wildrye. Higher elevation and the lowest elevation biophysical settings (below creosotebush-white bursage) were generally less departed from the natural range of variability than those at middle elevations. Biophysical settings in FRCC 2 did not account for many acres and included black sagebrush, mixed salt desert scrub, subalpine-montane mesic meadow, montane riparian, and mesquite dune and loamy bottom.

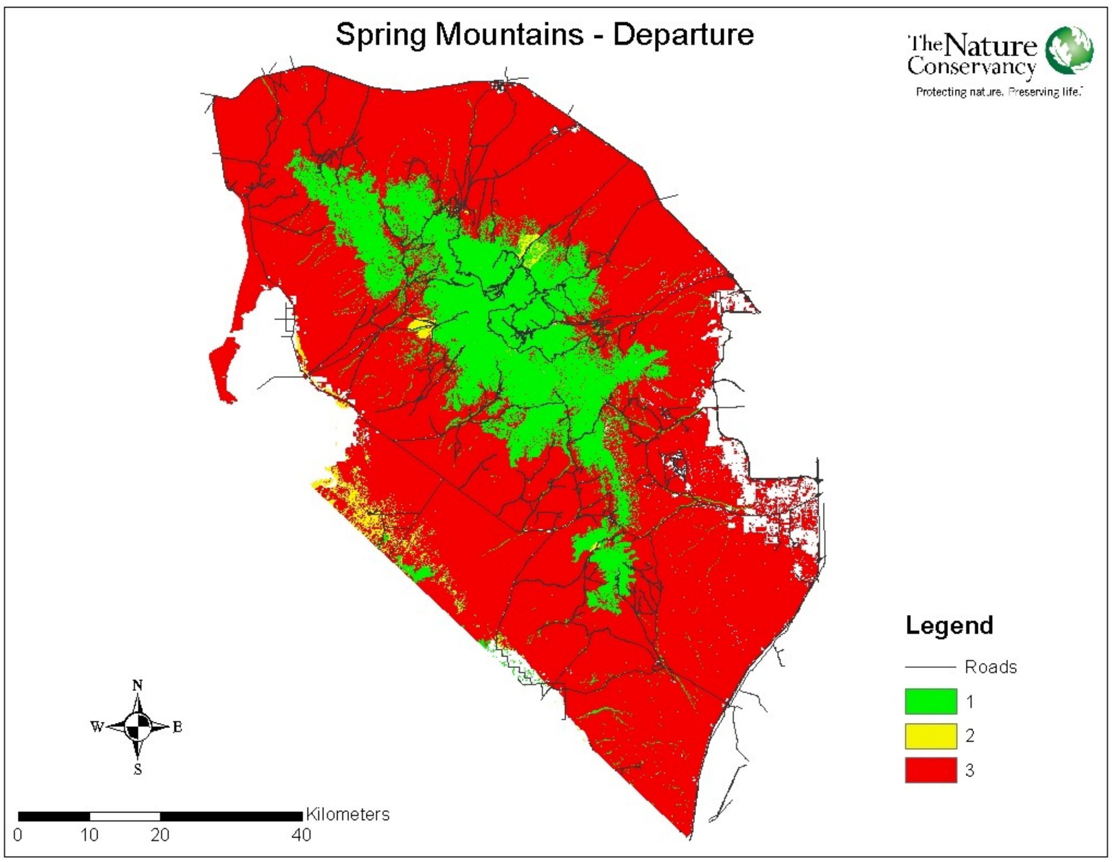

Fig. 4. Fire Regime Condition Class map of the Spring Mountains, Nevada. Legend: FRCC 1 in green, FRCC 2 in yellow, and FRCC 3 in red.

Black sagebrush, mesic meadows, and montane riparian generally were on lands managed by the USFS or by private interests. Montane riparian was very limited in extent and wildlife, and wild horses and burros were often observed during field or helicopter visits. Moreover Biophysical settings in FRCC 1 represented a greater surface of the project area than those in FRCC 2 and included all woodlands, with pinyon-juniper woodland at approximately 11% of the Spring Mountains, chaparral, semi-desert grassland, alpine fell-field, subalpine-montane wet meadows, and desert washes. With the exception of semi-desert grasslands and desert washes mostly located on lands managed by the BLM, other biophysical settings generally were managed by USFS. Overall condition of wet meadows was highly variable: some meadows were converted to mud pools by ungulates, which were always observed standing in the mud, whereas many others had little trace of damaging use.

The fire regime conditions of six biophysical settings were close to the boundary between two FRCC (table 4). Pinyon-juniper woodland was at the boundary with 33% departure, therefore this large biophysical setting could have easily been in FRCC 2 instead of FRCC 1. Ponderosa pine woodland, seral aspen, and semi-desert grassland, all in FRCC 1, were within 3% of being in FRCC 2. Montane riparian in FRCC 2 was <1% from being in FRCC 1. The only system at higher departure was black sagebrush with a fire regime condition of 64%, therefore 2% from FRCC 3.

Table 4. FRCC value by biophysical settings of the Spring Mountains, Nevada.

Biophysical Setting	FRCC	FRC (%)[&]
Pinyon-Juniper Woodland	1	33.0
Subalpine Limber-Bristlecone Pine Woodland	1	1.1
Mesic Montane Mixed Conifers	1	31.9
Ponderosa Pine Woodland	1	32.7
Seral Aspen	1	27.2
Curlleaf Mountain Mahogany Woodland	1	19.3
Black Sagebrush	2	64.0
Basin Wildrye	3	94.8
Mixed Salt Desert Scrub	2	50.0
Blackbrush	3	91.6
Creosotebush-White Bursage	3	95.3
Mogollon Chaparral	1	4.0
Montane Sagebrush Steppe	3	95.9
Semi-Desert Grassland	1	30.0
Alpine Fell-Field	1	7.6
Subalpine-Montane Mesic Meadow	2	45.0
Subalpine-Montane Wet Meadow	1	11.4
Montane Riparian	2	33.7
Mesquite Dunes and Loamy Bottom	2	58.3
Warm Desert Riparian Systems-Washes	1	7.5

[&] Calculated using formula in footnote of Table 2 and percentages of Table 5.

An important aspect of FRCC analysis is the extent of a biophysical setting, therefore the extent of the landscape. As a rule of thumb, the longer the mean fire return interval (or the dominant stand replacing disturbance if fire was not an important disturbance), the more extensive the assessment area needs to be to capture good representation of all the succession vegetation classes of a biophysical setting. When the size of a biophysical setting is too small relative to its mean fire return interval, FRCC values become more uncertain because one current vegetation class might dominate as the result of one random disturbance (for example, a very large fire). The 1.25 million acres project area was more than an adequate size to assess most biophysical settings except, perhaps, for the following: mixed salt desert scrub, semi-desert grassland, subalpine conifers, alpine, curlleaf mountain mahogany, black sagebrush, basin wildrye, and montane riparian.

- Mixed salt desert scrub, subalpine conifers, alpine, curlleaf mountain mahogany, mesquite, and black sagebrush have long mean fire return intervals, but the area of each biophysical setting was small in the project area. In part this is due to the arbitrary project boundary that minimized the presence of mixed salt desert scrub, mesquite, and semi-desert grassland. It is also due to the paucity of some biophysical settings in the Mojave Desert, such as subalpine conifers and alpine.
- Semi-desert grassland, basin wildrye, and montane riparian have intermediate mean fire return intervals that require a smaller assessment area than the previous biophysical settings, however occurrences of these systems were spotty. Basin wildrye and montane riparian were limited by the scarcity of water and their condition heavily affected by water withdrawals and heavy use from wild horses and burros. Semi-desert grasslands were expressed as two types: the more extensive type was found on stabilized sand sheets in one location near California, whereas frequent but very small grassland patches were found on the toe of steep middle elevation slopes with soil and gravel accumulation. Because these systems were located on BLM land and at middle to low elevations, QuickBird imagery that would have allowed to accurately map them at peak greenness was taken later in the summer when grass was senescent. As a result, semi-desert grassland was likely underestimated. In any case, the biophysical setting was small relative to its mean fire return interval.

Therefore, we recommend caution about the FRCC value for these systems. We would err towards more ecological departure (greater FRCC value) for black sagebrush, basin wildrye, curlleaf mountain mahogany, and montane riparian, but less departure for semi-desert grassland, subalpine conifers, and alpine. Mixed salt desert scrub appears to be correctly valued.

Relative Amount

The relative amount map and corresponding summary output table are standard output from the FRCC Mapping Tool, but rarely used by fuels management staff because the data and their use are not exactly transparent. These data, however, are the most valuable for land management planning. Relative amount essentially quantifies in acres by how much a current vegetation class (for example, late-development closed montane sagebrush steppe) departs from the natural range of variability. All pixels in this class receive the class label. The departure can be expressed as too much of a class (over-represented and abundant), too little (under-represented and trace), or approximately the same as the natural range of variability (similar).

Abundant and over-represented current vegetation classes dominated the Spring Mountains (Fig. 5). All uncharacteristic classes fit into these groups by definition (the natural range of variability is 0% for the U class). The higher elevations of the Spring Mountains crest contained proportions of current vegetation classes that were similar to the natural range of variability. Under-represented and trace proportions of current vegetation classes were more frequent in younger succession classes of chaparral and pinyon-juniper woodlands on the steep escarpments of Red Rock National Conservation Area, and in late-development classes of creosotebush-white bursage near the California border.

The summary output table offers a more detailed view of relative amount by biophysical settings. It is too tedious to explain all the results in this table. Instead, I will focus on the ponderosa pine woodland biophysical setting as a general example (Table 5). Ponderosa pine woodland was estimated to have an FRCC value of 1 (last column). The natural range of variability (fourth column) indicated that mid- and late-development classes with open canopies should dominate this biophysical setting. The late-development class with a closed canopy should represent no more than 1% of the biophysical setting under natural fire regimes. The percentage of current vegetation (fifth column) for both late-development classes revealed too much representation of closed canopy (14.9%) and too little representation of opened canopy (35.5%) classes. The percentage of the mid-development open-canopy class was similar to that predicted by the natural range of variability; however, the closed-canopy class was practically non-existent. The early succession class was over-represented at 28.4% compared to the 10% of the natural range of variability. Acre differences reflected those departures under the important assumption of returning to 0% departure, which is usually not feasible. Results show that managers need to thin with mechanical methods or prescribed fire 3,296 acres of late-development closed-canopy ponderosa pine to recruit into the opened canopy class. Because this leaves a shortage of approximately 2,600 acres of late-development opened-canopy class, only slow succession from the mid-development opened-canopy and early-development class can solve this problem. Moreover, maintenance of the late-development opened-canopy class is an important goal to prevent further loss of old, open stands. No other operation might be required.

Conclusion

We mapped 1.25 million acres of the Spring Mountains. Twenty biophysical settings were mapped. Four biophysical settings, including the very extensive creosotebush-white bursage and blackbrush systems, were in FRCC 3, 5 biophysical settings were in FRCC 2, and 11 in FRCC 1. The relative amount map and summary output table were also discussed as valuable data for planning future land management.

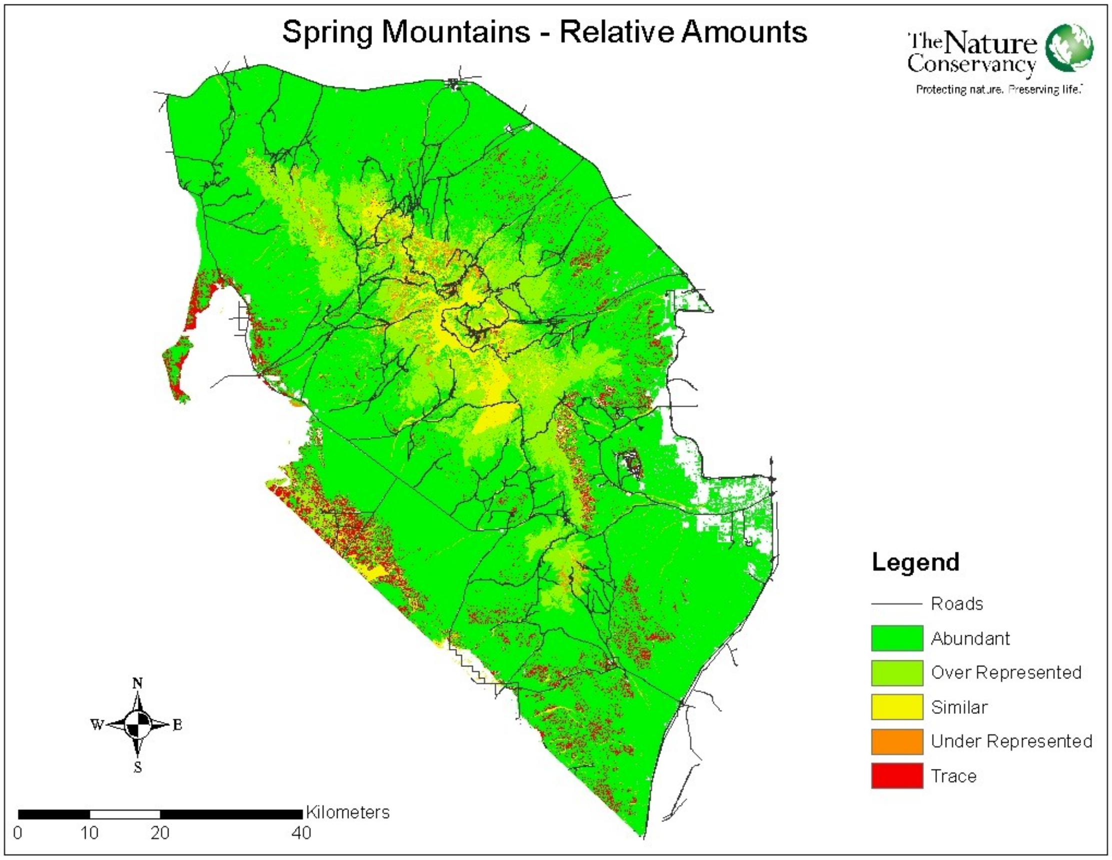

Fig. 5. Relative amount map for the Spring Mountains, Nevada. Each pixel was assigned a label that reflects the status the current vegetation class it belongs to relative to the percentage it should have according to the natural range of variability of the biophysical setting.

Table 5. Summary output data for the Spring Mountains, Nevada. This table is a trimmed and edited version of the original summary output table created by the FRCC Mapping Tool.

Biophysical Setting: Name	Code	Succession Class*	Natural Range of Variability (%)	Current Vegetation Classes (%)	Acre Difference[#]	Relative Amount	FRCC
Pinyon-Juniper Woodland	1019	A	5	1.8	-4665.8	under rep	1
Pinyon-Juniper Woodland	1019	B	5	0.1	-7259.8	trace	1
Pinyon-Juniper Woodland	1019	C	25	0.1	-36645.9	trace	1
Pinyon-Juniper Woodland	1019	D	65	98	48571.5	over rep	1
Pinyon-Juniper Woodland	1019	U	0	0	0		
Subalpine Limber-Bristlecone Pine Woodland	1020	A	15	13.9	-86.6	similar	1
Subalpine Limber-Bristlecone Pine Woodland	1020	B	15	15.2	17.2	similar	1
Subalpine Limber-Bristlecone Pine Woodland	1020	C	70	70.8	69.3	similar	1
Subalpine Limber-Bristlecone Pine Woodland	1020	U	0	0	0		
Mesic Montane Mixed Conifers	1052	A	10	39	5136	abundant	1
Mesic Montane Mixed Conifers	1052	B	30	1.1	-5119.3	trace	1
Mesic Montane Mixed Conifers	1052	C	15	14.4	-105.5	similar	1
Mesic Montane Mixed Conifers	1052	D	35	32.6	-417.3	similar	1
Mesic Montane Mixed Conifers	1052	E	10	12.9	506.1	similar	1
Mesic Montane Mixed Conifers	1052	U	0	0	0		
Ponderosa Pine Woodland	1054	A	10	28.4	4361.7	over rep	1
Ponderosa Pine Woodland	1054	B	9	0.8	-1936.5	trace	1
Ponderosa Pine Woodland	1054	C	20	20.4	86.7	similar	1
Ponderosa Pine Woodland	1054	D	60	35.5	-5808.3	under rep	1
Ponderosa Pine Woodland	1054	E	1	14.9	3296.4	abundant	1
Ponderosa Pine Woodland	1054	U	0	0	0		
Seral Aspen	1061	A	25	32.5	38	similar	1
Seral Aspen	1061	B	50	36.4	-68.6	similar	1
Seral Aspen	1061	C	15	4.8	-51.5	trace	1
Seral Aspen	1061	D	9	5.6	-17.4	under rep	1

Seral Aspen	1061	E	1	4.3	16.6	abundant	1
Seral Aspen	1061	U	0	16.4	83	abundant	
Curlleaf Mountain Mahogany Woodland	1062	A	10	0.5	-107.6	trace	1
Curlleaf Mountain Mahogany Woodland	1062	B	15	32	193.2	over rep	1
Curlleaf Mountain Mahogany Woodland	1062	C	10	2.4	-85.9	trace	1
Curlleaf Mountain Mahogany Woodland	1062	D	20	17.8	-25.6	similar	1
Curlleaf Mountain Mahogany Woodland	1062	E	45	47.2	25.5	similar	1
Curlleaf Mountain Mahogany Woodland	1062	U	0	0	0.3	abundant	
Black Sagebrush	1079	A	15	0.2	-613.1	trace	2
Black Sagebrush	1079	B	40	1.4	-1601.9	trace	2
Black Sagebrush	1079	C	20	29.8	407.5	similar	2
Black Sagebrush	1079	D	25	14.4	-440.2	under rep	2
Black Sagebrush	1079	U	0	54.1	2247.7	abundant	
Basin Wildrye	10801	A	20	5.1	-6.2	trace	3
Basin Wildrye	10801	B	60	0	-25		3
Basin Wildrye	10801	C	20	0.1	-8.3	trace	3
Basin Wildrye	10801	U	0	94.8	39.5	abundant	
Mixed Salt Desert Scrub	1081	A	5	0	-460.8	trace	2
Mixed Salt Desert Scrub	1081	B	50	99.7	4615.3	over rep	2
Mixed Salt Desert Scrub	1081	C	45	0	-4180		2
Mixed Salt Desert Scrub	1081	U	0	0.3	25.4	abundant	
Blackbrush	1082	A	25	1.9	-98461.4	trace	3
Blackbrush	1082	B	75	6.5	-291379.2	trace	3
Blackbrush	1082	U	0	91.7	389840.6	abundant	
Creosotebush-White Bursage	1087	A	15	0.6	-74218.1	trace	3
Creosotebush-White Bursage	1087	B	85	4.1	-417653.3	trace	3
Creosotebush-White Bursage	1087	U	0	95.3	491871.5	abundant	
Mogollon Chaparral	1104	A	10	6	-1130.7	under rep	1
Mogollon Chaparral	1104	B	90	94	1130.7	similar	1
Mogollon Chaparral	1104	U	0	0	0		
Montane Sagebrush Steppe	1126	A	20	0.2	-6815.5	trace	3
Montane Sagebrush Steppe	1126	B	50	0	-17226.2		3
Montane Sagebrush Steppe	1126	C	15	3.9	-3832.8	trace	3

Montane Sagebrush Steppe	1126	D	10	0	-3445.2		3
Montane Sagebrush Steppe	1126	E	5	0	-1722.6		3
Montane Sagebrush Steppe	1126	U	0	95.9	33042.4	abundant	
Semi-Desert Grassland	1135	A	30	0	-1152.7	trace	1
Semi-Desert Grassland	1135	B	70	93.6	906.8	similar	1
Semi-Desert Grassland	1135	U	0	6.4	245.8	abundant	1
Alpine Fell-Field	1143	A	5	12.6	26.7	over rep	1
Alpine Fell-Field	1143	B	95	87.4	-26.7	similar	1
Alpine Fell-Field	1143	U	0	0	0		
Subalpine-Montane Mesic Meadow	11450	A	5	0	-5.2		2
Subalpine-Montane Mesic Meadow	11450	B	40	0	-41.8		2
Subalpine-Montane Mesic Meadow	11450	C	55	100	47	over rep	2
Subalpine-Montane Mesic Meadow	11450	U	0	0	0		
Subalpine-Montane Wet Meadow	11451	A	5	2.2	-0.7	under rep	1
Subalpine-Montane Wet Meadow	11451	B	40	51.4	2.8	similar	1
Subalpine-Montane Wet Meadow	11451	C	55	46.4	-2.1	similar	1
Subalpine-Montane Wet Meadow	11451	U	0	0	0		
Montane Riparian	1154	A	25	9.7	-26.2	under rep	2
Montane Riparian	1154	B	55	59.7	8.1	similar	2
Montane Riparian	1154	C	20	1.6	-31.4	trace	2
Montane Riparian	1154	U	0	28.9	49.5	abundant	
Mesquite Dunes and Loamy Bottom	11550	A	30	15	-469.2	under rep	2
Mesquite Dunes and Loamy Bottom	11550	B	20	46.3	820.1	over rep	2
Mesquite Dunes and Loamy Bottom	11550	C	50	6.7	-1350.5	trace	2
Mesquite Dunes and Loamy Bottom	11550	U	0	32	999.7	abundant	2
Warm Desert Riparian Systems-Washes	11551	A	25	32.5	897.7	similar	1
Warm Desert Riparian Systems-Washes	11551	B	75	67.5	-897.7	similar	1
Warm Desert Riparian Systems-Washes	11551	U	0	0	0		

Acre difference is calculated as: (proportion of the vegetation class in the current vegetation × area of biophysical setting) - (proportion of the same class in the natural range of variability× area of biophysical setting).

* Succession class was defined in Table 1.

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Appendix I. Implementation of mid-scale fire regime condition class mapping.

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Implementation of mid-scale fire regime condition class mapping

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Abstract. We used mid-scale Fire Regime Condition Class (FRCC) mapping to provide Hawthorne Army Depot in the Mount Grant area of Nevada, USA, with data layers to plan fuels restoration projects to meet resource management goals. FRCC mapping computes an index of the departure of existing conditions from the natural range of variability, and consists of five primary steps: (1) mapping the Potential Natural Vegetation Types (PNVT) based on interpretation of a soil survey; (2) refining PNVTs based on additional information; (3) modelling the natural range of variability (NRV) per PNVT; (4) using field verification, calculation and mapping of departure of current distribution of structural vegetation classes interpreted by remote sensing (IKONOS 4-m resolution satellite imagery) from the NRV; and (5) mapping structural vegetation classes that differ from reference conditions. Pinyon–juniper and mountain mahogany woodlands were found within the NRV, whereas departure increased from moderate for low and big sagebrush PNVTs and mixed desert shrub to high for riparian mountain meadow. Several PNVTs showed departures that were close to FRCC class limits. The common recommendation to reach the NRV was to decrease the percentage of late-development closed and cheatgrass-dominant classes, thus increasing the percentage of early and mid-development classes.

Additional keywords: DOD, fire management, Great Basin, LANDFIRE, Nevada, pinyon–juniper, rangeland, sagebrush, soil survey, state-and-transition, woodland.

Introduction

Fire managers across diverse landscapes recognise the need to reduce hazardous fuel loads, restore fire regimes and ecosystems, and decrease the threat of catastrophic wildfires. The United States Department of Agriculture (USDA) Forest Service recently published national-level, coarse resolution data to address the nature and degree of departure of current vegetation and fuels from natural conditions (Hann and Bunnell 2001; Hardy *et al*. 2001; Schmidt *et al*. 2002; Menakis *et al*. 2003). These data, termed Fire Regime Condition Class (FRCC), were important in integrating and mapping of biophysical, vegetation, fire occurrence, and ecological community information and providing an ecological basis for prioritising resources for fire regime restoration, fuels treatment, and biodiversity conservation. However, although these data were intended to be used for broad geographic regions, the lack of similar data at finer scales has led to misuse of these data for prioritisation and planning at the regional and project scales. Until recently, available FRCC data addressed prioritisation between regions and states, but did not consider specific land management projects.

The LANDFIRE project (www.landfire.gov/Documents/landfirecharter.pdf, accessed September 2007; Wildland Fire Leadership Council 2004) was implemented to consistently map FRCC using remote sensing and gradient modelling, but will not be completed for the entire USA until 2007 to 2010. The Rapid Assessment component of LANDFIRE was based entirely on expert rules applied to imagery interpretation for mapping of FRCC and was made available in 2006 for the entire USA, while the National-LANDFIRE maps will be produced by 2010, as the latter are dependent on plot data. Availability of continuous and nationally consistent spatial FRCC and associated data on reference and current vegetation conditions will help prioritise and coordinate restoration and fire hazard reduction in landscapes with multiple ownerships and from the watershed to regional scale.

The FRCC concept was readily adopted by the US Congress in 2003 (Healthy Forest Restoration Act 2003 – Congressional Bill H.R. 1904) and by public land managers as a useful landscape-scale metric to partially measure the success of hazardous fuels and ecosystem restoration projects. Locally, the FRCC mapping approach can be used to assess local issues, such as the modification of natural fire regimes by invasive weeds, and the likelihood that a landscape can conserve wide-ranging species of special management concern (e.g. Greater Sage-grouse, *Centrocercus urophasianus*). Contrary to public perception, however, FRCC is not a predictor of wildland fire hazard because fuels loadings are not used in the calculation of FRCC. Instead, FRCC measures departure of the vegetation structure from reference conditions. For example, fuel loads in some ecological systems are naturally high (e.g. *Pinus contorta* forests), whereas other ecological systems differ substantially from natural conditions because they might be managed to keep fuel loads low to protect human settlements (e.g. *Pinus ponderosa* woodlands).

The objectives of the present FRCC assessment were two-fold: (1) map FRCC for the Mount Grant area on the United

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States Department of Defence Hawthorne Army Depot in western Nevada based on methods proposed by Shlisky and Hann (2003), and (2) provide FRCC and associated data layers to Hawthorne Army Depot managers to address their key resource management priorities. These priorities included developing an interagency fire management plan to prioritise fire suppression activities, protecting water resources, planning fuels restoration and maintenance projects, implementing strategies for biodiversity protection, tracking success of restoration strategies, and revising the Hawthorne's resource land management plan. These key resource management priorities were defined in 2003 based on an initial conservation assessment by The Nature Conservancy where Hawthorne Army Depot staff and external natural resource specialists identified the risk of catastrophic fire due to long-term fire suppression as the highest threat to the integrity of surface water quality and the viability of sagebrush shrubland, pinyon woodlands, and Greater Sage-grouse habitat (J. Nachlinger, unpubl. data, 2003).

Methods

We adopted the mid-scale FRCC assessment process proposed by Shlisky and Hann (2003; additional references at www.frcc.gov, September 2006) because these resulting maps (FRCC and others) can be used to plan local fuels management projects based on the analysis of large landscapes. We incorporated remote-sensing based on high-resolution imagery, a soil survey, and field verification to the mid-scale FRCC assessment to increase its accuracy and applicability. The concept of scale is different among disciplines and a source of confusion (Quattrochi and Goodchild 1997); the discipline of fire and FRCC mapping uses its own meaning of scale. The scale in 'mid-scale' proposed by Shlisky and Hann (2003) means that the data can be used to design local-scale fuels projects, which often range from 80 to 5000 ha for public agencies. Henceforth, we replaced the term 'mid-scale' with 'local-scale'. The resolution of satellite imagery conventionally associated with the local-scale assessment in the field of fire mapping is $\leq$30 m (Hann 2004). Hann (2004) suggested that a coarse-scale assessment is inappropriate for anything finer than regional and national comparisons and is often associated with a satellite imagery resolution $\geq$1 km^2. The local-scale methodology is composed of five primary tasks (Fig. 1): (1) map initial Potential Natural Vegetation Types (PNVT); (2) refine PNVTs; (3) model the Natural Range of Variability (NRV); (4) calculate and map departure from the NRV; and (5) map vegetation classes that are over- or under-represented based on the NRV. These methods were based on mapping environmental gradients (Keane *et al*. 2002), using reference ecological conditions in ecosystem management (Kaufmann *et al*. 1994; White and Walker 1997; Swetnam *et al*. 1999), and calculating departure of current from reference conditions (Hann and Bunnell 2001; Hann *et al*. 2003*b*). Similar methods were described by Hann (2004) and McNicoll and Hann (2004) to classify FRCC at finer project sizes.

Two important points need to be made about these FRCC methods. First, qualitative methods are required to a certain extent for FRCC assessments because they use a high degree of qualitative assessments, expert opinion and modelling, and rule-based methodologies. Second, we did not incorporate departure of fire regimes (fire-free interval and intensity) for Mount Grant, although the complete FRCC methodology includes choosing the most departed values between structural vegetation classes and fire regimes based on reference conditions (Hann and Strom 2003). We lacked empirical data about fire on Mount Grant, which is a common fact for non-forestlands, although photography of some mountain slopes suggested old fire scars in pinyon–juniper woodlands.

Study area

The Mount Grant project area (North American Datum 1927 Universal Transverse Mercador for the Continental United States of America, latitude, 38°34′18″N; longitude 118°47′26″W) is 18 218 ha and contained within Hawthorne Army Depot, a 59 609-ha military installation in the Wassuk Range located in western Nevada, USA (Fig. 2). The Wassuk Range is representative of western Great Basin mountain ranges, with clearly defined zonal vegetation types distributed from the alpine summit of Mount Grant reaching 3426 m in elevation, to the valley bottoms at 1280 m of elevation. The Mount Grant project area is managed by Hawthorne Army Depot with surrounding areas in the Wassuk Range managed by the Bureau of Land Management, US Forest Service, and private owners. Much of the land at higher elevations is part of a 1930s public lands withdrawal where multiple uses and public access have been limited for years, including the removal of livestock grazing for surface water management.

Thirteen ecological systems occur on the slopes of Mount Grant. The nine upland ecological systems include mixed desert shrub, big sagebrush (*Artemisia tridentata*) semidesert, pinyon (*Pinus monophylla*)–juniper (*Juniperus osteosperma*) woodland (as defined by Miller *et al*. 2000), curlleaf mountain mahogany (*Cercocarpus ledifolius* var. *intermontanus*) woodland, mountain big sagebrush (*A. tridentata* ssp. *vaseyana*), low sagebrush (*A. arbuscula*), subalpine pine forest, and alpine (often dominated by low sagebrush). Subalpine pine forest, which is dominated by limber pine (*Pinus flexilis*) and whitebark pine (*P. albicaulis*), occupies small patches within the mountain big sagebrush–low sagebrush matrix. The four mesic ecological systems include cottonwood (*Populus fremontii*) forest, willow (*Salix* spp.) riparian shrubland, montane meadow, and aspen (*Populus tremuloides*) forest. The big sagebrush semidesert, mountain big sagebrush, and low sagebrush matrix communities are important for several sagebrush obligates, including Greater Sage-grouse, which is part of a genetically distinct California population of special concern.

Initial mapping of potential natural vegetation types

Potential natural vegetation types (PNVT) are 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 (Schmidt *et al*. 2002; Shlisky and Hann 2003). Biophysical characteristics that to a large extent control fire regimes and the distribution of vegetation are reflected in the distribution of PNVTs (Keane *et al*. 2002). For example, fire-free landforms would be expected to support fire-sensitive species (Miller and Rose 1995). The PNVT represents the vegetation type that would exist under the natural regimes of ecological processes and natural disturbances,

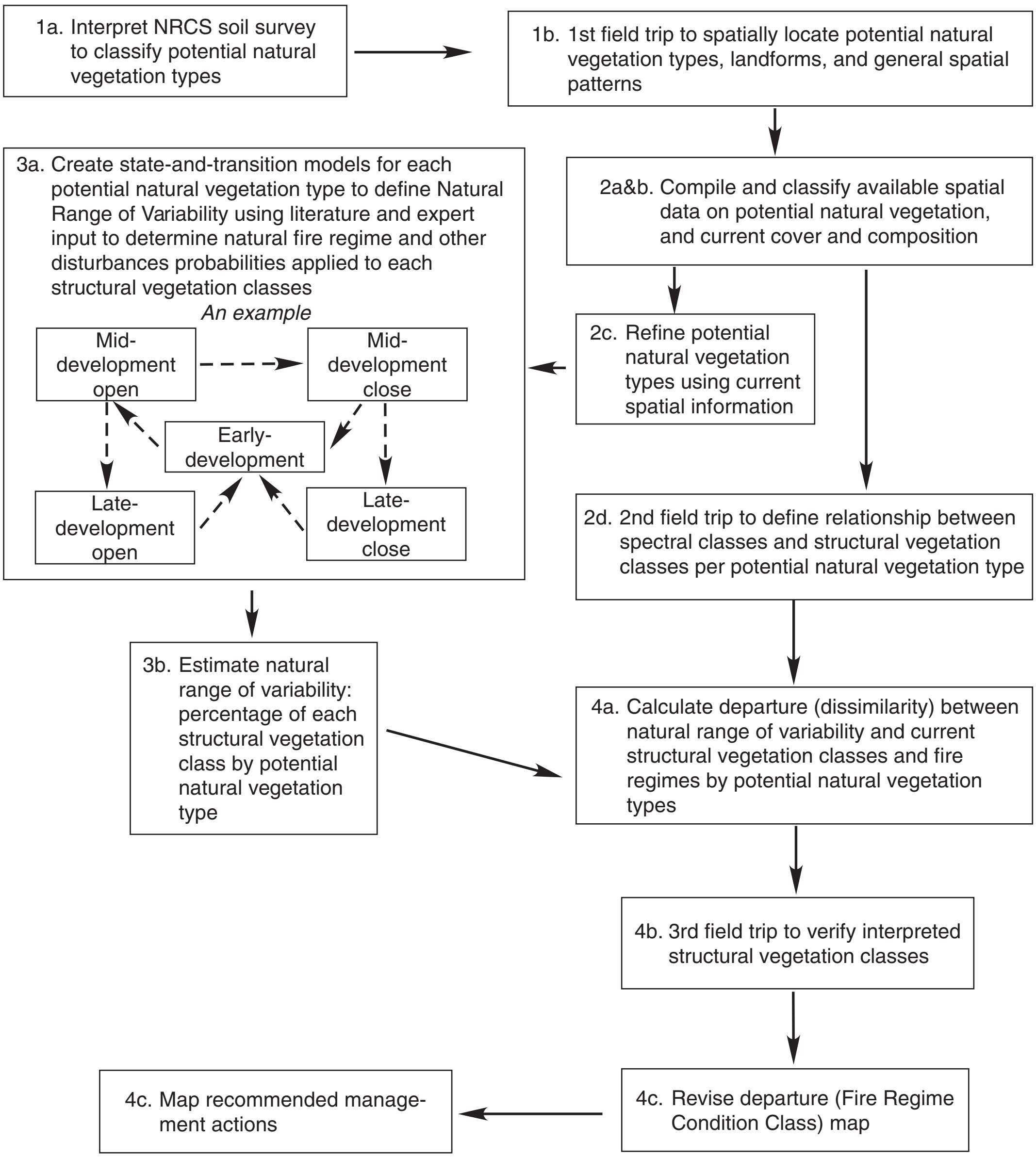

Fig. 1. Rapid Fire Regime Condition Class (FRCC) Assessment process (adapted from Shlisky and Hann 2003). The dashed arrows in Box 3a represent arbitrary succession and disturbance transitions among structural vegetation classes for a Potential Natural Vegetation Type example.

including Native American presettlement disturbances, in the absence of modern human interference (Schmidt *et al.* 2002; Shlisky and Hann 2003). Thus, the PNVT is informed by both pre-Euro-American settlement vegetation and current climate. For the present project, PNVTs were the foundation for stratification of reference and current vegetation, the development of reference models, and calculation of departures of current vegetation conditions from reference conditions.

PNVTs for Mount Grant were first identified by interpreting an order III soil survey completed in 1991 by the United States Department of Agriculture Natural Resources Conservation Service (NRCS) for Hawthorne Army Depot (No. 799; USDA Soil Conservation Service 1991). Soils take centuries to form as an interaction of climate, geology, and vegetation. Therefore, they can be used to approximate the natural, long-term ecological potential based on the best available science for soil–vegetation interactions (Haines-Young 1991; Franklin 1995). Given that the presettlement period ended ~150 years ago in the Great Basin, current soils should be reliable predictors of PNVTs unless soil horizons were removed mechanically or severely eroded owing to post-settlement land management practices.

There were no other comprehensive data layers that described PNVTs, except perhaps the coarse-scale PNV Group map published by the US Forest Service (www.fs.fed.us/fire/fuelman/pnv2000/maps.html, accessed October 2005). We did not use this coarse-scale map because its spatial scale (1-km resolution)

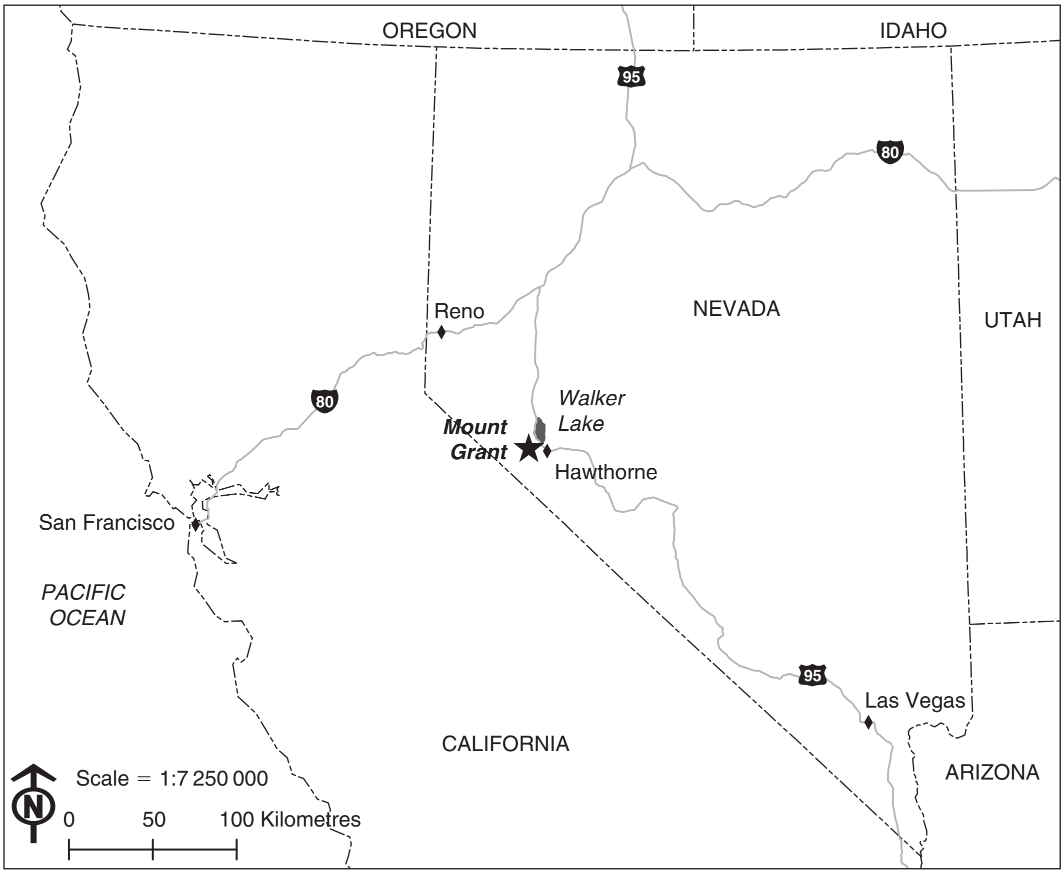

Fig. 2. Location of Mount Grant located in western Nevada, USA. The large star symbol is the location of Mount Grant.

was incompatible with local-scale FRCC mapping and displayed only one PNVT for the Mount Grant area, which has a net elevation change of ~2000 m, supporting at least seven PNVTs.

Soil survey interpretation is based on the natural, long-term ecological potential for a site defined as 'ecological site' by the NRCS (National Forestry Manual, www.nrcs.usda.gov/technical/ECS/forest/2002_nfm_complete.pdf, accessed November 2007). The NRCS defines ecological site as 'A distinctive kind of land with specific physical characteristics that differs from other kinds in its ability to produce a distinctive kind and amount of vegetation'. The ecological site generally represents a special case of PNVT based on biophysical characteristics. For example, mountain big sagebrush was a PNVT in our study; however, NRCS listed at least three different mountain big sagebrush ecological sites that differed by slope, average precipitation, or landform position.

Order III soil surveys do not map ecological sites <4.04 ha, which are termed inclusions, but these small ecological sites are listed as imbedded in the ecological site. Soil survey polygons, each describing a soil association, were mapped. A soil association might contain anywhere from one to three ecological sites, but it is shown as one polygon in an order III survey (see below *Refinement of PNVT map using current spatial data*). Dominant upper-layer species were matched with each ecological site. The dominant upper-layer species were obtained from the list of characteristic species per ecological site supplied by NRCS's attribute tables. All ecological sites sharing the same dominant species in the upper layer (e.g. mountain big sagebrush) were combined into a PNVT. In more recent soil surveys, the potential ecological community associated with a soil type (i.e. the ecological site) is provided and can be directly translated into a PNVT.

Refinement of PNVT map using current spatial data

We found that order III soil surveys need to be refined because NRCS map polygons commonly contain multiple soils and inclusions, thus multiple ecological sites per mapping unit (polygons) that primarily depend on landform position and slope. When mapping units are not refined to single PNVTs, it is impossible to define the vegetation reference condition to calculate FRCC. A first field survey in November 2003 confirmed that the initial map of PNVTs based on the NRCS soil survey was too coarse because it did not consistently separate many ecological sites. For example, fine-scale patterns between low sagebrush and mountain big sagebrush were commonly observed in the field.

Current vegetation imagery was used to refine NRCS ecological sites only for PNVTs that were edaphically controlled and whose dominant upper-layer species were not prone to at least moderately rapid expansion or contraction because of modern human interference. Also, current imagery was used to map ecological sites that were already identified within existing polygons by NRCS. In a few cases, current imagery was used to correct polygons that were incorrectly identified by NRCS, such as when an ecological site was mapped at an elevation that was biologically incompatible with the growth of the dominant upper-layer species. Vegetation types that were edaphically controlled were low sagebrush, curlleaf mountain mahogany, and mixed desert shrub. Low sagebrush is the only sagebrush that survives water-logged soils caused by a claypan that prevents infiltration of water to deeper soil layers (USDA-NRCS 2003). Therefore, the presence of low sagebrush today was an excellent predictor of this species' dominance during the long process of soil formation. This criteria made the separation of low and mountain big sagebrush relatively easy for most of Mount Grant above 2133 m. Curlleaf mountain mahogany is similarly dependent on a few soil types (USDA-NRCS 2003) and because this species is slow-growing and a long-lived species (>500 years lifespan), it could be reliably mapped as potential vegetation wherever found: these ecological sites were often inclusions. Mixed desert shrub could also be mapped with current imagery because no other vegetation types could survive in the dry and saline soils at some elevations.

Other PNVTs could be very carefully refined with current imagery. These included: (1) Wyoming big sagebrush and mountain big sagebrush PNVTs that may appear smaller than their potential because of pinyon and juniper encroachment with fire exclusion, and (2) the pinyon–juniper woodland PNVT that may appear larger than its potential owing to the same encroachment process. This mapping difficulty only occurred when the NRCS soil survey listed, but did not map, a big sagebrush type and woodland type in the same soil association polygon. Examination of landforms and slope, and field visits generally resolved this problem because big sagebrush shrublands should be found on deeper soils of alluvial fans with shallow to moderate slopes whereas pinyon–juniper woodlands should be found on shallow soils with moderate to steep slopes. The challenges with using current imagery to refine a soil survey for Wyoming big sagebrush, mountain big sagebrush, and pinyon–juniper woodlands were mainly a difficulty associated with the upper and lower elevation limits of pinyon and juniper establishment. Therefore, mountain big sagebrush could be considered edaphically controlled above pinyon–juniper woodlands and its spatial distribution refined with current imagery.

We also refined the NRCS soils data with a 1990 plant community description and mapping based on aerial photography and field surveys for Mount Grant (J. Nachlinger, unpubl. data, 1990) and current vegetative conditions identified from IKONOS satellite imagery. For example, in many areas along the slopes and drainages of Mount Grant, narrow bands of mountain big sagebrush in deeper soils extended into areas identified only as low sagebrush by the NRCS data. Most likely, patches of mountain big sagebrush were the inclusions described in the soil survey. It was determined by the 1990 mapping effort (J. Nachlinger, unpubl. data, 1990) and local ecologists that these narrow bands of mountain big sagebrush were indeed representative of the mountain big sagebrush PNVT and should be mapped as such. The interpretation of the IKONOS imagery clearly identified the presence of mountain big sagebrush; therefore, the draft map was revised to include the more spatially detailed mountain big sagebrush PNVT. Similar processes were used to spatially refine the low sagebrush and mountain mahogany PNVTs as described above. We also refined the infrequent-fire pinyon–juniper PNVT, but mostly by excluding barren areas formed by talus slopes and bedrock, and inclusions of low sagebrush and curlleaf mountain mahogany. In a few cases, inclusions of Wyoming big sagebrush and mountain big sagebrush without any trees were located and mapped within the infrequent-fire pinyon–juniper PNVT because the cover of shrubs was uncharacteristic for this PNVT.

Modelling the NRV

The NRV was defined as the distribution of structural vegetation classes and mean fire return intervals expected under natural ecological conditions, including ecologically acceptable human fire use (as characterised by Native American burning) (Shlisky and Hann 2003). The NRV is also referred to as the reference condition by the LANDFIRE project, Shlisky and Hann (2003), and by fire practitioners in general. Henceforth, we use 'vegetation reference condition' instead of 'reference condition' to indicate that our study does not include presettlement fire regimes. Structural vegetation classes were defined for each PNVT and were composed of vegetation attributes of development time (e.g. succession described by either early-, mid-, or late-development), cover of the dominant and upper layer plant species (open or closed canopy), plant height, and common plant species. Modelled structural vegetation classes were identified using standard US interagency terminology (Shlisky and Hann 2003; Hann 2004; The Nature Conservancy *et al*. 2006) as early development, mid-development open, mid-development closed, late-development open, and late-development closed. We also added a non-standard structural vegetation class termed late-development wooded found only in Wyoming big sagebrush. This simple classification is consistent with local-scale spatial data likely to be available for vegetation structure and composition.

Because quantitative fire history and vegetative data are generally lacking for the presettlement period, particularly for non-forested land, the NRV is often modelled. State-and-transition modelling (Westoby *et al*. 1989; Bestelmeyer *et al*. 2004) was used to estimate the distribution of structural vegetation classes Fig. 1, Box 3*a*) and fire return intervals (Shlisky and Hann 2003). Where presettlement data are available for all PNVTs in a landscape to predict the NRV, they should be used preferentially or in tandem with modelling (The Nature Conservancy *et al*. 2006). Estimating the NRV by modelling is also at the heart of the LANDFIRE methodology.

We modelled the NRV because quantitative data about the distribution of structural vegetative classes and fires were absent for Mount Grant. Models were developed using Vegetation Dynamics Development Tool software (*VDDT* from ESSA Technologies, Inc., http://www.essa.com/downloads/vddt/download.htm, accessed January 2005; Barrett 2001; Beukema *et al*. 2003) and methods were based on the LANDFIRE Vegetation Dynamics Modelling Manual (The Nature Conservancy *et al*. 2006; http://www.landfire.gov/participate_veg_workshops.php, hyperlink: vegetation modelling manual, accessed August 2006). Seven LANDFIRE VDDT models were parameterised with succession and fire disturbance probabilities reflecting either

Table 1. Potential natural vegetation types (PNVT) of Mount Grant and equivalent LANDFIRE ecological systems used to obtain the natural range of variability (NRV)

Original PNVT	LANDFIRE ecological system	LANDFIRE mapping zone	LANDFIRE code
Infrequent fire pinyon–juniper	Juniper steppe and pinyon–juniper steppe woodland (infrequent fire)	Great Basin Region	R2PIJU[A]
Low sagebrush	Intermountain basins montane sagebrush steppe (low)	16	1126 Low[B]
Curlleaf mountain mahogany	Intermountain basins mountain mahogany woodland and shrubland	12 and 17	1062[B]
Mountain big sagebrush (no tree invasion)	Intermountain basins montane sagebrush steppe	Great Basin Region	R2SBMT[A]
Wyoming big sagebrush with potential for pinyon–juniper invasion	Intermountain basins big sagebrush shrubland	16, 12 and 17	1080[B]
Riparian mountain meadow	Rocky Mountain riparian herbaceous (crosswalk requires interpretation and compromise with old PNVG)	16	1164[B]
Mixed desert shrub	Intermountain basins semi-desert shrub steppe	16	1127[B]

[A]From LANDFIRE's Rapid Assessment modelling for the Great Basin Region.
[B]From National-LANDFIRE models developed for the Great Basin Region Mapping Zones 12, 16, and 17. Within the LANDFIRE process, coarse-scale Rapid Assessment modelling preceded finer-scale National-LANDFIRE modelling.

presettlement or natural post-settlement conditions and run with 10 Monte Carlo replicates for 500–1000 years, or until the distribution of structural vegetation classes of each PNVT stabilised. The most important outputs of these models were the percentage of each structural vegetation class on the landscape (e.g. percentage of the mid-development open class in low sagebrush), the fire return intervals for replacement, mixed severity, surface fires, and the total fire return interval.

The seven VDDT models for Mount Grant were obtained from two sources (Table 1) used to model the NRV: (1) The LANDFIRE Rapid Assessment models (www.landfire.gov/ModelsPage1.html, accessed November 2007) were developed based on a series of regional expert workshops in 2004–2005, was the source of two models (Infrequent Fire Pinyon–Juniper and Mountain Big Sagebrush Without Tree Invasion). (2) National-LANDFIRE models (www.landfire.gov/VegetationModels.html, November 2007), which were developed for mapping zones 16 (Utah High Plateau), 12 (Western Great Basin), and 17 (Eastern Great Basin) through series of regional expert workshops, peer-reviewed, and completed in 2005 were used for the remaining five models. LANDFIRE models were designed for a specific region and incorporated the most recent ecological knowledge on estimated successional transition times, fire frequency and severity, and disturbance probabilities between a relatively simple set of structural vegetation classes (PNVT classes) expected to occur historically, and representing vegetation reference conditions (Table 2). The description of each PNVT, models, and parameter values are downloadable from www.landfire.gov/reference_models.php (accessed November 2007) for the Rapid Assessment products (PNVTs will soon be downloadable from National-LANDFIRE as Biophysical Settings) or obtained from L. Provencher for National-LANDFIRE. These descriptions include sections on the geographic distribution, biophysical setting, vegetation composition, disturbance regimes, comments by experts, structural vegetation classes (i.e. early, mid-closed, mid-open, late-open, and late-closed) and their dynamics, and the mean fire return intervals for surface, mixed severity, and replacement fire.

Classifying and mapping current vegetation development and canopy cover

We used IKONOS satellite imagery (4-m multispectral resolution; SpaceImaging Corporation, Dulles, VA, USA; Taylor 2005) to classify and map vegetation types, vegetation development, and canopy cover. IKONOS satellite imagery of the Mount Grant area was obtained on 10 July 2004, during a period of maximum vegetation productivity.

For the majority of the assessment, an unsupervised classification of the IKONOS satellite imagery resulted in mapping spectral classes (defined in Lilles and Kiefer 2000) obtained by thematic stratification that were evaluated against field-based data, and existing Geographic Information System (GIS) data, aerial imagery, or any other available ancillary data to determine the relationship between the spectral classes from the satellite imagery and current structural vegetation classes listed in Table 2. As spectral classes were defined, the unsupervised classification was repeated for the remaining undefined spectral classes. Other ancillary data included GIS data such as the US Geological Survey's (USGS) Digital Elevation Model and USA Environmental Protection Agency's GAP classification data used to aid in refining the resulting map through minor GIS modelling. The US Geological Survey GAP vegetation data had limited usefulness because it misclassified PNVTs and did not resolve fine spatial patterns among them. GIS models included the use of elevation and aspect zones to correctly assign a structural vegetation class depending on whether or not a PNVT was correctly defined. For example, any wooded structural vegetation classes of pinyon–juniper woodland could be found on a steep slope, whereas significant cover of pinyon and juniper on a shallow slope would generally be assigned to a late-development closed

Table 2. Natural range of variability (NRV) percentages per potential natural vegetation types (PNVT)
The terms early-, mid-, and late-development referred to the succession age of a PNVT recovering from a stand-replacing disturbance, and were determined by experts and the literature. The conditions 'open' and 'closed' refer to the upper layer plant species, not necessarily the dominant plant species, and were not based on an absolute cover value, but are relative to the potential natural maximum canopy closure of a PNVT. PJ, pinyon–juniper

	PNVT						
Structural vegetation classes	Infrequent fire PJ (%)	Low sagebrush (%)	Mountain mahogany (%)	Mountain big sagebrush (%)	Wyoming with PJ (%)	Riparian mountain meadow (%)	Mixed desert shrub
Early	5	10	10	20	15	5	10
Mid closed	5	N/A	15	35	25	70	40
Mid open	15	35	10	45	50	10	50
Late open	35	N/A	20	N/A	N/A	N/A	N/A
Late closed	40	55	45	N/A	5	15	N/A
Late wooded (for Wyoming/ PJ invasion)[A]	N/A	N/A	N/A	N/A	5	N/A	N/A

[A]Late-development wooded is not used in LANDFIRE terminology.

or wooded class of either Wyoming or mountain big sagebrush PNVT on loamy soil depending on elevation.

The most important and early step of the unsupervised classification was the collection of field data from 29 to 31 July 2004 for 94 preselected sites corresponding to specific spectral classes of interest that could not be classified or that were tentatively identified to a combination of PNVT and structural vegetation classes. At each field site, a set of digital photographs was taken and specific visual estimates of existing vegetative cover were made to fully characterise the current vegetation type, current structural vegetation class (i.e. early-, mid-, or late-development), and current vegetative canopy cover (i.e. open, closed, or wooded).

The field data, which also included subjective field notes and expert opinion, were combined, when necessary, with ancillary GIS data to create a penultimate map of structural vegetation classes that was designed to be verified in the field. 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 map.

The penultimate draft of the structural vegetation class map was qualitatively verified with 61 preselected plots on 23 June, 21 July, and 13 October 2005. Additional unplanned plot visits also contributed to verification. Although estimates of error rates between the previous and penultimate maps were calculated, they were likely biased because a formal quantitative assessment using a statistically robust sampling design, such as random and stratified random, was not feasible and would have cost more than the current study. Our field assessment used targeting sampling by qualitatively locating plots to represent the range of spectral classes or thematic attributes. Verification plots were preferentially situated close to roads and trails, or accessible roadless terrain and there was not a direct relationship between the verification of interpreted spectral classes and the frequency of those spectral classes throughout the landscape. At each plot, we determined whether or not the mapped PNVT and structural vegetation class were correct. We also briefly described the vegetation and bare ground cover and other characteristics such as soil colour and slope, and we photographed the plot. Field data were used in a final iteration of thematic characterisation of structural vegetation classes. The last iteration in the final draft map of structural vegetation classes was used to calculate the FRCC.

Calculating and mapping departure in vegetation, and fire frequency and severity

The departure in vegetation development classes was calculated by comparing the structural vegetation class proportions obtained from the modelled NRV by PNVT to the proportions of structural vegetation classes in the current vegetation condition. The general methodology employed is described by Hann *et al*. (2003*a*) and can be applied at any spatial scale.

Percentage area coverage of each structural vegetation class (i.e. early development, mid-development closed, mid-development open, late-development closed, late-development open, or late-development wooded) for each PNVT was computed from the final structural vegetation class map for the current condition and indicated the cover of the current structural vegetative class within each PNVT. These current vegetative condition cover proportions were directly compared with the NRV proportions (Table 2) calculated through VDDT modelling for each PNVT. By summing the lowest of the two area coverage percentages between the NRV and current conditions for each structural vegetation class combination, a measure of 'similarity' was obtained. Subtracting this similarity measure from '100' rendered a measure of 'dissimilarity' between the NRV and current conditions:

$$\text{Fire Regime Condition} = 100\% - \sum_{i=1}^{n} \min\{Current_i, NRV_i\}$$

where n is the number of structural vegetation classes used in the analysis for each PNVT, $Current_i$ is the percentage of pixels in the current vegetation class i, and NRV_i is the percentage of pixels that should be in vegetation class i according to VDDT models.

Following US interagency protocols and publications on FRCC (Hann and Bunnell 2001; Schmidt *et al*. 2002; Hann and Strom 2003), dissimilarity measures (i.e. combined vegetation and fire regime departures, which we lacked) ranging from 0 to 33% per PNVT were classified as 'intact' or unaltered (FRCC 1). Departures ranging from 34 to 66% and 67 to 100% were classified as 'moderate' (FRCC 2) or 'high' (FRCC 3) departure, respectively.

Mapping departed structural vegetation classes

Maps of FRCC are less informative and practical to managers than a PNVT-specific map of departure that identifies the over- and under-represented structural vegetation classes in a landscape. Although users understand that a whole PNVT is assigned one FRCC value (i.e. every pixel in a given PNVT has the same FRCC value), they do not always grasp that each pixel also belongs to a vegetation development class that may be either similar, under-represented, or over-represented compared with the NRV regardless of its FRCC value. Therefore, in addition to the calculation of FRCC across the Mount Grant study area, we identified vegetation structural classes that departed from vegetation reference conditions by comparing percentages between the current conditions and NRV values. We evaluated each 4-m pixel on the map based on the relationship between current conditions and NRV. If the current percentage of a class is ±5% within the NRV, the vegetation development class is similar to the vegetation reference condition and the percentage should be *maintained*. Otherwise, the vegetation development class differs from reference conditions and its percentage needs to be either *decreased* or *increased* depending on whether it is, respectively, too abundant or too under-represented compared with the vegetation reference condition. These data are referred to as the Management Action Map when plotted spatially. The terms 'decreased', 'maintained', and 'increased' do not apply to fuels loads, but to the percentage of the structural vegetation class throughout the landscape. Therefore, not all pixels that differ from reference conditions require management because these data only indicate that a pixel belonged to a structural vegetation class that departed from the NRV by more than 5%. The 5% buffer around the NRV percentage was arbitrary and chosen based on trial-and-error experimentation and practical considerations. The point of the 5% buffer is to show true difference in departure, but not disqualify structural vegetation classes that are only moderately departed. In practical terms, we might want to identify structural vegetation classes that at least differed moderately because the amount of corresponding area that is treatable after management constraints are applied can shrink so much as to limit the manager's ability to restore a landscape to a lower FRCC. Moderately departed structural vegetation classes might also be easier or cheaper to treat than highly departed classes (Forbis *et al*. 2006) and contribute just as much to an improved FRCC. The Management Action Map used in conjunction with the FRCC map can provide strong guidance for identifying alternative areas needing management action, such as fuels reduction.

Results

Mapping PNVTs

Seven PNVTs were interpreted from the NRCS soil survey: mixed desert shrub, Wyoming big sagebrush (*Artemisia tridentata* spp. *wyomingensis*) with pinyon–juniper, infrequent-fire pinyon–juniper, curlleaf mountain mahogany, low sagebrush, mountain big sagebrush, riparian mountain meadow. Models and descriptions of these PNVTs were ultimately obtained from the FRCC Guidebook and LANDFIRE (Table 1).

The draft map of PNVTs (Fig. 3*a*) was refined with the 1990 map from J. Nachlinger (unpubl. data, 1990; Fig. 3*b*) and IKONOS imagery (Fig. 3*c*) to separate those PNVTs that might belong to different landforms, slopes, and soils. The result of this process provided a broad-scale characterisation of PNVTs throughout the Mount Grant study area that more closely and appropriately matched the spatial resolution of the 4-m IKONOS satellite imagery (Fig. 3*c*). The greatest challenge encountered in using current imagery to separate PNVTs was to differentiate shrubland inclusions from the first two vegetation development classes of pinyon–juniper woodlands. This problem represented only a small fraction of the area on Mount Grant. Shrub cover in pinyon–juniper woodlands is generally much lower and mineral soil more exposed than in both of the big sagebrush PNVTs.

Non-random field verification results showed an overall mislabelling rate of 11% for PNVTs (Table 3). Low sagebrush and Wyoming big sagebrush were mislabelled most often (21.4 and 20.0%, respectively), whereas mountain big sagebrush, mixed desert shrub, and riparian mountain meadow were always correctly identified. Infrequent-fire pinyon–juniper woodlands and curlleaf mountain mahogany were both incorrectly classified at an intermediate rate of 11%.

Modelling the NRV

Table 2 contains the modelled NRV values based on vegetation structure and composition. The infrequent-fire pinyon–juniper, curlleaf mountain mahogany, and low sagebrush PNVTs were dominated by late-development classes that were both open (5–30% cover for mountain mahogany and 11–30% for pinyon–juniper) and closed (10–55% cover for mountain mahogany and 21–40% for pinyon–juniper) for the woodlands and closed (11–20% cover) for low sagebrush. The mixed desert shrub, Wyoming big sagebrush, mountain big sagebrush, and riparian mountain meadow PNVTs were dominated by mid-development classes, which were open for the upland PNVTs (5–15% cover for mixed salt desert shrub, 11–25% cover for Wyoming big sagebrush, and 6–25% for mountain big sagebrush) but closed (80–100% herbaceous cover) for the riparian mountain meadow.

Classifying and mapping structural vegetation class and canopy cover

The current conditions land cover map using the PNVT terminology (Fig. 4) and the structural vegetation class map (Fig. 5) were derived from the processed 4-m IKONOS satellite imagery. Non-random field verification results showed an overall mislabelling rate of 16.7% for structural vegetation classes, provided that the PNVT was correctly identified (Table 3). The percentages of mislabelled structural vegetation classes varied from 100% for mixed desert shrub, 40% for Wyoming big sagebrush, and 33.3% for riparian mountain meadow to 0% for curlleaf mountain mahogany (Table 3). Cheatgrass detection was the greatest source of mislabelling of structural vegetation classes for mixed desert shrub and Wyoming big sagebrush PNVTs. Also, one unplanned visit to large areas of pinyon–juniper woodlands revealed that one spectral class that

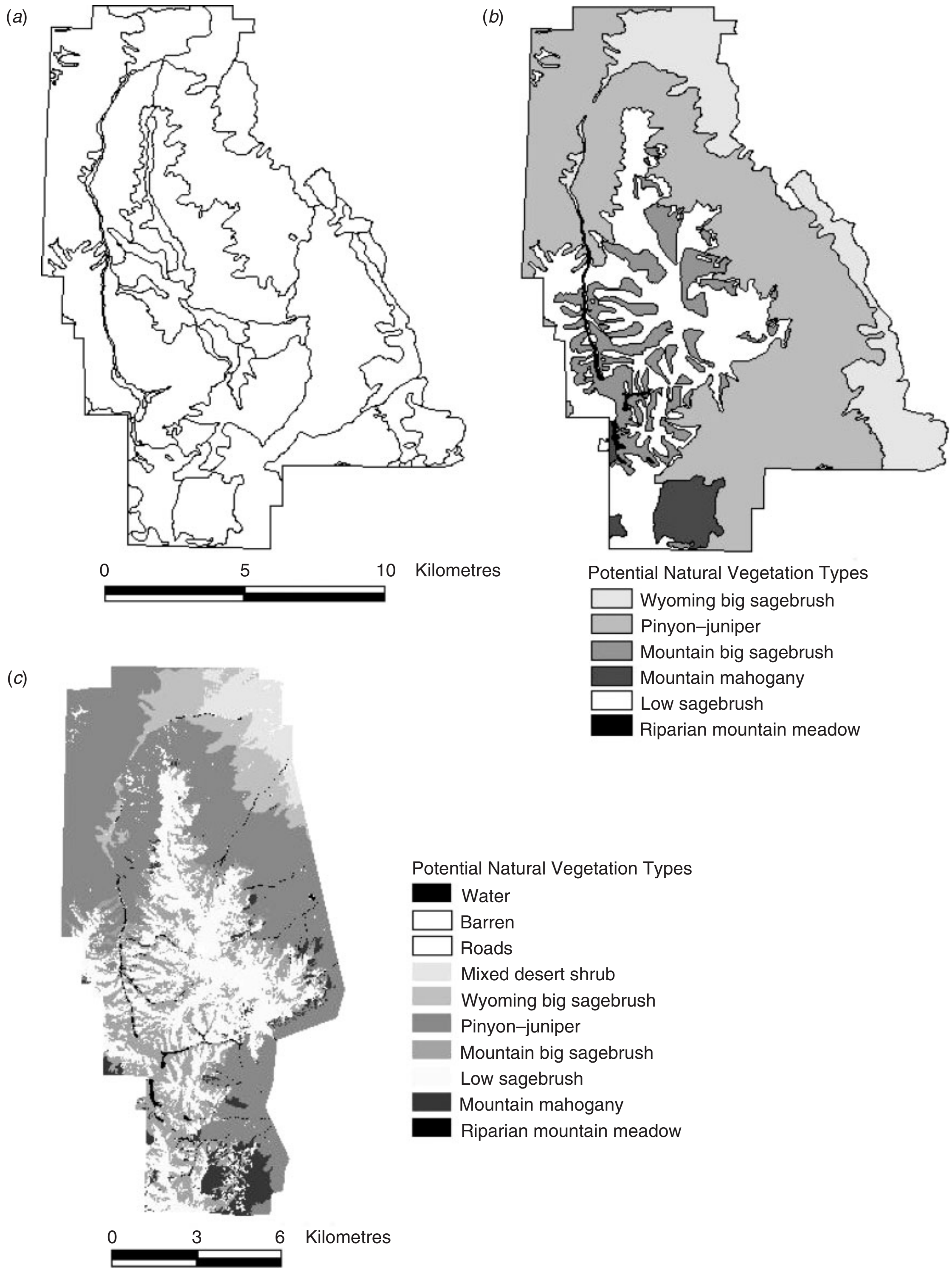

Fig. 3. Potential Natural Vegetation Type (PNVT) map developed from Natural Resources Conservation Service (NRCS) soils data, The Nature Conservancy plant community classification mapping (J. Nachlinger, unpubl. data, 1990), and IKONOS satellite imagery (10 July 2004). (*a*) First draft of the interpreted USDA NRCS soil survey showing only polygons of soil associations; (*b*) improved PNVT map obtained by overlaying the interpreted soil survey and vegetation mapping conducted by Nachlinger (1990); and (*c*) final PNVT map obtained by refining the map shown in (*b*) with IKONOS satellite imagery. Note that the boundary of final map differed from those of (*a*) and (*b*) as a tradeoff between the cost of IKONOS imagery and shape requirements imposed by SpaceImaging Corporation.

Table 3. Percentage of verification plots where (1) potential natural vegetation types (PNVTs) were incorrectly identified, and (2) structural vegetation classes were incorrectly identified by imagery interpretation given the correct PNVT was found on site

A total of pre-assigned 61 plots were visited. Plots were chosen because imagery interpretation indicated ambiguous colour or texture characteristics; therefore, plots were not randomly chosen and were generally located close to roads and trails for convenience

PNVT	Percentage PNVT incorrect	Percentage of structural vegetation classes incorrect given PNVT was correct	Number of verification plots
Infrequent fire pinyon–juniper	11.1	11.1	9
Low sagebrush	21.4	7.1	14
Curlleaf mountain mahogany	11.1	0.0	18
Mountain big sagebrush (no tree invasion)	0.0	10.0	10
Wyoming big sagebrush with potential for pinyon–juniper invasion	20.0	40.0	5
Riparian mountain meadow	0.0	33.3	3
Mixed desert shrub	0.0	100	2
Percentage of total plots incorrect	11.5	16.7	

was initially interpreted as mid-development closed vegetation was, in fact, a late-development open class. Because this spectral class was very common, it changed the FRCC from 3 to 1. Fig. 5 represented the final version.

Calculating and mapping departure in vegetation

Infrequent-fire pinyon–juniper and curlleaf mountain mahogany were largely intact relative to modelled vegetation reference conditions (FRCC 1), whereas low sagebrush, mountain big sagebrush, Wyoming big sagebrush, and mixed desert shrub were moderately degraded owing to a greater than expected proportion of either late-development vegetation classes or uncharacteristic classes (FRCC 2; Table 4; Fig. 6). Only riparian mountain meadow was highly departed from the NRV (FRCC 3) owing to the under-representation of the younger vegetation class and the dominance of woody (shrubs and trees) vegetation cover, the older vegetation development class. The Fire Regime Condition, which is a continuous percentage value representing ecological departure between the current conditions and NRV, was close to the class limits between different FRCCs for many PNVTs (Table 4). Low sagebrush and mountain big sagebrush, respectively, were within 1–2 percentage points from being in FRCC 1 and 3, respectively, whereas Wyoming big sagebrush and riparian mountain meadow were within 4 percentage points from being in FRCC 3 and 2, respectively. The FRCC 2 for low sagebrush, which has a long fire return interval, was the result of a combination of encroachment of mostly pinyon into high-elevation low sagebrush and over-representation of late-development structural vegetation classes of low sagebrush compared with the NRV. The FRCC 2 for the mountain big sagebrush PNVT was consistent with an early field survey that revealed the predominance of late-development closed shrub cover.

Mapping departed structural vegetation classes

For all shrubland PNVTs and the riparian mountain meadow, the most common recommended action for reaching the NRV was to decrease the percentage of late-development closed vegetation states and cheatgrass (in Wyoming big sagebrush) and increase the percentage of early and mid-development open (closed for the riparian mountain meadow) pixels (Table 2 *v.* Table 4; Table 5). In other words, late-development structural vegetation classes are currently too abundant in these PNVTs. For woodlands sites (infrequent-fire pinyon–juniper and curlleaf mountain mahogany), the recommended action was primarily to increase the percentage of late-development structural vegetation classes.

Discussion

Currently, Hawthorne Army Depot does not have a fuels crew to implement prescribed burns and other fuel reduction operations or fire management plan for Mount Grant – complete fire suppression is the default policy. We mapped FRCC as a first step of data acquisition for Hawthorne Army Depot to develop an interagency fire management plan to address the practical need of attacking wildfire incidents within and outside its ownership and to protect surface water and conservation of natural resources by managing fuels. We supported this effort by implementing the methodology of Shlisky and Hann (2003) and incorporated additional data from a soil survey, field verification, and high-resolution imagery to refine maps.

Lessons learned

Three lessons were learned during the present project and all greatly affected FRCC calculations.

(1) Verifying interpreted spectral classes using field data during various stages of the project greatly improved the accuracy of the mapping project. However, field verification is often the first task eliminated or reduced in scope when financial resources are limited. We conducted three field surveys to broadly define large landforms and PNVT types, to define ranges for vegetation development and cover, and finally to verify the interpretation of spectral classes to structural vegetation classes. As a result of the third field verification, we were able to more accurately identify the spectral

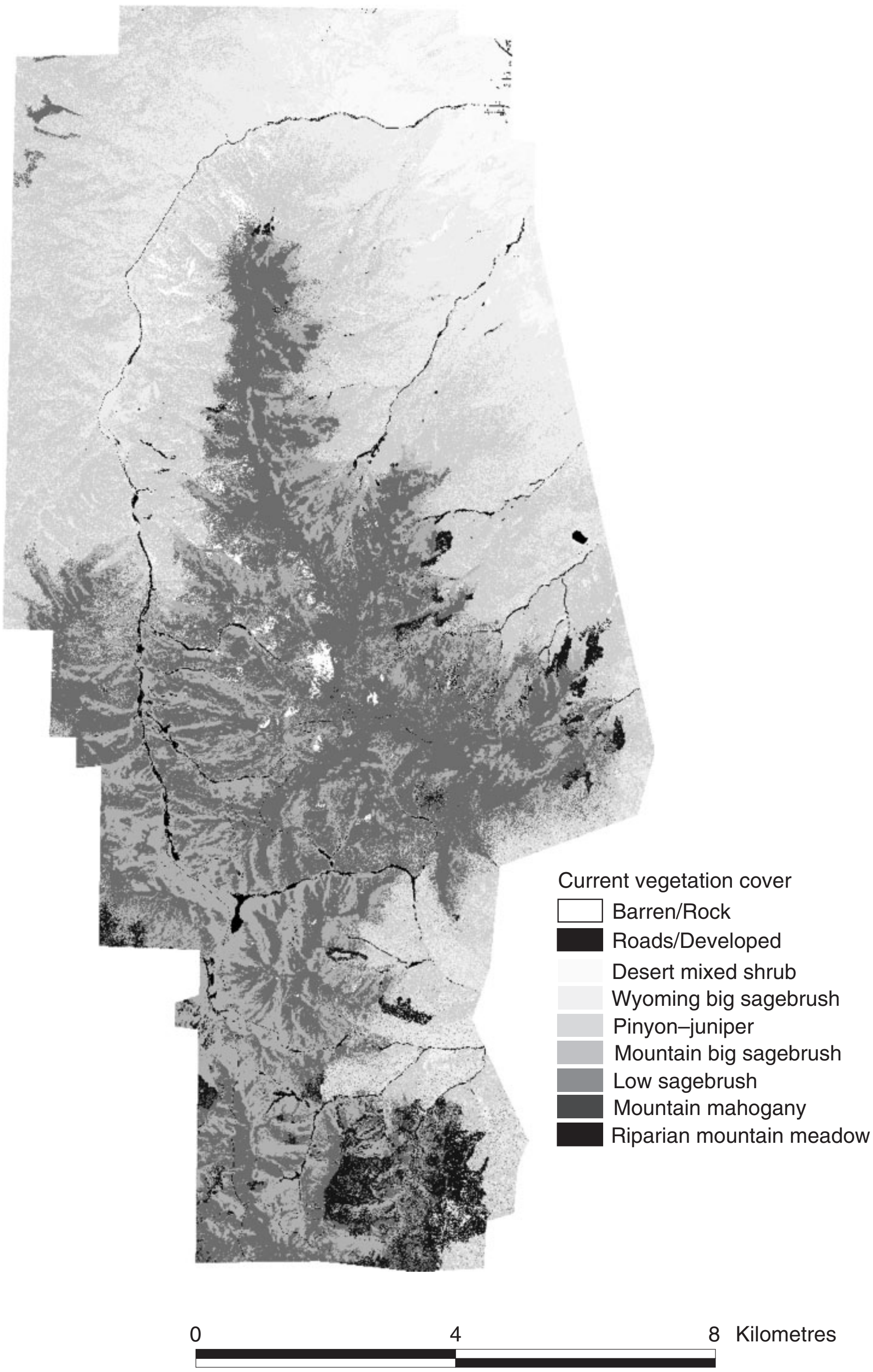

Fig. 4. Current Land Cover Classification developed from IKONOS satellite imagery. The map is based on raster data.

classes dominated by cheatgrass and the FRCC of four PNVTs changed substantially. Other local-scale FRCC mapping projects (Hann and Strom 2003; Shlisky *et al*. 2003; Hann 2004; McNicoll and Hann 2004) have used available field data or expert knowledge to classify spectral classes *a priori*, but did not describe field methods or results to test the accuracy of their maps after completing of the mapping process.

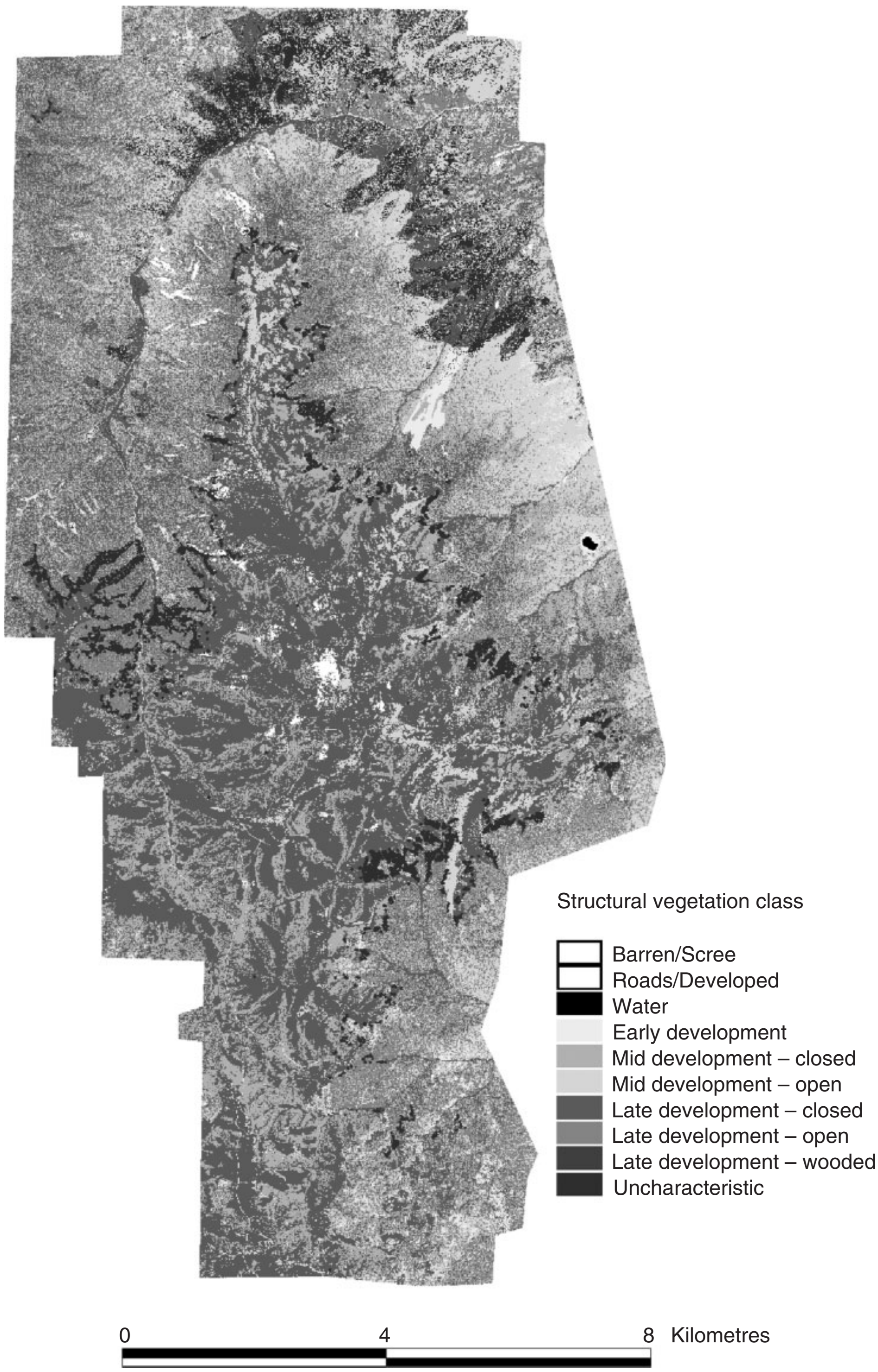

Fig. 5. Current structural vegetation class classification developed from IKONOS satellite imagery.

(2) Soil surveys from the USDA NRCS are often the only data available to create a first approximation of a complete PNVT map for local-scale assessments and, therefore, these data are invaluable for mapping FRCC. For relatively intact landscapes that function naturally today, the PNVT map should theoretically be the current vegetation type map. Previous FRCC mapping efforts have followed the local-scale methodology using current vegetation data layers as

Table 4. Percentages for the current condition of structural vegetation classes by potential natural vegetation type (PNVT) at Mount Grant
Fire regime condition class is given in bottom line where 1 represents intact condition, 2 is moderate departure condition, and 3 is high departure condition. PJ, pinyon–juniper; FMCC, Fire Regime Condition Class

	PNVT						
Structural vegetation classes	Infrequent fire PJ	Low sagebrush	Mountain mahogany	Mountain big sagebrush	Wyoming with PJ	Riparian mountain meadow	Mixed desert shrub
Early	3.0	0.8	11.4	0.6	0.2	0.2	2.0
Mid closed	22.0	N/A	21.3	54.5	8.7	11.2	2.9
Mid open	24.0	11.0	21.2	0.1	20.5	2.7	41.2
Late open	24.0	N/A	25.3	N/A	N/A	N/A	26.3
Late closed	26.0	82.6	20.8	35.3	32.8	85.9	12.0
Late wooded (for Wyoming/ PJ invasion)	N/A	N/A	N/A	N/A	3.3	N/A	
Late – uncharacteristic					0.1		
Early – uncharacteristic	1.0				34.4		15.6
PJ invaded – uncharacteristic		5.6		9.5			
Sum of lower percentages (SIMILARITY)[A]	73.0	66.8	75.8	35.7	39.4	29.1	46.1
DISSIMILARITY	27.0	33.2	24.2	64.3	60.6	70.9	53.9
FRCC	1	2	1	2	2	3	2

[A] Similarity was based on differences between reference values from Table 2 and actual current values provided here and calculated using index from Shlisky and Hann (2003).

the potential vegetation with either USDA Forest Service vegetation mapping data (Hann and Strom 2003), USGS GAP mapping data (McNicoll and Hann 2004), USDA Forest Service vegetation mapping and field assessments (Hann 2004), or classified digital orthophoto quadrangles (Shlisky *et al*. 2003). None of these studies used NRCS soil surveys to map the vegetation reference condition, probably because soil surveys were unavailable on the US Forest Service lands where these studies were conducted. Maps of PNVTs should be distinct from current vegetation maps for altered landscapes, otherwise part of the departure between natural and current conditions due to species expansion or contraction caused by management will not be included in calculations of FRCC.

For altered landscapes, we know of only two sources of information to map vegetation for local-scale assessment that, by definition, might have existed at presettlement. One option is to model the position of vegetation types based on biophysical rules using GIS software and data layers (Keane *et al*. 2002). The GIS option was not available to us because those rules and the data were largely non-existent. The second option is to interpret a soil survey using the correlation between soil type and vegetation type proposed by NRCS. A single soil survey at the county level can take years to complete because it requires extensive field visits to identify plant species, dig and analyse soil pits and characterise landforms, remote sensing analysis of aerial photography and satellite imagery, and extensive internal agency quality control. Despite the effort invested in soil surveys, application of the local-scale FRCC mapping method required further refinement of soil associations to distinguish PNVTs, especially where fire regimes or vegetation structures were significantly different from natural conditions.

(3) In addition to modelling PNVTs and estimating NRV values, ecologists must fully describe the PNVT and, especially, the cover values, vegetation height, dominant and upper-layer plant species, and dominant signature species. Without these descriptions, the remote sensing specialist lacks the needed information to separate structural vegetation classes. At the onset of the project in 2004, we did not have this information and this resulted in confusion and additional costs. The descriptions of PNVT from LANDFIRE's Rapid Assessment (PNVT) or National-LANDFIRE (Biophysical Settings) provide comprehensive information that can be locally modified.

Spatial scale

Calculated FRCC values can theoretically vary with spatial scale if the size of the stratification unit greatly changes the proportion of vegetation structural classes (Hann 2004). In the present study, current condition percentages and FRCC values were calculated by PNVT considering the entire study area as one stratification unit. We also could have summarised structural vegetation class percentages for the current condition and calculated FRCC values at several spatial stratification units (e.g. sub-watershed, first order hydrologic units). An approach of this sort would have rendered a more spatially robust characterisation of FRCC; however, there is a lower area limit below which FRCC calculation becomes nonsensical because a few development classes dominate current condition as an artefact of size. We encountered the problem of insufficient PNVT size with Wyoming big sagebrush and mixed desert shrub. These systems were extensive outside of the project area, but the artificial ownership boundary forced us to assess small portions of these shrublands found at the lower elevations. For Wyoming big sagebrush, a simple remedy

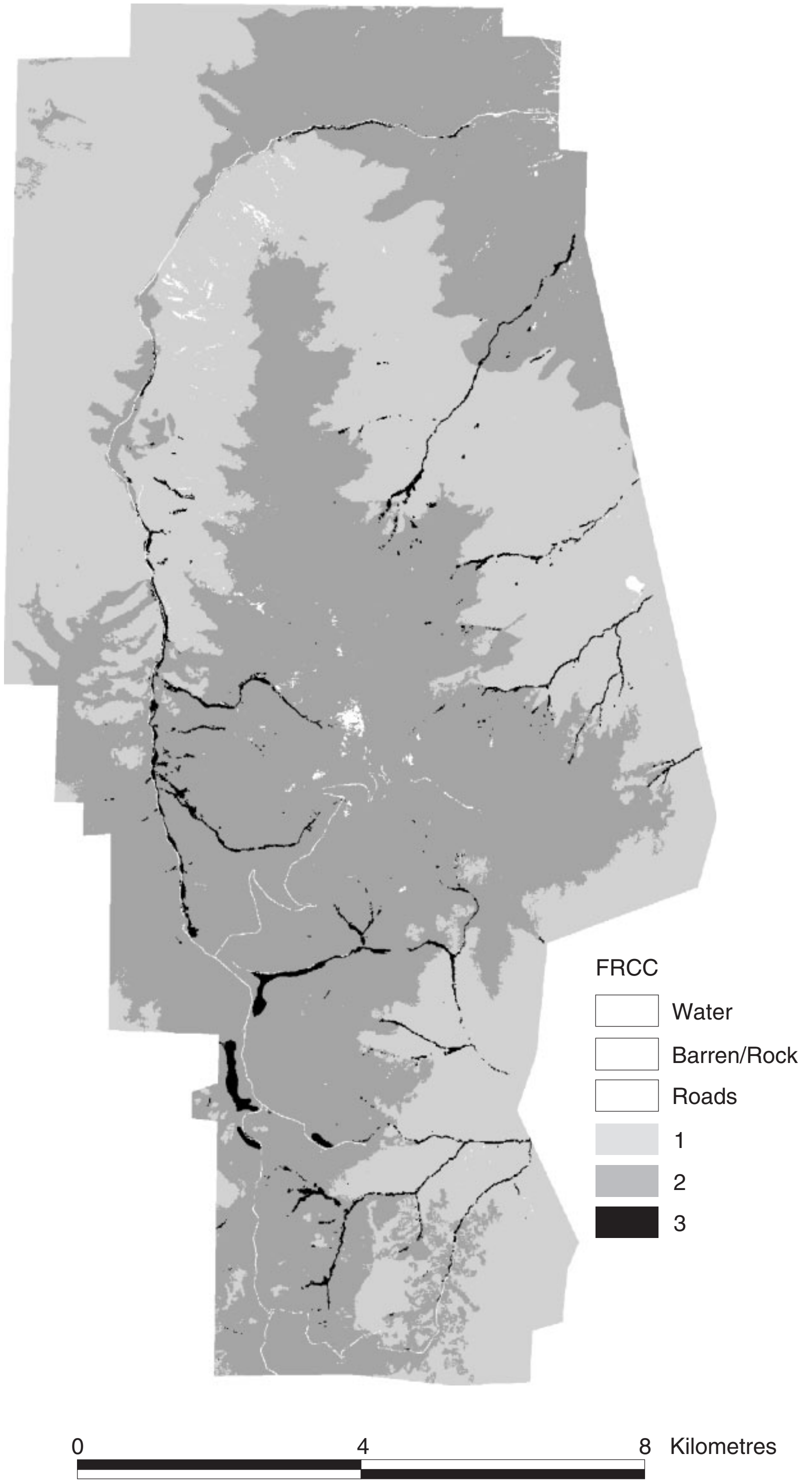

Fig. 6. Fire Regime Condition Class (FRCC) Map for Mount Grant. FRCC 1 is considered intact, whereas FRCC 2 and FRCC 3 are interpreted as moderate and high departure from natural range of variability, respectively.

to increasing area would have been to add a narrow belt of vegetation below pinyon–juniper woodlands, assuming additional funding. The more appropriate action for mixed desert shrub would have been to exclude it or merge it with Wyoming big sagebrush. Although Hawthorne Army Depot managers should critically evaluate the FRCC 2 for Wyoming big sagebrush and mixed desert shrub, their main challenge is controlling extensive cheatgrass invasion at the lower elevations.

Table 5. Recommended actions obtained by comparing the current condition to the natural range of variability (NRV) by structural vegetation classes for each potential natural vegetation type (PNVT) at Mount Grant
PJ, pinyon–juniper

	Infrequent fire PJ	Low sagebrush	Mountain mahogany	Mountain big sagebrush	Wyoming with PJ	Riparian mountain meadow	Mixed desert shrub
Early	Increase	Increase	Maintain	Increase	Increase	Maintain	Increase
Mid closed	Maintain	N/A	Maintain	Decrease	Increase	Increase	Increase
Mid open	Maintain	Increase	Decrease	Increase	Increase	Increase	Increase
Late open	Increase	N/A	Increase	N/A	N/A	N/A	Decrease
Late closed	Decrease	Decrease	Maintain	Decrease	Decrease	Decrease	Decrease
Late wooded (for Wyoming/ PJ invasion)	N/A	N/A	N/A	N/A	Maintain	N/A	
Late – uncharacteristic					Decrease		
Early – uncharacteristic					Decrease		
PJ invaded – uncharacteristic		Decrease		Decrease			

FRCC v. *Management Action Map*

Much attention is placed on FRCC maps because the information is used to prioritise wildland fuels management funding under the 2003 Healthy Forest Restoration Act in the USA (Congressional Bill H.R. 1904). For fuels management project planning, however, FRCC maps are less useful than a PNVT-specific Management Action Map. We have not shown the Management Action Map here because we found that managers (and the authors) have difficulty understanding it because too much information is summarised in a few management classes, whereas they easily grasp the results per PNVT in tabular form (Table 5) or when one Management Action Map is presented per PNVT; thus at most seven maps would be required for the current project. FRCC is a landscape-scale metric with true meaning at a scale that captures the full distribution of all vegetation development stages and fire regimes, whereas the Management Action Map shows the structural vegetation classes that might be targeted for fuels management because their proportions in the landscape depart from the NRV. Fuels management projects may be planned by applying constraints and decision rules to the Management Action Map, such as Wilderness Areas restrictions, military restrictions, inaccessible landforms, degree of departure, availability of methods to treat a fuel type, and so on. In the case of Hawthorne Army Depot, the next step would be to use the FRCC map and, especially, the Management Action Map data to identify restoration projects that support the military mission through natural resources management.

Management implications based on tested assumptions

FRCC results were counter-intuitive for Mount Grant and suggested several management activities different than initially anticipated.

First, we assumed that Mount Grant's pinyon–juniper woodlands would at least moderately depart from the NRV because other Great Basin woodlands show higher than expected tree density. The main cause of pinyon–juniper woodland densification (recruitment of younger trees under the older trees; Burkhardt and Tisdale 1976; Tausch *et al*. 1981; West 1999; Weisberg *et al*. 2007) is apparently decreased competition between grass and pinyon or juniper seedlings due to the removal of grasses by historic livestock grazing, mostly by domestic sheep. Active management would be required to counter the effect of densification, especially to prevent post-fire sedimentation into perennial water corridors. Our assumption proved wrong as pinyon–juniper woodlands had an FRCC of 1 and required no special management, including prescribed fire, because the mean fire return interval is long (>200 years for replacement fire). In fact, the mountain slopes supporting pinyon–juniper woodlands were sufficiently steep as to preclude future mechanical operations and past anthropogenic disturbances, including livestock grazing.

Second, we expected that the riparian mountain meadow PNVT should be protected from fire to maintain surface water quality by preventing sedimentation. The primary concern was that fire within the riparian corridor or from pinyon–juniper woodlands on surrounding slopes would cause massive sedimentation and affect the untreated water supply of Hawthorne Army Depot. Both the FRCC Map and Management Action data, however, identified a need for more urgent management attention, perhaps in the form of prescribed burning of shrub-dominant cover in riparian corridors to increase the herbaceous component. Greater cover of native bunchgrasses would form a barrier to sedimentation.

Third, we did not expect low sagebrush to moderately depart from the NRV because this PNVT, which is found mostly at higher elevation, experiences only infrequent fire (Table 4), and hence was assumed to be less affected by fire exclusion practices. Tree encroachment and over-representation of the late-development structural class were the causes of departure for low sagebrush. It is possible that naturally low cover values for low sagebrush rendered separation of the mid- and late-development classes more difficult; thus it may be a source of misclassification between these types (Table 3). The more serious concern for managers, however, should be the encroachment of pinyon from below, often from tree-encroached mountain big sagebrush, into high-elevation low sagebrush, because trees would make this habitat type unsuitable for Greater Sage-grouse (Connelly *et al*. 2000). The extent of this problem on Mount Grant is small enough to be reasonably remedied with mechanical thinning of trees in the low sagebrush PNVT and mosaic prescribed burning of low sagebrush by starting fire in mountain big sagebrush encroached by trees. The problem of tree encroachment into low sagebrush is, however, a more widespread problem in other regions of the Intermountain West, especially where a greater number of conifer species can encroach into low sagebrush.

Fourth, we assumed that fire exclusion was the source of more late-development closed mountain big sagebrush than expected under the NRV. This PNVT is close to becoming highly departed from the NRV and is important Greater Sage-grouse nesting and winter habitat. The 'typical' mountain big sagebrush can experience mean fire return intervals from 40 to 80 years (Burkhardt and Tisdale 1969, 1976; Houston 1973; Miller and Fowler 1994; Miller and Rose 1995; Miller *et al*. 2000; Crawford *et al*. 2004), which is a range consistent with the 50-year mean fire return interval used in the LANDFIRE VDDT model of the current project. The mountain big sagebrush PNVT on Mount Grant, however, is frequently found in elongated patches on concave landforms surrounded by large patches of low sagebrush (Fig. 3), which act as a fire break. We are uncertain, therefore, if the VDDT model for mountain big sagebrush is adequate or needs to be adjusted to reflect a naturally longer fire return interval caused by the spatial influence of low sagebrush, which could change the NRV. A prudent management approach given this uncertainty would be to conduct small, patchy prescribed burns to increase herbaceous and insect productivity for Greater Sage-grouse chick rearing and minimise the size of the early development vegetation class, which cannot be used as winter habitat by Greater Sage-grouse (Connelly *et al*. 2000; Crawford *et al*. 2004).

Conclusions

We implemented the local-scale FRCC methodology proposed by Shlisky and Hann (2003) to help Hawthorne Army Depot managers address their key resource management priorities for Mount Grant. Our analysis for Mount Grant used information not usually incorporated in published FRCC studies: interpreted NRCS soil surveys, high-resolution satellite imagery, and field visits to verify the interpretation of satellite imagery. Although soil surveys may not be readily available, high to moderate resolution imageries are available and field verification is generally feasible. The accuracy of these projects is limited by funding to purchase and, especially, analyse imagery and to pay field crews. The small investment we made in field visits before and after interpretation of imagery was probably the most important contribution to improve the accuracy of maps for Mount Grant. The greatest challenge to mapping FRCC is the development of the PNVT map, which should not be the current vegetation type map unless ecological systems are functioning naturally in the landscape of interest. In places where soil surveys or LANDFIRE products are not available, users will have little choice but to combine GIS modelling and current imagery to map PNVT. We found that local soil scientists who study the interaction between vegetation types and soil properties often have the best understanding of biophysical rules needed in GIS modelling for PNVT mapping. Soil scientists also work at a level of spatial analysis that is often finer than required by FRCC mapping; therefore, interdisciplinary teams that include a soil scientist, an ecologist with experience developing more general VDDT models, and a GIS and remote sensing expert are more likely to succeed in mapping PNVTs than any of these individuals working independently.

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Appendix II. Biophysical setting descriptions

LANDFIRE Biophysical Setting Model

Biophysical Setting: 1019sm Great Basin Pinyon-Juniper Woodland

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

General Information

Contributors (also see the Comments field) **Date** 7/14/2005

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Modeler 2			**Reviewer**		
Modeler 3			**Reviewer**		
			FRCC		

Vegetation Type

Upland Forest and Woodland

Dominant Species*

PIMO PUST
JUOS ARPA
CELE3 ARTE
SYOR ELEL5

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

12
17
13

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 mountain ranges of the Mojave Desert region and eastern foothills of the Sierra Nevada.

Biophysical Site Description

System typically found from 5500-8000 ft above the blackbrush (Coleogyne ramosissima) zone. This type generally occurred on most soil types and landforms, including fire-safe sites of steep and rocky slopes. 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 stony, cobbly, gravelly sandy loams to clay loam or clay.

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, Arctostaphylos pungens, Artemisia nova, Artemisia tridentata, Cercocarpus ledifolius, Cercocarpus intricatus, Coleogyne ramosissima, Purshia stansburiana, Ceanothuss greggii, Symphoricarpus oreophilus, Garrya flavescens, Yucca baccata, and bunch grasses Pseudoroegneria spicata, Achnatherum hymenoides, Elymus elymoides, and Poa fendleriana. Quercus gambelii and Quercus turbinella may be present. Sphaeralcea is a common forb.

Since disturbance was uncommon to rare in this ecological system and the overstory conifers may live several hundred years, patches were primarily composed of later seral stages (D; see below) 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. The age structure may vary from uneven to even aged. The overstory cover is normally less that 25%, although it can sometimes be higher (<50%) where pinyon

*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.

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. Replacement fires of a scale beyond a few trees were uncommon to rare (average FRI of 100-1000 yrs) and occurred primarily during extreme fire behavior conditions and during long droughts. Fire events may be caused by importation from adjacent shrub and grassland dominated vegetation of lower and higher altitudinal zones. 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.

Ethnobiological studies of Great Basin and Mojave Desert tribes (Fowler et al. 2003) describe the common use of fire for stimulating tobacco growth in the gaps between old pinyons and junipers, in addition to the common practice of roasting pine cones in pits. Burning for tobacco could be the source of surface fires in these systems and of fire scars.

Prolonged 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

This system occurs at lower elevations than Colorado Plateau Pinyon-Juniper Woodland (BPS 1016) where sympatric and is generally found at higher elevations than Inter-Mountain Basins Juniper Savanna (BpS 131115).

Due to livestock removal of grasses, thus competition for tree seedlings, and fire exclusion for more than a century, pinyon-juniper stands have experience densification. Older trees (>300 years) are surrounded by younger conical trees <100 years old. The shrubland matrix around these woodlands have also experienced invasion of pinyon and juniper, and the greater occurrence of crown fires that spread to true woodlands.

Two major modern issues, climate change and invasive plant species (especially annual grasses red brome and 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 annual grass component in the understory experience greater fire frequency, and result in more intense fire and greater spread. Moreover, fire from adjacent BpS invaded by annual grasses will spread more frequently into in BpS 1019, which is fire sensitive.

Since disturbance was uncommon to rare in this ecological system and the overstory conifers may live several hundred years, patches were primarily composed of later seral stages (D; see below) 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. The age structure may vary from uneven to even aged. The overstory cover is normally less that 25%, although it can sometimes be higher (<50%) where pinyon occurs.

Native Uncharacteristic Conditions

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

Cover greater than 60% of trees is uncharacteristic.

Scale Description

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

BpS 131019 occurs at scales of 10,000 acres, although the more common scale is 1000s of acres.

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 a maximum of 1000's acres. This type may also have mixed-severity fires of 10-100's of acres.

Issues/Problems

There is much uncertainty in model parameters, particularly the fire regime. 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, perhaps of Native American origin, 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 1019sm is very similar to BpS 1310190 except that mixed severity fire was dropped to reflect new fire severity definitions from LANDFIRE. The Natural Range of Variability did not change.

BpS 131019 for the Majove Desert is based on modifications of BpS 171019, developed by Peter Weisberg (pweisberg@cabnr.unr.edu) for the Great Basin and reviewed by Louis Provencher (lprovencher@tnc.org). Modifications to model 171019 for MZ 13 included species composition, biophysical gradients, lumping classes D and E because these were structurally hard to distinguish by satellite and their dynamics were nearly identical. The insect/disease rate was changed to 1/1000 from 2/1000 for class B because it was observed that outbreaks are rare in younger stands. The reviewer added one forb species to Vegetation Description and corrected one typographical error.

BpS 171019 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 closed. Replacement fire occurs every 300 yrs on average.

Indicator Species* and Canopy Position

ELEL5 Mid-Upper
SPHAE Upper
ZIPA2 Mid-Upper
POFE Mid-Upper

Upper Layer Lifeform

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

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	30 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

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

Class B 5 %

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. It is important to note that replacement fire at this stage does not eliminate perennial grasses.

Indicator Species* and Canopy Position

ARTR2 Upper
ARPU5 Middle
PIMO Lower
JUOS Lower

Upper Layer Lifeform

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

Fuel Model 5

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	30 %
Height	Shrub 0m	Shrub 3.0m
Tree Size Class	None	

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

Class C 25 %

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. It is important to note that replacement fire at this stage does not eliminate perennial grasses.

Indicator Species* and Canopy Position

PIMO Upper
JUOS Upper
ARTR2 Middle
CELE3 Middle

Upper Layer Lifeform

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

Fuel Model 5

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	20 %
Height	Tree 0m	Tree 10m
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 is 10-40%. Height is 0.5-3m.

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Mortality from insects, pathogens, and drought occurs at a rotation of approximately 1000 yrs and cause a transition to class B by killing older trees.

Class D **65 %**

Late Development 1 Open

Description

Community dominated by young (<300 yrs) to old (>300 yrs) junipers and pines of mixed age structure. Juniper and pinyon becoming competitive on site and beginning to affect understory composition. Duration 800 years unless replacement fire (average FRI of 1000 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
CELE3	Middle
ARTR2	Middle

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	20 %	60 %
Height	Tree 5.1m	Tree 10m
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 1 Closed

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

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

Disturbances

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

Fire Regime Group:** 3

Historical Fire Size (acres)

Avg 10

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	400	100	1000	0.0025	80
Mixed					
Surface	1666	5	1000	0.00060	19
All Fires	322			0.00311	

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: 1020sm — **Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland**

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

General Information

Contributors (also see the Comments field) **Date** 7/14/2005

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Modeler 3			**Reviewer**		
			FRCC		

Vegetation Type

Upland Forest and Woodland

Dominant Species*

PILO ARTR
PIFL2 ARAR
RIBES
SADO

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16
12
17
13

Model Zones

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

Geographic Range

Dry wind-swept ridges, mountain slopes, and exposed upper elevations of Nevada, Utah, southern Idaho and eastern California.

Biophysical Site Description

Elevation ranges from 9,000 to 12,500 feet on mid to upper slopes. These areas are typically in rain shadows, and are the dry and cold extent of tree cover. Stands occur on both thin, stony soils (south aspects and high wind swept ridges) and deep colluvial soils on northerly aspects, and open slopes with minimal ground cover.

Vegetation Description

Pinus longaeva and Pinus flexilis can exist separately or as mixed stands. Pure stands of P. longaeva are found at the highest elevations. Sparse understory of forbs, grass and short shrubs. Understory species include Artemisia tridentata, A. arbuscula, Ribes montigenum, R. cereum, and Ericameria compacta. Carex rossii is a common graminoid. Seed dispersal of limber and bristlecone pines highly dependent on seed-caching birds.

Disturbance Description

This group contains some of the oldest trees in the area, with Pinus longaeva 1000 years old or more (up to 6,000 years documented) and Pinus flexilis ages of 500+ years. Understories are often sparse, with little fine fuel to carry fires across the surface. On windswept and south aspects, the lack of fine fuels to the complete absence of surface fire. Fire occurrence is typically low frequency and surface fires (mean FRI of 500+ years). In the absence of wind, fires are likely limited in extent (2 acres or less). Fires greater than 0.1 acre in size are mostly on north aspects. Stand replacement fires (mean FRI of 1000 years) are usually wind-driven, especially in older stands (class C). Susceptible to bark beetles (esp. Pinus flexilis), but generally drought-

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tolerant.

Adjacency or Identification Concerns

A new and uncharacteristic disturbance is the potential for the introduction of white pine blister rust in both of these species. Blister rust is not yet occurring in the Utah High Plateau, western Great Basin, and Mojave Desert. Note: blister rust has been found in NV in PIAL. Surveys in 2004 in NV bristlecone found no blister rust in PILO.

Native Uncharacteristic Conditions

Cover of native trees greater than 50% is considered uncharacteristic.

Scale Description

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

Stands vary from tens to thousands of acres in size. Stand replacement fires of 1/10th acres to 100 acres have been experienced.

Issues/Problems

Comments

BpS 131020 was based on BpS 171020 by Julia Richardson (jhrichardson@fs.fed.us) and Cheri Howell (chowell02@fs.fed.us). Modifications for BpS 131020 were for species composition (PIEN, PIAL, and PSEUD7 are not present), geographic range, and landform/soil position. Comments by one reviewer caused editorial and model changes: 1) Artemisia tridentata and A. arbuscula were added as important shrub species. 2) Upper elevation was increased to 12,500 ft. 3) Deleted sentences about endemism in the Spring Mountains because high endemism is unique to these mountains. 4) Increased the age of Pinus longaeva to 6,000 yrs. 5) Added comments about the important role of aspect and position on fuel loads and fire regimes and size. 6) Duration of classes A and B were increased by 50 yrs (reviewer suggested 100 yrs but this made the HRV even less desirable) and increased duration of all FRIs, especially in class A. These changes reduced the percentage of class A from 20% to 15%. This also caused a change from FRG III to V. The other reviewer added understory species to Vegetation Description and suggested no other changes.

BpS 171020 was adopted with minor edits on species composition from the mapzone 16 version created by Bruce Short (bshort@fs.fed.us), Stanley Kitchen (skitchen@fs.fed.us), and Linda Chappell (lchappell@fs.fed.us).

For mapzone 16, BPS 1057 was included in BPS 1020 as both are ecologically similar and have very small coverage.

Vegetation Classes

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Class A 15 %

Early Development 1 All Stru

Description

Bare ground and talus with sparse ground cover of forbs, grasses and low shrubs. Occasional old survivors may be present. Infrequent stand replacement fires (mean FRI of 1000 years) will setback succession to age zero. Surface fire (mean FRI of 1000 years) and weather-related stress affect this class, but without consequences to dynamics. Succession to class B after 150 years.

Indicator Species* and Canopy Position

PILO All
PIFL2 All
ARTR2 Low-Mid
ARAR8 Lower

Upper Layer Lifeform

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

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	40 %
Height	Shrub 0m	Shrub >3.1m
Tree Size Class	Sapling >4.5ft; <5"DBH	

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

Cover of trees will be <10% with heights <5m.

Class B 15 %

Mid Development 1 Open

Description

Open woodland < 40% crown closure of seedlings, saplings, and survivors. The only disturbances are surface and replacement fires with replacement and surface FRIs, respectively, of 1,000 and 500 years. Succession to class C after 200 years.

Indicator Species* and Canopy Position

PILO Upper
PIFL2 Upper
ARTR2 Low-Mid
ARAR8 Lower

Upper Layer Lifeform

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

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	40 %
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:

Class C 70 %

Late Development 1 Open

Description

Open woodland < 40% crown cover of mixed diameters- 40" dbh to seedling. Sparse ground cover of grasses and low shrubs. Very old trees can develop in this class. Fire frequency and severity as in previous class B.

Indicator Species* and Canopy Position

PILO Upper
PIFL2 Upper
ARTR2 Low-Mid
ARAR8 Lower

Upper Layer Lifeform

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

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	40 %
Height	Tree 5.1m	Tree 10m
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 Open

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

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 5

Min 1

Max 1000

Sources of Fire Regime Data

- ☑ Literature
- ☑ Local Data
- ☐ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	1000			0.001	34
Mixed					
Surface	526			0.00190	65
All Fires	345			0.00291	

Fire Intervals (FI):

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

Additional Disturbances Modeled

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

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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: **1052sm** **Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland**

☑ *This BPS is lumped with: 131051*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 7/14/2005

Modeler 1	Jim Hurja	jhurja@fs.fed.us	**Reviewer**	Michele Slaton	mslaton@fs.fed.us
Modeler 2			**Reviewer**	Jan Nachlinger	jnachlinger@tnc.org
Modeler 3			**Reviewer**		
			FRCC		

Vegetation Type

Upland Forest and Woodland

Dominant Species*

ABCO	PILO
PIFL2	CELEI
PIP0S	JUSC2
POTR5	RIBES

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16
17
12
13

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 and high elevations of the Mojave Desert (MZ 13). Well represented in the Spring Mountains of southern Nevada.

Biophysical Site Description

Elevations range from 2100 to 3000 m. Occurrences of this system are found on cooler sites, which include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions and north- and east-facing slopes.

Vegetation Description

Abies concolor is most common canopy dominant, but Pinus flexilis and Pinus ponderosa are also co-dominants. Long FRIs of this system favor a mixed conifer composition. Pinus longeava may be present. This is truly a mixed conifer system with little bristlecone pine. This system includes small mixed conifer/Populus tremuloides stands on more cooler sites (but see Adjacency/Identification Concerns). Juniperus scopulorum is present as a midstory tree. A number of cold-deciduous shrub species can occur, including Cercocarpus ledifolius var intermontanus (CELEI4), Acer glabrum, Cornus serecea, Ribes cereum, Juniper communis, Holodicus spp., and Symphoricarpus oreophilus. Herbaceous species include Carex rossii, Bromus ciliatus, Pseudoroegneria spicata, Elymus, elymoides, Poa fendleriana, Erigeron spp, Astragulus spp, Luzula parviflora, 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 (selected) 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 of ponderosa pine and the more stand replacement regimes

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common in high elevation pine and fir ecosystems.

Surface fire and mixed severity fire intervals were about 35 to 100 years (Brown et al. 1994). Stand replacement fires occurred at intervals of 150 to 400+ years (Crane 1986; Barrett 1988; Bradley 1992a,b; Brown et al. 1994; Morgan et al. 1996). For MZ 13, the high end of these ranges was chosen and, in some cases, the FRIs were doubled compared to values for MZ 12 and 17 (Great Basin). Likelihood of stand replacement fires increased with canopy closure and fuel ladders caused by white fir growth.

Other disturbances included insect, disease, drought, and wind and ice damage. Fire was by far the dominant disturbance agent, and fire activity increases with drought and insects.

Adjacency or Identification Concerns

This ecological system is in the elevation belt between Southern Rocky Mountain Ponderosa Pine Woodland (BpS 1054) and Inter-Mountain Subalpine Limber-Bristlecone Pine Woodland (BpS 1020), as in the Spring Mountains of southern Nevada near Las Vegas (Nachlinger and Reese 1996). BpS 131052 is not a small system (patch size of 100 to 1000's acres).

Bps 131051, Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodlands, was lumped with BpS 131052 because it is a very small component of the landscape and, depending on aspect, completely intermingled within BpS 1052, thus probably not mappable. BpS 131151 is considered rare in the Mojave Desert. Douglas-fir, an important component of BpS 1051, is absent. The SW REGap mapped 131151 in the Spring Mountains exactly where BpS 131054 is found, which is ponderosa pine woodlands. The Spring Mountains are well known for their relatively pure ponderosa pine stands with shrubby understories. When mixed conifers occur, such as on the Spring Mountains, they are mesic and harbor aspen. White fir, limber pine, and ponderosa pine are found in equal amounts, with some bristlecone pines increasing in importance with elevation.

This system includes small patches of mixed conifer/Populus tremuloides (aspen) stands (much smaller than the mixed conifer component). If aspen is present in large patches and soils show a clear organic layer, BPS 1061 Intermountain Basins Aspen-Mixed Conifer Forest and Woodland should be used. For MZ 13, BpS 131061 was added to the list of Biophysical Settings based on Nachlinger and Reese's (1996) description of Aspen/White Fir communities associated with avalanche chutes and riparian corridors in the Spring Mountains. It is not clear whether BpS 131061 was more widespread during pre-settlement and replaced by BpS 131052 during the last century because of fire suppression and the association of aspen with riparian corridors and avalanches. Observation shows that avalanches and snow creep may be dominant disturbances and these occur regardless of fire suppression. Also, is not evident that Native American burning was prevalent in these small aspen communities.

Native Uncharacteristic Conditions

Native tree cover can reach 100% and remains characteristic of the pre-settlement condition.

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. Fire size is between 10 and 1000 acres.

Issues/Problems

Time Since Disturbance has a strong effect on the calculated Historic Range of Variability (HRV). We chose a period matching one fire cycle.

There is little data on this system in the Mojave Desert, except the description by Nachlinger and Reese

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(1996). FEIS describes results from other zones and completely lacks data from Nevada, especially southern Nevada, on some topics.

Comments

BpS 131052 was based on modifications to BpS 171052. Species were changed for the Mojave Desert, biophysical gradients simplified, and all FRI increased, sometimes doubled. For example, the conifers ABLA, PIEN, PSEUD7, and PICO are generally absent in the Mojave Desert. The maximum FRI for surface and mixed severity fire was increased to 100 from 50 years and the minimum FRI for replacement was increased to 150 years from 125 years. Moreover, the Time Since Disturbance in the late-development open class was increased to 65 from 35 years to reflect the longer FRIs of the Mojave Desert. Consequently, the FRG for BpS 131052 was changed to III from I.

Two experts reviewed the BpS for mapping zone 13. One reviewer, who once worked in this system in the Spring Mountains, made no changes. The second reviewer, less familiar with the type, recommended rejecting the BpS and replacing it with ponderosa pine woodland at the low end and bristlecone/limper pines at the high end. The main reason for rejection was the transitional nature of the BpS among ponderosa pine, seral aspen, and bristlecone/limber pines. The perception of the transitional nature of this system may be incorrect; in the Spring Mountains, where this system is most present, BpS 131052 is common and extensive, and does not contain much bristlecone (thus not BpS 131020), which is really at higher elevations. In response, the word "transitional" was removed from the text and BpS 1052 was described as occupying the elevation belt between BpS 131054 and 131020. The reviewer also thought that the presence of aspen in the BpS (part of the NatureServe description) warranted rejecting the model and using BpS 131061. The decision to pull out larger patches of seral aspen (BpS 1061) in avalanche chutes and cool/wet corridors (very small area of the total system) from BpS 1052 had already been made, but aspen remains present in this system. The reviewer wanted citations from the Great Basin and Mojave Desert; these are rare (nothing at FEIS) but the Nachlinger and Reese (1996) study from the Spring Mountains was added. This model was based on dynamics appropriate to MZ 13 and based on a Great Basin version (somewhat tailored for the White Mountains and Snake Range in the Great Basin) that was itself modified from a general model more applicable to the northern Great Basin region (ID, UT, and northern NV). Each adaptation caused generally longer FRIs and a change in species composition. The reviewer also suggested increasing the FRI compared to those of BpS 121052; this was not done because some FRIs were already doubled compared to those for MZ 12 and 17.

BpS 171052 was adopted with minor edits on species composition from the mapzone 16 version created by Mark Loewen (mloewen@fs.fed.us), Doug Page (doug_page@blm.gov) and Beth Corbin (ecorbin@fs.fed.us). Further review is needed to make sure this type is appropriately described for zones 12 and 17 - especially species occurrence.

This model was originally coded as R2PSMEnr and was changed to R2PSMEms on 12/13/2004 by Lynn Bennett (lmbennett@fs.fed.us). This model was changed into BPS 1052 by Mark Loehen, Doug Page, Beth Corbin, and Linda Chappell on 3/3/05. Reviewers of R2PSMEms were: Hugh Safford (hughsafford@fs.fed.us), Steve Barrett (sbarrett@mtdig.net), and Clinton K Williams (cwiliam03/@fs.fed.us).

Vegetation Classes

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

Class A **10 %**

Early Development 1 All Stru

Description

Tree seedling-shrub-grass-forb. Moderate to high herbaceous cover. Shrubs and trees species that resprout are Symphoricarpos oreophilus, Ribes, Populus, and Holodiscus. Succession to B after 30 yrs unless replacement fire occurs (average FRI of 120 yrs). Mixed severity fire (FRI of 50 yrs) occurs but does not change the successional age.

Indicator Species* and Canopy Position

SYMPH Mid-Upper
PIPO Upper
HOLO Mid-Upper
POTR5 Upper

Upper Layer Lifeform

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

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
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:

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 similar amounts of white fir, ponderosa pine, and limber pine. 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
PIPO Upper
PIFL2 Upper

Upper Layer Lifeform

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

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	31 %	100 %
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:

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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 %**

Mid Development 1 Open

Description

Forest canopy closure is <35%. Open pole-sapling/ grass scattered shrubs, maybe 90% white fir and fire resistant ponderosa pine. 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 open late-development after 70 years. Stand replacement fire occurs on average every 400 yrs.

Indicator Species* and Canopy Position

ABCO	Upper
PIPO	Upper
PIFL2	Upper

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 10m
Tree Size Class	Medium 9-21"DBH	

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

Class D **35 %**

Late Development 1 Open

Description

Forest canopy closure is < 35%. Open large tree/ grass and scattered shrubs. Mixed conifers with more fire-resistant types dominant; ponderosa pine and limber pine. White fir present to abundant. 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 65 years without fire, existing trees will fill out the stand and cause succession to the late closed condition (E).

Indicator Species* and Canopy Position

PIPO5	Upper
PIFL2	Upper
ABCO	Upper

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	30 %
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:

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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 **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 D and 40% to class C.

Indicator Species* and Canopy Position

ABCO	Upper
PIPO	Upper
PIFL2	Upper

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 10

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:

Disturbances

Fire Regime Group:** 3

Historical Fire Size (acres)

Avg 100
Min 10
Max 1000

Sources of Fire Regime Data

☑ Literature
☐ Local Data
☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	212	120	400	0.00472	18
Mixed	192	35	50	0.00521	20
Surface	64	35	50	0.01563	61
All Fires	39			0.02555	

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: **1054sm** **Southern Rocky Mountain Ponderosa Pine Woodland**

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

General Information

Contributors (also see the Comments field) **Date** 9/1/2005

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Modeler 2			**Reviewer**		
Modeler 3			**Reviewer**		
			FRCC		

Vegetation Type

Upland Forest and Woodland

Dominant Species*

PIPO SYLO
ABCO PSSP6
PIFL POFE
ARPU CELEI

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

16
12
17
13

Model Zones

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

Geographic Range

BpS is found on a few ranges in the Great Basin and Mojave Desert, and southern Utah High Plateau.

Biophysical Site Description

These woodlands occur at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from 1700 m to 2200 m in MZ 13. Occurrences are found on all slopes and aspects, however, moderately steep to very steep slopes or ridgetops are most common. This ecological system generally occurs on igneous, metamorphic, and sedimentary material derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acid pH, an abundance of mineral material, rockiness, and periods of drought during the growing season.

Vegetation Description

Pinus ponderosa is the predominant conifer; Pinus monophylla, Abies concolor, and Juniperus spp may be present in the tree canopy. The understory is usually shrubby with Artemisia nova, Artemisia tridentata, Arctostaphylos pugens, Cercocarpus ledifolius var. intermontanus, Purshia stansburiana, Ribes cereum, Purshia tridentata, Quercus gambelii, Symphoricarpos spp., Amelanchier utahensis, and Rosa spp. Common grass species include Pseudoroegneria spicata and species of Hesperostipa, Achnatherum, Hymenoides, and Poa fendleriana.

Disturbance Description

These sites are in a Fire Regime Group I. Some portions of these sites are transition zones to Fire Regime Groups II and III. Frequent low severity fires (FRG I) were the common fire regime characteristics (Bradley, 1992), with mixed severity being predominant (as in group III) due to the presence of shrubs with a MFRI of less than 35 years. Surface fire intervals ranged from 10 to 50 years, and replacement severity occurred at

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intervals of 150 to 400+ years (Brown, 2000; Crane, 1986; Bradley, 1992a; Bradley, 1992b; Barrett, 1988; Morgan et al, 1996; Brown, 1994). Stand replacement fires were generally restricted to the closed canopy forest and the stand initiation conditions. Topography (aspect, substrate depth, slope, position, etc.) exerted strong control over fire behavior producing spatially and temporally mixed severity regimes.

Bark beetle outbreaks are highly related to stand density. Denser stands in relation to site capacity will favor outbreaks, which will decrease as trees are thinned.

Adjacency or Identification Concerns

This ecological system is often transitional between pinyon-juniper woodlands at lower elevations and white fir/limber pine/ponderosa pine (BpS 131052) at higher elevations. It is usually found on sites that are dry montane with a variety of slopes, aspects, and soil conditions. If a large component of aspen is present, model BpS 131061 should be used.

Native Uncharacteristic Conditions

Ponderosa pine cover greater than 60% is uncharacteristic. When ponderosa pine is encroached by white fir

Scale Description

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

BpS is found throughout the Great Basin and in southern Nevada (Spring Mountains and Sheep Range) of the Mojave Desert, although it is not common. Patch size is mostly 10-100 acres with 1,000 acres less common. Fires will be restricted to these sizes and may spread to surrounding other types.

Issues/Problems

Ponderosa pine woodlands and savannas should be better researched for the Great Basin and Mojave Desert. Many scattered PIPO patches were completely logged during the mining era of 1850-1900 and during the railroad construction era throughout the western USA. Old sawmill structures in the Sheep Range indicate past logging close to extant ponderosa pine stands. It is also thought that the dominance of shrubs in understories is greater today than during pre-settlement because livestock grazing greatly reduced grasses in the southern portion of the Great Basin and Mojave Desert, but there is no quantitative or recorded evidence to support this plausible notion.

Southwest ReGap completely misidentified this BpS for BpS 1051.

Comments

BpS 131054 is essentially BpS 171054 (and 121054) developed by Julia H. Richardson (jhrichardson@fs.fed.us). Most modifications to BpS 171054 for MZ 13 were about species composition.

BpS 171054 (and 121054) was adopted from the mapzone 16 version created by Mark Loewen (mloewen@fs.fed.us), Doug Page (doug_page@blm.gov), Beth Corbin (ecorbin@fs.fed.us), and Linda Chappell (lchappell@fs.fed.us).

For MZ 16, 12, and 17, this ecological system includes much of the dry Douglas-fir (not in MZ 13) and/or white fir and ponderosa pine ecosystems. Original model was Rapid Assessment model R2PPDFcp by Lynn Bennett (lmbennett@fs.fed.us) modified for BPS 1054. R2PPDFcp was reviewed by Stanley G. Kitchen (skitchen@fs.fed.us) and Clinton K. Williams (cwilliams03/@fs.fed.us).

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
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Class A 10 %

Early Development 1 All Stru

Description

Openings with grass, shrub, and forbs created after replacement fire. May have seedlings of ponderosa pine or other species (e.g., white fir). Succession to class C after 40 yrs. Replacement fire every 100 years.

Indicator Species* and Canopy Position

PIPO	Upper
CELEI4	Upper
SYOR	Upper
POFE	Lower

Upper Layer Lifeform

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

Fuel Model 5

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	60 %
Height	Shrub 0m	Shrub 3.0m
Tree Size Class	Pole 5-9" DBH	

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

Class B 9 %

Mid Development 1 Closed

Description

Forest canopy closure is 35% or greater. Closed pole- sapling/ grass and shrubs. Shrub cover can be dense. Replacement fire occurs every 150 yrs on average. Mixed severity fire (FRI of 25 yrs) will open stand structure, thus causing a transition to class C. Surface fire is considered unlikely in dense stands with shrubs acting as fuel ladders.

Indicator Species* and Canopy Position

PIPO	Upper
PIMO	Mid-Upper
CELEI4	Low-Mid
ABCO	Mid-Upper

Upper Layer Lifeform

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

Fuel Model 5

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	60 %
Height	Tree 0m	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 20 %

Mid Development 1 Open

Description

Forest canopy closure is <35%. Open pole-sapling/ grass and shrubs. Ponderosa pine dominates with white fir and limber pine present. Replacement fire every 400 yrs causes a transition back to class A, whereas surface fire (FRI of 25 yrs) and mixed severity fire (FRI of 35 yrs) maintain the open structure of the class. Without fire, the stand will transition to the closed condition (class B) after 25 years.

Indicator Species* and Canopy Position

PIPO	Upper
ABCO	Upper
CELEI4	Low-Mid
PSSP6	Lower

Upper Layer Lifeform

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

Fuel Model 9

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	30 %
Height	Tree 0m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

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

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

Class D **60 %**

Late Development 1 Open

Description

Forest canopy closure is <35%. Open large trees / grass and shrubs. Ponderosa eventually outnumbers white fir due to insect/disease and difference in fire resistance. Limber pine becomes codominant with ponderosa pine. Rare transition to class A is caused by replacement fire every 400 yrs. Surface fire (FRI of 20 yrs) and mixed severity fire (FRI of 35 yrs) maintain vegetation in class D indefinitely. Without fire for 50 yrs, vegetation will close and transition to class E.

Indicator Species* and Canopy Position

PIPO	Upper
PIFL	Upper
POFE	Lower
PSSP6	Lower

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	30 %
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:

Class E **1 %**

Late Development 1 Closed

Description

Forest canopy closure is 35% or greater. Closed large, trees, poles, saplings, and shrubs. Replacement occurs every 150 yrs on average. Mixed severity fire (FRI of 20 yrs) and mountain pine beetle outbreaks (every 50 years on average) will return vegetation to class D. This class is maintained indefinitely in the absence of disturbance.

Indicator Species* and Canopy Position

PIPO	Upper
PIFL	Upper
ABCO	Upper
SYOR	Lower

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	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:** 1

Historical Fire Size (acres)

Avg 100
Min 1
Max 200

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	256	150	400	0.00391	6
Mixed	39	10	35	0.02564	39
Surface	28	10	50	0.03571	55
All Fires	15			0.06526	

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

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Steele, R., R. D. Pfister, R. A. Ryker, and J. A. Kittams. 1981. Forest Habitat Types of Central Idaho. USDA For. Serv. Tech. Rep. INT-114, 138 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401

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LANDFIRE Biophysical Setting Model

Biophysical Setting: **1061sm** **Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland**

☑ *This BPS is lumped with: 131011*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 9/21/2005

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Modeler 3			**Reviewer**		
			FRCC		

Vegetation Type

Upland Forest and Woodland

Dominant Species*

POTR	SYOR
ABCO	ROWO
AMAL	CARO
PRVI	BRCI2

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

12
17
13

Model Zones

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

Geographic Range

Although this BpS is widespread in the west, it occurs infrequently on cool upper montane chutes and slopes of MZ 13.

Biophysical Site Description

Elevations range from 2100 to 3000 m (approx. 5900-9850 feet). Occurrences of this system are found on cooler sites, which include avalanche chutes, cooler northerly slopes, and drainages. Soils are derived from alluvium, colluvium and residuum from a variety of parent materials but most typically occur on sedimentary rocks.

Vegetation Description

The tree canopy is dominated by Populus tremuloides. With time and lack of fire or stand replacing disturbances, Populus tremuloides is slowly reduced until the conifer species become dominant. Conifers include mostly Abies concolor and minor occurrences of Pinus flexilis and Pinus ponderosa (Nachlinger and Reese 1996). A number of cold-deciduous shrub species can occur, including Acer glabrum, Ribes cereum, Juniper communis, Holodicus spp., and Symphoricarpus oreophilus. Herbaceous species include Carex rossii, Bromus ciliatus, Elymus elymoides, Erigeron spp, Astragalus spp, Luzula parviflora, and Thalictrum fendleri.

Disturbance Description

This is a strongly fire adapted community 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. 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

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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 drainage, 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).

BPS 131061 has elements of Fire Regime Groups II (chosen), III, and IV. Mean FRI for replacement fire is every 60 years and 120 years on average, respectively, before and after severe conifer encroachment, except during early development where no fire is present. The FRI of mixed severity fire increases from 40 years in stands <80 years to 50 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 of 1000 yrs), whereas 80% of outbreaks would thin older trees >40 yrs (average return interval 250 yrs). Older conifers (>100 years) would experience insect/diseases damage about every 50 years causing 60% of times stand thinning and 40% of times total mortality of conifers. Occasional weather-related stress every 200 yrs will thin the older conifers.

Sites in MZ 13 are prone to snowslides, mudslides, and rotational slumping. Flooding may also operate in these systems. Uncertainty exists about the return interval of avalanches. We assumed that avalanches/flood events caused stand replacement every 50 yrs on average. Sufficient snow accumulates about every 10 yrs in the Mojave Desert and the chance that an avalanche returns to the same coulee was assumed be one out of 5 snow years. For the youngest vegetation class, only very powerful avalanches about every 100 yrs would cause stand replacing events.

Adjacency or Identification Concerns

This BpS is adjacent to BpS 131054, Southern Rocky Mountain Ponderosa Pine Woodlands, and BpS 1052, Rocky Mountains Mesic Montane Mixed Conifer Forest and Woodlands, which may contain isolated stems and small patches of aspen. This type is highly threatened by conifer replacement.

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 30% aspen cover in classes B, C, and D is uncharacteristic and likely due to excessive native or liv

Scale Description

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

This type occurs as small linear drainage corridors and avalanche chutes from 1-10 acres.

Issues/Problems

For MZ 13, it is not clear to what extent Native American burning maintained this system which is small and associated with the disturbance regimes of avalanche chutes and steep slopes, and small riparian corridors. Without frequent Native burning, model results would change.

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

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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 131061 is closely based on BpS 121061 (and 171061) developed by Julia H. Richardson (jhrichardson@fs.fed.us) and Louis Provencher (lprovencher@tnc.org). Changes made to BpS 131061 were 1) species composition was modified to resemble more the Spring Mountains, 2) geography restricted, 3) biophysical gradients were narrowed to cooler steep slopes and drainages, 4) classes D and E (including disturbances) were replaced, respectively, by classes B and E from BpS 131052, and 5) stand replacing avalanches/flooding were added to all vegetation classes.

BpS 1061 for MZ 12 and 17 was 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.

Vegetation Classes

Class A 25 %

Early Development 1 All Stru

Description

Tree seedling-shrub-grass-forb. Moderate to high herbaceous cover. Shrubs and trees species that resprout are Populus termuloides, Symphoricarpos oreophilus, Ribes, and Holodiscus. Generally, this is expected to occur 1-3 years post-disturbance. Fire is absent and succession occurs to class B after 10 years. Avalanches or flood events with an average return interval of 100 yrs maintain this class.

Indicator Species* and Canopy Position

POTR5	Upper
SYOR2	Middle
RIBES	Middle
HOLO	Middle

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
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 50 %

Mid Development 1 Closed

Description

Aspen saplings over 6' tall dominate. Canopy cover is highly variable. Replacement fire occurs every 60 yrs on average. Mixed severity fire (average FRI of 40 yrs) does not change the successional age of these stands, although this fire consumes litter and woody debris and may stimulate suckering. Avalanches or flood events with an average return interval of about 50 yrs cause stand replacement. Succession to class C after 30 years.

Indicator Species* and Canopy Position

POTR Upper
SYOR2 Low-Mid
RIBES Low-Mid

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	40 %	100 %
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 15 %

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 thinning some trees, promotes suckering and maintains vegetation in this class. Insect/disease 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. Avalanches or flood events with an average return interval of 50 yrs cause a transition to class A. Fire will maintain vegetation in the class; otherwise conifer encroachment causes an alternate succession to class D after 40 years.

Indicator Species* and Canopy Position

POTR Upper
SYOR2 Middle
RIBES Middle

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	40 %	100 %
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:

---

*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 **9 %**

Late Development 2 Closed

Description

Forest canopy closure is >35%. This class includes closed trees, sapling, large poles, grass and scattered shrubs. Aspen is dominant but being encroached by conifers. Composition of conifers consists of similar amounts of white fir, ponderosa pine, and limber pine. Primary succession is to class E, the closed late development condition after 30 yrs. Mixed severity fire (FRI of 50 yrs) kills most conifers, especially white fir, thus causing a transition to class C. Insects/disease (50 years mean return interval) cause minor mortality to this stage. Avalanches or flood events with an average return interval of 50 yrs and replacement fire (FRI of 60 yrs) cause a transition to class A.

Indicator Species* and Canopy Position

POTR	Upper
ABCO	Mid-Upper
PIPO	Mid-Upper
PIFL2	Middle

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	90 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

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

Class E **1 %**

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). 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 D and 40% to class C. Avalanches or flood events with an average return interval of 50 yrs cause a transition to class A.

Indicator Species* and Canopy Position

ABCO	Upper
PIFL2	Upper
PIPO	Upper
POTR	Mid-Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	90 %
Height	Tree 25.1m	Tree 50m
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.

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	80	50	300	0.0125	41
Mixed	55	10	50	0.01818	59
Surface					
All Fires	33			0.03069	

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) avalanche/flood
☑ Wind/Weather/Stress ☐ Competition ☐ Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting: **1310620** **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** 10/21/2005

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

Vegetation Type

Upland Forest and Woodland

Dominant Species*

CELE3	PIMO
ARTR	HYCO
PUTR2	ELEL5
SYMP	JUOS

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

16
12
17
13

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). Found on the mountains ranges of the Mojave Desert.

Biophysical Site Description

Curlleaf mountain mahogany (Cercocarpus ledifolius var. intermontanus) communities are usually found on upper slopes and ridges between 1940 m to 2,950 m (average 2,355 m) of elevations (Nachlinger and Reese 1996, NRCS 2003). Curlleaf mountain mahogany stands occur on many aspects, but southwestern slopes are more common. Slope ranges from 3-35 degrees. Most stands occur on rocky shallow soils and outcrops, with mature stand cover between 10-55%. In the absence of fire, old stands may occur on somewhat deeper soils, with more than 55% cover.

Vegetation Description

Curlleaf mountain mahogany (Cercocarpus ledifolius var. intermontanus) is dominant. Singleleaf pinyon (Pinus monphylla), Utah juniper (Juniperus osteosperma), big sagebrush (Artemisia tridentata), snowberry (Symphoricarpos spp), and Cooper's rubberweed (Hymenoxys cooperi) 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 spp.) 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. Black sagebrush is infrequently associated. White fir, ponderosa pine, and limber pine may be present, with less than 10% total cover.

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

Disturbance Description

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 disturbance. Fires are not common in early seral stages, when there is little fuel, except in chaparral. Replacement fires (mean FRI of 150-500 yrs) become more common in mid-seral stands, where herbs and smaller shrubs provide ladder fuels. By late succession, two classes and fire regimes are possible depending on the history of mixed severity and surface fires. In the presence of surface fire (FRI of 50 yrs) and past mixed severity fires in younger classes, the stand will adopt a savanna-like woodland structure with a grassy and shrubby understory. Trees can become very old and will rarely show fire scars. Without past mixed severity or surface fires, herbs and small forbs will be nearly absent from late, closed stands. Replacement fires will be uncommon (FRI of 500 yrs), requiring extreme winds and drought, because thick duff provides fuel for more intense fires. Mixed severity fires (mean FRI of 50-200 yrs) are present in all classes, except the late closed one, and more frequent in the mid-development classes.

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

Adjacency or Identification Concerns

In the Mojave Desert, BpS 131062 is adjacent or intermingled with BpS 131019, Great Basin Piynon-Juniper Woodlands. Nachlinger and Reese (1996) always describe curlleaf mountain mahogany as part of the Pinus monophylla-Cercocarpus ledifolius var. intermontanus/Artemisia tridentata association for the Spring Mountains. On this mountain range, curlleaf mountain mahogany is also associated with white fir (BpS 131052) and ponderosa pine (BpS 131054) (Nachlinger and Reese 1996).

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 big sagebrush types, now uncharacteristic because of fire exclusion.

Native Uncharacteristic Conditions

Cover greater than 70% is uncharacteristic.

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 scale, and are spatially separated from each other by other communities that occur on different aspects or soil types. A few curlleaf mountain mahogany stands may be much larger than 100 acres.

Issues/Problems

Data on intense native grazing of mahogany seedlings are lacking, but consistently observed by experts in the Great Basin; in the model, only class A had a reversal of woody succession of -20 for native grazing, whereas effect was specified for classes B and C, which do not have many seedlings. It is not clear how well seedling herbivory carries to the Mojave Desert.

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

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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 131062 was adapted from BpS 171062 (same as 121062) 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). Major changes to adapt to MZ 13 were changes in species composition and biophysical site description. The model from MZ 12 and 17 was maintained.

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 modification (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). BPS 1062 for mapping zone 16 was based on R2MTMA with moderate revisions to the original model. Current description is close to the 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.

Vegetation Classes

Class A 10 %

Early Development 1 All Stru

Description

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

Indicator Species* and Canopy Position

CELE3 Upper
ARTR2 Upper
CHRYS Upper
SYMPH Upper

Upper Layer Lifeform

☐ Herbaceous
☑ Shrub
☐ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	70 %
Height	Shrub 0m	Shrub 3.0m
Tree Size Class	None	

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

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**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.

mixed severity (average FRI of 100 yrs), and native herbivory (2 out every 100 seedlings) of seedlings all affect this class. Replacement fire and native herbivory will reset the ecological clock to zero. Mixed severity fire does not affect successional age. 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 can result in either maintenance (mean FRI of 80 yrs) in the class or a transition to Class D (mean FRI of 200 yrs). Succession to class E after 90 years.

Indicator Species* and Canopy Position

CELE3 Upper
ARTR2 Mid-Upper
PUTR2 Mid-Upper
SYMPH Mid-Upper

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	30 %	70 %
Height	Shrub 3.1m	Shrub >3.1m
Tree Size Class	None	

- [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 C **10 %**

Mid Development 1 Open

Description

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

Indicator Species* and Canopy Position

CELE3 Upper
ARTR2 Low-Mid
CHRYS Low-Mid
SYMPH Low-Mid

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	10 %	30 %
Height	Shrub 3.1m	Shrub >3.1m
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.

Succession to class B after 40 yrs.

Class D **20 %**

Late Development 1 Open

Description

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

Indicator Species* and Canopy Position

CELE3	Upper
ARTR2	Low-Mid
PUTR2	Low-Mid
ELEL5	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 10m
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.

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

Indicator Species* and Canopy Position

CELE3	Upper
PIMO	Upper
JUOS	Upper
SYMPH	Middle

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	30 %	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:** 3

Historical Fire Size (acres)

Avg 50
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	285	100	500	0.00351	24
Mixed	149	50	150	0.00671	47
Surface	238	50	200	0.00420	29
All Fires	69			0.01442	

Fire Intervals (FI):

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

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☐ 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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**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: **1079sm** **Great Basin Xeric Mixed Sagebrush Shrubland**

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

General Information

Contributors (also see the Comments field) **Date** 9/8/2005

Modeler 1 Jan Nachlinger jnachlinger@tnc.org **Reviewer**
Modeler 2 **Reviewer**
Modeler 3 **Reviewer**
FRCC

Vegetation Type

Upland Shrubland

Dominant Species*

ARNO
ACHY
ACTH

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12
17
13

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. In MZ 13, especially common in the Desert National Wildlife Refuge (Sheep Range; Ackerman 2003).

Biophysical Site Description

This type describes black sage and low sagebrush, mostly on convex slopes with big sagebrush occurring in concave slopes and inset alluvial fans. Alluvial fans, piedmont, bajadas, rolling hills and mountain slopes. Can also be found on flats and plains. Other species include horsebrush, spiny hopsage, rubber rabbitbrush, although these are mostly associated with big sagebrush areas. Low/green rabbitbrush is associated with black sagebrush, as well as shadscale. Elevations range from 1500m to 2600m. Low sagebrush tends to grow where claypan layers exist in the soil profile and soils are often saturated during a portion of the year. Black sagebrush tends to grow where there is a root-limiting layer in the soil profile. 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), low sagebrush (Artemisia arbuscula), and big sagebrush (Artemisia tridentata) 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 big sagebrush and winterfat 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.), Sandberg's bluegrass (Poa secunda) and Indian ricegrass (Achnatherum hymenoides). Forbs often include buckwheats (Eriogonum spp.), fleabanes (Erigeron spp.), phloxs (Phlox spp.), paintbrushes (Castilleja spp.), globemallows (Sphaeralcea spp.), lupines (Lupinus spp.), and milkvetches (Astragalus spp.).

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Disturbance Description

Black sagebrush generally supports more fire than other dwarf sagebrushes. FRG could be either IV or III. Bare ground acts as a micro-barrier to fire between low statured shrubs. Stand-replacing fires (average FRI of 200-240 yrs) can occur in this type when successive years of above average precipitation are followed by an average or dry year. Stand replacement fires dominate in the late successional class where the herbaceous component has diminished or where trees dominate.

Grazing by wild ungulates occurs in this type due to its high palatability (mostly for A. nova and A. arbuscula). 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.

Severe drought occurs on average every 75 years (10 yr duration) and causes two equally probably transitions: moderate thinning of the stand (maintaining conditions in the current class), or severe thinning (causing a transition to the previous development class).

Burrowing animals and ants breaking through the root restrictive zone of low and black sagebrush types 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

The black and low sagebrush type tends to occur adjacent to either big sagebrush (nearly exclusively basin big sagebrush in the Mojave Desert; BpS 131080) types and adjacent to Mojave Desert mixed scrub and blackbrush (BpS 131082) at lower elevations. The big sagebrush types create a mosaic within the black and low sagebrush types. These big sagebrush types have a different fire regime that acts to carry the fire, with black and low sagebrush serving as fire breaks most of the time.

After mixed- or low-severity 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

Shrub cover greater than 30% is considered uncharacteristic. Tree cover greater than 40% is uncharacteristic.

Scale Description

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

Black sagebrush can occupy large areas (50,000 acres) in MZ 13. 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

The effect of insect outbreaks (independent of drought) on mature pinyon and juniper in class D can cause a 50% reduction in class D (from 10 to 5%) if part or all of the outbreak sufficiently thins older trees (transition to class C). We assumed that 25% of outbreaks results in a transition to class C from D.

Comments

BpS 131079 is essentially BpS 171079 developed by Crystal Kolden (ckolden@gmail.com) and Gary Medlyn (gmedlyn@nv.blm.gov). Modifications to BpS 171079 for MZ 13 are for species composition and reducing the return interval of drought from 200 to 75 years as used in other Mojave Desert models. Therefore, changes to the model and output were made with the greatest difference being a 5% absolute

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reduction of class D. Another modification was to reduce the maximum tree cover in class D from 40% to 30%, as in juniper savanna (BpS 131115).

BpS 171079 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 Stru

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. Prolonged drought every 200 yrs on average maintains vegetation in class A. Succession to B after 25 years.

Indicator Species* and Canopy Position

ACTH7 Middle
POSE Low-Mid
ACHY Middle

Upper Layer Lifeform

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

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	20 %
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).

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. 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

Indicator Species* and Canopy Position

ARNO4 Upper
POSE Lower
ACHY Mid-Upper

Upper Layer Lifeform

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

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	21 %	30 %
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

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

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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.

event. Replacement fire (FRI of 250 yrs) causes a transition to A. In the absence of fire for at least 120 yrs, the site will follow a successional path to C.

Class C **20 %**

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. Insect attack the vegetation in this state every 60 yrs on average, but does not causes a transition to another state. Severe droughts (return interval of 200 yrs) causes two thinning disturbances: to class B (50% of times) and within class C. Replacement fire is every 200 years on average. Succession is to class D after 75 yrs.

Indicator Species* and Canopy Position

ARNO4 Upper
JUOS Upper
POSE 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 %	20 %
Height	Tree 0m	Tree 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%

Class D **25 %**

Late Development 1 Closed

Description

Late seral community with a closed canopy of conifer trees (6-30% cover). The degree of tree canopy closure differs depending on whether it is a low sagebrush (max 15%) or black sagebrush (max 40%) community. In low sagebrush communities a mixture of herbaceous and shrub vegetation with >10% sagebrush canopy cover would still be present. In black sagebrush communities the herbaceous and shrub component would be greatly reduced (<1%). When Ips beetle outbreaks occur the pinyon component is reduced

Indicator Species* and Canopy Position

JUOS Upper
PIMO Upper
ARNO Middle
ACHY Lower

Upper Layer Lifeform

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

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	30 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

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

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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.

(return interval of 60 yrs): 75% of times thinning is not intense enough to cause a transition whereas in 25% of cases a transition to class C will occur. The only fire is replacement (FRI of 150 yrs) and driven by a greater amount of woody fuel than in previous states. Prolonged droughts have the same effect as before. Succession from class D to D without fire.

Class E **0 %**

Late Development 1 Open

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class	None	

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

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

Fuel Model

Disturbances

Fire Regime Group:** 3

Historical Fire Size (acres)

Avg 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	232	100	250	0.00431	38
Mixed	141	75	140	0.00709	62
Surface					
All Fires	88			0.01141	

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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**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: 1080bwsm 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** 3/13/2008

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

Vegetation Type

Upland Savannah/Shrub Steppe

Dominant Species*

LECI4 PASM
ARTR ACHY
ERTE1
LETR5

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
6	0
0	0
0	0
0	0

Model Zones

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

Geographic Range

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

Biophysical Site Description

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

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

Growing degree days range from 90 to 120 days.

Vegetation Description

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

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

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

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

Other shrubs will generally represent less than 10% of the overall cover and will include various species and subspecies of rabbitbrush (e.g., Chrysothamnus nauseosus, Chrysothamnus viscidiflorus). Other species will generally be cool season bunchgrasses, such as Hespirostipa comota, Thurber's and Western needlegrass 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 and include Arabis spp. and annual forbs such as Eriastrum and Gilia spp.

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 bd1080 (Inter-Mountain Basins Big Sagebrush) and can be confused with bd1080bwor bd1126 during the early seral phase 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

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the soils and can be found in playas of basins in the Great Basin.

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 1080bwsm was taken as is from BpS BD1080bw with no modification for the Spring Mountains.

BpS bd1080bw was taken as-is from BpS gr1080bw.

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

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

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

Vegetation Classes

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Class A **20 %**

Early1 Open

Description

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

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

Indicator Species* and Canopy Position

ARTRT Lower
ERTE1 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
ERTE1 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
ERTE1 Mid-Upper
LECI4 Mid-Upper
ACHY Middle

Upper Layer Lifeform

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

Fuel Model 1

Structure Data (for upper layer lifeform)

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

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

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

Class D **0 %**

Late1 Open

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

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

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	%
Height		
Tree Size Class	None	

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

Class E **0 %**

Late1 Closed

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

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

Fuel Model

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	%
Height		
Tree Size Class	None	

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

Disturbances

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

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 50
Min 10
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	43	10	100	0.02326	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

☑ 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.

LANDFIRE Biophysical Setting Model

Biophysical Setting: **1081sm** **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** 7/19/2005

Modeler 1	Sandee Dingman	Sandee_Dingman@nps.gov	**Reviewer**
Modeler 2	Todd Esque	todd_esque@usgs.gov	**Reviewer**
Modeler 3			**Reviewer**
			FRCC

Vegetation Type

Upland Shrubland

Dominant Species*

ATCO
ARSP5
KRLA
ELEL5

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

16
12
17
13

Model Zones

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

Geographic Range

Great Basin (OR, ID, UT, NV, and CA) and Colorado Plateau. This ecological system occupies sites west of the Wasatch Mountains, east of the Sierra Nevada, south of the Idaho batholith, and north, and into the northern part, 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 inches 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 ARTR2, ARAR8, and ARNO4 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.

*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.

Common shrubs are shadscale, winterfat, budsage, Nevada ephedra, horsebrush, low rabbitbrush, broom snakeweed, and spiny hopsage. Shrub dominance is highly dependent 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 vegetation 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).

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 are also common in the big sagebrush and black sagebrush communities 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.

Indian ricegrass can dominate sites with sandy surface textures (as in BpS1135; Inter-Mountain Basins Semi-Desert Grassland), 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 red brome and cheatgrass. Other nonnative problematic annuals include Russian knapweed, Schismus spp, and several mustards.

In modern days, water diversions and groundwater pumping can cause local droughts from unnatural drops in the water table, thus altering the disturbance dynamics of this system and causing uncharacteristic ranges of variability.

Native Uncharacteristic Conditions

*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.

Native shrub cover greater than 30% is considered uncharacteristic.

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-settlement. 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 1 acre, but may exceed hundreds of acres with a good grass crop.

Issues/Problems

Comments

BpS 131081 was based on BpS 171081 (same as MZ12) with minor editorial modifications, especially with one addition about groundwater pumping and induced drought to the Adjacency section. The VDDT model was not changed. Cover changes were made to classes A and B to create exclusive classes based on 10% breaks according to most recent LANDFIRE guidelines. The original break was 5%, which was changed to 10%.

BPS 1081 for MZ 12 & 17 was modified from BPS 1081 for MZ 16 and reviewed by Mike Zielinski (mike_zielinski@nv.blm.gov). 1) Pinyon-juniper steppe was removed as potential adjacent type in vegetation description. 2) The model was clearly defined following the dynamics of shadscale and bud sagebrush where mortality of shadscale in class B causes a transition to bud sagebrush dominant class C for a short period before abundant shadscale seed allow the return to class B. 3) In this revised model it is not possible to have an alternate succession from class A to C.

BPS 1081 for MZ 16 was initially based on R2SDSH. Greasewood box was removed from R2SDSH by Jolie Pollet, Annie Brown, and Stanley Kitchen to build BPS 1081 for MZ 16. The model was greatly simplified at this time. Original descriptions by Bill Dragt were kept. Reviewers of R2SDSH were Stanley Kitchen (skitchen@fs.fed.us), Mike Zielinski (mike_zielinski@nv.blm.gov), and Jolie Pollet (jpollet@blm.gov).

Vegetation Classes

Class A 5 %

Early Development 1 All Stru

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.

Indicator Species* and Canopy Position

ACHY	Upper
ATCO	Upper
KRLA	Lower
ELEL5	Low-Mid

Upper Layer Lifeform

☐ Herbaceous
☑ Shrub
☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	20 %
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

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

*Dominant 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

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

KRLA Lower
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	21 %	30 %
Height	Shrub 0m	Shrub 0.5m
Tree Size Class	None	

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

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 55 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	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 %

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

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

Fuel Model

Structure Data (for upper layer lifeform)

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

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

Class E 0 %

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

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

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

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

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

Fuel Model

Disturbances

Fire Regime Group:** 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)

References

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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: **1082sm** **Mojave Mid-Elevation Mixed Desert Scrub**

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

General Information

Contributors (also see the Comments field) **Date** 7/15/2005

Modeler 1	Patti Novak-Echenique	Patti.novak@nv.usda.gov	**Reviewer**	Jan Nachlinger	jnachlinger@tnc.org
Modeler 2			**Reviewer**		
Modeler 3			**Reviewer**		
			FRCC		

Vegetation Type

Upland Shrubland

Dominant Species*

CORA
ACSP1
BOER
AMDU

General Model Sources

☑ Literature
☐ Local Data
☐ Expert Estimate

Map Zones

13

Model Zones

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

Geographic Range

Mojave Mid-Elevation Desert Scrub (blackbrush is dominant) occurs in the southern Great Basin region, in the Mojave desert from California, through Nevada to Utah and Arizona. Within the Mojave-Colorado plateau ecotone, blackbrush is found on dry slopes and benches above the river canyons of southern Utah and northern Arizona. It is also found midslope on mountain ranges throughout this area.

Biophysical Site Description

This ecological system represents the extensive desert scrub in the transition zone above Larrea tridentata - Ambrosia dumosa desert scrub and below the lower montane woodlands (700-1800 m elevations) that occurs in the eastern and central Mojave Desert. It is also common on lower piedmont slopes in the transition zone into the southern Great Basin. Blackbrush occurs therefore on mesic and thermic soils that are predominantly shallow to a root restrictive layer, on low hills and mountains and broad alluvial fans. Elevation ranges from 2200 to 6500 feet. Precipitation ranges from 5 to 12 inches, with most occurring from November through April. Summers are hot and dry with many days reaching above 100 degrees.

Vegetation Description

The vegetation in this ecological systems is quite variable. Codominants and diagnostic shrub species include Ambrosia dumosa, Coleogyne ramosissima (blackbrush), Eriogonum fasciculatum, Ephedra nevadensis, Grayia spinosa, Menodora spinescens, Opuntia acanthocarpa, Yucca brevifolia, or Yucca schidigera. The dominant shrub of the Mojave Mid-Elevation Desert Scrub is blackbrush (Coleogyne ramosissima). Blackbrush is considered to be one of the most flammable native plant assemblages in the Mojave Desert, although this desert does not have a history of fire. There are many ecological site descriptions for blackbrush in the Mojave Desert and the bioregional transition between the Mojave Desert and Great Basin or Colorado Plateau that describe the various sites by vegetation composition and soils published by the NRCS. In general terms, blackbrush dominates the site with 50 to 60% of total cover.

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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.

Although 185 species of vascular plants have been found growing within blackbrush, they are never abundant in the Mojave Desert, except at upper- and lower-elevational ecotones. Desert perennial grasses, including Achnatherum hymenoides, Achnatherum speciosum, Boutela eriopoides, Muhlenbergia porteri, Pleuraphis jamesii, Pleuraphis rigida, or Poa secunda dominate the herbaceous layer. Scattered Juniperus osteosperma or desert scrub species may also be present. Beatley (1976) stated that "so nearly complete is the dominance of this shrub species that in areas that are not ecotonal there are only a few associated shrubs species, and these occur usually as scattered plants in an otherwise pure stands of Coleogyne."

Disturbance Description

Low amounts of fine fuels in interspaces probably limited fire spread to only extreme fire conditions, during which high winds, low relative humidity, and low fuel moisture led to high intensity stand-replacing crown fires. Historical fire return intervals appear to have been on the order of centuries (mean FRI = 400) allowing late seral blackbrush stands to re-establish. The FRI of 400 years was an average between the 650 yrs FRI of creosote (BpS 171087) and the 115 yrs FRI of big sagebrush semi-desert (BpS 171080). Lightning strikes in these dense shrublands of flammable material was the primary source of ignition.

Adjacency or Identification Concerns

On the upper elevation, adjacent ecological systems include black sagebrush, big sagebrush semi-desert, and woodlands communities, and at lower elevations creosotebush and bursage communities in the Mojave Desert. Within the upper and lower limits exist adjacent problem areas of blackbrush that are characterized by burned patches with early seral characteristics that have been degraded by overgrazing and prescribed burning in the mid-1900's. There is increased cover of early seral shrubs such as Chrysothamnus spp., Gutierrezia spp., and Eriogonum fasciculatum, early seral herbaceous perennials such as Sphaeralcea ambigua and Astragalus spp, and alien annual plants such as Bromus rubens, Bromus tectorum and Erodium cicutarium. Burned stands can also have a large perennial grass component. Other areas are annual grasslands dominated by Bromus rubens, and Bromus tectorum from repeated burning.

For all practical purposes, BpS 1082 and 1078 are essentially undistinguishable in most aspects relevant to LANDFIRE. Species composition differences may exist due to the presence of monsoonal rains on the Colorado Plateau.

Native Uncharacteristic Conditions

Native shrub cover greater than 50% is considered uncharacteristic.

Scale Description

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

Although the BPS can be extensive (>100,000 acres) in the Mojave Desert. The typical scale of common disturbance extent ranges from 100 to 1000 acres. Exceptions do occur in excess of 1000's of acres.

Issues/Problems

We don't have much data on this community.

Comments

BpS 131082 was closely based on BpS 171082. Modifications were made to the biophysical site description, species composition, and FRIs. The FRI of 400 years was an average between the 650 yrs FRI of creosote (BpS 171087) and the 115 yrs FRI of big sagebrush semi-desert (BpS 171080). A FRI of 1000 yrs was judged too long because this BpS experiences many lightning strikes and blackbrush is very flammable. Moreover, fire from BpS from higher precipitation zone will enter this system. The same FRI was used in both classes of the model, whereas they were different in past versions of BpS 1082 (333 yrs for A and 1000 yrs for B). Finally, the maximum fire size was increase to 1000s acres because of noted large fires (>5,000 acres) in Owens Valley, CA. The reviewer only added two species to Vegetation Description.

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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.

The BpS 171082 and description was developed by Gary Medlyn (gmedlyn@nv.blm.gov) from the blackbrush PNVG R2BLBR for the Great Basin Rapid Assessment. The main body of literature on blackbrush is from the eastern Mojave Desert. Therefore, R2BLBR was initially based on Mojave Desert dynamics, which was emphasized for MZ 12 and 17. Reviewers of R2BLBR were Patti Novak-Echenique (patti.novak@nv.usda.gov), Jolie Pollet (jpollet@blm.gov), and James Bowns (Bowns_JE@suu.edu).

Vegetation Classes

Class A 25 %

Early Development 1 All Stru

Description

Historically, fire was relatively uncommon in this vegetation. The average FRI for replacement fire was 400 years. When burned, the fire tolerant/crown-sprouting shrubs such as spiny menodora, horsebrush, and snakeweed will dominate the site. At higher elevations of mesic blackbrush, a big sagebrush-desert bitterbrush community typically replaces blackbrush for a protracted period. This class can express itself for over a hundred years with varying amounts of blackbrush gradually establishing after decades and eventually succeeding to Class B. A few examples of this that have been observed in the field are believed to be over 60 plus years old. The ground cover varies by elevation and moisture regime with mesic sites being generally 10 to 35 percent with some sites only capable of 10 percent cover. The thermic sites are generally, 10 to 15 ground cover with exception going as high as 35 percent.

Indicator Species* and Canopy Position

GUSA2	Upper
MESP2	Upper
EPNE	Upper
TETRA	Upper

Upper Layer Lifeform

☐ Herbaceous
☑ Shrub
☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	50 %
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 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 75 %

Late Development 1 Closed

Description

This community class seems to be stable and occurs after a threshold is crossed. Composition is 50 to 70 percent blackbrush dominated. Other species are perennial grasses of desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn. Lesser shrub composition includes: Nevada ephedra, turbinella oak, desert bitterbrush, fourwing saltbush, and Anderson's wolfberry in mesic sites and Nevada ephedra, creosotebush, Mojave buckwheat, snakeweed, prickly pear, white bursage and spiny menodora in thermic sites. There are other shrubs also. The FRI for replacement fire is 400 years, which causes a rare transition to class A.

Indicator Species* and Canopy Position

CORA	Upper
EPNE	Upper
YUSC2	Upper
LATR2	Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	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 C 0 %

Mid Development 1 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 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	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 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:** 5

Historical Fire Size (acres)

Avg 10
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	400	100	1700	0.0025	99
Mixed					
Surface					
All Fires	400			0.00252	

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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*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: **1087sm** **Sonora-Mojave Creosotebush-White Bursage Desert Scrub**

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

General Information

Contributors (also see the Comments field) **Date** 7/15/2005

Modeler 1	Patti Novak-Echenique	patti.novak@nv.usda.gov	**Reviewer**	Jan Nachlinger	jnachlinger@tnc.org
Modeler 2			**Reviewer**		
Modeler 3			**Reviewer**		
			FRCC		

Vegetation Type

Upland Shrubland

Dominant Species*

AMDU LYCIU
LATR2
EPNE
ATRIP

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12
17
13

Model Zones

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

Geographic Range

Found throughout the Mojave Desert.

Biophysical Site Description

Creosotebush Scrub is the most common community type in the Mojave Desert. Creosotebush scrub is typically found below the blackbrush zone on well-drained alluvial flats and slopes and above the saltbush zone. Elevations range from 500 to 6000 ft on lower mountain footslopes. Most of the valleys and basins in this area range between 2000 and 4000 ft. Creosotebush scrub occurs on several soil types from shallow to very deep. The site occurs on erosional fan remnants, fan piedmonts, and sideslopes of hills and lower mountains. Slopes range from 2 to 75%, but slope gradients of 2 to 15% are typical. Soils are predominantly well drained, available water capacity is very low to low, and runoff is moderate to rapid. Average annual precipitation ranges from 3 to 7 inches. Precipitation occurs primarily during the winter and early spring. In the eastern portion of MZ13, high intensity convection summer storms (July and August) occur frequently enough to influence the production and species composition of most native plant communities. The relative humidity is low, evaporation is high, solar radiation is high, and the daily and seasonal range in temperature is wide. Average annual temperature ranges from 65 to 75oF. Average frost-free period is generally 240 days.

Vegetation Description

Creosotebush (Larrea tridentata) dominates this scrub community. Plant community associates change from east to west Mojave Desert. Creosotebush codominants include saltbush (Atriplex spp.), white bursage (Ambrosia dumosa), ephedra (Ephedra spp.), and wolfberry (Lycium spp.). Joshua trees (Yucca brevifolia) can be part of this community type and can form woodlands. Perennial grass species include galleta grass (Pleuraphis rigida), bush muhly (Muhlenbergia porteri), desert needlegrass (Achnatherum speciosum),

*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.

Indian ricegrass (Achnatherum hymenoides), and threeawn (Aristida spp.).

Creosotebush scrub is characterized by low cover (5-30%) of woody shrubs of various heights. With the exception of Joshua tree, creosotebush has the highest cover and is the most wide-ranging plant species in the Mojave Desert.

Disturbance Description

Cresosotebush scrub is not fire tolerant because of its drought-tolerant features such as thin bark, slow growth, shallow root system, small leaves. Although some associated species resprout after fire depending on fire severity, the creosotebush scrub community is slow to recover or re-establish after fire.

We do not know the pre-settlement fire conditions in warm desert plant communities. However, it is thought that fires in creosotebush scrub were absent to rare events in pre-settlement desert habitats, because fine fuels from winter annual plants were probably sparse, only occurring in large amounts during the spring following exceptionally wet winters.

Adjacency or Identification Concerns

Fine fuels adjacency from alien annual grasses such as red brome or cheatgrass, currently represent the most important fuelbed component in creosotebush scrub. In years of good moisture, alien annual grasses can comprise 66-97% of the total annual biomass in this system.

Historic year round livestock grazing has contributed to the deterioration of this system.

Native Uncharacteristic Conditions

Cover of shrub greater than 30% is considered uncharacteristic.

Scale Description

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

Patch sizes, which can be very large (>100,000 acres), vary according to landform, aspect, and precipitation. Fire were small (<100 acres) and rare.

Issues/Problems

Little information is available regarding fire frequency and fire severity in pre-settlement fire conditions in warm desert plant communities. It is thought that fire was rare to absent.

Comments

BPS 131087 is based on BpS 171087. Many modification were made to the geographic range, biophysical site description, and species composition. Patch size was increased to reflect the extent of this type in the Mojave Desert compared to the Great Basin. Model structure was kept. The reviewer did not suggest any changes.

BPS 171087 is based on the Rapid Assessment model R2CRBU developed by Sandy Gregory (s50grego@nv.blm.gov). R2CRBU was reviewed by Patti Novak-Echenique (patti.novak@nv.usda.gov), Tim Duck (tim_duck@blm.gov), and Stanley D. Smith (ssmith@ccmail.nevada.edu).

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 15 %

Early Development 1 Open

Description

Creosotebush scrub is characterized by low cover 5 to 10%. Little disturbance was considered in Class A, except for replacement fire every 300 yrs on average. Historical condition where invasive annual grasses are absent, the fire return interval is virtually non-existent except for areas near the base of mountains experiencing locally higher rainfall and fine fuel buildup from native annual. After 100 yrs, class A transitions to B.

Indicator Species* and Canopy Position

PPGG	Lower
AMDU	Low-Mid
LATR2	Upper
HYSA	Low-Mid

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	20 %
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 cover is herbaceous, 5 to 10% canopy cover.

Class B 85 %

Late Development 1 Closed

Description

Greater than 15% shrub cover and 20-40 percent grass and forb cover; associated with more productive soils. Less fine fuels are associated with this community, therefore the FRIs for replacement fire and mixed severity fire is 650 years (min-max: 300-1000 yrs). Wind/weather stress also affected this community on average every 80 yrs, but did not cause a transition to class A.

Indicator Species* and Canopy Position

LATR2	Upper
AMDU	Low-Mid
EPHED	Low-Mid
LYCIU	Low-Mid

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	21 %	30 %
Height	Shrub 0m	Shrub 3.0m
Tree Size Class	None	

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

Class C 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:

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

Class D **0 %**

Late Development 1 Open

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

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:** 5

Historical Fire Size (acres)

Avg 10
Min 1
Max 100

Sources of Fire Regime Data

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

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	588	300	1000	0.00170	56
Mixed	769	300	1000	0.00130	43
Surface					
All Fires	333			0.00301	

Fire Intervals (FI):

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

Additional Disturbances Modeled

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

References

Brooks, M. L., T. C. Esque, and T. Duck. 2003. Fuels and fire regimes in creosotebush, blackbrush, and interior chaparral shrublands. Report for the Southern Utah Demonstration Fuels Project, USDA, Forest Service, Rocky Mountain Research Station, Fire Science Lab, Missoula, Montana. 17pp.

*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: **1104sm** **Mogollon Chaparral**

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

General Information

Contributors (also see the Comments field) **Date** 7/19/2005

Modeler 1	Matt Brooks	matt_brooks@usgs.gov	**Reviewer**	
Modeler 2			**Reviewer**	
Modeler 3			**Reviewer**	
			FRCC	

Vegetation Type

Upland Shrubland

Dominant Species*

CAHO QUTU
ARPU PUST
CEGR
CEM0

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

13

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 across central Arizona (Mogollon Rim), western New Mexico, southern Utah, and eastern and southeastern Nevada (MZ 17 and 13). It often dominates along the mid-elevation transition from the Mojave, Sonoran, and northern Chihuahuan deserts

Biophysical Site Description

Found in mountains from 1000-2200 m. It occurs on foothills, mountain slopes and canyons in drier habitats below the encinal (southwestern oak woodlands) and Pinus ponderosa woodlands and above desert grasslands. Stands are often associated with more xeric and coarse-textured substrates such as limestone, basalt or alluvium, especially in transition areas with more mesic woodlands.

Vegetation Description

The moderate to dense shrub canopy includes species such as Quercus turbinella, Quercus toumeyi, Cercocarpus montanus, Canotia holacantha, Ceanothus greggii, Forestiera pubescens (= Forestiera neomexicana), Garrya wrightii, Juniperus deppeana, Purshia stansburiana, Rhus ovata, Rhus trilobata, and Arctostaphylos pungens and Arctostaphylos pringlei at higher elevations. Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Stands occurring within montane woodlands are seral and a result of recent fires. Forty percent cover at dry sites to 80 % cover at wetter sites comprised of moderately tall statured (1-2.5m) evergreen woody shrubs with dense crowns

Disturbance Description

Typical fire regime in these systems varies with the amount of organic accumulation. The only significant disturbance to the system is stand-replacing fire occurring every 50 to 100 years on average. Shrubs resprout rapidly after fire, often making the vegetation impenetrable.

Adjacency or Identification Concerns

This BpS will be hard to distinguish from BpS 1103 (Great Basin Semi-Desert Chaparral) or 1108 (Sonora-

*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.

Mojave Semi-Desert Chaparral).

At higher elevations, chaparral vegetation may blend into ponderosa pine woodlands and oak woodlands (encinal). At lower elevations, desert grasslands can be encroached by chaparral where fire suppression and livestock grazing have increased fire return intervals. Stand replacement fires will periodically remove these trees.

Native Uncharacteristic Conditions

Scale Description

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

Vegetation found in small patches of 10 acres to whole mountain slopes of 10,000 acres.

Issues/Problems

Uncertainty exists about the size of this system in MZ 13.

Comments

BpS 131104 was based on BpS 171104. The main modification was to use an average FRI of 75 years (mid-point of the range) in both model classes compared to 50 yrs. Other changes were made to the vegetation and disturbance descriptions to adapt to Mojave Desert mapping zone.

This BPS for MZ 17 is essentially BPS 171103 with minor modifications to the descriptions. The components of BPS 1103 for MZ 16 were proposed by James Bowns and translated into VDDT by Louis Provencher on 3/2/05.

Vegetation Classes

Class A 10 %

Early Development 1 All Stru

Description

After fire, some shrubs resprout strongly from roots or from the base of plants. Shrubs can cause stands to become impenetrable. Stand replacement fire occurs every 75 years on average. After 10 years, succession to class B.

Indicator Species* and Canopy Position

QUTU2 Upper
ARPU5 Upper
CEGR Upper
CEMO2 Upper

Upper Layer Lifeform

☐ Herbaceous
☑ Shrub
☐ Tree

Fuel Model 4

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
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 **90 %**

Mid Development 1 Closed

Description

Dense shrubs with grasses present in the few openings. Shrub composition same as in class A. The only disturbance is stand replacing fire every 75 years on average. Canopy cover will generally be >50%.

Indicator Species* and Canopy Position

QUTU2 Upper
ARPU5 Upper
CEGR Upper
CEMO2 Upper

Upper Layer Lifeform

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

Fuel Model 4

Structure Data (for upper layer lifeform)

	Min	Max
Cover	51 %	100 %
Height	Shrub 3.1m	Shrub >3.1m
Tree Size Class	None	

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

Class C **0 %**

Mid Development 1 All Struct

Description

Indicator Species* and Canopy Position

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:

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:

Class E **0 %**

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

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

---

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

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

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

Fuel Model

Disturbances

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 500
Min 5
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	75	50	100	0.01333	100
Mixed					
Surface					
All Fires	75			0.01335	

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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Brooks, M. L, T. C. Esque, and T. Duck, 2003. Fuels and Fire Regimes in Creosotebush, Blackbrush, and Interior Chaparral Shrublands. Report for the Southern Utah Demonstration Fuels Project. USDA Forest Service. Rocky Mountain Research station, Montana. 18 pp.

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

Carmichael, R. S., O. D. Knipe, C. P. Pase, and W. W. Brady. 1978. Arizona chaparral: Plant associations and ecology. USDA Forest Service Research Paper RM-202. 16 pp.

Dick-Peddie, W. A. 1993. New Mexico vegetation: Past, present, and future. University of New Mexico Press, Albuquerque. 244 pp.

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

LANDFIRE Biophysical Setting Model

Biophysical Setting: 1126sm **Inter-Mountain Basins Montane Sagebrush Steppe**

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

General Information

Contributors (also see the Comments field) **Date** 9/8/2005

Modeler 1	Jan Nachlinger	jnachlinger@tnc.org	**Reviewer**	
Modeler 2			**Reviewer**	
Modeler 3			**Reviewer**	
			FRCC	

Vegetation Type

Upland Savanna and Shrub-Steppe

Dominant Species*

ARTR BRMA
PUTR2
SYOR
POFE

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12
17
16
13

Model Zones

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

Geographic Range

Montane and subalpine elevations across the western U.S. from 1000 m in eastern Oregon and Washington to over 3000 m in the southern Rockies, and within the mountains of Nevada, including southern Nevada, western Utah, southeast Wyoming, and southern Idaho. In MZ 13, restricted to the highest mountains such as the Panamint Range, Inyo Range, and Spring Mountains.

Biophysical Site Description

This ecological system occurs in many of the western United States, usually at middle elevations (1000-2500 m). Within the Mojave Desert mapping zone (MZ 13), elevation is generally above 2450 m, with known occurrences above 2790 m in the Panamint Range. Immediately north of the Mojave Desert, mountain big sagebrush shrublands occur up 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 25 to 90 cm/year (Mueggler and Stewart 1980, Tart 1996). Much of this precipitation falls as snow. Temperatures are continental with large annual and diurnal variation. In general this system shows an affinity for mild topography, fine soils, and some source of subsurface moisture. Soils generally are moderately deep to deep, well-drained, and of loam, sandy loam, clay loam, or gravelly loam textural classes; soils often have a substantial volume of coarse fragments, and are derived from a variety of parent materials. This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. Soils are typically deep and have well developed dark organic surface horizons (Hironaka et al. 1983, Tart 1996). However, at the high ends of its precipitation and elevation ranges mountain big sagebrush occurs on shallow and/or rocky soils. All aspects are represented, but the higher elevation occurrences may be restricted to south- or west-facing slopes. At lower elevations, mountain big sagebrush occurs in the understory of curlleaf mountain mahogany and pinyon-juniper woodlands.

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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.

Vegetation Description

Vegetation types within this ecological system are usually less than 1.5 m tall and dominated by Artemisia tridentata ssp vaseyana. Mojave Desert communities of montane sagebrush have received less description than northern mapping zones. A variety of other shrubs can be found in some occurrences, but these are seldom dominant. They include Artemisia arbuscula, Ericameria nauseosa, Chrysothamnus viscidiflorus, Ephedra viridis, Symphoricarpos oreophilus, Purshia tridentata, Peraphyllum ramosissimum, Ribes cereum, and Amelanchier alnifolia. 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 Boutela gracilis, Festuca ovina, Elymus elymoides, Danthonia intermedia, Stipa spp., Pascopyrum smithii, Bromus carinatus, Elymus trachycaulus, Koeleria macrantha, Pseudoroegneria spicata, Bromus anomalous and marginatus, Achnatherum therburianum, 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, Achillea millefolium, Antennaria rosea, and Eriogonum umbellatum, Artemisia ludoviciana, and many others. Mueggler and Stewart (1980), Hironaka et al. (1983), and Tart (1996) described several of these types. 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 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

Inter-Mountain Basins Montane Sagebrush Steppe dominated by mountain big sagebrush (BpS 1126) will contain low/black sagebrush in varying amounts. Small patches will naturally be part of BpS 131126, whereas more extensive areas truly belong to BpS 131079. Both systems (BpS 1126 and 1079) cover large high-elevation areas in the Intermountain West. Mountain big sagebrush is a medium-sized shrub with a mean FRI from 10-70 years, whereas high-elevation low sagebrush is a dwarf shrub with a mean FRI of 200+ years.

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The NatureServe description does not distinguish between mountain big sagebrush that can be invaded by conifers at mid to high elevations (i.e., within the tolerance of pinyon and juniper) and mountain sagebrush steppe that is too high elevation for pinyon to encroach. The ability for pinyon to invade has a large effect on predicted HRV and management.

This type may be adjacent to forests dominated by aspen, white fir, limber pine, and bristlecone pine. It also occurs adjacent to pinyon-juniper and curlleaf mountain mahogany woodlands. The ecological system, where adjacent to conifers, is readily invaded by conifers (whitebark pine, limber pine, pinyon-pine, juniper spp.) in the absence of historic fire regimes (Miller and Rose 1999).

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

Shrub cover greater than 50% is uncharacteristic and conifer cover greater than 80% is uncharacteristic wher

Scale Description

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

This type occupies areas ranging in size from 10's to 5,000's of acres, although patch sizes are generally smaller in the Mojave Desert. Disturbance patch size can range 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

BpS 1126 was found on elevation slopes, but this system was most frequent in dry washes of the Spring Mountains were cold air drafting might allow to grow at lower than normal elevations.

BpS 131126, Inter-Mountain Basins Montane Sagebrush Steppe, was not part of list of keyed BpS for this mapzone due to the paucity of data. BpS 131126 is found, however, in the Inyo Range (Inyo National Forest) and Panamint Range (Death Valley National Park), and, perhaps, in the Spring Mountains depending on whether or not pinyon has invaded shrublands.

Comments

BpS 131126 was derived from BpS 121126, which was developed by Gary Medlyn (gary_medlyn@nv.blm.gov) and Crystal Kolden (ckolden@gmail.com). Modifications to BpS 121126 for MZ 13 were for species composition, elevation, and scale.

BPS 1126 for MZ 12 and 17 was based on BPS 1126_a (Mountain Big Sagebrush) from LF Mapping Zone 16. BPS 1126_a is essentially PNVG R2SBMTwc (mountain big sagebrush with potential for conifer invasion) developed by Don Major (dmajor@tnc.org), Alan R. Sands (asands@tnc.org), David Tart (dtart@fs.fed.us), and Steven Bunting (sbunting@uidaho.edu). R2SBMTwc was itself based on R2SBMT developed by David Tart. R2SBMtwc was revised by Louis Provencher (lprovencher@tnc.org) following critical reviews by Stanley Kitchen (skitchen@fs.fed.us), Michele Slaton (mslaton@fs.fed.us), Peter Weisberg (pweisberg@cabnr.unr.edu), Mike Zielinski (mike_zielinski@nv.blm.gov), and Gary Back (gback@srk.com). Reviewers and modelers had very different opinions on the range of mean FRIs and mountain big sagebrush recovery times for rapid Assessment models R2SBMT and R2SBMTwc where the (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

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12 and 17, modelers placed this system in Fire Regime Group IV.

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 has a mean FRI of 80 years. Succession to class B after 12 years.

Indicator Species* and Canopy Position

POFE	Upper
BRMA4	Upper
SYOR2	Lower
ARTRV	Lower

Upper Layer Lifeform

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

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	80 %
Height	Herb 0m	Herb 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. Shrub cover will be <10% and <0.5m tall.

Fuel Model 1

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
PIPO5	Lower
SYOR2	Lower

Upper Layer Lifeform

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

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	20 %
Height	Shrub 0m	Shrub Tall >3.0 m
Tree Size Class	Seedling <4.5ft	

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

Herbaceous cover is the dominant lifeform with canopy >50%. Shrub cover is 6-25% and the upper lifeform.

Fuel Model 1

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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, ponderosa pine, or white fir) 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
SYOR2 Low-Mid
CONIF Mid-Upper

Upper Layer Lifeform

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

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	50 %
Height	Shrub 0m	Shrub Tall >3.0 m
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, ponderosa pine, limber pine, or white fir). 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	0 %	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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Class E 5 %

Late Development 2 Closed

Description

Conifers are the dominant lifeform (juniper, pinyon-juniper, ponderosa pine, limber pine, or white fir). Conifer cover ranges from 26-80% (pinyon-juniper 36-80%(Miller and Tausch 2000), juniper 26-40% (Miller and Rose 1999), white fir 26-80%). Shrub cover 0-20%. Herbaceous cover <20%. The mean FRI for replacement fire is longer than in previous states (75 yrs). Conifers are susceptible to insects/diseases that cause diebacks (transition to class D) every 75 years on average.

Indicator Species* and Canopy Position

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

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 6

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	80 %
Height	Tree 0m	Tree 10m
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 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	49	15	100	0.02041	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

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

LANDFIRE Biophysical Setting Model

Biophysical Setting: **1135sm** **Inter-Mountain Basins Semi-Desert Grassland**

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

General Information

Contributors (also see the Comments field) **Date** 9/8/2005

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

Vegetation Type

Upland Grasslands and Herbaceous

Map Zones

13

Model Zones

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

Dominant Species*

ACHY GRSP
HECO PLRI
PLJA
ARTR

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

Occurs throughout the Intermountain western U.S. on sandsheets or stabilized dunes.

Biophysical Site Description

Ecological systems found at varying elevations in the Mojave Desert; 500 to 2000m. Also found at lower elevations in Death Valley National Park. These grasslands occur in lowland and upland areas and may occupy sandsheets, stabilized dunes, swales, playas, mesatops, plateau parks, alluvial flats, and plains, but sites are typically xeric. Substrates are often excessively to well-drained sandy or loamy-textured soils derived from sedimentary parent materials but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. Sometimes associated with specific soils, often well-drained clay soils. These grasslands typically occur on aridic sites. These grasslands occur on a variety of aspects and slopes. Sites may range from flat to moderately steep. Annual precipitation is 4-8 inches in the Mojave Desert (MZ 13) with monsoonal rains being an important source of precipitation.

Vegetation Description

Grasslands within this system are typically characterized by a sparse to moderately dense herbaceous layer dominated by medium-tall and short bunch grasses. The dominant perennial bunch grasses and shrubs within this system are all very drought-resistant plants. These grasslands are typically dominated or codominated by Achnatherum hymenoides, or Hesperostipa comata, and may include scattered shrubs and dwarf-shrubs of species of Artemisia tridentata, Atriplex canescens, Ephedra, or Krascheninnikovia lanata.

Disturbance Description

Two sources of fire exist for Great Basin grasslands in the Mojave Desert. 1) Fire occurred in these sites when adjacent shrublands (BPS 1079, 1080, 1082, 1087) burned under extreme fire behavior conditions; however, the FRI of these shrublands can be sufficiently long as to cause fire to be uncommon to rare

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(blackbrush has a FRI of 400 yrs). Therefore, the disturbance dynamics of this system are identical to those of the dominant and surrounding BPS (perhaps blackbrush, 131082) with stand replacing fires occurring every 400 years due to the continuity of fine fuels. 2) The second source of fire is small 10-20 acre burns that Native Americans set to flush rabbits and jackrabbits for hunting purposes. Fires would be stand replacing. Uncertainty exists about the estimated FRI. It was assumed that fires were set during the peak of rabbit and jackrabbit cycles, which would be from 7-12 years (10 years chosen). Assuming that Native Americans burned 0.2% (20 acres/10,000 acres) of a grassland per day per year and burned on 30 days during the peak of the rabbit cycle every 10 years (Probability/yr = 0.1), then 0.002 * 30 * 0.1 = 0.006/ yr or 166-yr FRI. Re-establishment following fire is from resprouting grasses with shrubs re-establishing from seed over time. These two sources of fire were combined for technical purposes in the VDDT model.

Other disturbances included insects (e.g., moths and grasshoppers that eat leaves, moth larval grubs that eat roots; return interval of 75 years), and periods of drought and wet cycles and shifts in climate corresponding to extended wet and dry cycles oscillating every two to three decades related to the Pacific Decadal Oscillation (PDO) with the influence of these longer term patterns moderated by short term variation associated with El Nino and La Nina patterns (return interval of 30 yrs). We assumed that 60% of times the effect of drought/wet cycles was stand thinning for shrubs (Probability/yr = 0.02), whereas 40% of times the effect was stand replacing for shrubs (Probability/yr = 0.013).

Adjacency or Identification Concerns

NatureServe description for BPS 1135 includes Muhlenbergia-dominated grasslands which flood temporarily. Muhlenbergia grasslands and flooding are not part of these sandy systems in Nevada.

Found adjacent to several BPS: 131079, 131080, 131082, and 131087.

Many of these sites were impacted by introduced grazing animals post-European settlement and have been converted to shrub dominated systems.

Red brome and Mediterranean grass (both Schismus arabicus and barbatus) are present in these ecological systems and can dominate disturbed high sand content areas. In addition, noxious weeds, such as Sahara mustard (Brassica tournifortii) are present and increasing.

Native Uncharacteristic Conditions

Herbaceous cover is rarely greater than 50%, however grass cover can reach higher values where bunch grass

Scale Description

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

Semi-desert grassland can be large (>10,000 acres) when associated with extensive sandsheet systems. Historic disturbance (fire) likely ranged from small (10-20 acres) when set by Native Americans during the peak of rabbit and jackrabbit cycles (10-yr cycle), and large (>1,000 acres) and infrequent when fire spread from adjacent shrublands under extreme fire conditions.

Issues/Problems

The scale of historic fire is unknown and numbers provided are a guess. Native burning was important for hunting but the calculation of a FRI involved two critical assumptions about area burned and lagomorph cycles.

Comments

BpS 131135 was derived from BpS 121135 (or 171135), which was developed by Mike Zielinski (mike_zielinski@nv.blm.gov) and Louis Provencher (lprovencher@tnc.org). Modifications to BpS 121135 for MZ 13 were important and included changes to species composition, biophysical site description, the list of non-native species in adjacency, and fire and weather disturbances. BpS 131135 is fundamentally

*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.

different from 121135 because the surrounding desert scrub landscape cannot be the source of frequent fire. The VDDT model was changed by Louis Provencher (lprovencher@tnc.org) to incorporate Native American burning based on input from Mojave Desert anthropologist Dr. Kay Fowler from University of Nevada, Reno (csfowler@scs.unr.edu), with additional guessestimates for rabbit/jackrabbit cycles by Dr. Bill Longland (longland@unr.nevada.edu) and Dr. Peter Brussard (brussard@biodiversity.unr.edu). Therefore, the old disturbance regime, which was the one from BpS 121125, was replaced (see Disturbance Description). The effect of weather was also borrowed from the wet/drought cycles from BpS 131085, with the difference that the weather cycle was separated into severe 75-yr events and less severe 50-yr events (for a total of 30-yr weather events).

National quality control of this model required combining the two sources of fire (both listed as "replacement fire") in VDDT. Their separate probabilities have been described for each vegetation class below.

BpS 1135 for MZ 12 and 17 was completely different from BpS 1135 for MZ 16. BpS 1135 used the model and disturbance regime of BpS 1125 (and 1080 without trees) for MZ 12 and 17 because the two systems were highly coupled, however BPS 1135 lacks class C because it is a grassland with shrub encroachment.

Vegetation Classes

Class A 30 %

Early Development 1 Open

Description

Perennial grasses and forbs dominate (generally 25-40% cover) where woody shrub canopy has been topkilled / removed by wildfire. Shrub cover is < 5%. Replacement fire occurs every 166 years (Native American fires) and 400 yrs (from adjacent shrublands) on average. Succession to class B after 20 years.

Indicator Species* and Canopy Position

ARTR2 Upper
HECO2 Upper
ACHY Lower

Upper Layer Lifeform

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

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	40 %
Height	Herb 0m	Herb 0.5m
Tree Size Class	None	

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

Class B 70 %

Mid Development 1 Open

Description

Shrubs compose the upper layer lifeform (5-25% cover) with diverse perennial grass and forb understory dominant. MFI is 166 years (Native American fires) and 400 yrs (from adjacent shrublands) on average. Insect/disease (return interval of 75 years), and weather related stress (return interval of 50

Indicator Species* and Canopy Position

ARTR2 Upper
HECO2 Low-Mid
ACHY Lower

Upper Layer Lifeform

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

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	30 %
Height	Shrub 0m	Shrub 1.0m
Tree Size Class	None	

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

Herbaceous layer is >25% cover whereas shrub cover is <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.

years) maintains vegetation in class B; severe drought/wet cycles events every 75 years will cause stand replacement for shrubs.

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	None	

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

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

Fuel Model

Class D **0 %**

Mid Development 1 Closed

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class	None	

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☐ Tree

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

Fuel Model

Class E **0 %**

Late Development 1 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

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

Fire Regime Group:** 4

Historical Fire Size (acres)

Avg 15
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	117	150	650	0.00855	100
Mixed					
Surface					
All Fires	117			0.00857	

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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*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: 131143 **Rocky Mountain Alpine Fell-Field**

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

General Information

Contributors (also see the Comments field) **Date** 12/30/2005

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

Vegetation Type

Shrubland

Dominant Species*

IVCR	ELELE
LEHI3	FEOV
ERCL	POSE
OXOR	AQSC

General Model Sources

☐ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

12	0
17	0
13	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 discontinuously at alpine elevations throughout the Rocky Mountains, west into the mountainous areas of the Great Basin, and on the highest ranges of the Mojave Desert (e.g., Spring Mountains).

Biophysical Site Description

Above treeline in the alpine zone. Elevation ranges from 3400-3700 m in the Spring mountains. These are wind-scoured fell-fields that are free of snow in the winter, such as ridgetops and exposed saddles, exposing the plants to severe environmental stress. Soils on these windy unproductive sites are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement.

Vegetation Description

Prevalent vegetation is a forbland dominated by cespitose perennial herbs and bunch grasses. Ground cover is approximately 5% soil, 50% gravel, 35% rokc fragments and bedrock, 7% wood and litter, and <5% basal vegetation (Nachlinger and Reese 1996). Common species are Ivesia cryptocaulis (endemic to Spring Mountains), Astragalus lentiginosus var. kernensis, Erigeron clockeyi, Festuca ovina var. brevifolia, Lesquerella hitchcockii (endemic to Spring Mountains), Oxytopis oreophila, Poa secunda, Elymus elymoides, and Sphaeromeria compacta (endemic to Spring Mountains).

Disturbance Description

Fire is not associated with this BPS, although rare lightning strikes could denude small patches. Disturbances are few and mostly associated with drought and snow accumulation. Severe droughts (e.g., two consecutive summers without precipitation) has been observed to kill plants (pers. comm., T. Forbis, The Nature Conservancy) in 2000-2001. Reestablished is slow and proceeds from rocky substrate with graminoids dominant for years.

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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.

Herbivory and burrowing animals are uncommon in this system.

Adjacency or Identification Concerns

This BpS is adjacent to BpS 131020 where bristlecone pine reaches at higher elevations.

Native Uncharacteristic Conditions

Herbaceous cover may exceed 20%.

Scale Description

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

These systems are associated with narrow ridges and exposed areas and may be a few acres.

Issues/Problems

Not enough information on disturbances and recovery dynamics.

Comments

Based on Nachlinger and Reese (1996) and BpS 161143 (which was not retained in final list for MZ 16).

Vegetation Classes

Class A 2 %

Early1 All Structures

Description

Very sparse graminoids scattered across stony substrate. Initial years of recovery will be stony substrate and bare ground. Succession to class B after 20 years.

Indicator Species* and Canopy Position

POSE Upper
ELELE 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 0.5m
Tree Size Class	None	

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

Class B 98 %

Mid1 Open

Description

Cushion plants and graminoids occupying up to 20% cover with stony substrate in between. Rare lightining strikes imitating very localized replacement fire (mean FRI of 1000 years) are hypothesized to cause a transition to class A. Consecutive years of severe drought (i.e., no precipitation) will thin vegetation (mean return interval of 100 years).

Indicator Species* and Canopy Position

IVCR Upper
LEHI3 Upper
ERCL Upper
OXOR2 Upper

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	20 %
Height	Herb 0m	Herb 0.5m
Tree Size Class	None	

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

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

Class C **0 %**

Mid1 All Structures

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 D **0 %**

Late1 All Structures

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 %**

Late1 All Structures

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

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

Fire Regime Group:** 5

Historical Fire Size (acres)

Avg 1
Min 1
Max 1

Sources of Fire Regime Data

☐ Literature
☐ Local Data
☑ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	1000			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: **1145sm** **Rocky Mountain Subalpine-Montane Mesic Meadow**

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

General Information

Contributors (also see the Comments field) **Date** 9/8/2005

Modeler 1	Jan Nachlinger	jnachlinger@tnc.org	**Reviewer**	
Modeler 2			**Reviewer**	
Modeler 3			**Reviewer**	
			FRCC	

Vegetation Type

Upland Grasslands and Herbaceous

Dominant Species*

BRCA	LUPIN
ACLE	OSMO
DECA	THALI
AGTR	ERIGE

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

12
17
16
13

Model Zones

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

Geographic Range

Found in the Rocky Mountains, Great Basin, and Mojave Desert on high elevation ranges. Found only on the highest ranges of MZ 13, which is mainly the Spring Mountains and Inyo Mountains. Infrequent BpS in MZ 13.

Biophysical Site Description

This ecological system is restricted to sites in the subalpine zone where finely textured soils, snow deposition, or wind-swept dry conditions limit tree establishment. Typically above 3000 m (9800 ft) in elevation in the southern part of its range such as MZ 13. The soils are typically cryic and seasonally moist to saturated in the spring, but will dry out later in the growing season. These upland communities occur on gentle to moderate-gradient slopes.

Vegetation Description

BPS 131145 is grass-dominated in the Mojave Desert, which is different from the forb-dominated types in the Great Basin. Important taxa include Acnatherum lettermanii, A. columbianum, Bromus carinatus, Deschampia caespitosa, Elymus trachycaulus, E. elymoides, Agastache urticifolia, Arabis pendulina, Antenennaria microphylla, Chamerion angustifolium, Cirsium clokeyi, Erigeron clokeyi, Senecio spp., Mertensia spp., Penstemon leiophyllus, Hackelia spp., Hymenoxys lemmonii, Linum lewisii, Lupinus argentatus., Solidago spp., Ligusticum spp., Osmorhiza spp., Thalictrum spp., Valeriana spp., and Silene verecunda. Burrowing mammals can increase forb diversity.

Disturbance Description

Fires are primarily replacement and occur about every 40 years. Fire Regime groups could be IV or II. The ignition source in this type is probably associated with native burning in the fall and spring, but fire spreads from an adjacent shrub or tree dominated sites, such as mountain big sagebrush and upper montane and

*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.

subalpine conifers.

Adjacency or Identification Concerns

BpS 131145 is graminoid dominated in the Mojave Desert and resembles very closely BpS 131146. The tall forbs community represented by 1145 does not exist in the Mojave Desert as it does in Mapping Zones 12, 16, and 17. Forbs are much less common than graminoids in MZ 13.

Often adjacent to mountain big sagebrush (BpS 131126) and bristlecone/limber pine (BpS 131020).

Bromus tectorum (cheatgrass) is present in minor amounts at higher elevations.

Native Uncharacteristic Conditions

Herbaceous cover can reach 100%, whereas woody shrub cover greater than 20% is considered uncharacteris

Scale Description

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

This type ranges in size from less than 10 acres to 100 acres. In MZ 13, the Spring Mountains are high enough to support this BpS and experts estimate patches to be very small (<10 acres).

Issues/Problems

No data or literature on this system in MZ 13.

Comments

BpS 131145 is based on BpS 121145 (or 171145) that was developed by Cheri Howell (chowell02@fs.fed.us) and Julia H. Richardson (jhrichardson@fs.fed.us). Modifications to BpS 121145 for MZ 13 were many and focused on the vegetation description. This BpS is very different in the Mojave Desert than the Great Basin with a high dominance by grass rather than forbs. The system is also infrequent to rare in MZ 13.

There was not much information about BpS 121145. 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 fall and spring when the summer's green and wet biomass would be dead and cured, replacement fire has little effect on tall forbs themselves and probably result in exposing more bare ground. Fires would affect encroaching shrubs.

Vegetation Classes

Class A **5 %**

Early Development 1 Open

Description

Vegetation is typically graminoid-rich, with forbs contributing some herbaceous cover. Important taxa include Acnatherum lettermanii, A. columbianum, Bromus carinatus, Deschampia caespitosa, Elymus trachycaulus, E. elymoides, Agastache urticifolia, Arabis pendulina, Antenennaria microphylla, Chamerion

Indicator Species* and Canopy Position

ACLE	Upper
BRCA	Upper
AGTR	Upper
ASTER	Upper

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	60 %
Height	Herb 0m	Herb 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.

angustifolium, Cirsium clokeyi, Erigeron clokeyi, Senecio spp., Mertensia spp., Penstemon leiophyllus, Hackelia spp., Hymenoxys lemmonii, Linum lewisii, Lupinus argentatus., Solidago spp., Ligusticum spp., Osmorhiza spp., Thalictrum spp., Valeriana spp., and Silene verecunda. Succession to class B after 3 years. Replacement fire (mean FRI of 40 years) presumably occurred during the fall and spring.

Class B **40 %**

Mid Development 1 Closed

Description

Vegetation is typically forb-rich, with graminoids contributing more to overall herbaceous cover than forbs. Important taxa include Acnatherum lettermanii, A. columbianum, Bromus carinatus, Deschampia caespitosa, Elymus trachycaulus, E. elymoides, Agastache urticifolia, Arabis pendulina, Antenennaria microphylla, Chamerion angustifolium, Cirsium clokeyi, Erigeron clokeyi, Senecio spp., Mertensia spp., Penstemon leiophyllus, Hackelia spp., Hymenoxys lemmonii, Linum lewisii, Lupinus argentatus., Solidago spp., Ligusticum spp., Osmorhiza spp., Thalictrum spp., Valeriana spp., and Silene verecunda. There is some increase in shrub component, but will occupy less than 5% cover. Succession to C after 20 years. Replacement fire removes shrubs (mean FRI of 40 years).

Indicator Species* and Canopy Position

ACLE	Upper
BRCA	Upper
AGTR	Upper
ASTER	Upper

Upper Layer Lifeform

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

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	60 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

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

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

Class C 55 %

Late Development 1 Open

Description

Vegetation is typically forb-rich, with graminoids contributing more to overall herbaceous cover than forbs. Important taxa include Acnatherum lettermanii, A. columbianum, Bromus carinatus, Deschampia caespitosa, Elymus trachycaulus, E. elymoides, Agastache urticifolia, Arabis pendulina, Antenennaria microphylla, Chamerion angustifolium, Cirsium clokeyi, Erigeron clokeyi, Senecio spp., Mertensia spp., Penstemon leiophyllus, Hackelia spp., Hymenoxys lemmonii, Linum lewisii, Lupinus argentatus., Solidago spp., Ligusticum spp., Osmorhiza spp., Thalictrum spp., Valeriana spp., and Silene verecunda. 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

ACLE	Middle
BRCA	Middle
POTR5	Upper
ARTR2	Upper

Upper Layer Lifeform

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

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	20 %
Height	Shrub 0m	Shrub >3.1m
Tree Size Class	Seedling <4.5ft	

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

Up to 10% of cover in late seral may be woody species from adjacent plant communities such as Populus tremuloides (acting as a shrub), Artemisia cana, Artemisia tridentata, Rosa woodsii, Ribes spp. and Amelanchier spp..

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:

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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:** 4

Historical Fire Size (acres)

Avg 50
Min 1
Max 300

Sources of Fire Regime Data

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

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	40			0.025	80
Mixed	161			0.00621	20
Surface					
All Fires	32			0.03122	

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: **1145wmsm** **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** 3/13/2008

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
6	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 mountain 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 ssp. juncifolia), sedges (Carex spp), tufted harigrass (Deschampsia cespitosa; drier meadows), rushes (Juncus spp), slender wheatgrass (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), 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 springs and 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 1080bw).

With heavy grazing these sites can convert to undesirable forbs (for example, Irs missouriensis) 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 BpS ranges in size from less than 10 acres to 300 acres.

Issues/Problems

Comments

BpS 1145wm_sm was taken from BpS bd1145wm for the Mojave Desert. The Natural range of Variability changed slightly.

BpS bd1145wm was taken as-is with very few changes from BpS gr1145wm.

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.

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

Vegetation Classes

Class A 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:

*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
- [x] Shrub
- [ ] Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	10 %
Height	Shrub Dwarf <0.5m	Shrub Tall >3.0 m
Tree Size Class	Seedling <4.5ft	

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

Graminoid cover remains high from 60-90%.

Class D **0 %**

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

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:

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

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.

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: **1154sm** **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** 9/8/2005

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

Vegetation Type

Wetlands and Riparian

Dominant Species*

POPU ABCO
SALIX JUSC2
ROWO
BETU

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

13

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 Sieera Nevada of California, Columbia Plateau, western edge of northern Rockies, and mountains of the central and western Mojave Desert.

Biophysical Site Description

This ecological system is found within a broad elevation range from about 1220 m (4000 feet) to over 2135 m (7000 feet). These forests and woodlands require flooding and some gravels for reestablishment. They are found in low- to mid-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 and willow. 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 may be tree or shrub dominated. Dominant trees may include Abies concolor, Juniperus scopulorum, Betula occidentalis, Populus angustifolia, Populus balsamifera ssp trichocarpa, Populus fremontii, Salix laevigata, and Salix gooddingii. Dominant shrubs include Cornus sericea, Salix exigua, Salix lasiolepis, Salix lemmonii, or Salix lutea. Herbaceous layers are often dominated by species of Carex and Juncus, and perennial grasses and mesic forbs such Deschampsia caespitosa, Elymus trachycaulus, Glyceria striata, Maianthemum stellatum, or Thalictrum fendleri. Important shrubs include Rosa woodsii, Amelanchier alnifolia, and Prunus virginiana.

*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 50-yr events for mature trees. Beaver (Castor canadensis) are not present in this BpS for the Mojave Desert.

Although fuels are continuous and abundant, they are high in moisture, but dry out during the summer. Therefore, replacement fire sweeps through BpS 131154 and is caused by importation from adjacent systems, that may include basin big sagebrush (total FRI of 50 yrs), southern ponderosa pine woodlands (total FRI of 15 yrs), black sagebrush (total FRI of 88 yrs), and other types. Native American burning was somewhat present in these Great Basin montane riparian systems but camps were generally located at the mouth of canyons (Kay Fowler from University of Nevada, Reno, pers. communication, 09/2005). An average FRI of about 50 yrs was used in mid-development and late-development classes of vegetation. Therefore, FRG is IV because the total FRI is about 67 years and dominated by replacement fire.

Adjacency or Identification Concerns

Livestock grazing is a major influence in the alteration of structure, composition, and function of the community. Livestock can result in the nearly complete removal of willow and cottonwood regeneration, and bank slumping in places where water is accessible.

Exotic trees of Elaeagnus angustifolia and Tamarix spp are common in some stands. Introduced forage species such as Agrostis stolonifera, 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 medium linear features in the lansdscape. In larger, low-elevation riverine systems, this system may exist as mid to large patches.

Issues/Problems

Comments

BpS 131154 is based on BpS 121154 (and 171154). Modifications to BpS 121154 for MZ 13 are the removal of beaver activity, changes to species composition (no Columbia Plateau influence), a recognition that BpS 131154 is a mountain riparian system more than a bottomland system (unlike BpS 121154), 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 121154 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 was similar to BPS 1159 with only slight modifications to vegetation species composition because BPS 1154 and 1159 for MZ 12 and 17 overlap in elevations and describe the lower part of meandering river systems of the Great Basin.

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

Vegetation Classes

Class A 25 %

Early Development 1 All Stru

Description

Immediate post-disturbance responses are dependent on pre-disturbance vegetation composition. Generally, this class is expected to occur 1-5 years post-disturbance. Typically shrub dominated, but grass may co-dominate. Salix spp dominates after fire, whereas Populus spp and Salix spp co-dominate after flooding. Silt, gravel, cobble, and woody debris may be common. Composition highly variable. Modeled disturbances include weather-related stress expressed as 7-year annual flooding events. Succession to class B after 5 years.

Indicator Species* and Canopy Position

POPUL Upper
SALIX Upper
ROWO Upper
CAREX Lower

Upper Layer Lifeform

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

Fuel Model 3

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	50 %
Height	Shrub 0m	Shrub 3.0m
Tree Size Class	None	

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

Class B 55 %

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 5-yr annual flooding events, which maintains vegetation in class B, and 2) 20-yr flooding events (weather-related stress) causing stand replacement. Replacement fire occurs about every 50 yrs on average. Succession to class C after 15 years.

Indicator Species* and Canopy Position

POPUL Upper
ROWO Upper
SALIX Mid-Upper

Upper Layer Lifeform

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

Fuel Model 3

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	100 %
Height	Tree 0m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

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

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

Class C 20 %

Late Development 1 Closed

Description

This class represents the mature, large cottonwood, conifer, etc. woodlands. 50-yr flooding events (weather-related stress) cause a transition to class A, whereas 20-yr flood events cause a transition to class B. Replacement fire occurs about every 50 yrs on average.

Indicator Species* and Canopy Position

POPUL	Upper
ROWO	Mid-Upper
SALIX	Mid-Upper
	Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 3

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

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

Class D 0 %

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Structure Data (for upper layer lifeform)

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

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

Class E 0 %

Late Development 1 All Struct

Description

Indicator Species* and Canopy Position

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Structure Data (for upper layer lifeform)

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

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

Disturbances

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

Fire Regime Group:** **4**

Historical Fire Size (acres)

Avg 10
Min 1
Max 100

Sources of Fire Regime Data

☐ Literature
☐ Local Data
☐ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	67	15	90	0.01493	100
Mixed					
Surface					
All Fires	67			0.01495	

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.

LANDFIRE Biophysical Setting Model

Biophysical Setting: **1155pro** **Warm desert Mesquite Dunes and Loamy Bottom**

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

General Information

Contributors (also see the Comments field) **Date** 9/9/2008

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

Vegetation Type

Upland Savannah/Shrub Steppe

Map Zones

13

Model Zones

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

Dominant Species*

PROS
SPAI
ACHY
ACSP1

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

Found in the warm deserts of the southwestern USA.

Biophysical Site Description

Biophysical setting occurs as both mesquite bosque established on sand dunes and in loamy bottoms (silty soil) at low elevations. Frequently adjacent to playas.

Vegetation Description

On sand dunes, either honey or screwbean mesquite are dominant, often monotypic. Patches of drought resistant grasses adapted to sandy soils (Indian ricegrass, desert needlegrass) or salt desert shrubs will be associated with dunes. Loamy bottom mesquite is found on ususally flat areas with sediment accumulation where alkali sacaton dominates with mesquite at the fringe or dotting grasslands. The dune and loamy bottom mesquite types are often adjacent and intermingled.

Disturbance Description

Severe freeze is the main stand replacement event to affect mesquite bosque, a subtropical tree, sometimes followed by basal resprouting. Severe freezing in 1978 caused above-ground mortality of many riparian mesquite in southern Arizona. A severe freeze is a freeze lasting several days, which we modeled as a 100-yr event. Prolongued drought is also an infrequent event (150 year mean return interval). It was assumed that 90% of times, drought will thin mesquite bosques, but not cause a transiiton to other succession classes. Only 10% of times will drought be severe enough to cause a stand replacing event. Flash flooding can affect bosques in loamy bottoms as these landforms are usually at the bottom of long alluvial fans. Herbaceous vegetation in the early development class is affected by 7-yr flood events, mid-development class woody vegetation is returned to the early development class by 20-yr flood events, and lte development classes are either thinned by 20-yr events or returned to an early development state by 200-yr events. Replacement fire

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occurs every 1,000 years on average and only in the late development class. Mesquite will reprout after fire.

Mesquite Bosque were important fuel and food sources for Native Americans and were often tended through the clearing of midstroy shrubs and limbering of lower branches of mesquite. Native Americans, such as the Pima in MZ 14 and 15, avoided burning mesquite (A. Rea, pers. communication). We assumed that this was generally true of most tribes.

Adjacency or Identification Concerns

Livestock grazing can be a major influence in the alteration of structure, composition, and function of the community.

Groundwater pumping can also affect the availablity of water to the deep roots of mesquite.

Native Uncharacteristic Conditions

Scale Description

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

These systems exist as small to linear features in the landscape. Mesquite bosque are associated with dunes complexes along playas. Loamy bottoms are frequently found in shallow depression or washes with weak slopes.

Issues/Problems

We are uncertain about the average return interval of severe freezes that would kill mesquite, a sub-tropical tree. Model results are sensitive to this parameter. Because several experts and the literature indicated that mesquite trees older than 100 years are uncommon in MZ 13 and 14 even in non-riparian, non-flooding systems, despite their ability to live longer, suggests that stand replacing events may have in role in limiting stand age. Therefore, fire and/or severe freezes with return intervals of at least 100 years.

Comments

BpS 1155mesquite is a new model based on the dynamics of loamy bottoms supporting basin wildrye in the Great Basin (1080bw) and adapted from the description of Warm Desert Riparian Systems (1155).

Vegetation Classes

Class A 30 %

Early Development 1 All Stru

Description

The early development class is primarily herbaceous with resprouting mesquite: 10-50% cover of dunes (sand), 10-40% cover Indian ricegrass, desert needlegrass, 10-20% cover of rabbitbrush, resprouting honey mesquite (after fire); loamy bottom — 20-40% cover of alkali sacaton, inland saltgrass, big galleta, 5-10% cover of rabbitbrush. Due to their low elevation position, loamy

Indicator Species* and Canopy Position

ACHY	Mid-Upper
SPAI	Upper
ACSP1	Upper
PROSO	Lower

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	50 %
Height	Herb 0m	Herb 1.0m
Tree Size Class	None	

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

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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.

bottoms are subject to 7-yr flash flood events that cause stand replacement of herbaceous and small shrubs species. This class will last up to 10 yrs before a transition to class B.

Class B 20 %

Mid Development 1 Closed

Description

Young mesquite dominate the upper layer lifeform. Cover is: dunes — 5-20% cover of fourwing saltbush, 5-20% cover of young mesquite, 20-30% cover of grasses (Indian ricegrass, desert needlegrass, alkali sacaton), 20-40% dunes; loamy bottom — 20-40% cover of alkali sacaton, inland saltgrass, big galleta, 5-10% cover of rabbitbrush, fourwing saltbush, 5-20% cover of young mesquite. Severe freezing events return every 100-yr event on average. Drought every 150 years on average thins the mesquite 90% of times, but topkill mesquite 10% of times. 20-yr flashflood events will cause a return to the early succession class. This class will last from 10 to 25 years followed by a transition to class C.

Indicator Species* and Canopy Position

PROSO Upper
SPAI Lower
ACSP1 Lower
ACHY Lower

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	50 %
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:

In loamy bottom, alkali sacaton can be the dominant cover.

Class C 50 %

Mid Development 2 Closed

Description

Mesquite increases in importance in the midstory and lower canopy. Cover varies between dunes and loamy bottoms: dunes — 20-40% of honey mesquite and/or screwbean mesquite, 20% cover of fourwing saltbush, creosote bush, white bursage, and other shrub, 10-20% Indian ricegrass, desert needlegrass, alkali sacaton, big

Indicator Species* and Canopy Position

PROSO Upper
SPAI Lower
ACSP1 Lower
ACHY Lower

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	50 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

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

In loamy bottom, alkali sacaton can be the dominant cover.

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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.

galleta, 5% cover of perennial forbs, 10-40% cover dunes; loamy bottom — 10-20% cover of mesquite, 3-40% cover of alkali sacaton, big galleta, inland saltgrass, 15% cover of fourwing saltbush. Disturbances are the same as the previous class, with the addition of 200-yr- flash flooding events.

Class D **0 %**

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

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

Fuel Model 8

Class E **0 %**

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

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

Fuel Model

Disturbances

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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.

Fire Regime Group:** 5

Historical Fire Size (acres)

Avg 1
Min 0
Max 10

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	2000	1000	1000	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
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [x] Other (optional 1) severe freeze
- [x] Other (optional 2) flashflood

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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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*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: **1155wash** **North American Warm Desert Riparian Systems-Washes**

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *Original BpS 131155 was split between 131155a dominated by mid to large perrennial rivers where Native American use was possible and 131155b that represents smaller riparian stringers with either intermittent water or subsurface groundwater flow (washes, canyon corridor, small streams) imbedded in the creosote and blackbrush matrix vegetation.*

General Information

Contributors (also see the Comments field) **Date** 9/9/2008

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

Vegetation Type

Wetlands and Riparian

Dominant Species*

HYME	DISP
SAEX	SPAI
PROP	ACIC1
PLRI3	CHRY

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zones

13

Model Zones

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

Geographic Range

Found in the warm deserts of the southwestern USA. Intermittent to dry warm desert (Mojave and Sonoran Deserts) drainages with mostly subsurface flow in southern CA, NV, AZ, and southwest UT.

Biophysical Site Description

Narrow riparian systems occur primarily along low elevation shrublands (creosote, blackbrush, and paloverde matrix vegetation) and in canyons, washes, or as spring brooks. Elevation is typically below 5000 ft.

Vegetation Description

The vegetation is a mix of riparian shrublands dotted with patches of shrubs including burrobrush, Acacia spp., Salix exigua, Prosopis spp., grasses and forbs (Distichlis spicata, Sporobolus airoides, Carex spp., and Pluchea sericea). Mesquite occurs as dispersed shrubs, not bosque. Halophytic shrub-dominated patches occur on drier sediment deposits or saltier surfaces. Vegetation is dependent upon periodic flash flooding. Gravel, cobble, and mineral soil is common. Native Americans had a minor effect on these riparian systems compared to larger floodplains.

Disturbance Description

This BpS is a flash flood-dependent ecosystem. The entire range of flood magnitudes contribute to ecological processes such as nutrient cycling, recruitment, species composition. 2-10-yr events (7-yr event used) primarily impact herbaceous vegetation, 7-50 yr events (20-yr events used) result in patchy removal of

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shrubs and saplings. 50+-yr events (50-yr event used) remove stands of larger trees.

In general fuels are typically continuous and fuel loads high, but fuel moisture content is also often high. Wildfires may not carry except under extreme fire weather conditions. The average FRI for replacement fire is 500-1000 yrs; assumed 1000 yrs ofr mid-development riparian vegetation and 500 yrs for late-development vegetation. Native American burning of desert washes was assumed rare. Willow and mesquite resprouts after fire.

Adjacency or Identification Concerns

Creosote (BpS 131087) and blackbrush (BpS 131082) will be immedaitely adjacent to BpS 1311552 and the transition is sharp to riparian vegetation.

Water diversions and groundwater pumping have greatly modified hydrologic regimes and water levels, perhaps permanently.

Livestock grazing can be a major influence in the alteration of structure, composition, and function of the community.

Exotic trees of Elaeagnus angustifolia and Tamarix spp are common in some stands.

In some riparian woodlands, the invasives saltcedar (Tamarix spp), and less frequently giant reed (Arundo donax), can create ladder fuels that allow fire to spread from surface fuels of willow (Salix spp.), saltbush (Atriplex spp.), sedge (Carex spp.), reed (Juncus spp.), and arrow weed (Pluchea sericea) into the crowns of overstory Fremont cottonwood trees, top-killing them. After an initial fire, these invasives quickly recover and surpass their pre-fire dominance, promoting increasingly more frequent and intense fires which, can eventually displace most native plants.

In palm oases, Washington fan palms depend on surface fire to clear understory species and facilitate recruitment. However, these sites can be pre-empted by saltcedar as it rapidly recovers after fire. The ladder fuels saltcedar creates can also carry fire into the crown of Washington fan palms, increasing the incidence of crown fires lethal to other species.

Native Uncharacteristic Conditions

Canopy cover can reach 100% in class B.

Scale Description

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

These systems exist as small linear features <60 m wide in the landscape. Flash flooding will disturb miles of riparian vegetation, whereas fires may burn < 100 acres in long linear patches.

Issues/Problems

Comments

BpS 1155wash is a trimmed down version of 1311552. Class C was removed as dry washes of the Spring Mountains rarely contain perennial water or wetted areas that allow cottonwood growth without becoming a perennial riparian system. Species composition was also change to describe a sysytem dominated by gravel, cobble, burrobrush, rabbitbrush, grasses, and other shrubs.

BpS 131155b was split from 131155 by Louis Provencher (lprovencher@tnc.org) at the request of the Missoula Fire Lab. This version of the model is restricted to stringers; therefore the Native American influence on fire regimes, farming, and wood collection was removed, A longer FRI of 500-1000 yrs was retaned. The system is nearly entirely dependent on flash flooding.

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BpS 131155, now 131155a, was originally created by Matt Brooks (matt_brooks@usgs.gov) and Louis Provencher (lprovencher@tnc.org) and substantially revised with the input of several reviewers: Kay Fowler (csfowler@scs.unr.edu), Amadeo M. Rea (San Diego SU), Janet Grove (jgrove@fs.fed.us), Holly Richter (hrichter@tnc.org), Jony Cockman (jcockman@blm.gov), Julie Stromberg (jstrom@asu.edu), and Brooke Gebow (bgebow@tnc.org). All reviewers, except Kay Fowler, Amadeo Rea, and Julie Stromberg participated in modeling at TNC's Ramsey Canyon Preserve, AZ on 9/18/05.

Following further discussions with Jeri Kruger (jkruger@fws.edu), Julie Stromberg, and literature reviews, Louis Provencher (lprovencher@tnc.org) modified the model by adding a fifth class resulting from stand replacement fire that does not cause cottonwood and willow germination because this case is not associated with flooding. Many changes were done to the original model by M. Brooks. Floods causing stand replacing events were more frequent (5-50 yr, 50+-yrs, for respectively, mid- and late-development classes). Classes C and D in 131155a were merged into new class D (mature cottonwood and willow; still accounting for Native American influences). Class E was added for Mesquite Bosque, which is the last successional phase in the floodplain, with 500-yr flood events and replacement fire every 250 yrs on average; and, although Native American influences were maintained, the importance of mixed severity was implicitly reduced by removing time since disturbance from the original BpS. In the original model, and it's revision from 9/18/05, replacement fire was assumed to cause a return to class A, which is impossible. Class A is only the result of stand replacing flood events where cottonwood and willow germination is only possible. Replacement fire does not change the elevation of a terrace or create a seedbed for willows and cottonwoods, but allows resprouting and seed establishment by mesquite and other shrubs (e.g., Salix gooddingii). Therefore, class C is the recipient of all replacement fire and will eventually succeed to Mesquite Bosque unless a 50-yr flood event scours the more fragile soils of class C. To accommodate the LANDFIRE limit for one early S-Class, class C starts at age 1 and is considered mid-development. In reality, class C behaves as an alternative early-development class.

One reviewer suggested several changes to clarify the geographic location of the BpS, its elevation, and species/patch composition. The reviewer indicated that pre-settlement warm desert riparian systems were very patchy (Jeri Krueger from FWS NV forwarded accounts from early explorers of the Virgin River that support the patchy nature of the vegetation and importance of mesquite) and probably contained more grasslands and shrub patches that we find today, and, therefore, may have supported a greater amount of fine fuels and fire. These issues were addressed, although the fire frequency was not changed as it is frequent enough in the current version. The reviewer also recommended adding references on southwestern riparian systems by Busch, Ellis, and Davis, which was done.

Native American burning was introduced as a very plausible disturbance. However, no data or expertise were available at the creation of the original model. Reviews by ethnobiologists Kay Fowler and Amadeo Rea resulted in important modifications to the original model and description (Fowler 2003; Rea 1983). The Native American influence was greater than initially thought with farming of mud flats (not in late development stands as initially modeled), irrigation, massive fuel wood collection, and extensive small-scale burning for willow control, basketry, general access, and hunting. Therefore, very frequent mixed severity fire was added by Louis Provencher to all mid-development and late-development classes (except Mesquite Bosque, class E), and farming and fuel collection were added, respectively, as model parameters in early and late-development open classes. Amadeo Rea explained that warm desert rivers of MZ 14 and 15 were more heavily farmed by the Pimans Indian than those of MZ 13 (Mohave and Shoshone Indians) (also suggested by Dr. Fowler). In all cases, he agreed that Native people probably modified the vegetation structure and composition of warm desert river floodplains far more than currently understood. Dr. Rea also explained that Native burning was used to flush rodents, even more than jackrabbits, and that fire was avoided in

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mesquite Bosque, in cultivated fields, and near fences. Burning was especially intense in riparian grasslands dominated by Sporobolus spp, marshes, and shrubby areas.

Vegetation Classes

Class A 25 %

Early Development 1 All Stru

Description

Immediate post-disturbance responses are dependent on pre-disturbance vegetation composition. 20-50% cover may be gravel, sands, and/or flood debris, 10-20% cover of burrobrush, rabbitbrush, willows, 10-30% cover of grasses (big galleta, bush muhly, alkali sacaton)

Generally, this class is expected to occur 1-5 years post-disturbance. Modeled disturbances include stand-replacing flood events for herbaceous vegetation and seedlings approximately every 7 years.

Transition to Class B after 5 years.

Indicator Species* and Canopy Position

HYME	Upper
SAEX	Upper
DISP	Lower
SPAI	Lower

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	50 %
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 B 75 %

Mid Development 1 Closed

Description

Highly dependent on the hydrologic regime. Vegetation composition includes tall shrubs and small trees (willows, maybe cottonwoods if surface water is present) with patches of graminoids and halophytic shrubs. 30-50% cover of hollyleaf bursage, burrobrush, Anderson's wolfberry, rabbitbrush, acacia, mesquite, 5-10% cover of grasses (big galleta, bush muhly, alkali sacaton), <30% of gravel and rocks. Modeled disturbances include 20-yr flooding events on mid-level terraces

Indicator Species* and Canopy Position

PROSO	Upper
SAEX	Upper
HYME	Middle
SPAI	Lower

Upper Layer Lifeform

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

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	51 %	100 %
Height	Shrub 1.1m	Shrub >3.1m
Tree Size Class	Pole 5-9" DBH	

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

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

causing stand replacement and 7-yr events than maintain the stand in class B. The FRI of replacement fire is 1000 years. This class is an ideal bed for mesquite germination and establishment.

Class C **0 %**

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

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

Fuel Model

Class D **0 %**

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

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

Fuel Model 8

Class E **0 %**

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

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

Fuel Model 8

Disturbances

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

Fire Regime Group:** 1

Historical Fire Size (acres)

Avg 50

Min 1

Max 100

Sources of Fire Regime Data

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

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	1250	500	1000	0.0008	98
Mixed					
Surface					
All Fires	1247			0.00082	

Fire Intervals (FI):

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

Additional Disturbances Modeled

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

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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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*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 III. Remote sensing plot photographs.

Site No.	X-coordinate[#]	Y-coordinate
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12	642204.887	3945229.91
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14[&]	643098	3946582
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119	637202.9992	3961051.459
121	637392.7426	3962203.677
122	637917.458	3961731.269
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126	642623.0707	3962009.294
214	650019.1764	3968898.524
215	649253.9657	3968880.388
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220	644426.1039	3966991.902
238	633316.5935	3967314.987

256	626601.6871	3971191.929
257	627527.4304	3970683.761
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263	629851.8515	3969560.813
268	635951.2346	3969931.575
281	651444.5313	3970319.707
289	656172.9987	3973131.927
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302	650214.9305	3973249.598
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MtGriffith#9[&]	621977	4010429

[#]Coordinates are UTM zone 11 NAD83. Photographs follow the list of coordinates.

[&] Not part of the originally pre-selected plots.

First Field Trip: 26 May – 2 June, 2008


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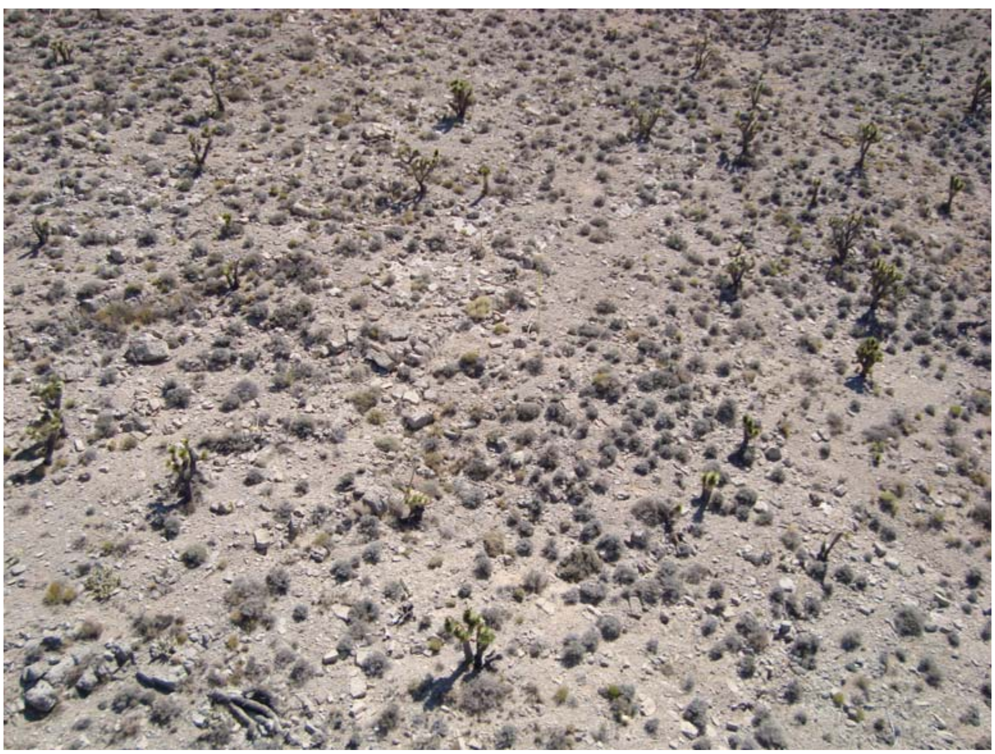
SpringMtns_plot13_helicopter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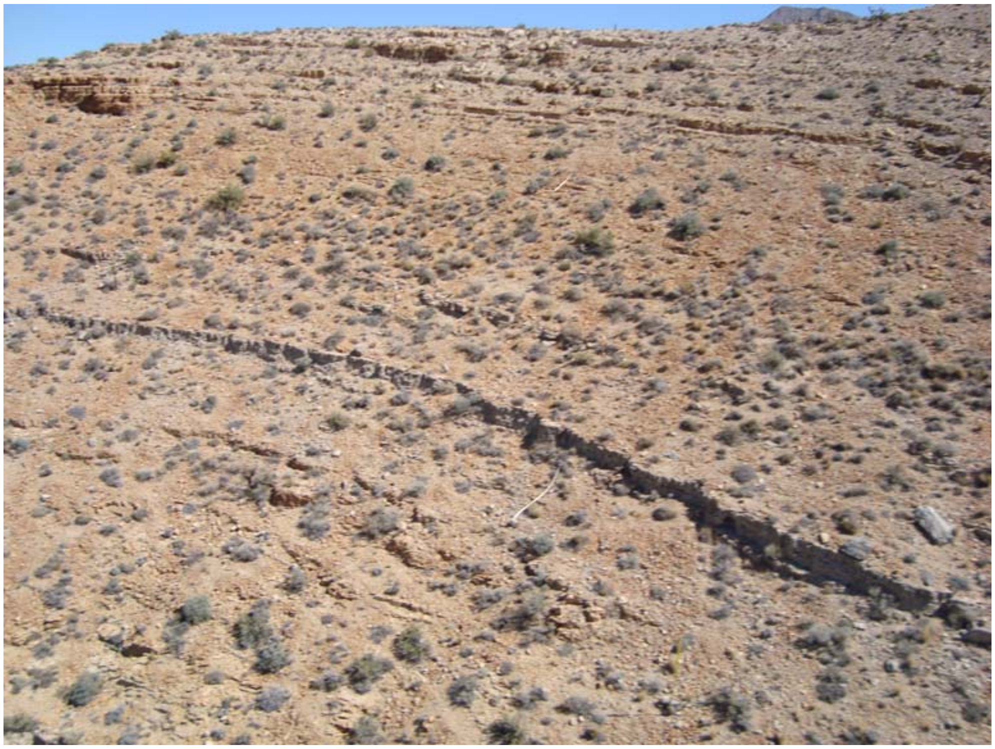
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SpringMtns_plot72_helicopter


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SpringMtns_plot78_helicopter


SpringMtns_plot111_helicopter


SpringMtns_plot117_helicopter


SpringMtns_plot118_helicopter


SpringMtns_plot119_helicopter


SpringMtns_plot121_helicopter


SpringMtns_plot122_helicopter


SpringMtns_plot124_helicopter


SpringMtns_plot125_helicopter


SpringMtns_plot126_helicopter


SpringMtns_plot214_helicopter


SpringMtns_plot215_helicopter


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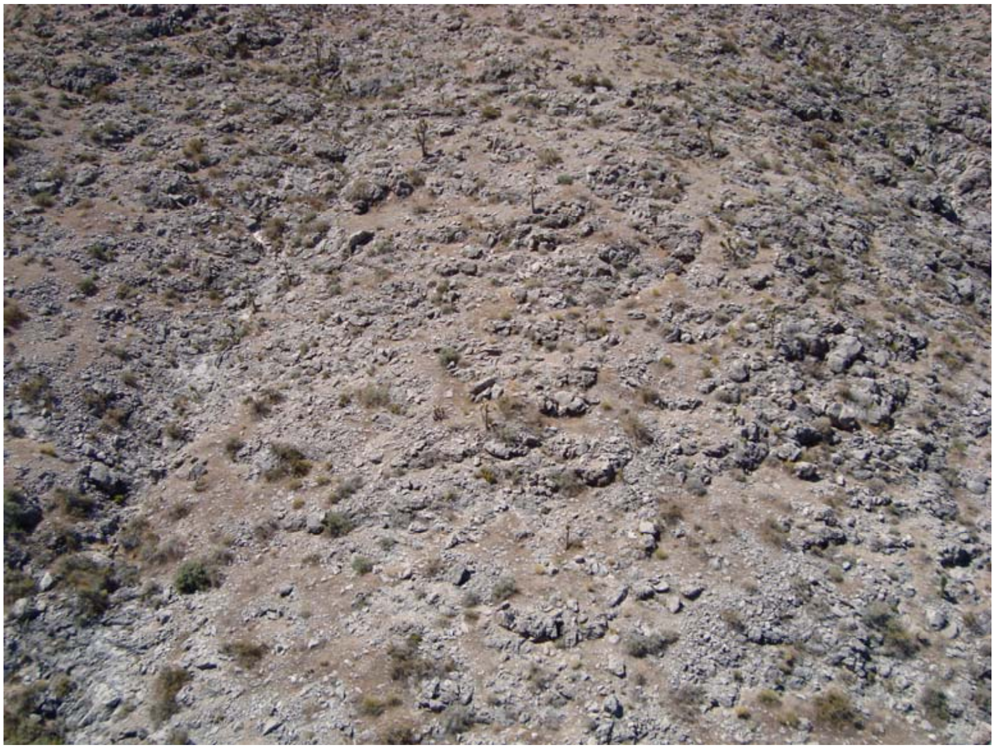
SpringMtns_plot256_helicopter


SpringMtns_plot257.jpg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SpringMtns_plot289_helicopter

SpringMtns_plot290_helicopter


SpringMtns_plot292_helicopter


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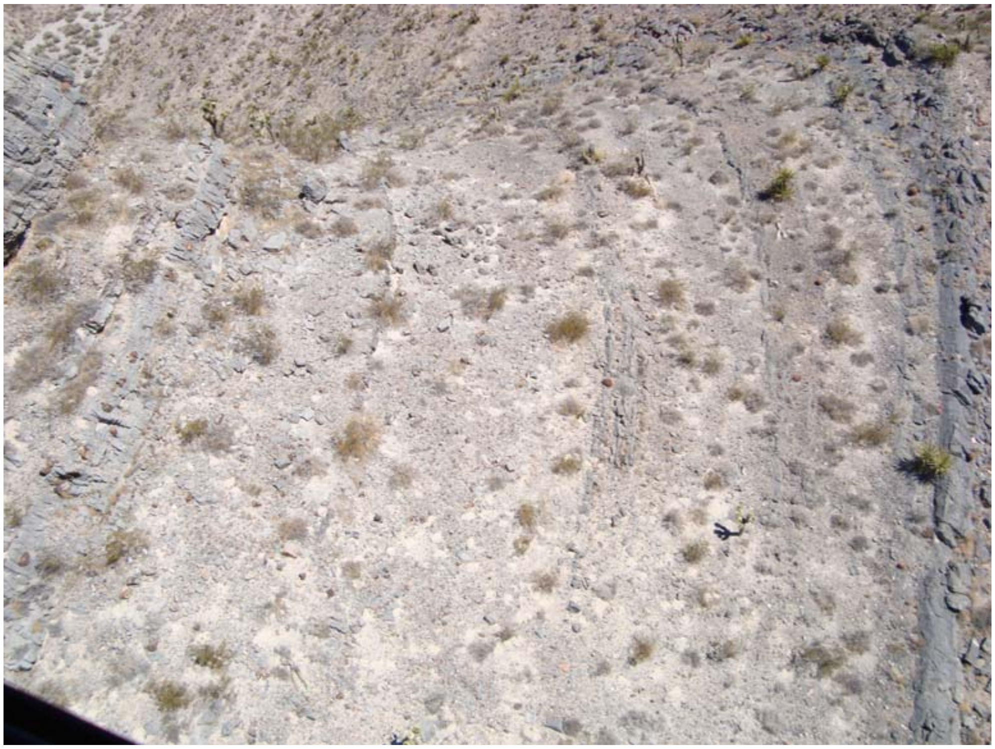
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SpringMtns_plot413_helicopter


SpringMtns_plot416_helicopter


SpringMtns_plot421_helicopter

SpringMtns_plot423_helicopter

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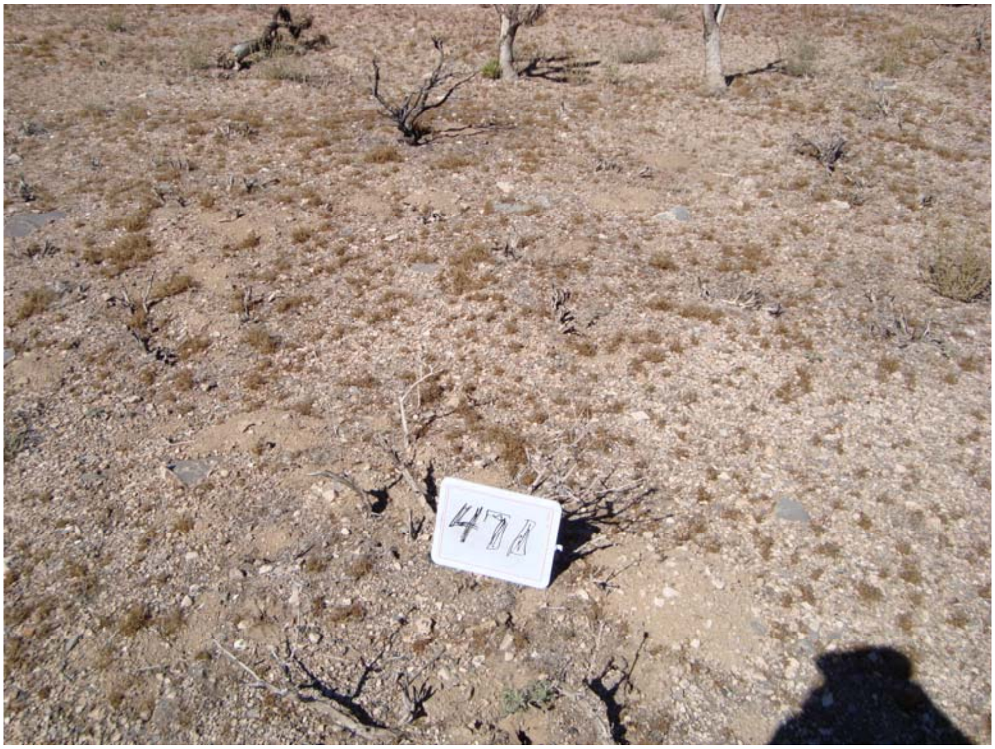

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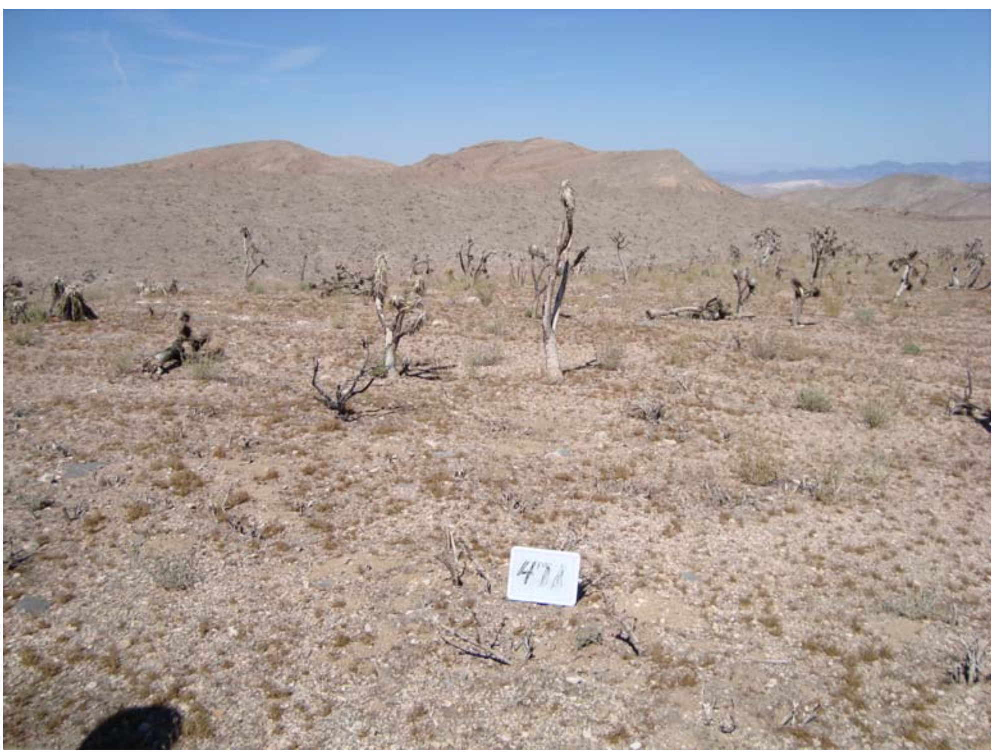
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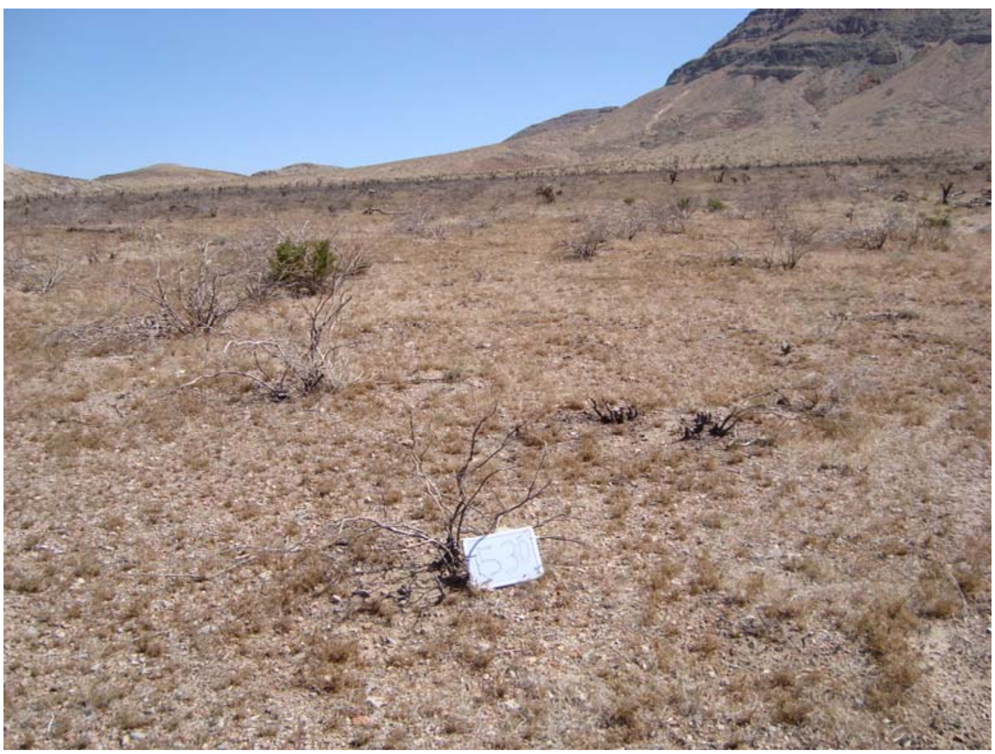

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SpringMtns_plot575_helicopter


SpringMtns_plot576

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SpringMtns_plot582#2_060108

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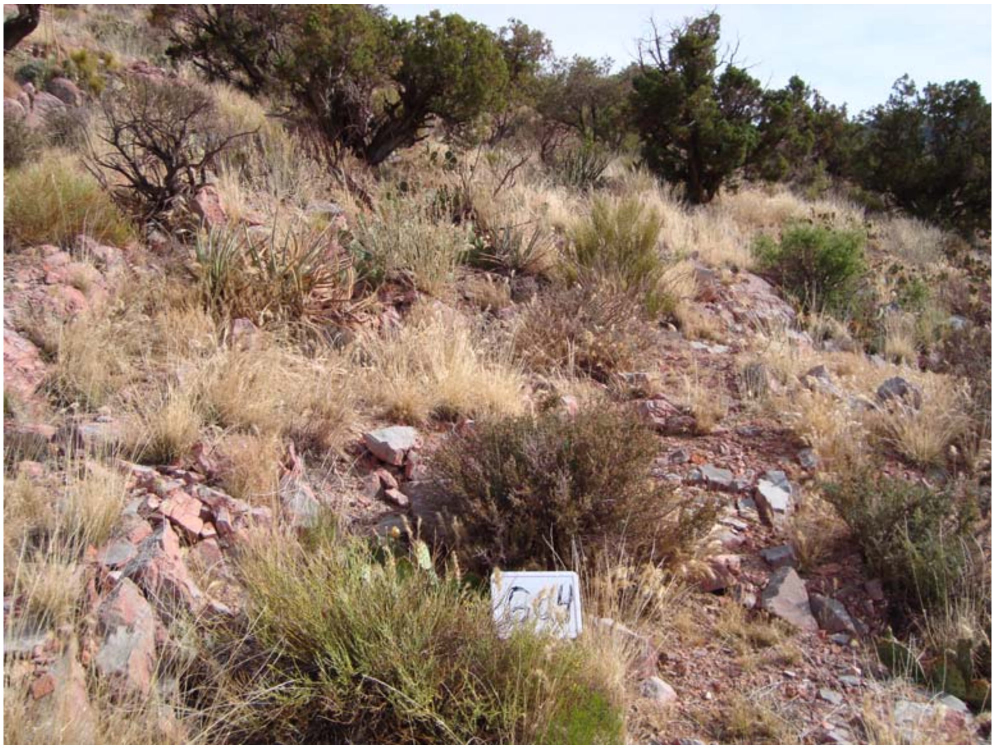
SpringMtns_plot604#1_060108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SpringMtns_Plot610_helicopter

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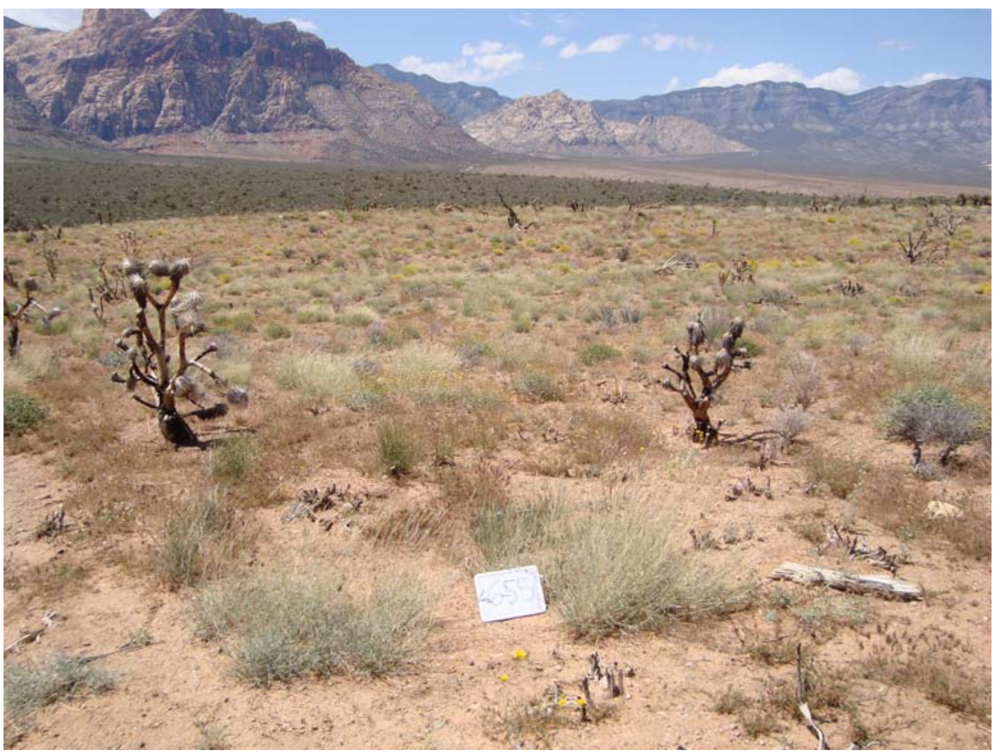

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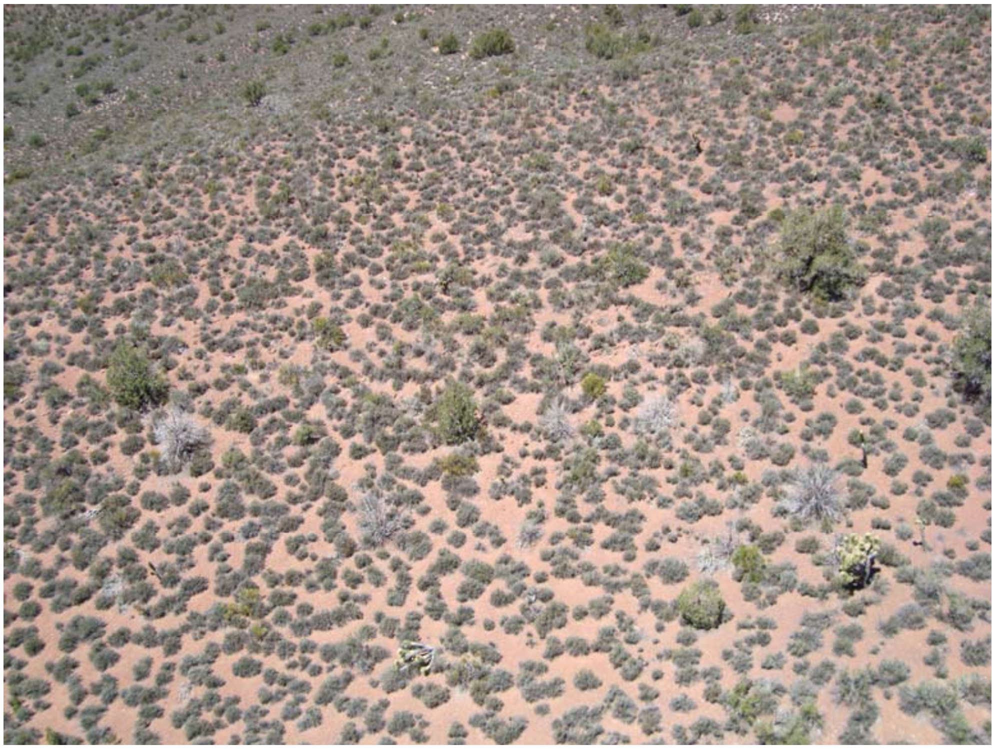
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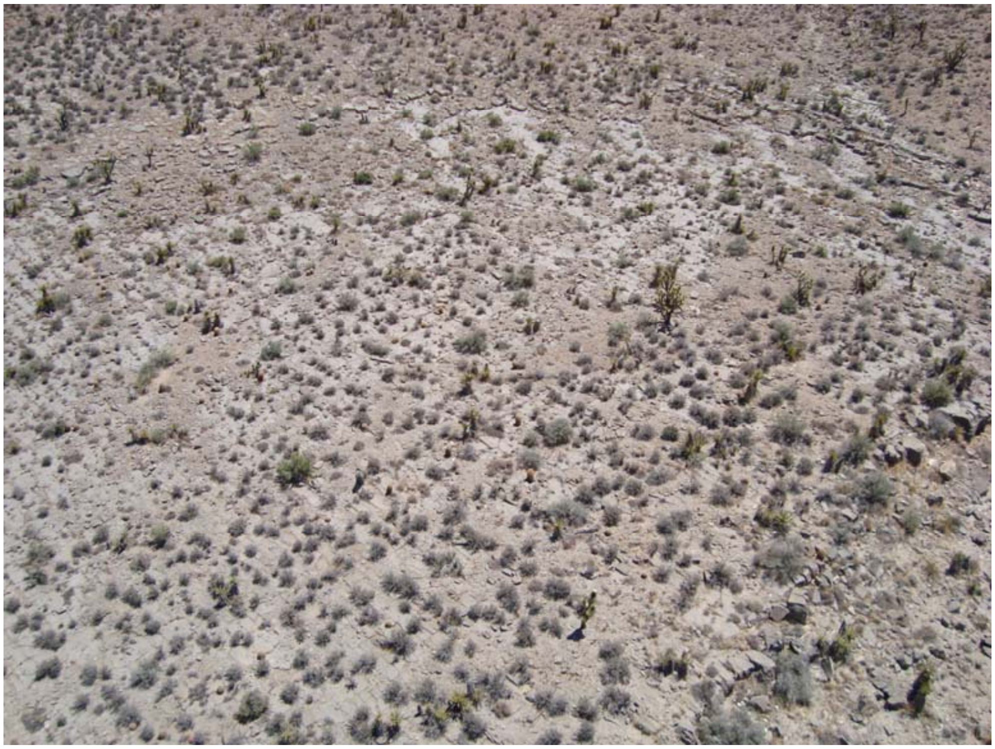
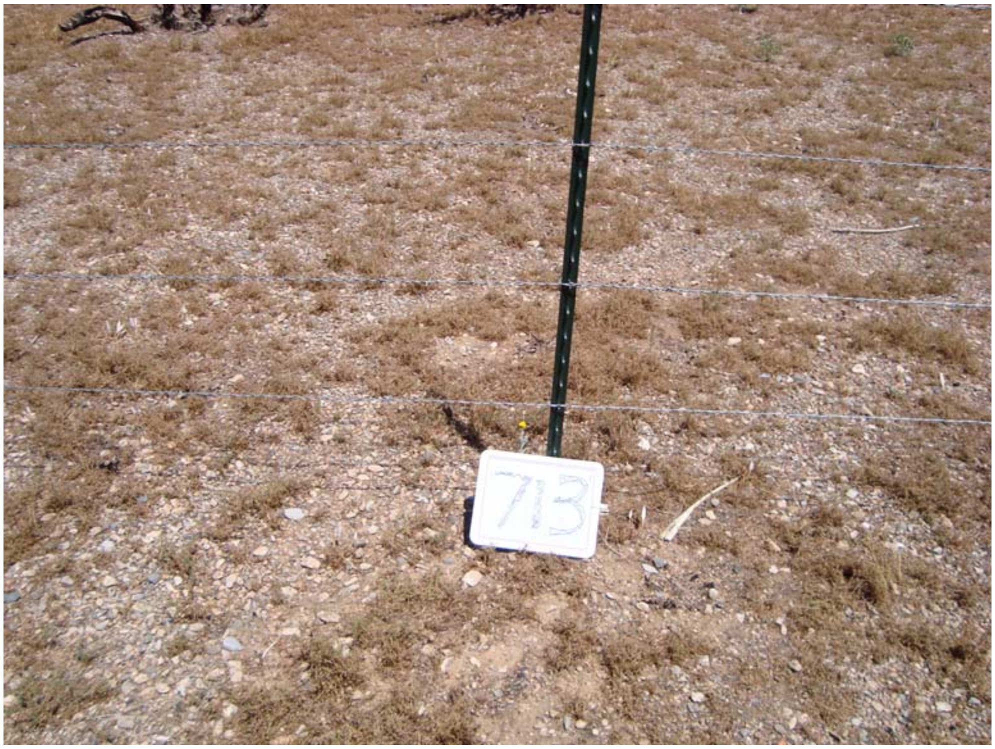
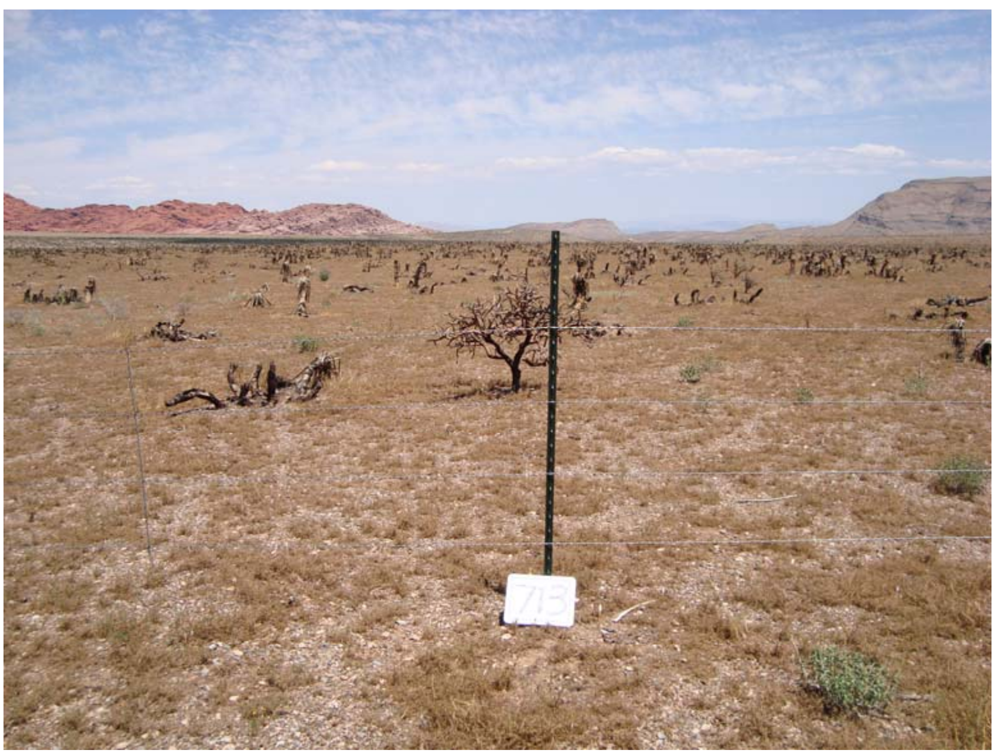
SpringMtns_Plot665_helicopter


SpringMtns_Plot683_helicopter


SpringMtns_Plot685_helicopter



SpringMtns_plot713#1_052808



SpringMtns_plot713#2_052808

SpringMtns_plot714#1_052808

SpringMtns_plot714#2_052808

SpringMtns_plot715#1_052808

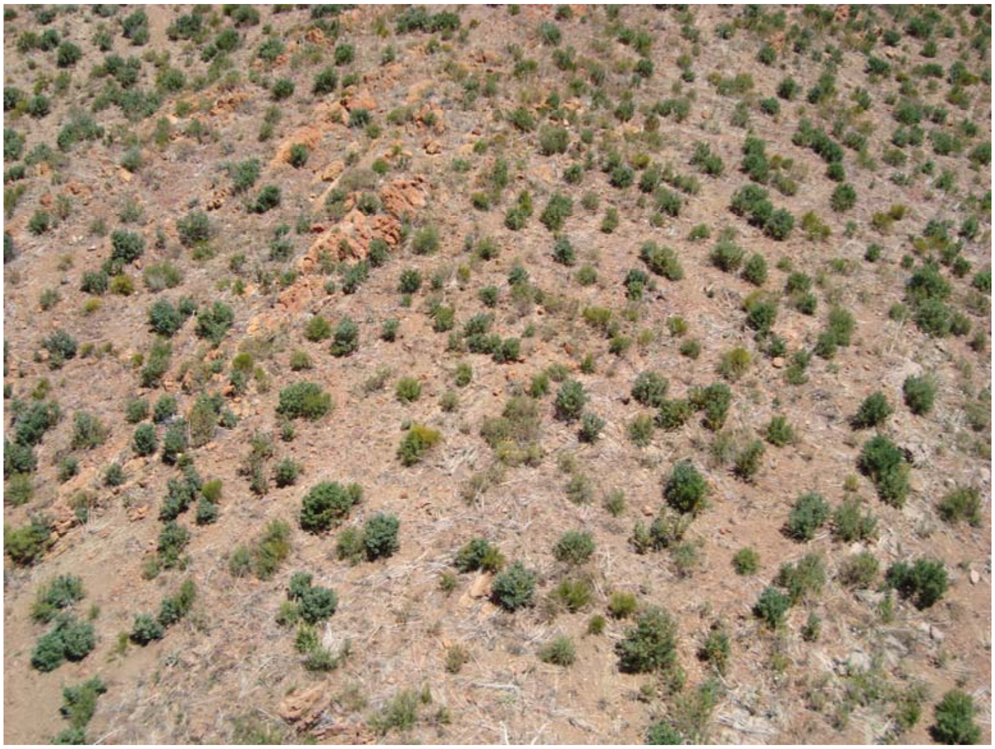

SpringMtns_plot715#2_052808

SpringMtns_plot717#1_052808

SpringMtns_plot717#2_052808


SpringMtns_Plot718_helicopter


SpringMtns_Plot720_helicopter


SpringMtns_Plot721_helicopter


SpringMtns_Plot722_helicopter


SpringMtns_Plot723_helicopter


SpringMtns_Plot724_helicopter

SpringMtns_Plot733#1_053108

SpringMtns_Plot733#2_053108

SpringMtns_Plot735#1_053108


SpringMtns_Plot735#2_053108

SpringMtns_Plot737#1_053108

SpringMtns_Plot737#2_053108

SpringMtns_Plot758#1_053108

SpringMtns_Plot758#2_053108

SpringMtns_Plot759#1_053108

SpringMtns_Plot759#2_053108

SpringMtns_Plot760#1_053108


SpringMtns_Plot760#2_053108

SpringMtns_Plot764#1_053108

SpringMtns_Plot764#2_053108

SpringMtns_plot772#1_052808

SpringMtns_plot772#2_052808

SpringMtns_plot778#1_052808

SpringMtns_plot778#2_052808

SpringMtns_plot780#1_052808

SpringMtns_plot780#2_052808

SpringMtns_Plot820#1_053108

SpringMtns_Plot820#2_053108


SpringMtns_Plot867_helicopter


SpringMtns_Plot896_helicopter


SpringMtns_Plot897_helicopter


SpringMtns_plot916#1_052608


SpringMtns_plot916#2_052608


SpringMtns_plot918#1_052608

SpringMtns_plot918#2_052608


SpringMtns_plot920#1_052608


SpringMtns_plot920#2_052608


SpringMtns_plot923#1_052608

SpringMtns_plot923#2_052608

SpringMtns_plot926#1_052908

SpringMtns_plot926#2_052908

SpringMtns_plot928#1_052908


SpringMtns_plot928#2_052908

SpringMtns_plot930#1_052908


SpringMtns_plot930#2_052908

SpringMtns_Plot960#1_053008

SpringMtns_Plot960#2_053008

SpringMtns_Plot961#1_053008


SpringMtns_Plot961#2_053008

SpringMtns_Plot963#1_053008

SpringMtns_Plot963#2_053008

SpringMtns_Plot967#1_053008


SpringMtns_Plot967#2_053008

SpringMtns_Plot975#1_053008


SpringMtns_Plot975#2_053008

SpringMtns_plot984#1_052908

SpringMtns_plot984#2_052908

SpringMtns_plot986#1_052908


SpringMtns_plot986#2_052908

SpringMtns_plot987#1_052908

SpringMtns_plot987#2_052908

SpringMtns_plot996#1_052608


SpringMtns_plot996#2_052608

SpringMtns_plot997#1_052608


SpringMtns_plot997#2_052608

SpringMtns_plot1002#1_052608

SpringMtns_plot1002#2_052608


SpringMtns_plot1005#1_052608


SpringMtns_plot1005#2_052608

SpringMtns_plot1005west#1_052608

SpringMtns_plot1020#1_052608

SpringMtns_plot1020#2_052608

SpringMtns_plot1027#1_052908


SpringMtns_plot1027#2_052908

SpringMtns_Plot1034#1_053008

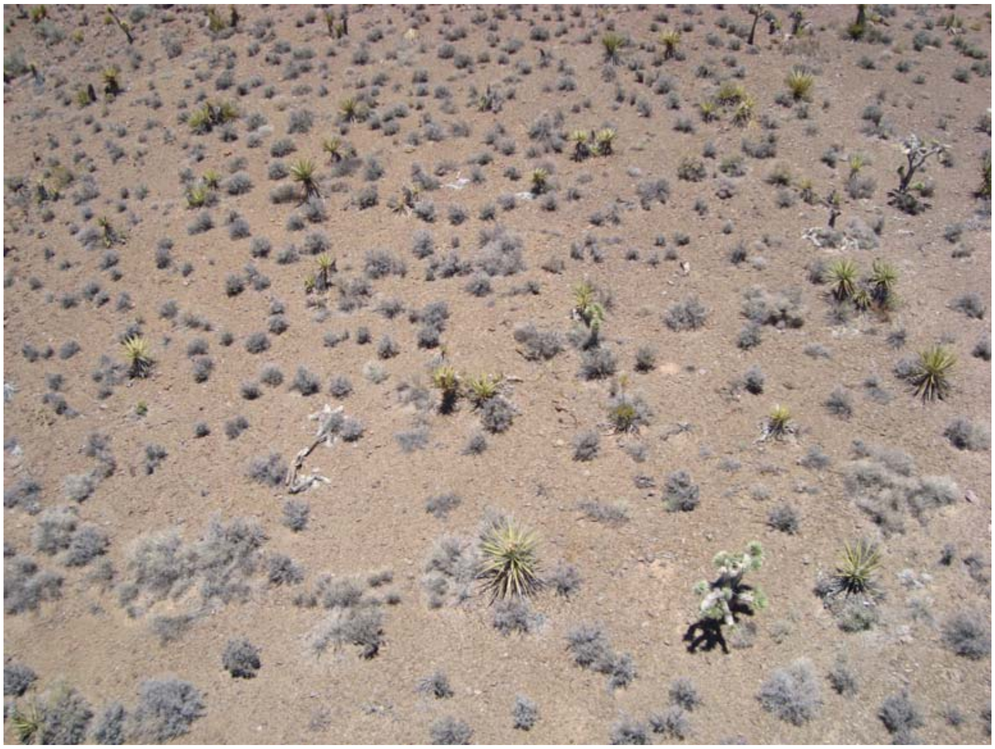

SpringMtns_Plot1034#2_053008

SpringMtns_Plot1038#1_053008


SpringMtns_Plot1038#2_053008

SpringMtns_Plot1040_helicopter

SpringMtns_Plot1044_helicopter


SpringMtns_Plot1045_helicopter


SpringMtns_Plot1048_helicopter


SpringMtns_Plot1057_helicopter


SpringMtns_plot1070_helicopter


SpringMtns_plot1071_helicopter


SpringMtns_plot1073_helicopter


SpringMtns_plot1074_helicopter


SpringMtns_plot1079#1_052608


SpringMtns_plot1079#2_052608

SpringMtns_plot1088_helicopter

SpringMtns_plot1090_helicopter

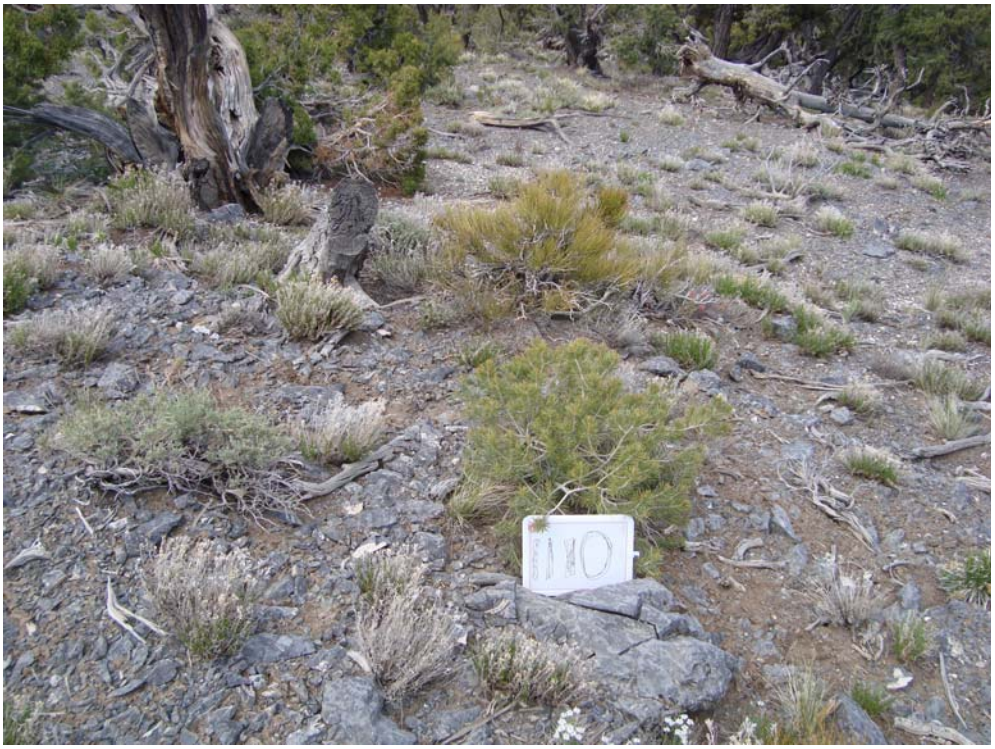
SpringMtns_plot1092#1_052908


SpringMtns_plot1092#2_052908

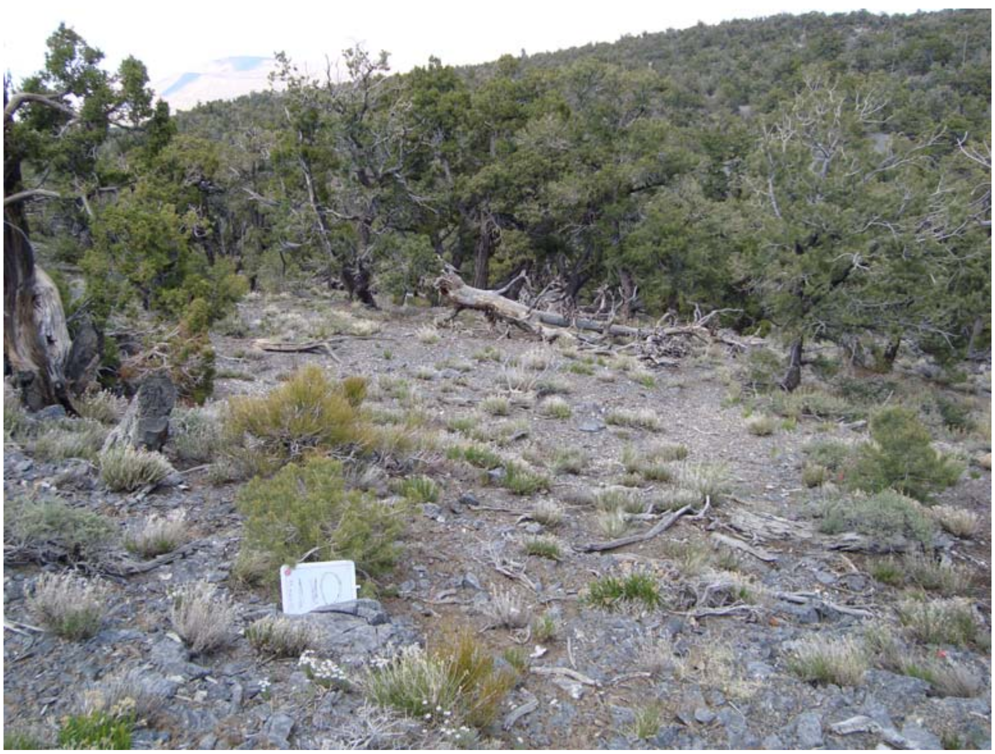

SpringMtns_Plot1098_helicopter

SpringMtns_Plot1103#1_053008


SpringMtns_Plot1103#2_053008



SpringMtns_plot1110#1_052908


SpringMtns_plot1110#2_052908


SpringMtns_plot1111_helicopter


SpringMtns_plot1112#1_052908


SpringMtns_plot1112#2_052908

SpringMtns_plot1127#1_052908

SpringMtns_plot1127#2_052908


SpringMtns_Plot1131#1_052708


SpringMtns_Plot1131#2_052708

SpringMtns_Plot1132#1_052708

SpringMtns_Plot1132#2_052708

SpringMtns_plot1133_helicopter

SpringMtns_plot1136_helicopter


SpringMtns_Plot1141#1_053008


SpringMtns_Plot1141#2_053008

SpringMtns_Plot1142#1_053008

SpringMtns_Plot1142#2_053008


SpringMtns_Plot1145


SpringMtns_Plot1162#1_052708


SpringMtns_Plot1162#2_052708


SpringMtns_Plot1163#1_052708


SpringMtns_Plot1163#2_052708

SpringMtns_Plot1168#1_052708


SpringMtns_Plot1168#2_052708

SpringMtns_plot1172#1_052608 (note different # on board)

SpringMtns_plot1172#2_052608

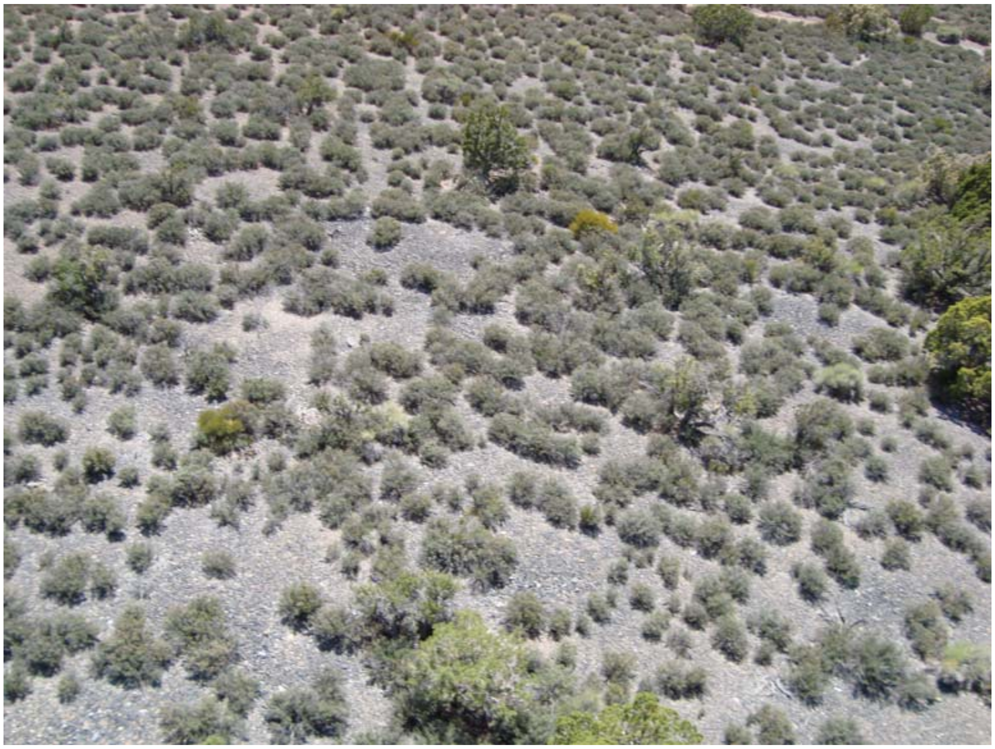

SpringMtns_Plot1183#1_052708.jpg


SpringMtns_Plot1183#2_052708

SpringMtns_Plot1186#1_052708

SpringMtns_Plot1186#2_052708

SpringMtns_Plot1188_helicopter



SpringMtns_Plot1204_helicopter


SpringMtns_Plot1209#1_052708


SpringMtns_Plot1209#2_052708

SpringMtns_plot1221#1_052708


SpringMtns_plot1221#2_052708


SpringMtns_Plot1239_helicopter

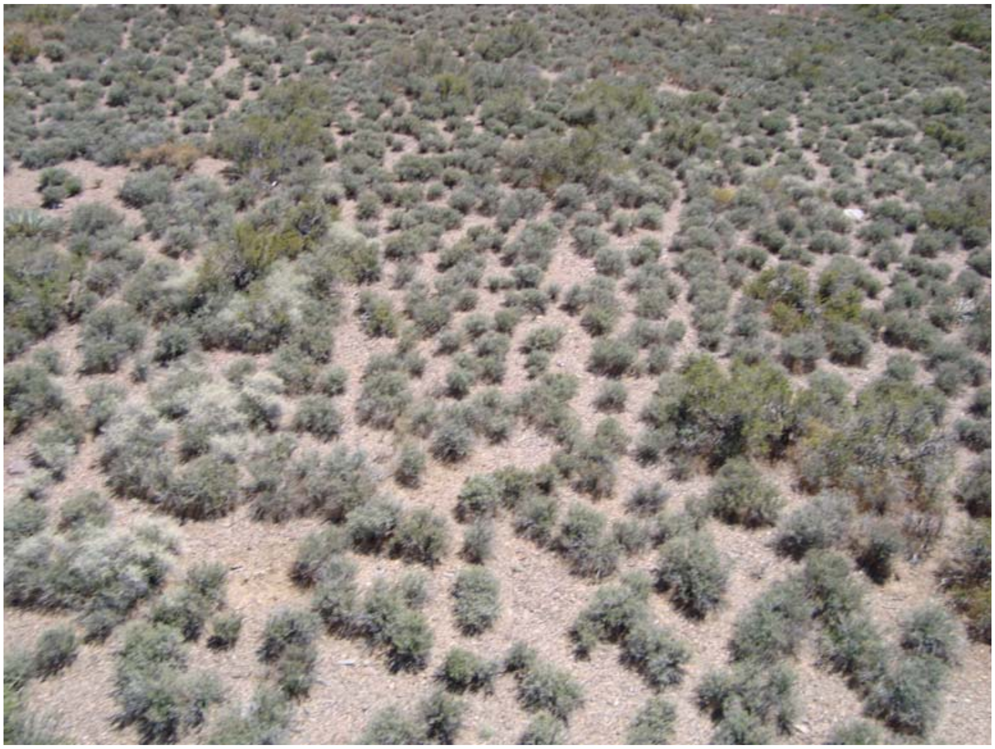

SpringMtns_Plot1240_helicopter


SpringMtns_Plot1245_helicopter


SpringMtns_Plot1254_helicopter


SpringMtns_Plot1255_helicopter


SpringMtns_Plot1256_helicopter


SpringMtns_Plot1257_helicopter


SpringMtns_Plot1260_helicopter


SpringMtns_Plot1325#1_052708


SpringMtns_Plot1325#2_052708


SpringMtns_Plot1326#1_052708


SpringMtns_Plot1326#2_052708

SpringMtns_Plot2000#1_053108

SpringMtns_Plot2000#2_053108

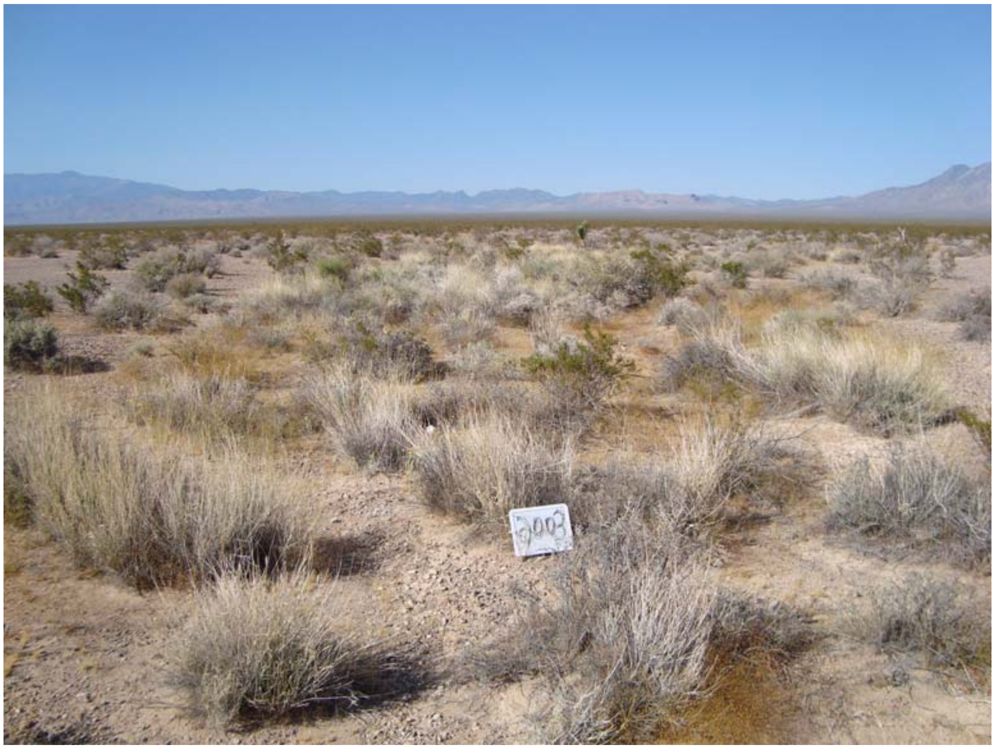
SpringMtns_Plot2001#1_053108


SpringMtns_Plot2001#2_053108

SpringMtns_Plot2002#1_053108

SpringMtns_Plot2002#2_053108

SpringMtns_Plot2003#1_053108



SpringMtns_Plot2003#2_053108


SpringMtns_plot2004_helicopter


SpringMtns_plot2007#1_052608


SpringMtns_plot2007#2_052608

Second Field Trip: 21-24 July, 2008


SpringMtns_3000#1_1082_072108


SpringMtns_3000#2_1082_072108


SpringMtns_3001#1_1082_072108


SpringMtns_3001#2_1082_072108


SpringMtns_3002_072108_helicopter


SpringMtns_3003#1_072208


SpringMtns_3003#1_072208


SpringMtns_3004#1_072208


SpringMtns_3004#2_072208


SpringMtns_3005#1_072208


SpringMtns_3005#1_072208


SpringMtns_helicopter_#7a_0724087


SpringMtns_helicopter_#7b_0724087


SpringMtns_helicopter_#8_0724087


SpringMtns_helicopter_#9_0724087


SpringMtns_helicopter_#10_0724087


SpringMtns_helicopter_#11a_0724087


SpringMtns_helicopter_#14_0724087


SpringMtns_helicopter_#21a_0724087


SpringMtns_helicopter_#21b_0724087


SpringMtns_helicopter_#22a_0724087


SpringMtns_helicopter_#22b_0724087

SpringMtns_helicopter_#22c_0724087

SpringMtns_helicopter_#22d_0724087


SpringMtns_helicopter_#25_0724087


SpringMtns_helicopter_#26_0724087


SpringMtns_helicopter_#27_0724087


SpringMtns_helicopter_#28_0724087


SpringMtns_helicopter_#32_0724087


SpringMtns_helicopter_#34_0724087

SpringMtns_helicopter_#35_0724087


SpringMtns_helicopter_#36a_0724087


SpringMtns_helicopter_#36b_0724087


SpringMtns_helicopter_#37_0724087


SpringMtns_helicopter_#38_0724087


SpringMtns_helicopter_#40_0724087


SpringMtns_helicopter_#41a_0724087


SpringMtns_helicopter_#41b_0724087


SpringMtns_helicopter_#48_0724087


SpringMtns_helicopter_#71_0724087

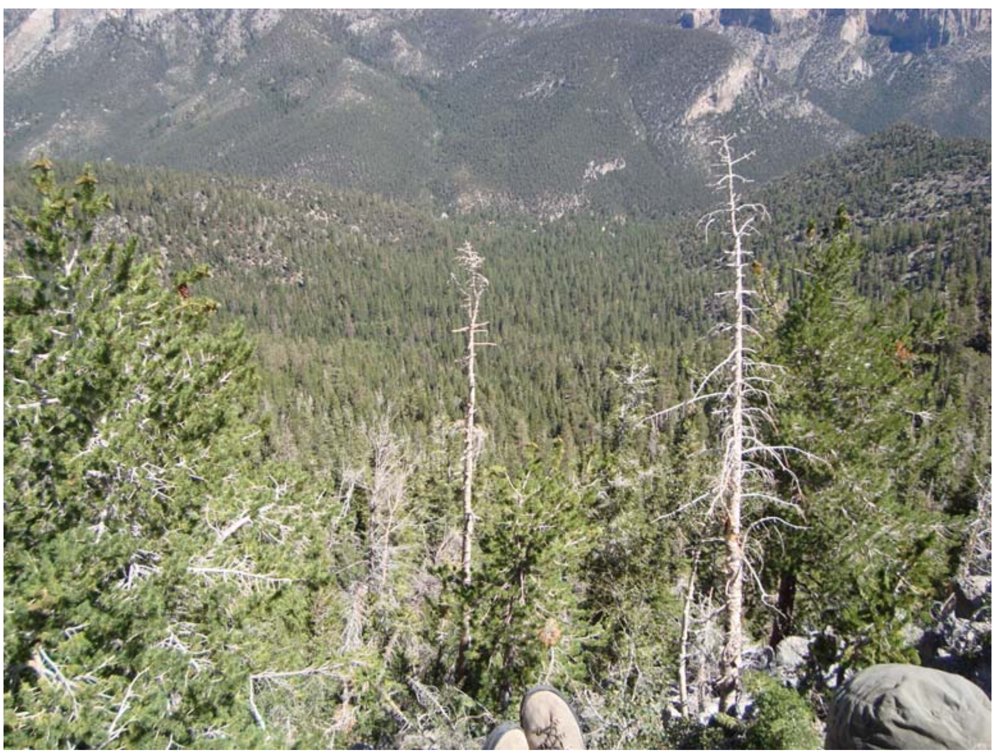

SpringMtns_helicopter_#72_0724087


SpringMtns_Hike_MtGriffith#1a072308.jpg


SpringMtns_Hike_MtGriffith#1b_072308


SpringMtns_Hike_MtGriffith#2_072308


SpringMtns_Hike_MtGriffith#3_072308


SpringMtns_Hike_MtGriffith#4_072308


SpringMtns_Hike_MtGriffin#8a_0723087


SpringMtns_Hike_MtGriffin#8b_0723087


SpringMtns_Hike_MtGriffith#9_0723087


SpringMtns_Wilderness_1082_#1000a_072108


SpringMtns_Wilderness_1082_#1000b_072108