

Landscape Conservation Forecasting™ Pine Valley and Mountain Home Range

Report to Bureau of Land Management, Cedar City Field Office
in partial fulfillment of Cooperative Agreement No. L16AC00162



Clockwise from top-left: Wah Wah Range; Pine Grove Canyon in Wah Wah Range; pinyon and juniper old growth off Jockey Road; looking at the Mountain Home Range from lower Wah Wah Range slopes.

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Executive Summary

Starting in 2012, The Nature Conservancy (TNC) applied the Landscape Conservation Forecasting™ (LCF) process to the Hamlin Valley and Black Mountains landscapes, managed by the Bureau of Land Management’s Cedar City Field Office (CCFO). That initial study provided guidance on what, how, and how much land/vegetation to treat to achieve habitat or restoration goals under historic climate forecasted into the future. BLM managers then requested a second study in those same landscapes to understand if proposed management actions would be adequate in a warmer or drier future climate – and especially if additional cost would be needed to achieve the same objectives as with historic climate.

Building on the these two prior LCF studies, BLM managers then engaged with TNC under terms of Cooperative Agreement No. L16AC00162 to do a climate-variability-informed LCF project on a new adjacent landscape within the CCFO. This adjacent landscape comprises the areas known as Pine Valley and the Mountain Home Range (PV-MH), covering an area of about 238,000 acres. The features, ecological setting, and management issues of the PV-MH landscape were similar to those of the adjacent Hamlin Valley and Black Mountains areas. This current report presents the results of the LCF study for the PV-MH landscape.

Process and Methods

The LCF process for the PV-MH project consisted of five primary steps:

1. Develop maps of potential vegetation types, termed ecological systems (= biophysical settings), and of current vegetation classes within each system, by conducting remote sensing of satellite imagery.
2. Refine computerized predictive state-and-transition ecological models for the ecological systems by updating TNC’s models for Hamlin Valley and the Black Mountains, or by creating new models.
3. Determine current condition of ecological systems using the metric of Unified Ecological Departure: the dis-similarity between current vegetation and vegetation expected under reference conditions. Determine current suitability of habitat for greater sage-grouse using Resource Selection Functions proposed by experts and based on state-level data.
4. Use the computerized ecological models to forecast anticipated future condition of ecological systems, and of habitat suitability for sage-grouse, under minimum management (analogous to the “no-action” alternative of NEPA) within three future climate scenarios.
5. Use the computerized ecological models to forecast anticipated future condition of ecological systems, and of habitat suitability for sage-grouse, under “active” management (suites of specific actions or treatments) within the same three future climate scenarios as used for minimum management.

Prior to running simulations designed to improve ecological systems, it was necessary for BLM CCFO staff and other stakeholders to set the stage by developing a set of guiding management objectives. Such objectives influenced the types of management actions that were then modeled and reported. The text box below shows the guiding management objectives, consistent with multiple-use management of public lands, for the CCFO's LCF Project for the Pine Valley - Mountain Home Range area.

Management Objectives for the LCF project for Pine Valley - Mountain Home Range

- Maintain or improve landscape-scale “health,” as measured by Unified Ecological Departure, of the major upland vegetation types (ecological systems) in the project area.
- Maintain or enhance the integrity of riparian corridors and wet meadows in the project area.
- Maintain or enhance the quality of wildlife habitat, with special attention to greater sage-grouse, in the project area.
- Prevent expansion, and reduce the extent if possible, of undesirable vegetation classes in the project area – vegetation that is difficult or expensive to treat successfully, such as excessive spread of conifers or invasive annual grasses.
- Decrease fuel loads, or maintain reduced fuel loads, to reduce wildfire hazard to public-land resources and to human settlements and infrastructure in and around the project area.
- Develop and prioritize active management treatments, and make treatment projects competitive for potential funding sources.
- Assess how types and amounts of active management treatments may need to be adjusted to achieve the above Objectives in a scenario of a warmer and drier future (climate variability forcing).

Because mapping vegetation was the first major step of LCF, TNC contracted with Spatial Solutions, Inc. to produce maps of ecological systems and their current vegetation classes. This was done via remote sensing of 1.5-m resolution Spot 6/7 satellite imagery from July 2, 2017, verified by observations from extensive on-the-ground field trips that occurred during July 7-18 and August 6-11, 2017. During the summer of 2017, 4,384 rapid observations and 3,622 photographs were documented. Final map layers were delivered in the late spring of 2018.

To develop the predictive ecological models used in this project, the existing state-and-transition models from the Hamlin Valley and Black Mountains project were used as-is or with minor revisions. Two ecological systems found in the PV-MH landscape had not been previously modeled, and required the creation of two new models that were derived from comparable models. Models were constructed and spatially run using the modeling software

ST-Sim, a product of ApexRMS, Ltd. Spatial modeling was required to estimate sage-grouse habitat suitability because the species' fitness depends on the proximity of landscape features.

The current condition of ecological systems was reported using the metric known as Unified Ecological Departure (UED). This is a single, integrated measure that combines concepts of: (1) ecological departure from reference conditions in the traditional sense; (2) uncharacteristic vegetation classes that are particularly undesirable (e.g., dominated by exotic species and/or expensive to restore); and (3) allowable amounts of certain uncharacteristic vegetation classes that are unharmful or benign, such as introduced-species seedlings that provide important wildlife habitat. UED thus gives a more realistic accounting of condition or health from the perspective of land managers, and is the official metric of condition for ecological systems in this report.

The condition of habitat for greater sage-grouse was reported at the landscape-scale using an index of habitat suitability. Habitat suitability is calculated via resource selection functions (RSFs) that are applied to the rasters of ecological systems, vegetation classes, and land ownership within the ST-Sim simulation software. Heuristic RSFs were developed because only very limited movement data and no demographic data exist from collared sage-grouse from the distinct Hamlin Valley (including Pine Valley) and Black Mountains populations. Calculation of the habitat suitability index was presented in the two previous reports to the BLM CCFO (Provencher et al. 2015, 2018).

Using the computer-based models, TNC simulated the likely future condition of each ecological system (measured by UED), and of greater sage-grouse (measured by the habitat suitability index), after 60 years (year 2077) under different combinations of management and climate scenarios. Twelve ecological systems were selected for restoration because their condition deteriorated under status-quo management, or they were of special management concern to the BLM CCFO.

The approach of this study was that of compensation: We sought to achieve the same outcomes using active management under alternative future climates, as we did using active management under forecasted historic climate (hereafter, PREFERRED+HISTORIC scenario) – compared to doing no special active management at all (hereafter, MINIMUM+HISTORIC scenario) within budgetary limits. In other words, a goal of this project was to achieve no difference in outcome among three actively managed climate scenarios (generally termed PREFERRED MANAGEMENT scenarios) by varying management action implementation rates among those climates' PREFERRED MANAGEMENT scenarios.

The climate variability forcing scenarios (Local Climate Analogs or LOCAs) that were factorially crossed with the MINIMUM and PREFERRED MANAGEMENT scenarios were the same as in Provencher et al. (2018): The ACCESS1 LOCA was selected as the driest in all seasons, especially in the summer. The CCSM4 LOCA most likely fit expert opinion about a changing climate in southwestern Utah, although this LOCA predicted winter to be drier and hotter (at least with minimum temperature).

Historic climate and LOCAs were each replicated 20 times per scenario by statistically forecasting 60 years into the future the time series of precipitation, minimum temperature, and maximum temperature. Each climate scenario was then combined with either a PREFERRED MANAGEMENT scenario or MINIMUM MANAGEMENT scenario, for a total of six scenarios (three climates × two levels of management). One Standard Precipitation Index (SPI) time series was estimated from forecasted precipitation time series for each historic or LOCA climate replicate. The SPI is a drought index which can be calculated at different temporal intervals (Hayes et al. 1999) and is expressed in positive (wet) and negative (dry) standard deviations from the mean. The variability around the base parameter value of most ecological processes (for example, the rate of area burned) in the simulation were made a function of SPI. The variability of some ecological processes associated with peak flooding in riparian systems and lethal spring freezes in aspen were estimated directly from time series of temperature and precipitation.

Some trial-and-error adjustments to restoration implementation rates of the PREFERRED+ACCESS1 and PREFERRED+CCSM4 scenarios were conducted to imitate vegetation class outcomes seen with the PREFERRED+HISTORIC scenario. We used the area of key vegetation classes that affect fire management and sage-grouse – such as non-native annual grassland, tree-encroached shrublands with or without annual grass, shrubs with annual grass, depleted sagebrush, and exotic forbs – to guide adjustments of implementation rates because we could not use habitat suitability for feedback in a timely manner. As a result, we did not expect, and did not achieve, large differences among vegetation classes and, therefore, habitat suitability.

The more relevant results to maintain matching outcomes among scenarios were the realized implementation rates for different time periods, and the amount of money required per scenario and system. In other words, would BLM need to pay more or less to compensate for variation in climate scenarios?

Findings

Two levels of analysis addressed: (1) system-specific vegetation responses to management, and (2) landscape-level estimation of greater sage-grouse habitat suitability. Statistically, management level effects generally were stronger than climate scenario effects. In part, this was caused by our choice to compensate under budget limitations among climate scenarios to maintain key vegetation class results expected under HISTORIC Climate (i.e., forecasted PRISM climate series) for the priority systems on which sage-grouse most depend.

Vegetation

- Twenty-five ecological systems were found and mapped in 2017. The largest was black sagebrush (82,210 acres), and the smallest was Stansbury cliffrose (11 acres). The three largest systems were all sagebrush shrublands: black sagebrush, Wyoming big sagebrush-upland soils (51,760 acres), and montane sagebrush steppe (44,145 acres).
- New models were built for two systems: calcareous grassland (920 acres; tentatively-named unresearched grassland), and little-leaf mountain mahogany (2,328 acres). The calcareous

grassland system had never been observed before. The little-leaf mountain mahogany system had been observed before in nearby landscapes, but only as very small occurrences (<10 acres total), and it was previously subsumed in another model. But little-leaf mountain mahogany was found in large areas of the Wah Wah Range and therefore needed its own model in the PV-MH landscape.

- In addition to little-leaf mountain mahogany, the extents of four-wing saltbush (211 acres), semi-desert grassland (3,254 acres; on sandy soils), juniper savanna (400 acres), and winterfat (18,318 acres; on silty soils) were unusually greater than what we had observed elsewhere (with the exception of juniper savanna that is also found in the southern part of the Black Mountains).
- Wet meadows, which are critical to sage-grouse brood rearing, occupied 63 acres. However, several meadows were far from the only lek near the center of the study area west of the Pine Valley Road. As a result, wet meadows distant from the lek could not contribute to chick rearing (Gibson et al. 2017; Kane et al. 2017).
- In 2017, Unified Ecological Departure (UED) calculations showed that eighteen systems were highly departed, six systems were moderately departed, and one system (juniper savanna) was slightly departed from reference conditions (i.e., the natural range of variability, NRV).
- Twelve ecological systems were selected for active management based on future decline without management, wildlife management priority, and cultural/social reasons. The twelve are aspen woodland, black sagebrush, calcareous grassland, montane riparian, montane sagebrush steppe, pinyon-juniper woodland, ponderosa pine, semi-desert grassland, Stansbury cliffrose, Utah serviceberry, wet meadow-montane, and Wyoming big sagebrush. The pinyon-juniper woodland was the only system selected for cultural (pine nut harvesting) and social (fire risk) reasons.
- Without additional active management (i.e., under the MINIMUM MANAGEMENT scenario), all but four systems (aspen woodland, pinyon-juniper woodland, ponderosa pine, and Utah serviceberry) became increasingly departed from reference conditions by 2077.
- Large occurrences of black sagebrush and Wyoming big sagebrush in reference condition were found in the central part of the landscape (from Jackson Wash Road area to Cougar Spar and Jockey Road area).

Ecological System Management

- PREFERRED MANAGEMENT scenarios decreased the departure from reference conditions (reduced UED) for ten of the twelve focal ecological systems. Reduction in departure was counter-intuitively achieved using seedings composed of native and introduced grass species, which are uncharacteristic classes of vegetation that increase departure from reference conditions above a fixed management threshold. Investment in improved native species seeding success would greatly reduce departure from reference conditions. The two systems whose departure from reference conditions increased (greater UED) were ponderosa pine and Stansbury cliffrose.
- In ponderosa pine, restoration of historically logged stands was successful using mastication of fire-sensitive conifers (other than ponderosa pine) and curl-leaf mountain mahogany,

followed by planting ponderosa pine plugs. However, the area of chainsaw thinning to open up closed stands was too small compared to the large proportion of new plantings that followed a closed-canopied fire-suppressed succession pathway (by unintentional design). This closed-canopied succession was the cause of greater departure, compounded by an untested key, probably erroneous, model assumption that allowed wildfire to naturally “restore” the fire-sensitive conifer class (thus giving an edge to MINIMUM MANAGEMENT scenarios). This model assumption needs to be revised.

- While Stansbury cliffrose was improved according to its management objective, the estimation of UED for this small system of 11 acres could be biased because a single management action or natural disturbance could shift all the vegetation to a different class, thus causing the scale-dependent departure observed.
- Black sagebrush restoration resulted in the largest expenditure of about \$12 million, mostly incurred from 2020 to 2034. The second and third largest expenditures were for montane sagebrush steppe (about \$7 million, after year 2034), and for Wyoming big sagebrush (about \$5.6 million, mostly in years 2020 to 2034). Successful restoration of tree-encroached shrublands and non-native annual grasslands accounted for most of the area treated and money spent in these three sagebrush systems. Chainsaw thinning and lopping of young conifers, and native species improvements to older seedlings, were additional actions that were less extensive and expensive.
- Forecasted tree removal included the use of about 1.5 times more mastication than two-way chaining, compared to using nearly only two-way chaining in Hamlin Valley and the Black Mountains (Provencher et al. 2018). Because mastication is considerably more expensive than chaining and chaining often provides equal or better ecological outcomes compared to other mechanical methods (Tausch and Tueller 1977; Provencher and Thompson 2014), this resulted in less restoration for all systems within the budgetary limits.
- Three other systems had moderately sizable expenditures: aspen woodland at \$1.1 million (mostly from 2020 to 2034), ponderosa pine at \$0.9 million (mostly from 2035 to 2044), and wet meadow-montane at \$0.71 million (from 2020 to 2077). Actions in these systems used fencing (aspen and wet meadow) and mastication (ponderosa pine) that had very high costs per area, applied to small areas.
- The smallest amounts of funding were devoted to improving mule deer habitat suitability in the very small Stanbury cliffrose and Utah serviceberry systems. These low-hanging-fruit projects could be achieved with chainsaws in one or a few days.
- The two grasslands (semi-desert and calcareous) shared similar uncharacteristic vegetation classes, probably caused by decades of preferential grazing, that required similar solutions to increase grass content and reduce woody cover of early-successional shrubs. The costs of restoration were modest, and the terrain on which actions would be applied is smooth and on gentle slopes.
- Thinning of conifers in pinyon and juniper stands for cultural and social reasons was surprisingly expensive at about \$515,000. This number may be over-estimated because we found that juniper woodlands (not juniper savanna) were a large fraction of the area of pinyon-juniper woodlands, whereas it was likely that pinyon dominance was targeted. We recommend that land managers inspect stands before taking action because pinyon may be

absent, and we rarely found dense stands of true pinyon woodland. Moreover, many pinyon stands were on steep and rocky slopes where only chainsaws can be used.

- Montane riparian should be viewed as a maintenance system where the primary action was to control noxious weeds. The set of actions also included the experimental action “Water-Table-Uplift” that includes substitutable inexpensive actions in the form small rock dams and beaver dam analogs to stop incisions and reconnect the water table to the floodplain (Clothier and Zeedyk, 2014). Inspection of incisions would be important to tailor the needed water-table-uplift action to the severity of the incision and gradient of the stream.
- About 37,000 acres were forecasted to be seeded with a mix of native and introduced species, and 4,000 acres forecasted to be seeded with a mix of only native species. For every acre successfully seeded, about 0.2 - 0.3 acres were seeded but assumed to fail, not including the loss to herbivory and drought. Also, a small fraction of the successfully seeded mixed introduced and native species areas theoretically became invaded, but not dominated, by non-native annual species, especially during wetter years.
- Climate scenarios had strong but different effects among ecological systems on the fate of vegetation classes. The ACCESS1 LOCA was clearly the driest of climate scenarios. As a result, this scenario’s dryness reduced overall fire activity, which caused a greater forecasted retention of tree-encroached shrublands and late-successional shrubland classes without trees, compared to the HISTORIC Climate and the CCSM4 LOCA. In addition, the ACCESS1 LOCA caused greater initial failure of seeding establishment, but greater preservation of late-successional classes of established seedings. For instance, about 5,000 acres less of mixed native and introduced species seedings successfully established in black sagebrush in the ACCESS1 LOCA than in the other climate scenarios.
- The CCSM4 LOCA often showed intermediate effects on vegetation classes between the ACCESS1 LOCA and the HISTORIC Climate. In several cases, the CCSM4 LOCA and the HISTORIC Climate produced indistinguishable outcomes for vegetation classes. Moreover, we compensated with implementation rates of management actions for climate differences. Therefore, as in the previous report (Provencher et al. 2018), we recommend that land managers choose the levels of implementation we forecasted for the CCSM4 scenario as a path for the future. CCSM4 also had spring and summer rains that land managers depend on for successful seeding. The ACCESS1 LOCA represented a worst-case scenario for land managers. Table 35 in the **Key Findings and Conclusions** section summarizes recommended actions for the CCSM4 scenario.

Greater Sage-Grouse

- In 2017, the average sage-grouse habitat suitability index was 39.87%. Without management, the habitat suitability index declined to 25.5% after 30 years (2047), and to 24.8% after 60 years (2077).
- PREFERRED MANAGEMENT significantly increased the average habitat suitability index by about 4% and 5%, respectively, compared to the MINIMUM MANAGEMENT scenario in years 2047 and 2077 (i.e., comparing within the same year).

- Average climate effects on the habitat suitability index were significantly different, but small (<1) compared to management effects, only in year 2047. The ACCESS1 LOCA had the highest suitability value as a result of reduced fire activity, whereas the HISTORIC Climate and CCSM4 LOCA were not different.
- While overall the single area-wide value of the habitat suitability index decreased over time with MINIMUM MANAGEMENT, maps of the index showed large areas of improvement and a few focused areas of degradation within the years 2047 and 2077. Improvement and degradation areas were highest for the ACCESS1 LOCA compared to the other climate scenarios. Variation in frequency of wildfire activity appeared to explain results, with low fire frequencies increasing the index and higher frequencies decreasing the index.
- With additional management (PREFERRED MANAGEMENT) that increased (improved) the average habitat suitability index, maps showed that improvement areas were focused compared to widespread degradation areas where management was not a modeled priority, although still allowed. This pattern for the PREFERRED MANAGEMENT scenarios was the opposite observed for the MINIMUM MANAGEMENT scenarios. The largest area of improvement under management was in the central portion of the landscape near the intersection of the Pine Valley Road and Jackson Wash Road and westward. Important areas of improvement were also observed near the foothills of the Mountain Home Range in the northern portion of the study area. Again, the spatial layout of fire frequencies appeared to explain most patterns.

Introduction

Project Background

Starting in 2012, The Nature Conservancy (TNC) applied the Landscape Conservation Forecasting™ (LCF) process to the Hamlin Valley and Black Mountains landscapes, managed by the Bureau of Land Management’s Cedar City Field Office (CCFO). That study will hereafter be referred to as the ‘original study,’ and its final report (Provencher et al. 2015) as the ‘original report.’

The original study provided guidance on what, how, and how much land/vegetation to treat to achieve habitat or restoration goals under historic climate forecasted into the future. BLM managers then wanted to understand if proposed management actions would be adequate in a warmer or drier future climate – and especially if additional cost would be needed to achieve the same objectives as with historic climate. The temperature and precipitation variability that trends towards warmer and drier or wetter future climate is termed “climate variability forcing.”

Accordingly, the BLM and TNC undertook a second, follow-up study to evaluate the effects of climate variability forcing in the Hamlin Valley and Black Mountains landscapes. Particular attention was given to achieving the same modeled vegetation and habitat-suitability outcomes with climate variability forcing and without climate variability forcing (the latter under historic climate; i.e., the original study). That second Hamlin Valley - Black Mountains study will hereafter be referred to as the ‘supplemental study,’ and its final report (Provencher et al. 2018) as the ‘supplemental report.’

Building on the original and supplemental LCF studies, BLM managers then engaged with TNC under terms of Cooperative Agreement No. L16AC00162 to do a climate-variability-informed LCF project on a new adjacent landscape within the CCFO. This adjacent landscape comprises the areas known as Pine Valley and the Mountain Home Range (PV-MH), covering an area of about 238,000 acres and shown in Figure 1. The features, ecological setting, and management issues of the PV-MH landscape are similar to those of the adjacent Hamlin Valley and Black Mountains areas, which were described in the original report, and thus are not repeated here.

This current report presents the results of the LCF study for the PV-MH landscape.

Management Objectives

At the heart of the LCF process are modeled simulations of management actions that are aimed at improving the ecological “health” of the overall landscape, and of habitats for certain wildlife species. Prior to running any such simulations, however, it was necessary for BLM-CCFO staff and other stakeholders to set the stage by developing a set of guiding management objectives. Such objectives influenced the types of management actions that are then modeled and reported. The text box below shows the guiding management objectives, consistent with

multiple-use management of public lands, for the CCFO's LCF Project for the Pine Valley - Mountain Home Range area.

Management Objectives for the LCF project for Pine Valley - Mountain Home Range

- Maintain or improve landscape-scale "health," as measured by Unified Ecological Departure, of the major upland vegetation types (ecological systems) in the project area.
- Maintain or enhance the integrity of riparian corridors and wet meadows in the project area.
- Maintain or enhance the quality of wildlife habitat, with special attention to greater sage-grouse, in the project area.
- Prevent expansion, and reduce the extent if possible, of undesirable vegetation classes in the project area – vegetation that is difficult or expensive to treat successfully, such as excessive spread of conifers or invasive annual grasses.
- Decrease fuel loads, or maintain reduced fuel loads, to reduce wildfire hazard to public-land resources and to human settlements and infrastructure in and around the project area.
- Develop and prioritize active management treatments, and make treatment projects competitive for potential funding sources.
- Assess how types and amounts of active management treatments may need to be adjusted to achieve the above Objectives in a scenario of a warmer and drier future (climate variability forcing).

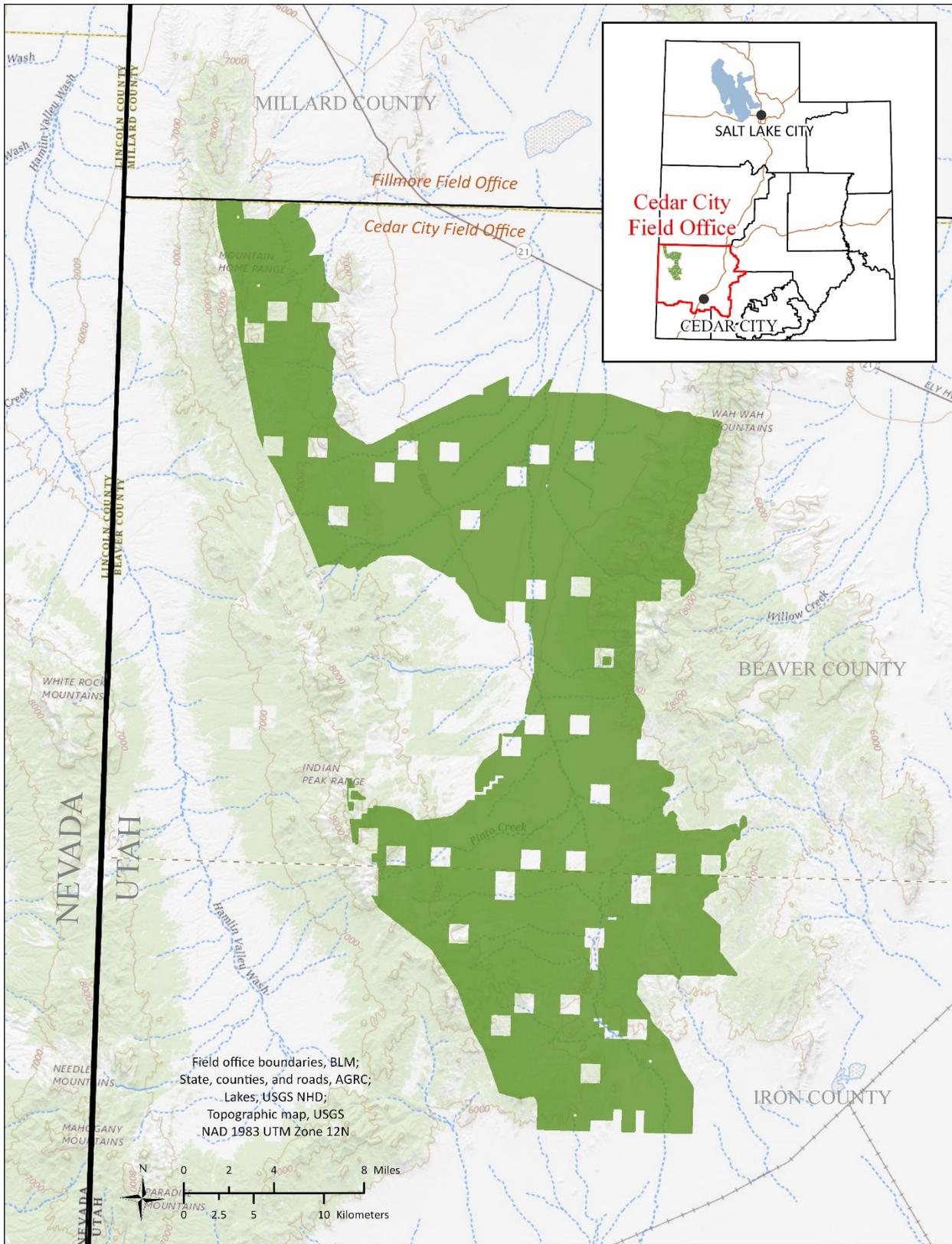


Figure 1. The Pine Valley - Mountain Home Range Project Area.

Methods

The methods used in this PV-MH study are very similar to those of the original and supplemental studies. Therefore, the sections below provide detailed information only if it is specific to the new PV-MH project area, or if it represents a change in methods from the prior Hamlin Valley - Black Mountains studies. Otherwise, methods for this PV-MH study will reference their counterparts in the original and supplemental reports.

Vegetation Mapping

The fundamental elements of vegetation mapping are the distributions of: (1) ecological systems, and (2) current vegetation classes within each ecological system.

Ecological systems, also known as biophysical settings (BpS) by the national LANDFIRE program (Landscape Fire and Resource Management Planning Tools; www.landfire.gov), are dominant *potential* vegetation types expected in the physical environment (geology-soil-landform-climate) under “natural” disturbance regimes. Thus, ecological systems are fundamentally abiotic units, NOT units of existing vegetation. Each ecological system supports (expresses) a particular kind of dominant vegetation, which is named by its dominant upper-layer lifeform vegetation.

Within each ecological system, vegetation classes are based on factors such as (Provencher et al. 2016):

- Successional stages – early to mid to late.
- Vegetation canopy – all (variable structural outcomes often after replacement events), open, or closed.
- Reference (native) versus Uncharacteristic vegetation or site characteristics – defined later in the subsection titled **Predictive Ecological Models**.

It is important to understand that a vegetation class label or attribute is *meaningless* unless it is associated with an ecological system.

Ideally, ecological systems and their vegetation classes would be mapped by interpreting ecological sites from Natural Resource Conservation Service (NRCS) soil surveys, because ecological systems and NRCS’s ecological sites are very similar. The NRCS defines an ecological site as “a distinctive kind of land with specific physical characteristics that differs from other kinds of 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). However, ecological sites of the PV-MH area were not mapped in Beaver County, and Order III soil surveys are not spatially distributed enough within map units to be useful for mapping at the level of single ecological systems.

Therefore, a customized process was used to map the project area’s ecological systems, and their component vegetation classes, as described below.

Definition and Description of Vegetation Prior to Mapping

Vegetation descriptions were compiled of ecological systems and their component vegetation classes that were believed to occur in the PV-MH project area based in large part on the Hamlin Valley and Black Mountains vegetation descriptions, which were updated to suit the PV-MH area. The resulting PV-MH vegetation descriptions appear in Appendix 1. These PV-MH descriptions include a few ecological systems that were not expected to be encountered but were retained because of the remote possibility of finding small occurrences. Gambel Oak-Mountain Shrub is an example of an unlikely system that could possibly be found in the PV-MH landscape. Conversely, we encountered two ecological systems in PV-MH that we had not encountered in Hamlin Valley or the Black Mountains: Little-leaf Mountain Mahogany and Calcareous Grassland (name suggested by TNC for this grassland not yet described by NRCS in Beaver County [*personal communication*, Lynn Kitchen, NRCS, Beaver County]). We added these to the final version of the vegetation descriptions for PV-MH. The list of ecological systems and their vegetation classes was used for vegetation mapping, preliminary analysis, field work, and state-and-transition simulation modeling (see below in **Predictive Ecological Models** section).

Remote Sensing Analysis and Ground-Truthing

Spatial Solutions, Inc. was contracted by TNC to conduct vegetation mapping via interpretation of satellite imagery of the PV-MH project area. Remote sensing was conducted with 1.5-m resolution Spot 6/7 multi-spectral satellite imagery from July 2, 2017. The imagery was clipped to the boundary defined by the CCFO, and then buffered outward by 100 m. Private inholdings were excluded from the imagery.

TNC sent descriptions of ecological systems and vegetation classes (see above) to Spatial Solutions. Spatial Solutions used these data to develop an unsupervised vegetation classification of the selected satellite imagery. In an unsupervised classification, the image processing software classifies an image based on natural groupings of the spectral properties of the pixels, without the analyst specifying how to classify any portion of the image. This contrasts with supervised classification, in which the analyst defines “training sites” – areas in the map that are known to be representative of a particular land cover type – for each land cover type of interest to guide the assignment of classes to each pixel.

Spatial Solutions used the software Imagine® from Leica Geosystems to conduct an iterative unsupervised classification of the imagery. The unsupervised classification of the satellite imagery was used to interpret rasters and is described in Provencher et al. (2008, 2009, 2013) and Low et al. (2010). Draft raster layers were created of ecological systems and current vegetation classes with similar spectral characteristics (combinations of blue, green, red, and near infrared reflectance).

To support initial interpretation of spectral classes (Lillesand and Kiefer 2000), Spatial Solutions and TNC conducted field work for ground-truthing from July 7-18 and August 6-11, 2017. The

PV-MH landscape was explored mostly on roads in a 4WD vehicle, but also by hiking and a drone for less-accessible locations. The goal of this field work was to visit all unique spectral class signatures (i.e., representing all systems and classes present) and document their vegetation and site features via rapid observations. During the summer of 2017, 4,384 rapid observations and 3,622 photographs were documented.

Each rapid road/hiking observation point included the identity of the ecological system and its vegetation class, and two geo-referenced photographs (landscape context and site) for use in future analysis. Additional comments about vegetation and topography were added to the data if time allowed. In past projects, formal training plots were visited, where the cover values of dominant species and cover types were recorded, which were supplemented with rapid observations. Over time, a high ratio of rapid observations to formal training plots was eventually replaced by rapid observations only: A large number (e.g., 3,000+) of rapid geo-referenced observations is far more valuable than a small number of formal training plots (e.g., 60-100 at most) given the short duration of field surveys. The portability of ruggedized computers, with GPS reception and Imagine® software running live, enabled the two field workers to map vegetation accurately by simply going within the boundary of spectral signatures, or by viewing them from a distance with binoculars or with a drone in more difficult terrain.

Using field observations, Spatial Solutions completed final maps of ecological systems and their current vegetation classes, which were delivered as one combined (System × Class) map to TNC on May 24, 2018. TNC staff conducted quality control and translated Spatial Solutions' mapping codes to TNC's simulation codes. While a "native" 1.5-m resolution of the combined vegetation map has been retained, TNC staff resampled the native map to a 30-m resolution map layer using a Python script that gave priority to small patch systems, wet meadows, and occurrence of exotic perennial forb and tree species. These systems occur in smaller, often linear patches on the landscape, and would be underrepresented with standard resampling methods. It is important that wet meadows and riparian corridors be represented in the map as these systems are ecologically important. We used the resampled 30-m raster in the ecological models; the file size of the native 1.5-m resolution raster is too large to process using our available computing power. The final vegetation maps were reviewed at the project's workshop with TNC, Utah Division of Wildlife Resources and BLM staff held October 15-17, 2018.

Notes on Field Observations

The PV-MH project area was remarkable compared to other Great Basin landscapes previously mapped. Whereas the vegetation of the Mountain Home Range and Indian Peak Range in the western portion was familiar, the proportional representation of several systems and new systems conferred a different character to Pine Valley and the southern Wah Wah Range. Five ecological systems occupied areas that were far larger than observed elsewhere by TNC in western Utah and eastern Nevada (see Appendix 1): semi-desert grassland, winterfat, four-wing saltbush, little-leaf mountain mahogany, and juniper savanna (except for the Black Mountains). In addition, the new calcareous grassland was surprising as it resembled grasslands one would

expect in northern Arizona, but without warm-season grass dominance (see Appendix 1). Semi-desert grassland on sandy soils and little-leaf mountain mahogany on shallow soils over carbonate bedrock usually are very small and uncommon systems, but in the PV-MH landscape these systems were in the thousands of acres. On the Wah Wah Range, little-leaf mountain mahogany is so dominant as to ecologically replace montane sagebrush steppe in many portions of the range.

Two other field observations were noteworthy. First, large areas of Wyoming big sagebrush, black sagebrush, and juniper savanna in the southern half of the project area and along the lower slopes of the Wah Wah Range had high native grass cover compared to other Great Basin landscapes we mapped, with the exception of Hamlin Valley (UT) and the Upper Terrace Road of Ward Mountain near Ely, NV. Second, exceptional and apparently ancient stands of juniper woodlands and pinyon and juniper woodlands were found on badland soils along Jockey Road on the slopes of the Wah Wah Range (juniper and pinyon woodland) and south of Mountain Springs off Pine Valley Road (juniper woodland; about UTM 12S 271200 E, 4210800 N).

Some difficulties were encountered during remote sensing. The following challenges and solutions were dealt with:

1. The most difficult mapping was in the old burns on the lower slopes of the Wah Wah Range in the northwestern part of the project area. This area supported large tracts of winterfat and black sagebrush. Winterfat occurred on slopes steeper than we were accustomed to – slopes that would be more characteristic of black sagebrush. In burned areas, the transition between winterfat and black sagebrush was difficult to detect because fire thoroughly removed woody vegetation and both ecological systems have high soil reflectance. We visited many unburned examples of black sagebrush and winterfat until it was noted that black sagebrush had slightly brighter soils. As a solution, the brighter signature of black sagebrush was used to separate it from winterfat unless clear woody remnants revealing the latter species were found. The method is expected to produce some accuracy errors.
2. Mapping was challenging at the bottom of northern Pine Valley where mixed salt desert, winterfat, four-wing saltbush, and stunted black sagebrush co-occurred. Soil reflectance overpowered light reflected by vegetation. Small changes in landform and soils appeared to cause major plant community differences. Considerable field observations were required to separate systems. Fortunately, we found that four-wing saltbush was more concentrated along shallow drainages with presumably deeper soils.
3. Semi-desert grassland and the upper slopes of winterfat on the northwestern slope of Pine Valley had the same spectral signatures and shared many grass species. Higher elevation winterfat supported greater grass cover than at lower elevation and common grass species were Indian ricegrass, needle-and-tread, and squirreltail that were also found in semi-desert grasslands. Interestingly, the sandy soils of grasslands had comparable reflectance to the siltier soils of winterfat. Again, many observations were required to track sandy soils supporting semi-desert grassland and the presence of winterfat plants.
4. Finding the new calcareous grassland and determining that it was unique compared to the adjacent black sagebrush and juniper savanna systems required rapid improvisation.

Calcareous grassland could easily be perceived as an early-successional phase of either black sagebrush or juniper savanna. Because we found no trace of fires or charred tree stumps (later confirmed by BLM and NRCS), but we found a few older and live individual black sagebrush, the idea of an early-successional phase was rejected. A classification of the vegetation was borrowed from the semi-desert grassland state-and-transition model, which allowed us to take coherent and abundant observations until a more formal model was developed for calcareous grassland.

5. It was generally straightforward to distinguish between big sagebrush or black sagebrush and pinyon-juniper woodland ecological systems. Special attention was given to cases where separation of treed black sagebrush from true pinyon-juniper woodlands occurring on low hills with gentle to moderate slopes was less obvious. Although not limited to one area, several of these treed low hills were found along Jackson Wash Road (about UTM 12S 267030 E, 4224840 N). Several hills were found to have badland soils, some with erosional features typical of lacustrine deposits, and supported true pinyon-juniper woodlands. Shrublands encroached by trees usually contain dead sagebrush shrubs, little perennial grass cover, and trees are usually conical indicating ages of <125 years (Low et al. 2010). True woodlands generally have live shrubs and perennial grasses in the understory, and several trees should show signs of old age (large diameter lateral branches and flat-topping). Off Jackson Wash, the true woodlands contained ancient trees of large diameter where the open canopy had a distinct texture on the imagery, but the understory was sparse (but not dead) presumably due to very low productivity of the soils. This type of true pinyon-juniper woodland on low-lying badland hills is not unique to Pine Valley as we also found them in the northern part of the US Forest Service Pine Valley Ranger District about 60 miles to the southeast off the Pinto Road (Tuhy et al. 2014).
6. While it was relatively easy to detect riparian corridors in the project area, two occurrences caused strange spectral signatures that required specific visits. One occurrence on the east-facing slope of the northern Mountain Home Range was populated by mature velvet ash. Mature velvet ash looked like cottonwood on the imagery, but the drainage gradient was too steep and rocky to be cottonwood. No roads could be used to access the area; therefore, several miles of hiking were required to verify the vegetation. A second occurrence was easily accessible and was revealed to be a large clump of bigtooth maple at the base of a hill in a drainage, but at least 100 m from water (UTM 12S 272509.10 E, 4245880.85 N). The maple extended up the drainage without being clearly riparian. The *a priori* uncertainty was to determine if this vegetation with a strong infra-red signature was riparian vegetation, aspen woodland (also present in the drainage), Gambel oak, or well-developed mountain shrubs. We assigned the bigtooth maple vegetation to the Utah serviceberry ecological system due to the presence of Utah serviceberry, and because LANDFIRE's Bigtooth Maple Ravine BpS did not describe well the conditions found in the Wah Wah Range.
7. Ponderosa pine was ubiquitous in the project area's mountain ranges. Occurrences in the Indian Peak Range (southwestern boundary) were initially confusing because of dry and rocky drainages where individual large ponderosa pine trees were widely scattered at elevations lower than expected amongst heavy undergrowth of pinyon, juniper, and curl-leaf mountain mahogany (for example, about UTM 12S 260530 E, 4219810 N). It was unclear if these sites were ponderosa pine, until old sawed pine stumps were occasionally found. We

hypothesized that ponderosa pine occupied these sites in greater abundance until historic logging removed them. As a result of logging and fire exclusion, fire-sensitive species such as pinyon, juniper and curl-leaf mountain mahogany dominated the midstory. The fire-sensitive vegetation class, even with very scattered old ponderosa pine, did not fit into the established state-and-transition simulation model used in many other projects. Therefore, we created four classes labelled FIC (Fire-Intolerant-Conifer) corresponding to mid-successional open and closed canopy structure, and late-successional open and closed canopies. Both the openness of the canopy structure and the successional age referred to the fire intolerant conifers, and not those of ponderosa pine. Also at these sites, smooth brome and intermediate wheatgrass were seeded where past fires burned into the drainages of ponderosa pine in addition to the larger areas of montane sagebrush steppe. Seeded classes were therefore added to the model.

Predictive Ecological Models

The LCF process includes the simulation of management scenarios using state-and-transition predictive models for each ecological system (reviewed in Daniel et al. 2016, Daniel et al. 2017, and Provencher et al. 2015). A state-and-transition model is a discrete, box-and-arrow representation of the continuous variation in vegetation composition and structure of an ecological system (Westoby et al. 1989). Examples of state-and-transition models are shown in Forbis et al. (2006) for mountain big sagebrush from eastern Nevada, and in Provencher et al. (2016: Figs. 13.1 and 13.2) for Wyoming big sagebrush upland gravelly loam in Utah and non-native buffelgrass (*Cenchrus ciliaris*) invasion in Arizona. To build the full suite of state-and-transition models for this project, TNC updated models from LCF projects completed with the BLM Cedar City Field Office, as described in the original and supplemental reports.

Vegetation Classes

Different boxes in the model belong either to: (a) different *states*, or (b) different *phases* within a state. States are formally defined in rangeland literature (Bestelmeyer et al. 2004) as: persistent vegetation and soils per potential ecological sites that can be represented in a diagram with two or more boxes (phases of the same state). Different states are separated by “thresholds.” A threshold implies that substantial management action would be required to restore ecosystem structure and function. Unlike thresholds, relatively reversible changes (e.g., fire, flooding, drought, insect outbreaks, and others) operate between phases *within* a state.

In accord with LANDFIRE terminology (Rollins 2009), TNC refers to boxes in the models as vegetation *classes* – including both states and phases – because the simulation software cannot display states and phases differently. Internal model dynamics determine whether a class is a phase or state in ST-Sim software (Daniel and Frid 2012).

Predictive models for ecological systems include two categories of vegetation classes: *reference* and *uncharacteristic*. The classes of pre-European settlement vegetation are considered to be each ecological system’s core succession reference classes. At their core, therefore, all models

have the reference condition represented by some variation around the A-B-C-D-E reference classes originally developed by LANDFIRE (Rollins 2009), although many of the models whose results are presented here differ substantially from the A-B-C-D-E template. The A-E classes typically represent succession (passage of time and maturation of vegetation), usually from herbaceous vegetation to increasing woody species dominance, either shrubs or trees. Said another way, the A-E classes are different (successional) *phases* within a single reference *state*.

Many ecological systems of the PV-MH landscape contain vegetation classes that would not be expected under natural disturbance regimes, and thus would not have been present in reference conditions (for example, a shrubland invaded by non-native annual species). These non-reference classes are termed uncharacteristic classes (designated with a “U:”). In addition to modeling reference conditions, therefore, predictive models also include the full range of uncharacteristic classes in the PV-MH project area. The two main categories of uncharacteristic classes result from:

1. Disturbances beyond what would be considered “natural,” whether directly or indirectly caused by human actions; examples include invasion/dominance by non-native grasses, depleted understories of shrublands, incised/entrenched riparian areas, etc.; or
2. Purposeful actions by land managers to manipulate or alter vegetation to meet specific management objectives, such as seedings with non-native introduced plant species to provide forage or habitat for livestock and wildlife.

A complete list of ecological systems with their reference and uncharacteristic classes appears in Appendix 1. Many models for the PV-MH project area contained more classes than those for Hamlin Valley and the Black Mountains (see original and supplemental reports) because it was judged necessary to add bare ground in many systems to capture more realistically adverse grazing effects (as opposed to creating only classes dominated by early-successional shrubs), and to increase successional differences of some uncharacteristic vegetation classes to improve distribution of management actions and estimation of sage-grouse habitat suitability. In addition, two new models were added to the PV-MH project area that were absent from Hamlin Valley and the Black Mountains, including one model that was new to any TNC project.

Probabilistic Transitions

Predictive models for ecological systems also include arrows (“transitions”) among classes that represent several types of pathways as follows:

1. Vegetation succession, or simply a change in vegetation structure/composition due to the passage of time, is generally modeled as a deterministic transition (but can be modeled probabilistically);
2. Disturbances that can be represented by probabilistic events include:
 - a. Natural ecological processes, such as fire or flooding;
 - b. Uncharacteristic disturbances, such as annual grass invasion or livestock grazing; and
 - c. Active management treatments, such as mechanical thinning or prescribed fire.

Furthermore, time-dependent and spatial controls were often applied to all types of transitions. For example, livestock grazing was turned off for 10 years by a temporary fence implemented as a management action in an aspen woodland that was burned using controlled burning, which was also a management action. These controls were often more important than the value of disturbance rates.

A complete list of model parameter values (probabilistic transitions) appears in Appendix 2.

Spatial Modeling

In prior LCF projects, there were no explicit spatial questions that justified the use of spatial modeling. Spatial modeling was difficult to conduct, and simulations required large amounts of computing power and time to run. Those constraints have been greatly reduced with improved simulation software and powerful computer servers. Spatial modeling was required for this study because we report here on species habitat suitability, where a species' fitness depends on the proximity of landscape features.

Spatial models are possible because rasters of ecological systems, their vegetation classes, and land ownership are supplied to the simulation software, ST-Sim. In other words, current vegetation rasters allow the estimation of current condition for ecological systems, and current species habitat suitability for greater sage-grouse. Similarly, future simulated vegetation rasters allow estimation of future condition for ecological systems, and future species habitat suitability for greater sage-grouse. To create alternative future rasters of vegetation under climate variability forcing, ST-Sim's spatial modeling necessitates input of additional data and rules to run simulations. There are five types of data/rules needed in this project: size distribution, spread distribution, patch prioritization, spatial multipliers, and direction multipliers.

The first set of additional spatial data consists of the size distributions for natural and management disturbances which govern the probability of a disturbance reaching a particular size. For example, based on federal fire occurrence data from 1980 to 2012 for this landscape, we determined that 7.5% of fires were less than 10 acres, 12.5% were between 10+ and 100 acres, 36.25% between 100+ and 1,000 acres, and 43.75% were between 1,000+ and 5,000 acres. This PV-MH study uses the same size distributions as the original study, which can be found in Appendix 3 of the original report.

The spread distribution applied only to the spread of non-native annual grasses (cheatgrass), exotic forb species, and native trees into shrublands from a source pixel into nearby or distant pixels. These values were changed to accommodate the new simulation pixel size of 30 m and to reign in invasions that may have been too high in the original and supplemental studies. For annual grasses, 99.999% of dispersal was within 3.5 m of a pixel, and the remaining 0.001% was within 15 m. For exotic forbs, the frequencies and distances were, respectively, 99.999% and 0.001% for 1 m and 15 m. For pinyon or juniper encroachment into shrublands, the frequencies and distances were, respectively, 99.999% and 0.001% for 7 m and 15 m.

Patch prioritization was only used to define the size of an exotic forb patch that would first be targeted for treatment. Actions were prioritized to first treat the smallest patches of exotic forbs, and then move to the next larger patches. This option is unchanged from the previous studies.

Spatial multipliers are used either to enhance or to constrain natural or managed disturbances. We used several types of multipliers:

1. No sage-grouse leks were found in the mapped PV-MH area, unlike in Hamlin Valley, therefore no raster to prevent removal or thinning sagebrush cover (in the simulations) within 500 m of any lek was needed.
2. A Wild Horse Herd Management Area (HMA) raster was used to restrict horse grazing only in the HMAs of the PV-MH project area (Figure 2).
3. Several management actions using tractors (not bulldozers or masticators) could not be applied on slopes >15%. While such a constraint raster was supplied in the past, the 15% slope threshold was important because the current landscape was steeper than prior areas (Figure 3).
4. Livestock grazing use was suppressed on increasingly steeper slopes using a raster. Cattle generally prefer to graze on gentler slopes (Ganskopp and Vavra 1987), although the effect of slopes is also seasonal. During spring and fall grazing, spatial multiplier values (Figure 4) were: 0.75× from 0% to 9% slopes; 0.18× from >9% to 19% slopes; 0.05× from >19% to 29% slopes; 0.02× from >29% to 39% slopes; 0× on slopes >39% (Ganskopp and Vavra 1987). The grazing by slope raster was not used in the original or supplemental studies.
5. Range shifts that were only included in climate variability forcing scenarios were constrained to be more likely at the lowest elevations of an ecological system and on the aspects with the greatest heat loading index (HLI). HLI is a measure of incident radiation based on latitude, slope, and aspect (McCune and Keon 2002). This process is described in the supplemental report, but the new raster for the PV-MH landscape is shown in Figure 5.
6. In the supplemental study, a non-random fire initiation layer based on decades of lightning strikes was used. The same dataset was recalculated for the PV-MH project area (Figure 6).

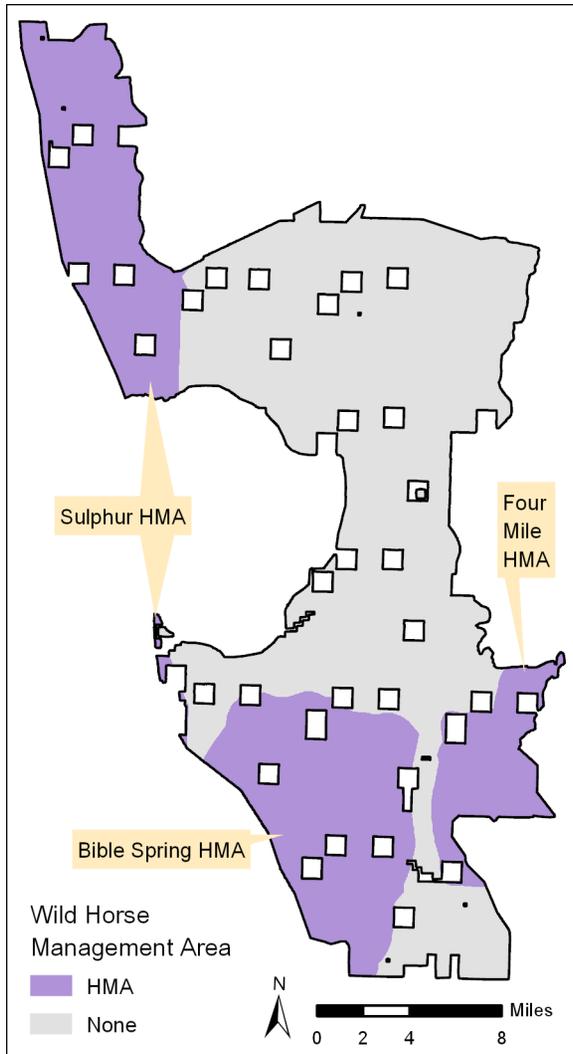


Figure 2. Wild Horse Herd Management Areas.

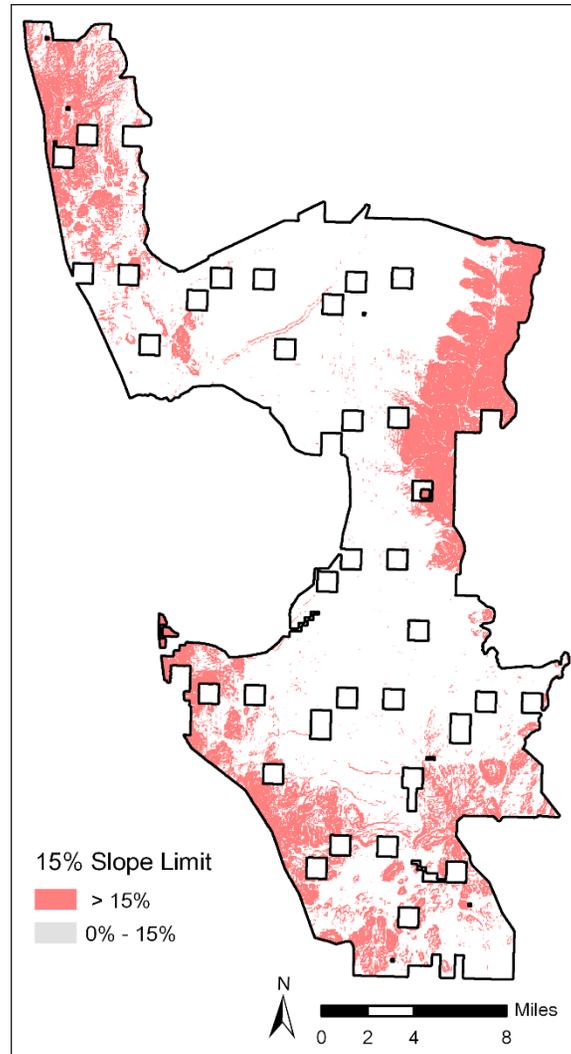


Figure 3. Areas with >15% slope, where some tractor-pulled equipment could not be used and treatments could not be used.

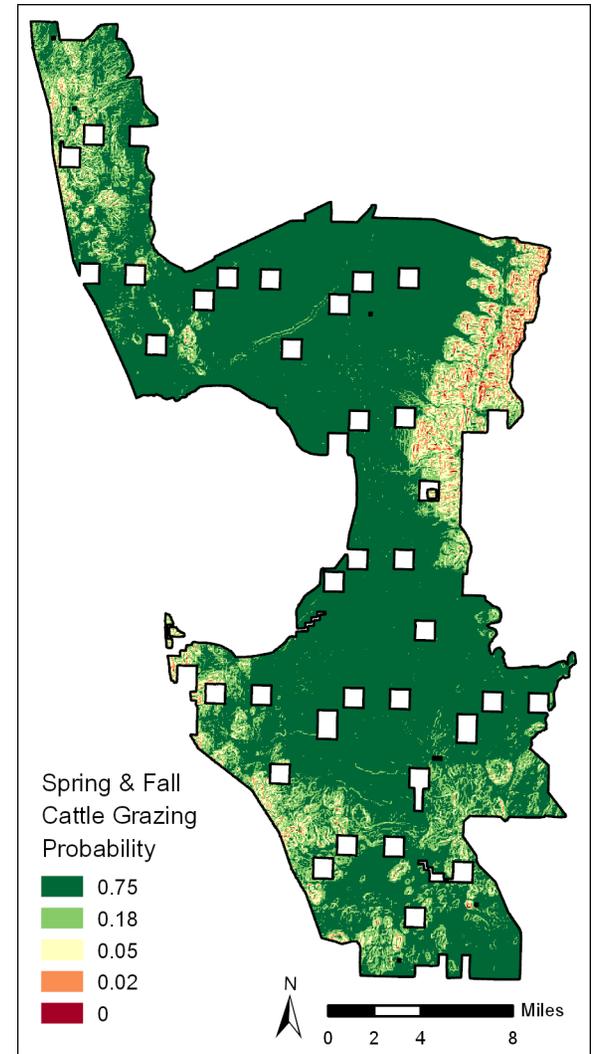


Figure 4. Locations where the likelihood of spring and fall grazing decreased due to slope.

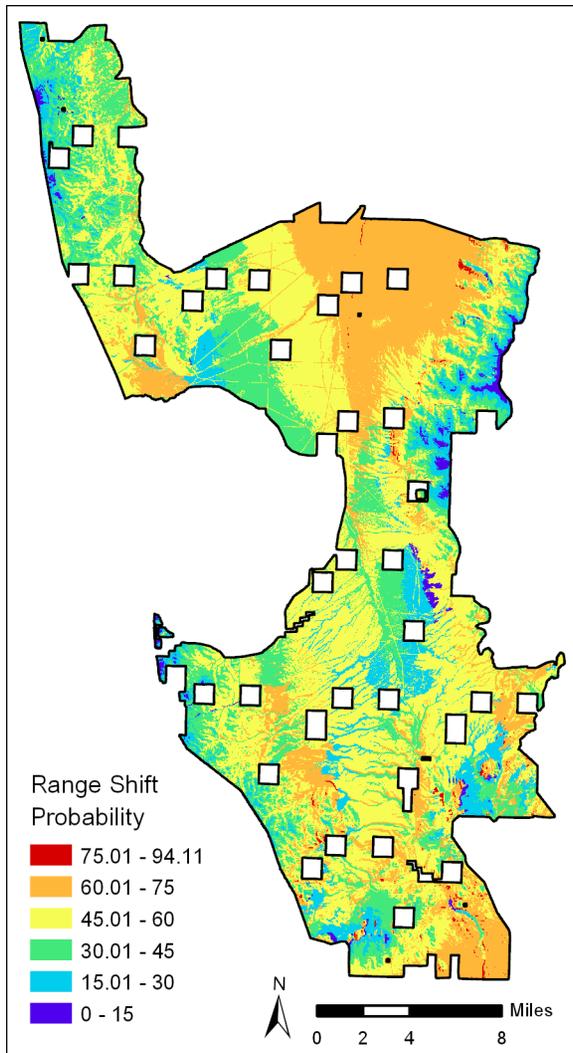


Figure 5. Probability that an ecological system will experience a range shift to other systems.

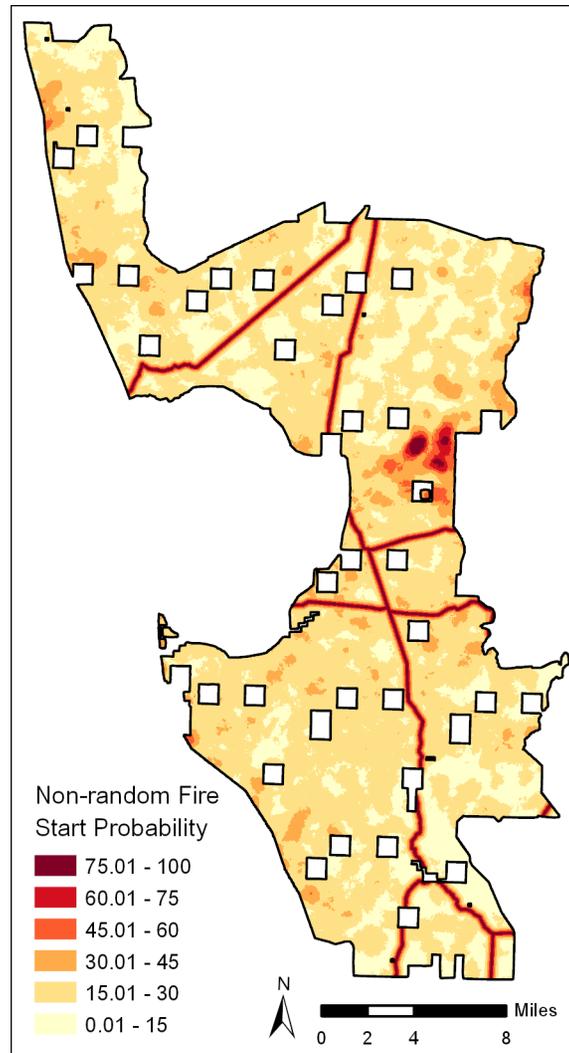


Figure 6. Likelihood (%) of fire starts based on a moving window frequency analysis of federal lightning strike data and distance from busy roads.

Direction multipliers governed the non-uniform direction of fire spread primarily following southwest to northeast prevailing winds. Table 1 shows the degree of fire spread and the multiplicative factor of fire spread that was used in both the original and supplemental studies, and also in this current PV-MH study.

An additional type of multiplier, that considers the effect of slope steepness, was used only in this current PV-MH study. Specifically, it comprises relationships governing the effect of negative and positive slopes relative to wind direction on fire spread, as shown in Table 2. These slope relationships were not available during the prior studies because they were not a menu in the older version of ST-Sim. The current version of ST-Sim allows this slope effect, thus it was used for the PV-MH project area.

Table 1. Direction multipliers for fire spread of all types (prior and current studies).

Transition Group	Direction (Degrees)	Multiplier
AllFire	0	5.5
AllFire	135	1.0
AllFire	180	0.8
AllFire	225	0.5
AllFire	270	1.0
AllFire	315	2.0
AllFire	45	7.0
AllFire	90	1.5

Table 2. Transition slope multipliers for fire spread of all types (current study only).

Transition Group	Slope Breakpoint (%)	Multiplier
AllFire	≤-16	0.4700
AllFire	-15 to -8	1.1320
AllFire	-7 to +7	1.0000
AllFire	+8 to +15	0.5600
AllFire	≥+16	3.9620

In addition to the spatial aspects of fire initiation and spread, suppression of fire regimes to current fire activity was expanded to other classes not considered in the original and supplemental studies.

Simulations for Management versus the Natural Range of Variability

Two fundamentally different types of model simulations are conducted for all LCF projects:

1. Management scenario simulations, either spatial or non-spatial, can be run multiple times with different parameters. The text above primarily applies to management scenario simulations.
2. A non-spatial simulation to quantify the Natural Range of Variability (NRV) of each ecological system is done only one time (with ten replicates). This simple type of simulation is required in order to calculate ecological departure from reference conditions (see below).

The NRV for each ecological system is the relative amount (percentage) of each vegetation class that would be expected to occur in an ecological system under its *reference* condition, i.e., under natural disturbance regimes and current climate (Hann and Bunnell 2001; Provencher et al. 2007, 2008; Rollins 2009). The NRV serves two purposes. First, and most relevant for the

work appearing in this report, each ecological state-and-transition model must reach a credible NRV, based on expected NRV from the literature, when simulating reference conditions. This allowed us to check model assumptions (e.g. fire return intervals, succession pathways, etc.). Second, NRV is required to determine the current or future condition (“ecological health”) of each ecological system, according to the measure of ecological departure.

NRV was generated from state-and-transition simulation models using the software ST-Sim within the SyncroSim platform (www.syncrosim.com; Daniel and Frid 2012). The NRV for each ecological system – i.e., the proportions of its reference classes – was derived by simulating models for 500 to 1,000 years without any post-European-settlement disturbances or uncharacteristic classes. The resulting NRV percentages of reference classes for each ecological system obtained in this way appear in Table A3-1 of Appendix 3.

Assessment of Condition

Ecological Systems: Unified Ecological Departure

For ecological systems, the metric used to report condition is known as Unified Ecological Departure (UED). The concept of UED was fully explained in the original report. However, the PV-MH project area contains some ecological systems and vegetation classes different from the Hamlin Valley - Black Mountains area. Also, some refinements have been made to the Undesirability and Threshold components of UED in the PV-MH project area. An explanation of UED as applied in the PV-MH project area is presented in Appendix 3.

Greater Sage-grouse: Habitat Suitability Estimation Models

Detailed explanation of the methods used to derive the Habitat Suitability measure for greater sage-grouse were contained in the original report. Upgrades and refinements to these original methods were presented in the supplemental report. No changes to the sage-grouse habitat suitability methods were made for the PV-MH project area. The reader is thus referred to the original and supplemental reports for details of the sage-grouse habitat suitability determination process.

Climate Variability Forcing

The topic of climate variability forcing was presented in detail in the supplemental report, and is not repeated here except for adjustments to range shifts shown in Tables 3 and 4. As stated in the supplemental report, the topic remains understudied.

Range shifts

The replacement of “cooler or wetter” ecological systems and their indicator species by “warmer or drier” systems and their indicator species due to climate variability forcing is called

“range shift.” Two systems (calcareous grassland and little-leaf mountain mahogany) not present in Hamlin Valley or the Black Mountains needed to be integrated in this section.

The rates of conversion from one ecological system to another were hypothesized based on four factors: (1) productivity; (2) whether the losing and gaining indicator species are the same (for example, Wyoming big sagebrush on upland soils to Wyoming big sagebrush on semi-desert soils); (3) different species that are already overlapping at the same location (for example, Wyoming big sagebrush to Mixed Salt Desert); and (4) species not currently present in the landscape (i.e., requiring long distance dispersal, Table 3).

The highest rates of range shifts (50% or 60%, depending on system) were used when three conditions were met: (1) the original and recipient indicator species are the same; (2) the pixels are in ecological systems with intermediate to high productivity; and (3) the systems are located at montane to subalpine elevations. All rates for shifts among the same indicator species drop by 10% for low productivity ecological systems (e.g., Low Sagebrush).

In Table 3 below, little-leaf mountain mahogany was in the subxeric woodland group, as was curl-leaf mountain mahogany, and in the class where the replacing dominant species (Stansbury cliffrose and black sagebrush) were in the same landscape, but not the same species as little-leaf mountain mahogany. Therefore, the 100-year replacement range shift percent was 5%. Calcareous grassland would fit under subxeric shrub as did semi-desert grassland. Replacing species are in the landscape, even present in the grassland, but dominating grasses were replaced by shrubs. Therefore, the rate of system replacement was 5%.

The guidelines of range shifts in Table 3 were incorporated to model range shifts for each ecological system in the PV-MH landscape (Table 4). TNC suggested several potential recipient ecological systems, and BLM allocated the 100-year conversion rates (percentage per 100 years) among the most probable recipient systems according to their best expert opinion (Table 4). For calcareous grassland, the few acres of range shifts resulted in conversion to mixed salt desert shrub at a rate of 0.004/year. Area of little-leaf mountain mahogany that experienced range shift were eventually occupied by Stansbury cliffrose 80% of times and black sagebrush for the remaining 20% of events. The rate of range shift was 0.0451/year (Table 4).

Ecological Processes

The discussion of climate variability forcing on ecological processes in the Hamlin Valley - Black Mountains project area also applies fully to the current PV-MH project area. The reader is thus referred to the supplemental report for details of effects on ecological processes.

Table 3. Hypothetical percentage of range shifts according to ecological systems productivity and indicator species distribution over 100 years. Ecological systems are approximately arranged by elevation in the Great Basin. Empty combinations were not found in the landscape.

Source BpS Type	Productivity								
	High			Medium			Low		
	Recipient Species in Landscape? Same Indicator Species?			Recipient Species in Landscape? Same Indicator Species?			Recipient Species in Landscape? Same Indicator Species?		
	Yes/ Same	Yes/ Different	No/ Different	Yes/ Same	Yes/ Different	No/ Different	Yes/ Same	Yes/ Different	No/ Different
Alpine				5%					
Limber- Bristlecone Pine dry							5%		
Spruce & Limber- Bristlecone Pine mesic				10%					
Subalpine Shrub				60%	15%		50%		
High Elevation Meadow		20%							
Aspen		20%							
Montane Forest					15%		10%		
Riparian Non- Carbonate	60%				15%				
Riparian Carbonate	10%								
Montane Shrub	60%			60%	10%				
Subxeric Woodland							5%		
Semi-desert Shrub & Grassland							40%	5%	1%

Table 4. Hypothesized directions and rates of range shifts for the Pine Valley - Mountain Home project area. Ecological systems are approximately arranged by elevation in the Great Basin.

Original Ecological System	100-yr Conversion (%)	Prob./yr in ST-Sim	New (Replacing) Ecological System	Allocation by new Ecological Systems (%)#
Limber-Bristlecone Pine	5	0.0166	Mixed Conifer	3
			Curl-leaf Mountain Mahogany	2
Aspen-Mixed Conifer	20	0.0714	Mixed Conifer	10
			Montane Sagebrush Steppe	5
			Ponderosa Pine	5
Mixed Conifer	10	0.0264	Pinyon-Juniper	5
			Ponderosa Pine	5
Curl-leaf Mountain Mahogany	5	0.0451	Black Sagebrush	2
			Pinyon-Juniper	2
			Wyoming Big Sagebrush	1
Aspen Woodland	20	0.0714	Montane Sagebrush Steppe	15
			Utah Serviceberry	5
Gambel Oak-Mountain Shrub	10	0.0604	Utah Serviceberry	2
			Wyoming Big Sagebrush	4
			Pinyon-Juniper	4
Ponderosa Pine	15	0.2048	Pinyon-Juniper	10
			Curl-leaf Mountain Mahogany	5
Pinyon-Juniper	5	0.0776	Black Sagebrush	2.5
			Wyoming Big Sagebrush	2.5
Montane Riparian	50	0.1640	Desert Wash	40
			Basin Wildrye	10
Montane Sagebrush Steppe	10	0.0302	Black Sagebrush	5
			Wyoming Big Sagebrush	5
Wet Meadow	50	0.0930	Basin Wildrye	35
			Gambel Oak-Mountain Shrub	5
			Alkali Sacaton-Wet Meadow	10
Low Sagebrush	5	0.0409	Mixed salt Desert	5
Basin Wildrye	20	0.0620	Four-Wing Saltbush	8
			Greasewood-Basin Big Sagebrush	8
			Wyoming Big Sagebrush	4
Little-leaf Mountain Mahogany	5	0.0451	Stansbury Cliffrose	4
			Black Sagebrush	1
Utah Serviceberry	10	0.0403	Wyoming Big Sagebrush	10
Stansbury Cliffrose	10	0.0302	Mixed Salt Desert	2.5
			Juniper Savanna	5
			Black Sagebrush	2.5
Black Sagebrush	5	0.0102	Mixed Salt Desert	5
Wyoming Big Sagebrush-upland soil	40	0.0080	Wyoming Big Sagebrush – semidesert soil	30
			Semi-Desert Grassland	10
Juniper Savanna	1	0.0776	Semi-Desert Grassland	1
Wyoming Big Sagebrush – semidesert soil	5	0.0040	Mixed Salt Desert	5

Table 4. Hypothesized directions and rates of range shifts for the Pine Valley - Mountain Home project area. Ecological systems are approximately arranged by elevation in the Great Basin.

Original Ecological System	100-yr Conversion (%)	Prob./yr in ST-Sim	New (Replacing) Ecological System	Allocation by new Ecological Systems (%)#
Semi-Desert Grassland	5	0.0040	Greasewood-Basin Big sagebrush	5
Calcareous Grassland	5	0.0040	Mixed Salt Desert	5
Mixed Salt Desert	5	0.0027	Greasewood-Basin Big sagebrush	5
Four-Wing Saltbush	5	0.0040	Mixed Salt Desert	5
Saline Meadow	5	0.0188	Greasewood-Basin Big Sagebrush	5
Greasewood-Basin Big Sagebrush	5	0.0010	Pickleweed	4
			Playa	1

Percentage reflects current abundance.

Modeling Simulations and Scenarios

Future simulations of active management are **the heart of the LCF process**. Such management simulations are aimed at meeting the Management Objectives for this LCF project, as described and listed in the **Introduction** section. More specifically, management simulations seek to meet the project’s Objectives by reducing ecological “problems” to habitats and certain wildlife species.

Before running any such simulations, however, it was necessary to review *current* conditions of ecological systems in the PV-MH landscape, to understand more clearly the problems now inherent in those systems. Examples of ecological problems include invasion of non-native annual grasses, excessive spread of conifers into shrubland systems, replacement of native vegetation by exotic forbs in wet meadows and riparian areas, etc.

Furthermore, it was necessary to understand what would happen in ecological systems, i.e., what their *future* condition would be, after a certain time (60 years in this study) without any active management aimed at reducing their ecological problems. For this purpose, modeling simulations were run for each ecological system under a management regime termed MINIMUM MANAGEMENT.

MINIMUM MANAGEMENT

MINIMUM MANAGEMENT essentially represents a custodial level of land management with no proactive projects other than the continuation of current management practices, including grazing and fire suppression. It achieves no vegetation treatments, no prescribed fire, no inventory or treatment of exotic forbs, etc.

MINIMUM MANAGEMENT simulations were run for each of three different future climate scenarios: HISTORIC (i.e., continuation of current climate), and two future climate models named CCSM4 and ACCESS1. The supplemental report contains a full description of these downscaled future climate models.

Knowledge of current conditions was combined with forecasts of future conditions under a MINIMUM MANAGEMENT regime (three climate scenarios) to define specific “needs for action” across the PV-MH landscape on the whole, and within its ecological systems in particular.

Management Actions

Project participants then identified various management actions, also termed treatments or strategies, fundamentally designed to: (1) abate the most serious current and future problems that face the ecological systems, and the PV-MH landscape on the whole; and thereby (2) improve the condition of ecological systems currently in an undesirable status.

Building on management actions used in the original and supplemental studies, participants at the PV-MH project’s single workshop (October 2018) made additions and refinements to arrive at the set of management actions for this new landscape. Each management action had a cost-per-acre figure specified, using various published sources as well as the local experience of agency staff and stakeholders. The management actions and their associated per-acre costs for the PV-MH project area appear in Appendix 4.

With both (1) needs for action and (2) management actions themselves now specified, TNC ran modeling simulations for each ecological system under an active management regime termed PREFERRED MANAGEMENT.

Active Management / PREFERRED MANAGEMENT

The types, amounts, and timing of management actions that comprise PREFERRED MANAGEMENT for each ecological system were identified interactively by BLM managers, stakeholders and TNC at the project’s October 2018 workshop. PREFERRED MANAGEMENT aims to reduce unified ecological departure and/or specific undesirable “problem” vegetation classes as much as possible within the constraints of anticipated (realistic) agency budgets, management funding availability, and regulatory requirements. Basically, PREFERRED MANAGEMENT identifies a set of management actions that produces a high return on investment, or ratio of benefit (improvement in condition) to affordable cost. As was the case with MINIMUM MANAGEMENT, simulations of PREFERRED MANAGEMENT were run for each of three different future climate scenarios: HISTORIC, CCSM4 and ACCESS1.

Computer Simulations and Reporting Variables

PREFERRED MANAGEMENT climate scenarios were simulated for each ecological system for 60 years. Ten model replicates were run for each scenario to capture variation in processes such

as fire activity, drought, and flash-flooding. PREFERRED MANAGEMENT simulations required budgets for each ecological system, which included costs of all management actions. Budgets were also expressed as area limits, which was the maximum area that could be treated per year for individual actions. If computer simulations reached a given management action's annual area limit, that management action was subsequently discontinued in the simulation for that year.

For ecological systems, the main reporting variable (output) for each simulation was the future-condition measure of unified ecological departure. Other measures reported for each system include acres actually treated and 60-year total costs of treatments. For greater sage-grouse the reporting variable was future habitat suitability, as both a single landscape-wide number, and as maps showing the distribution of habitat suitability (better/poorer) throughout the landscape.

Results

Ecological Systems

Twenty-five ecological systems were mapped in the PV-MH project area (Table 5 and Figure 7).

Table 5. The 25 Ecological Systems of Pine Valley - Mountain Home Range based on 1.5-m Spot 6/7 satellite imagery interpreted in 2017-18.

Ecological System	Acres	Ecological System	Acres
Aspen Woodland	67	Mixed Salt Desert	322
Aspen-Mixed Conifer	85	Montane Riparian	20
Basin Wildrye-montane	81	Montane Sagebrush Steppe	44,145
Black Sagebrush	82,210	Pinyon-Juniper Woodland	19,874
Calcareous Grassland	920	Ponderosa Pine	3,839
Curl-leaf Mountain Mahogany	5,227	Saline Meadow	56
Desert Wash	88	Semi-Desert Grassland	3,254
Four-Wing Saltbush	211	Stansbury Cliffrose	11
Greasewood	382	Utah Serviceberry	737
Juniper Savanna	400	Wet Meadow-montane	63
Little-leaf Mountain Mahogany	2,328	Winterfat	18,318
Low Sagebrush	286	Wyoming Big Sagebrush-upland	51,760
Mixed Conifer	64		
TOTAL			234,750

Among the 25 ecological systems of the PV-MH project area, 12 were selected for more detailed management analyses (Table 6). These 12 systems were selected based upon their size, degree of unified ecological departure – both current and likely in the future – and/or other features of importance to the BLM CCFO.

Table 6. The 12 Ecological Systems of Pine Valley - Mountain Home Range selected for management analyses.

Ecological System	Acres	Ecological System	Acres
Aspen Woodland	67	Ponderosa Pine	3,839
Black Sagebrush	82,210	Semi-Desert Grassland	3,254
Calcareous Grassland	920	Stansbury Cliffrose	11
Montane Riparian	20	Utah Serviceberry	737
Montane Sagebrush Steppe	44,145	Wet Meadow-montane	63
Pinyon-Juniper Woodland	19,874	Wyoming Big Sagebrush-upland	51,760
TOTAL			206,900

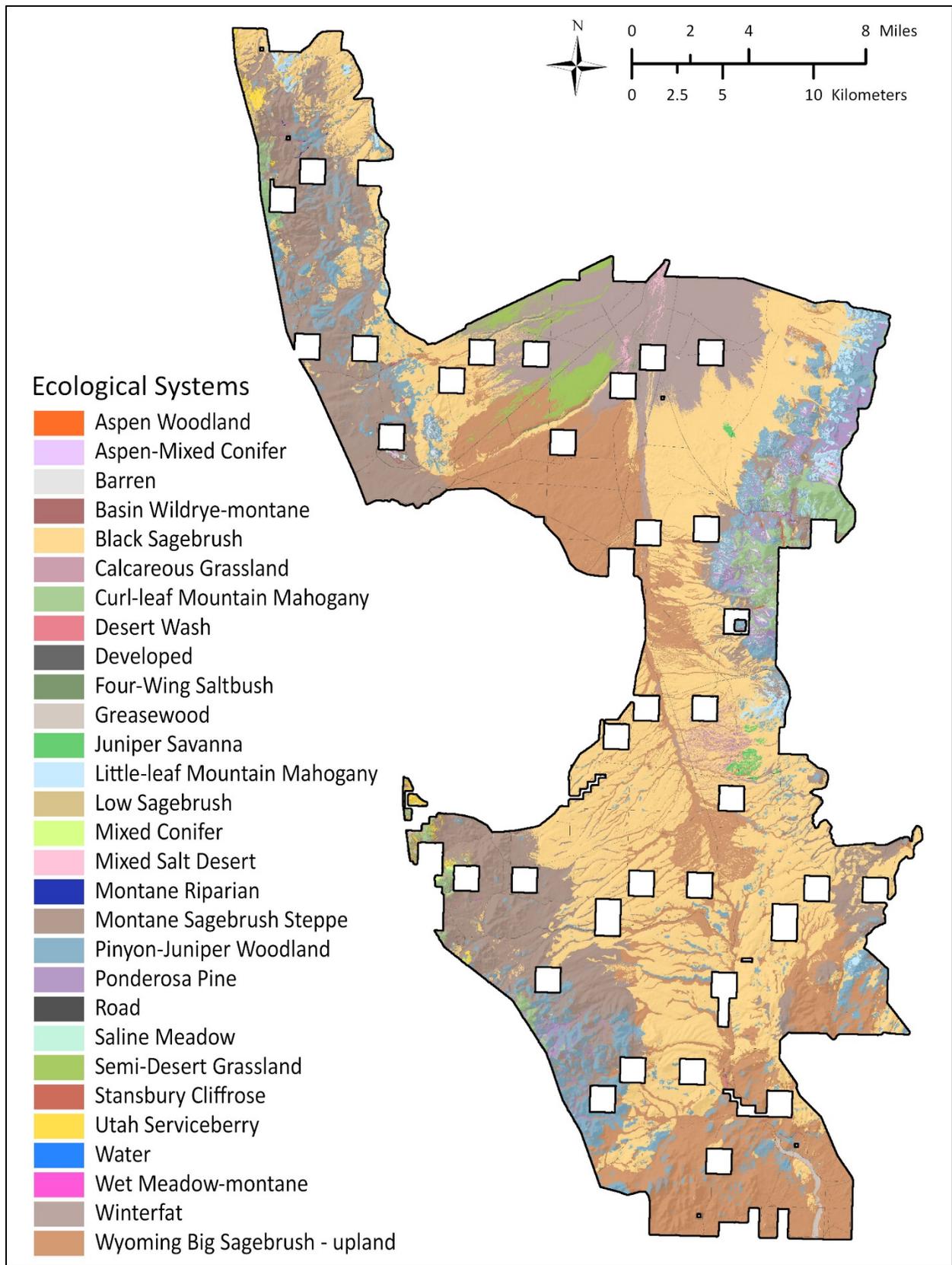


Figure 7. Ecological systems of the Pine Valley - Mountain Home Range Project Area.

The condition of ecological systems per the measure of Unified Ecological Departure is shown in Table 7 at the current time for all 25 systems, and in Table 8 after 60 years of MINIMUM MANAGEMENT for the 12 systems that were selected for management analyses.

Table 7. Current unified ecological departure in all ecological systems in the Pine Valley - Mountain Home Range Project Area. Systems shaded turquoise are those selected for management analyses.

Ecological System	UED	Ecological System	UED
Aspen Woodland	99	Mixed Salt Desert	100
Aspen-Mixed Conifer	74	Montane Riparian	81
Basin Wildrye-montane	100	Montane Sagebrush Steppe	100
Black Sagebrush	93	Pinyon-Juniper Woodland	35
Calcareous Grassland	99	Ponderosa Pine	50
Curl-leaf Mountain Mahogany	50	Saline Meadow	100
Desert Wash	96	Semi-Desert Grassland	100
Four-Wing Saltbush	100	Stansbury Cliffrose	36
Greasewood	98	Utah Serviceberry	97
Juniper Savanna	18	Wet Meadow-montane	100
Little-leaf Mountain Mahogany	54	Winterfat	100
Low Sagebrush	42	Wyoming Big Sagebrush-upland	100
Mixed Conifer	73		

Table 8. Unified ecological departure at the current time (2017), and as predicted under three climate scenarios after 60 years of MINIMUM MANAGEMENT (2077), of ecological systems selected for management analyses in the Pine Valley - Mountain Home Range Project Area.

Ecological System	Unified Ecological Departure (UED)*			
	Current (2017)	MINIMUM MANAGEMENT – 2077		
		HISTORIC	CCSM4	ACCESS1
Aspen Woodland	99	61 ± 7	62 ± 5	53 ± 5
Black Sagebrush	93	100 ± 0	100 ± 0	100 ± 0
Calcareous Grassland	99	100 ± 0	100 ± 0	100 ± 0
Montane Riparian	81	76 ± 6	80 ± 10	82 ± 8
Montane Sagebrush Steppe	100	100 ± 0	100 ± 0	100 ± 0
Pinyon-Juniper Woodland	35	30 ± 5	25 ± 4	13 ± 2
Ponderosa Pine	50	29 ± 1	28 ± 2	36 ± 3
Semi-Desert Grassland	100	100 ± 0	100 ± 0	100 ± 0
Stansbury Cliffrose	36	53 ± 8	50 ± 6	52 ± 5
Utah Serviceberry	97	53 ± 8	62 ± 7	77 ± 8
Wet Meadow-montane	100	100 ± 0	100 ± 0	99 ± 0
Wyoming Big Sagebrush-upland	100	100 ± 0	100 ± 0	100 ± 0

Code to UED cell colors in Tables 7 and 8: 0-33 34-66 67-100

* Each 2077 UED value is the mean of ten model runs (N=10), ± one 95% confidence interval.

In the sections that follow, summary descriptions of active-management modeling simulations are presented for each of the 12 ecological systems selected for analyses in the PV-MH Project Area. Each system description provides the following information:

1. The system's unified ecological departure:
 - at the current time (2017), and
 - after 60 years of MINIMUM MANAGEMENT (2077), under each of three climate scenarios.
2. The system's vegetation classes:
 - at the current time (2017), and
 - after 60 years of MINIMUM MANAGEMENT (2077), under each of three climate scenarios, including identification of the system's "problem" classes at those two times.
3. Objectives for the system in terms of ameliorating the "problem" classes.
4. Simulated management actions aimed at achieving the objectives (#3 above), including acres treated and cost, under each of three climate scenarios.
5. Forecasted results in terms of the system's unified ecological departure after 60 years of active ("PREFERRED") management (2077), under each of three climate scenarios.
6. Charts (graphs) showing forecasted change in the "problem" or other relevant vegetation classes resulting from MINIMUM and active ("PREFERRED") management, under each of three climate scenarios.

Aspen Woodland Ecological System

Current System Acres: 67

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

99
61 ± 7
62 ± 5
53 ± 5

Vegetation Classes

Table 9. Vegetation classes of the Aspen Woodland ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
ASP-A:All	8	0	—	0.00%	49.91%	52.42%	34.40%
ASP-B:Closed	25	0	—	42.59%	25.13%	21.08%	21.47%
ASP-C:Closed	39	0	—	2.04%	13.65%	13.41%	21.59%
ASP-D:Open	28	0	—	0.74%	3.09%	4.06%	9.09%
ASP-U:Depleted-B	0	1	0.0	1.48%	0.00%	0.00%	0.00%
ASP-U:Depleted-C	0	1	0.0	2.96%	0.00%	0.02%	0.02%
ASP-U:Depleted-D	0	1	0.0	50.19%	1.19%	1.80%	4.46%
ASP-U->MSS:All	0	1	0.0	0.00%	7.04%	7.21%	8.96%

Problems or Concerns

2017: The aspen woodland system was highly departed from NRV (99% UED). Depleted classes of aspen, especially the late-successional class (ASP-U:Depleted-D) at about 50% of the area, were the main causes of departure. Further decline of depleted aspen would result in the permanent loss of aspen clones. Also, reference classes did not match the NRV, but only natural aging and disturbances would restore reference class proportions.

After 60 years of MINIMUM MANAGEMENT: The late-successional depleted class (ASP-U:Depleted-D) declined from 50% of the area now, to a range from 1% (HISTORIC Climate) to 4% (ACCESS1 LOCA) in all MINIMUM MANAGEMENT scenarios by 2077 (Table 9). The area of clone loss (ASP-U→MSS:All) increased from zero to about 7-9% due to continued decline in vigor in the depleted condition, side effects of natural fires, grazing of early-successional aspen (ASP-A:All) and persistent grazing in the late-successional depleted class. The reference mid-successional class (ASP-B:Closed) dropped from 43% in 2017 to 21-25% in the HISTORIC Climate and CCSM4 LOCA, and to 22% in the ACCESS1 LOCA. This suggested that fire caused some of the decrease because less fire was observed in the drier ACCESS1 LOCA. The decrease in the reference mid-successional class (ASP-B:Closed) was directly matched by the increase of the early-successional

class (ASP-A:All). In addition, aging of the mid-successional class caused persistent recruitment into the late-successional closed class (ASP-C:Closed) and eventually into the late-successional open class (ASP-D:Open).

The ACCESS1 LOCA differed most from other climate scenarios (HISTORIC Climate and CCSM4 LOCA) (Table 9). Results for the latter two climates overlapped substantially. The drier climate of the ACCESS1 LOCA resulted in less fire and, therefore, in a smaller area of the early-successional reference class (ASP-A:All) originating from post-fire resprouting. But the ACCESS1 LOCA resulted in greater preservation of late-successional reference (ASP-C:Closed and ASP-D:Open) and depleted classes.

Objective(s) for Management Actions

Ultimately, the objective of management was to increase the area of all reference classes, while trying to match NRV and decrease the depleted classes.

Treatment Rates and Costs

The primary period of implementation was during the first 15 years (after an initial NEPA proposed action phase; Table 10). During this period, expenses were statistically similar among climate scenarios and ranged from \$1.13 million (ACCESS1 LOCA) to \$1.18 million (CCSM4 LOCA). Fencing was the greatest expense because it was also the most expensive action. Therefore, reliance on chainsaw thinning and limited prescribed fire lowered overall costs while achieving some objectives. Significantly less funding was required for prescribed fire during the last period (2045-2077) for the PREFERRED+ACCESS1 scenario than other scenarios, which were comparable. Expenses during this last period of implementation never exceeded \$17,300.

The most important action was fencing, which allows root reserves to build up in late-successional depleted stands before allowing prescribed fire or chainsaw thinning. Though prescribed fire and chainsaw thinning are different actions, they should be considered as interchangeable although prescribed fire might not be possible. Fencing was also critical at protecting aspen resprouts from herbivory. Chainsaw thinning and prescribed fire in depleted classes would cause transitions to the reference early-successional class (ASP-U:All) only if root reserves were restocked. Minor amounts of chainsaw thinning and prescribed fire were also used in both late-successional reference classes to cause a transition to the early-successional reference class as aspen became older.

Table 10. Realized rates and costs of management actions implemented in the Aspen Woodland ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period's cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred + Historic	Chainsaw-Thinning	\$112.50	46.8	0.0	0.0	
	Fence	\$10,000.00	112.5	0.0	0.0	
	RxFire	\$300.00	61.9	2.7	57.6	
	Cost →		\$1,148,714 a	\$801 a	\$17,287 a	\$1,166,801
Preferred + CCSM4	Chainsaw-Thinning	\$112.50	58.2	0.0	0.0	
	Fence	\$10,000.00	115.7	0.0	0.0	
	RxFire	\$300.00	44.6	2.1	50.0	
	Cost →		\$1,177,047 a	\$620 a	\$14,992 a	\$1,192,659
Preferred + ACCESS1	Chainsaw-Thinning	\$112.50	65.3	0.0	0.0	
	Fence	\$10,000.00	111.5	0.0	0.0	
	RxFire	\$300.00	33.3	1.5	37.5	
	Cost →		\$1,132,644 a	\$440 a	\$11,235 b	\$1,144,320

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	61 ± 7	49 ± 6
In 2077 under CCSM4 LOCA	62 ± 5	42 ± 4
In 2077 under ACCESS1 LOCA	53 ± 5	45 ± 2

Charts of Relevant Vegetation Classes

By 2077, UED was reduced by about 20% for the PREFERRED+HISTORIC and PREFERRED+CCSM4 scenarios, and by 8% for the PREFERRED+ACCESS1 scenario, compared to their respective MINIMUM MANAGEMENT scenarios. While area class distributions varied among climates for the PREFERRED MANAGEMENT scenarios, UEDs were comparable within the 95% C.I.s.

The late-successional depleted class was eliminated by 2030 for all PREFERRED MANAGEMENT scenarios, whereas this class, while progressively declining, persisted in all MINIMUM MANAGEMENT scenarios until 2077 (Figure 8). Twice as much area of clone loss (ASP-U→MSS:All) was registered under MINIMUM (~10 acres) vs. PREFERRED (~5 acres) MANAGEMENT scenarios, with the greatest increases in clonal loss being a side-effect of management actions before 2030 or natural fires. As a result of chainsaw thinning, fencing, and prescribed fire, a strong and traveling pulse of early to late-successional reference classes was observed, with most area found in the ASP-C:Closed class by 2077.

The areas of different classes under the PREFERRED+ACCESS1 scenario mimicked the patterns observed for the MINIMUM+ACCESS1 scenario compared to other climates: Lesser recruitment of reference early- and mid-successional classes, and greater retention of the reference late-successional closed class (ASP-C:Closed) for the drier ACCESS1 LOCA than for the moister HISTORIC Climate and CCSM4 LOCA. Late-successional uncharacteristic classes were eliminated by active management.

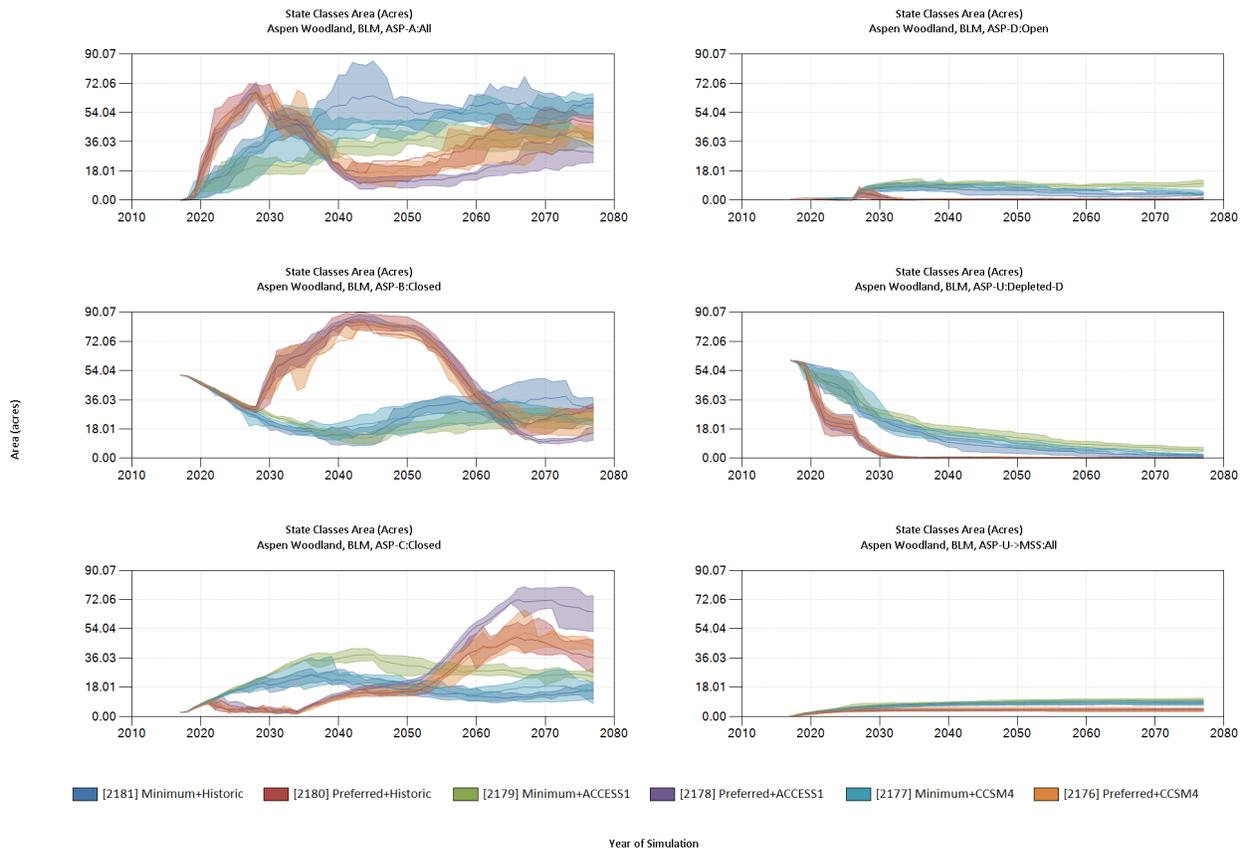


Figure 8. Dominant treated and recipient vegetation classes in the Aspen Woodland ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Black Sagebrush Ecological System

Current System Acres: 82,210

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

93
100 ± 0
100 ± 0
100 ± 0

Vegetation Classes

Table 11. Vegetation classes of the Black Sagebrush ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
BS-A:All	17	0	—	1.49%	5.55%	5.42%	2.00%
BS-B:Open	51	0	—	7.08%	5.76%	5.04%	6.28%
BS-C:Closed	19	0	—	4.79%	2.89%	3.18%	4.18%
BS-D:Open	12	0	—	10.84%	3.23%	3.13%	1.87%
BS-U:Annual Spp	0	1	0.0	0.70%	37.50%	32.90%	20.21%
BS-U:Bare Ground	0	1	0.0	0.00%	0.21%	0.20%	0.21%
BS-U:Depleted	0	1	0.0	2.72%	0.84%	0.99%	1.84%
BS-U:Early-Shrub	0	0	0.0	0.19%	4.05%	4.44%	5.55%
BS-U:Exotic Forb	0	0	0.0	0.01%	1.04%	1.05%	0.90%
BS-U:SA	0	1	0.0	1.00%	0.19%	0.21%	0.58%
BS-U:SA+	0	1	0.0	0.00%	0.01%	0.01%	0.07%
BS-U:SAP	0	0	0.0	2.54%	1.17%	1.26%	2.84%
BS-U:SAP+	0	1	0.0	0.00%	0.05%	0.11%	0.36%
BS-U:SAP-A	0	0	0.0	3.81%	0.74%	0.67%	0.88%
BS-U:Seeded Native	0	0	9.0	0.00%	0.00%	0.00%	0.00%
BS-U:SI-A	0	0	9.6	1.11%	3.48%	2.47%	1.30%
BS-U:SI-A+AG	0	0	0.0	0.47%	0.02%	0.02%	0.01%
BS-U:SI-B	0	0	30.0	7.13%	3.45%	3.26%	2.40%
BS-U:SI-B+AG	0	0	0.0	0.00%	0.02%	0.02%	0.01%
BS-U:SI-C	0	0	11.4	2.56%	3.21%	4.15%	6.49%
BS-U:SI-C+AG	0	0	0.0	0.00%	0.03%	0.02%	0.04%
BS-U:SI-D	0	0	0.0	0.91%	1.19%	1.52%	1.43%
BS-U:SI-D+AG	0	0	0.0	0.06%	0.07%	0.08%	0.09%
BS-U:TEA	0	1	0.0	52.59%	25.29%	29.85%	40.45%

Problems or Concerns

2017: Black sagebrush was highly departed (93%) from NRV even with allowable thresholds for seedings (Table 11). The primary cause of departure was that 53% of all 82,210 acres were encroached by pinyon or juniper (BS-U:TEA). As a result, the reference early-, mid-, and late-successional classes were woefully under-represented, with the exception of the late-successional open class (BS-D:Open), which was very close to the NRV of 12%. Adding to overall departure was the modest presence (2.5% to 3.8% of total area) of three uncharacteristic classes: Depleted sagebrush (BS-U:Depleted), shrub with annual and perennial grasses from the early-successional phase (BS-U:SAP-A), and late-successional phase (BS-U:SAP).

After 60 years of MINIMUM MANAGEMENT: Sixty years of primarily fires and modest amounts of drought mortality transformed the distribution of classes. Unified ecological departure increased to 100%. Half the area of tree-encroached black sagebrush with or without annual species (BS-U:TEA) transitioned to non-native annual species dominance (BS-U:Annual Spp). The area of annual species dominance ranged from 15,000 to 27,000 acres on average. Tree-encroached classes persisted, albeit in progressively declining area, between 18,000 and 30,000 acres on average. For other classes, the more noticeable temporal changes were the reduction of the area of the reference late-successional wooded class (BS-D:Open) that resulted in transitions to the early-successional reference class (BS-A:All) and the early-shrub class (BS-U:Early-Shrub).

Objective(s) for Management Actions

The main objectives were to: (1) reduce the area of tree-encroached black sagebrush, and (2) treat and seed non-native annual species grasslands (BS-U:Annual Spp) as fires created them. Both classes are detrimental to greater sage-grouse and increase fire risk. Other classes were targeted for management, albeit in small areas, because their burning would lead to more undesirable classes (e.g., from BS-U:SAP to BS-U:Annual Spp) or because they are not used by greater sage-grouse and are a source of pinyon and juniper seeds (e.g., BS-D:Open) leading to encroachment.

Treatment Rates and Costs

Six restoration actions were used that were front-loaded from years 2018 to 2034 (Table 12). Front loading was necessary because black sagebrush and Wyoming big sagebrush surround the few sage-grouse leks. Therefore, birds need improved habitat at the start of nesting and brood rearing before they move to higher elevations and to wet meadows and the Montane Sagebrush Steppe system. Only Chaining+Plateau+Seed was used in the very last period from years 2045 to 2077 to reduce the area of new annual species grasslands (BS-U:Annual Spp). As a result, most expenses were incurred in the first 15 years.

Two actions designed to reduce the area of tree-encroachment were 2xChaining+Seed and Masticate+Seed. These actions were deployed at high rates for the first 15 years. Mastication was used more than chaining (3:2 ratio). The primary intended class for restoration was the mixed native and introduced species seeding (BS-U:SI-A). Two actions were used to reduce the area of non-native annual species grasslands (BS-U:Annual Spp): Chaining+Plateau+Seed and Herbicide+Plateau+Seed. The first action, while being more expensive, was also more successful at incorporating seed into the soil and achieved higher success based on BLM's staff experience. This action was also used at a high rate both in the first 15 years and in the last period from 2045-2077. These criteria are especially important in the less productive soils of black sagebrush. The Chaining+Plateau+Seed treatment was also used in depleted sagebrush (BS-U:Depleted) and late-successional shrubs with annual and perennial grasses (BS-U:SAP) where chaining both breaks up the canopy of sagebrush and incorporates seed into the soil.

Supplemental seeding of native forbs and grasses (Forb+Grass-Native-Seeding+Chaining) into existing introduced species seedings was used to improve greater sage-grouse habitat, with chaining providing enough ground disturbance to incorporate seed in the soil. The success of this action was not expected to be high, as it was an experimental method with which CCFO BLM staff are gaining experience. Finally, Chainsaw-Thinning was deployed in most late-successional classes where trees either were young (for example, BS-U:SAP) or well-established with native understory cover (BS-D:Open).

From years 2018-2034, total treatment costs were not statistically different among climate scenarios. From 2045 to 2077, however, total costs were significantly lower in both LOCAs than in the HISTORIC Climate because lower fire activity in the LOCAs caused less fire, and thus created less non-native annual species grasslands. Variation in implementation rates among climate scenarios was notable, as more trees persisted due to less fire under the drier LOCAs. Therefore, rates of tree removal actions were highest for the ACCESS1 LOCA and least for HISTORIC Climate. Predictably, the opposite trend was observed for rates of actions that seeded into non-native annual grasslands.

Table 12. Realized rates and costs of management actions implemented in the Black Sagebrush ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period's cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred + Historic	2xChaining+Seed	\$202.50	8,418.3	0.0	0.0	
	Chaining+Plateau+Seed	\$160.00	8,527.0	0.0	5,269.6	
	Chainsaw-Thinning	\$112.50	2,655.4	0.0	0.0	
	Forb+Grass-Native-Seeding+Chaining	\$160.00	1,841.3	0.0	0.0	
	Herbicide-Plateau+Seed	\$117.50	1,985.1	0.0	0.0	
	Masticate+Seed	\$577.50	12,433.9	0.0	0.0	
	Cost →		\$11,076,187 a	\$0	\$843,135 a	\$11,919,322
Preferred + CCSM4	2xChaining+Seed	\$202.50	9,649.5	0.0	0.0	
	Chaining+Plateau+Seed	\$160.00	7,617.6	0.0	3,639.4	
	Chainsaw-Thinning	\$112.50	2,752.1	0.0	0.0	
	Forb+Grass-Native-Seeding+Chaining	\$160.00	1,954.1	0.0	0.0	
	Herbicide-Plateau+Seed	\$117.50	2,195.1	0.0	0.0	
	Masticate+Seed	\$577.50	12,968.0	0.0	0.0	
	Cost →		\$11,542,028 a	\$0	\$582,311 b	\$12,124,339
Preferred + ACCESS1	2xChaining+Seed	\$202.50	12,420.3	0.0	0.0	
	Chaining+Plateau+Seed	\$160.00	8,482.1	0.0	2,813.3	
	Chainsaw-Thinning	\$112.50	2,554.0	0.0	0.0	
	Forb+Grass-Native-Seeding+Chaining	\$160.00	1,833.1	0.0	0.0	
	Herbicide-Plateau+Seed	\$117.50	2,357.6	0.0	0.0	
	Masticate+Seed	\$577.50	13,024.4	0.0	0.0	
	Cost →		\$12,251,445 a	\$0	\$450,134 b	\$12,701,579

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	100 ± 0	55 ± 3
In 2077 under CCSM4 LOCA	100 ± 0	56 ± 4
In 2077 under ACCESS1 LOCA	100 ± 0	56 ± 3

Charts of Relevant Vegetation Classes

Treatments and implementation rates were adjusted to compensate for the effects of LOCAs to the extent budgets allowed; as a result, UED values were the similar among climates.

Two sets of figures show the vegetation classes targeted for restoration (Figure 9) and the classes that were the intended outcomes of restoration actions (Figure 10). The most remarkable result was the active reduction of the area of black sagebrush encroached by pinyon or juniper and possibly invaded by cheatgrass (Figure 9). By year 2034, when tree

removal ceased, there were 20,000 to 25,000 less acres of BS-U:TEA compared to MINIMUM MANAGEMENT scenarios. Differences among climate scenarios were small, due to compensatory implementation rates stated above. After year 2034, this class was very stable, perhaps because seedlings in proximity of remaining tree-encroached areas acted as fire breaks and tree encroachment continued while at the same time fires removed trees.

The next remarkable result was the reduction of non-native annual species grasslands (BS-U:Annual Spp), as they increased in area due to fire under the MINIMUM MANAGEMENT scenarios. Here we observed large differences among climate scenarios. The smallest reduction of about 10,000 acres of non-native annual species grassland between MINIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios was for the driest climate (ACCESS1 LOCA), whereas the largest reduction of about 20,000 acres was observed for HISTORIC Climate. Reduction under the CCSM4 LOCA was intermediate between the other two. Moreover, the ranking in area among climates from highest to lowest area for MINIMUM MANAGEMENT was respected for PREFERRED MANAGEMENT. These patterns easily explained the differences in implementation rates among climates for the years 2045 to 2077.

The BS-D:Open and BS-U:SAP classes had smaller areas in 2017 than those discussed above. All PREFERRED MANAGEMENT scenarios reduced the areas of BS-D:Open and BS-U:SAP. Again, climate scenarios had a strong influence on results. The BS-D:Open class experienced greater drought mortality in the drier ACCESS1 LOCA than other climates because fire was less prevalent in the ACCESS1 LOCA. As a result, intentional tree reduction was less for that LOCA than it was for others. Drier conditions of the ACCESS1 LOCA protected the late successional BS-U:SAP class from fire, thus its area was greater under the MINIMUM MANAGEMENT scenario. No differences were observed among climates for PREFERRED MANAGEMENT scenarios, in part due to compensatory implementation rates and the success of actions at bringing area to absolute low values.

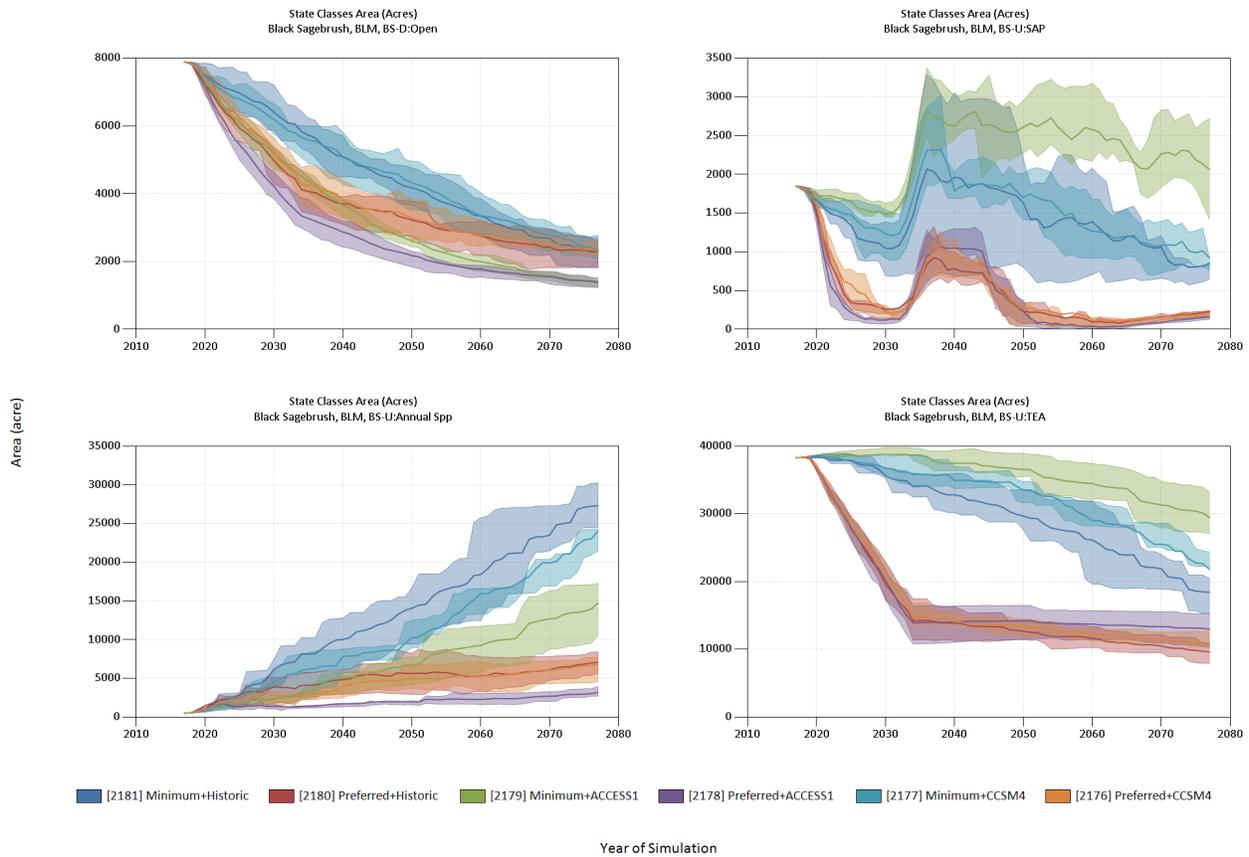


Figure 9. Dominant treated vegetation classes in the Black Sagebrush ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

With the exception of chainsaw thinning, all treatments caused transitions to early-successional mixed native and introduced species seedings (BS-U:SI-A). As seen in Figure 10, the area of BS-U:SI-A increased from <1,000 acres (existing seedings) to >23,000 acres from 2020 to 2034. The net increase of 22,000 acres represented at most 70% of planned implementation rates, because not all seeding attempts were successful in black sagebrush due to germination failure, different types of drought, and wild horse grazing during the regulatory no-livestock rest period. Toward the end of the simulations from years 2050 to 2077, the ACCESS1 LOCA showed 5,000 acres less area of BS-U:SI-A than both the CCSM4 LOCA and HISTORIC Climate.

Areas of early successional seedings started maturing into mid-successional seedings (BS-U:SI-B), which can become habitat for sage-grouse, after year 2035 (the 2020 to 2034 period approximately equaled the fastest succession duration). The net increase of this class at its peak ranged from 11,000 acres for HISTORIC Climate to 22,000 acres for the ACCESS1 LOCA, with the CCSM4 LOCA at about 16,000 acres. These results suggest that the substantial reduction of fire in the ACCESS1 LOCA, and to a lesser extent for the CCSM4 LOCA, caused mid-successional seedings to burn less than with HISTORIC Climate even though fire return intervals were long in

mixed native and introduced species seedings. In fact, the amount of burning in the BS-U:SI-B class nearly exactly matched the differences in the BS-U:SI-A class (the outcome of burning) from years 2050 to 2077.

The effect of burning mediated by different future climates dominated the results of the late-successional mixed native and introduced species seedings (BS-U:SI-C) regardless of the management that occurred earlier in the simulations. The two highest areas by scenario were both for the ACCESS1 LOCA where shrub cover was preserved with less fire, whereas other scenarios overlapped substantially.

While chainsaw thinning of trees in the reference late-successional wooded class (BS-D:Open) caused a transition to the mid-successional reference class (BS-B:Open; Figure 10), the net additional area gained only ranged by a few 100's of acres from 2020 to 2034. Climate differences accounted for more impact during the last period of simulations with the ACCESS1 LOCA resulting in greater retention of trees (about 1,000 acres) because of less fire under drier conditions.

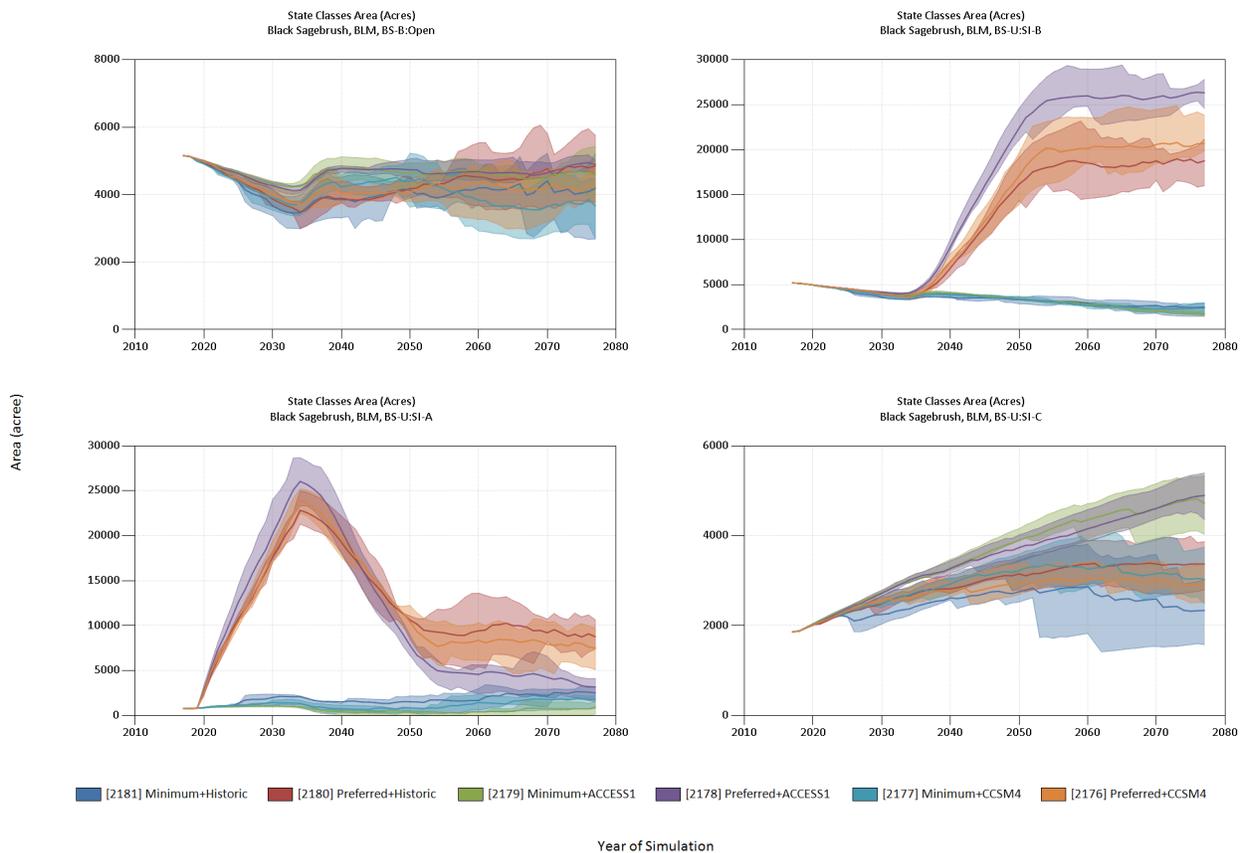


Figure 10. Dominant recipient vegetation classes in the Black Sagebrush ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Calcareous Grassland Ecological System

Current System Acres: 920

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

99

100 ± 0

100 ± 0

100 ± 0

Vegetation Classes

Table 13. Vegetation classes of the Calcareous Grassland ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
CG-A:Open	18	0	—	0.00%	0.49%	0.31%	0.14%
CG-B:Closed	82	0	—	1.45%	0.81%	1.00%	1.19%
CG-U:Bare Ground	0	1	0.0	0.00%	1.12%	1.36%	1.55%
CG-U:Depleted	0	0	0.0	98.54%	44.09%	62.73%	79.38%
CG-U:Early-Shrub	0	0	0.0	0.00%	49.05%	30.14%	13.09%
CG-U:SAP	0	1	0.0	0.00%	4.34%	4.37%	4.58%
CG-U:SAP-A	0	0	0.0	0.01%	0.09%	0.09%	0.08%
CG-U:Seeded Native	0	0	18.0	0.00%	0.00%	0.00%	0.00%
CG-U:SI	0	0	60.0	0.00%	0.00%	0.00%	0.00%
CG-U:SI+AG	0	0	0.0	0.00%	0.00%	0.00%	0.00%

Problems or Concerns

2017: Nearly all (98.5%) of the calcareous grassland system was depleted (CG-U:Depleted), which is an uncharacteristic class (Table 13). Unlike the definition of depleted for sagebrush systems, being depleted in a grassland implies that grass cover can be ≤10%.

After 60 years of MINIMUM MANAGEMENT: The depleted class mostly transitioned to the early shrub class (CG-U:Early-Shrub) from 98% in 2017, to about 44% (remaining in CG-U:Depleted) in 2077 for the HISTORIC Climate, 63% for the CCSM4 LOCA, and 79% for the ACCESS1 LOCA. Fire was the primary disturbance for these changes. Depleted grasslands were also invaded by non-native annual species in about 4% of the area, and thus became CG-U:SAP. Despite all the fire and remnant grass in the depleted class, very few areas became reference class (<2%).

Objective(s) for Management Actions

The main objective was to change areas from depleted grassland to either reference classes or native species seedings. Because depleted grassland was an acceptable class, albeit

uncharacteristic, with remnant grass cover higher than grass cover found in sagebrush systems, the objective was not to treat the entirety of the depleted grassland given the limited budget.

Treatment Rates and Costs

One action was used in different classes: Thin+Herbicide+Native-Seed (Table 14). While the primary class targeted for restoration was depleted grassland (CG-U:Depleted), the CG-U:SAP and early shrub (CG-U:Early-Shrub) classes were also targeted as these increased in importance. The period of implementation was the second one, from years 2035 to 2044. A significantly smaller implementation rate (about half) was realized for the ACCESS1 LOCA compared to the other two climates, although planned implementation rates were the same among climates.

Table 14. Realized rates and costs of management actions implemented in the Calcareous Grassland ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period’s cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred + Historic	Thin+Herbicide+Native-Seed	\$180.00	0.0	537.4	0.0	
	Cost →		\$0	\$96,731 a	\$0	\$96,731
Preferred + CCSM4	Thin+Herbicide+Native-Seed	\$180.00	0.0	591.7	0.0	
	Cost →		\$0	\$106,503 a	\$0	\$106,503
Preferred + ACCESS1	Thin+Herbicide+Native-Seed	\$180.00	0.0	208.0	0.0	
	Cost →		\$0	\$37,441 b	\$0	\$37,441

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	100 ± 0	92 ± 4
In 2077 under CCSM4 LOCA	100 ± 0	91 ± 5
In 2077 under ACCESS1 LOCA	100 ± 0	98 ± 1

Charts of Relevant Vegetation Classes

The clearest effect of restoration was to rapidly reduce the area of late-successional shrub with annual and perennial grass species (CG-U:SAP; Figure 11). This class became the native species seeding class (CG-U:Seeded Native) after treatment, as witnessed by the comparable loss and gain of area between the two classes. Climate differences had very little effect on CG-U:SAP or CG-U:Seeded Native.

Early-shrub (CG-U:Early-Shrub) was the primary class treated from 2035 to 2045, rather than the depleted class (CG-U:Depleted), because the early-successional reference class (CG-A:All) increased most during implementation. Restoration in the depleted class would have led to the mid-successional reference class (CG-B: Closed). The early shrub class partly was the result of the depleted class burning. The early-successional reference class increased by 90 acres for the ACCESS1 LOCA and by 290 acres for other climate scenarios. Having little to do with climate compensation of treatment rates, the ACCESS1 LOCA showed the least area of early-successional reference class because the realized implementation rate was half of that for other climate scenarios. This pulse of early-successional vegetation proceeded through succession by entering the mid-successional reference class (CG-B: Closed) where climate differences were maintained. These dynamics explained well the greater UED of 98% for the ACCESS1 LOCA compared to 91%-92% for other climates.

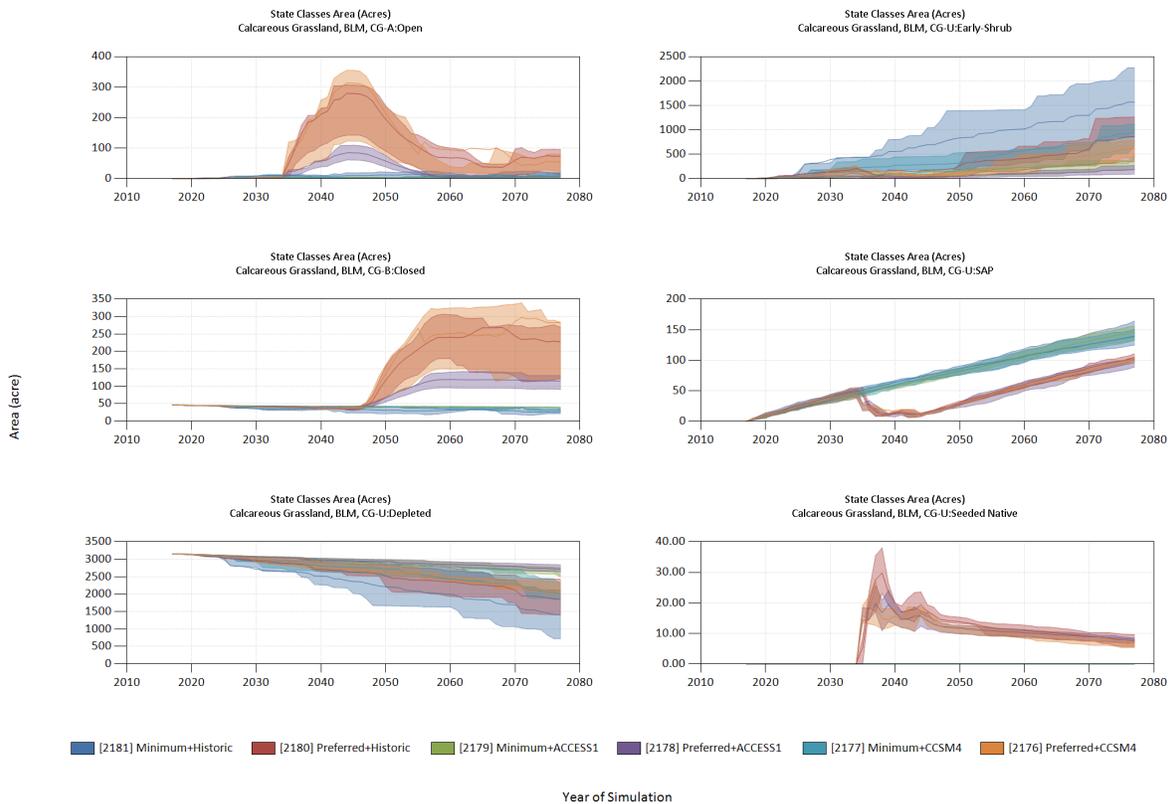


Figure 11. Dominant treated and recipient vegetation classes in the Calcareous Grassland ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Montane Riparian Ecological System

Current System Acres: 20

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

81
76 ± 6
80 ± 10
82 ± 8

Vegetation Classes

Table 15. Vegetation classes of the Montane Riparian ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
MR-A:All	3	0	—	0.00%	14.28%	11.40%	3.04%
MR-B:Open	92	0	—	10.31%	22.78%	21.72%	14.94%
MR-C:Closed	5	0	—	43.81%	10.21%	13.65%	31.17%
MR-U:Annual Spp	0	1	0.0	0.00%	0.21%	0.06%	0.00%
MR-U:Bare Ground	0	1	0.0	0.00%	0.26%	0.00%	0.16%
MR-U:Desertified	0	1	0.0	2.58%	4.22%	4.54%	4.94%
MR-U:EFT	0	2	0.0	0.00%	9.12%	8.37%	3.13%
MR-U:Hummocked	0	1	0.0	0.00%	0.26%	0.30%	0.17%
MR-U:SAP	0	1	0.0	0.00%	0.05%	0.06%	0.00%
MR-U:Seeded Native	0	0	0.0	0.00%	0.00%	0.00%	0.00%
MR-U:SFE	0	0	0.0	43.30%	38.50%	39.84%	42.35%
MR-U:SI+AG	0	1	0.0	0.00%	0.00%	0.00%	0.00%
MR-U:TEA	0	1	0.0	0.00%	0.10%	0.05%	0.11%

Problems or Concerns

2017: The Montane riparian system was highly departed from reference conditions at about 81% UED. As seen in Table 15, the departure was caused by 43% of the system’s area being in the shrub & forb encroached class (MR-U:SFE); 2.6% in the desertified class (MR-U:Desertified); 10% in the mid-successional reference class (MR-B:Open), compared to an NRV of 92%; and 44% in the late-successional reference class (MR-C:Closed), compared to an NRV of 5%.

After 60 years of MINIMUM MANAGEMENT: The MR-U:SFE class remained temporally stable from 2017 to 2077 (Table 15). The exotic forb and tree class (MR-U:EFT) increased from 0% to about 3% - 9%, with the lower area observed in the ACCESS1 LOCA and the higher value in the HISTORIC Climate. The desertified class (MR-U:Desertified) nearly doubled. One major natural improvement was the rebalancing of area among the reference classes, although not at NRV.

The drier ACCESS1 LOCA caused the greatest reduction of flows, which reduced stand-replacing flood events and the ability of the system to create younger reference classes needed to reach NRV. Despite the desirable effect of flooding, UED was not different from 2017 to 2077 because the increase of very undesirable exotic species classes and classes associated with incision carried more weight in the estimation of UED.

Objective(s) for Management Actions

The primary objectives were to reduce incised classes (MR-U:Desertified and others) by lifting the water table, and controlling noxious exotic forbs and trees.

Treatment Rates and Costs

Three actions were used in the Montane Riparian system: Water-Table-Uplift to reconnect the water table to the floodplain, and Exotic-Control and Weed-Inventory+Treat to control noxious weeds. Weed control was planned in all three periods, but Exotic-Control was only implemented from 2035 to 2044 and 2045 to 2077 as invaded areas grew in importance. The periodic inventory of weeds and occasional herbicide spraying of very small patches was implemented at a rate that reflected one-third of the area of riparian acres to visit per year (Table 16 below is the cumulative treated area during a period). The Water-Table-Uplift treatment was only implemented in very small areas and only from 2035 to 2044, because the area of desertified riparian was generally <1 acre in 2017. No difference in cost per period was detected among climate scenarios; however, no exotic control was needed for the ACCESS1 LOCA because of the assumed reduction of flows with drier climate – flows were positively correlated to the increase of noxious weed invasion. For the same reason, the wetter HISTORIC Climate scenario supported more weed invasion, and therefore was more frequently selected for exotic control.

Table 16. Realized rates and costs of management actions implemented in the Montane Riparian ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period’s cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred + Historic	Exotic-Control	\$360.00	0.1	0.2	4.1	
	Water-Table-Uplift	\$500.00	0.0	1.8	0.0	
	Weed-Inventory+Treat	\$253.00	68.1	45.1	153.0	
	Cost →		\$17,257 a	\$12,394 a	\$40,189 a	\$69,840
Preferred + CCSM4	Exotic-Control	\$360.00	0.0	0.0	4.8	
	Water-Table-Uplift	\$500.00	0.0	1.4	0.0	
	Weed-Inventory+Treat	\$253.00	63.3	46.1	149.6	
	Cost →		\$16,019 a	\$12,387 a	\$39,560 a	\$67,966
Preferred + ACCESS1	Exotic-Control	\$360.00	0.0	0.0	0.0	
	Water-Table-Uplift	\$500.00	0.0	1.6	0.0	
	Weed-Inventory+Treat	\$253.00	68.3	42.2	147.0	
	Cost →		\$17,274 a	\$11,477 a	\$37,194 a	\$65,944

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	76 ± 6	74 ± 6
In 2077 under CCSM4 LOCA	80 ± 10	67 ± 6
In 2077 under ACCESS1 LOCA	82 ± 8	76 ± 3

Charts of Relevant Vegetation Classes

The few areas of exotic noxious species (MR-U:EFT) were strongly controlled by both of the exotic control methods, resulting in practically undetectable levels (Figure 12). Successfully treated areas generally became one of the three reference classes, although the late-successional class (MR-C:Closed) was the greatest recipient.

Raising the water table using various small rock dams, rock weirs, or other structures imitating beaver dams rapidly reduced the area of many incised classes (primarily, MR-U:Depleted). Elevating the water table did not automatically create reference classes because incised vegetation can be devoid of willows or riparian trees. As a result, the shrub and forb encroached class (MR-U:SFE), which can share species in common with incised vegetation, was the recipient of restoration and grew distinctly during implementation. Only some incised seeded classes could transition to the early-successional reference class (MR-A:All), which increased.

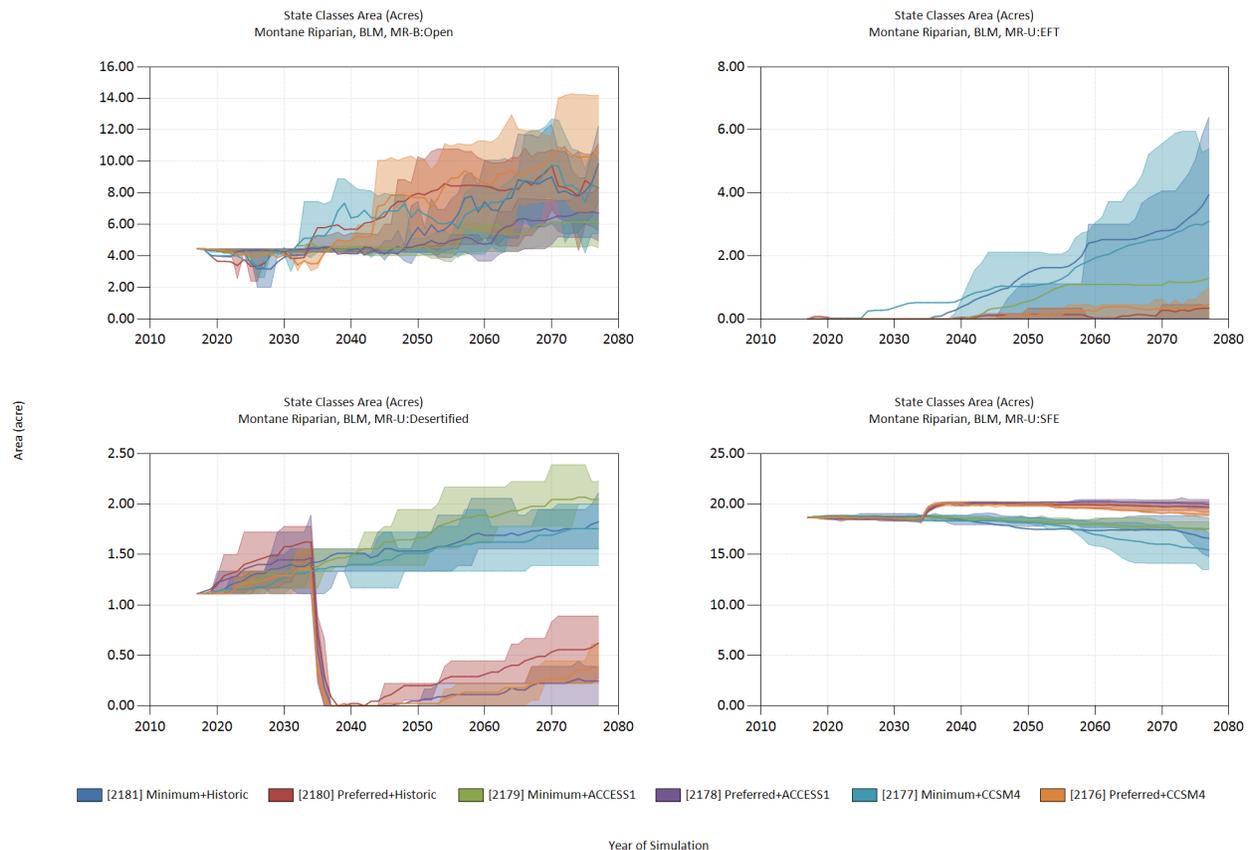


Figure 12. Dominant treated and recipient vegetation classes in the Montane Riparian ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Montane Sagebrush Steppe Ecological System

Current System Acres: 44,145

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

100

100 ± 0

100 ± 0

100 ± 0

Vegetation Classes

Table 17. Vegetation classes of the Montane Sagebrush Steppe ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
MSS-A:All	21	0	—	0.04%	0.93%	1.04%	0.28%
MSS-B:Open	34	0	—	0.00%	0.83%	0.71%	0.60%
MSS-C:Closed	39	0	—	0.42%	0.39%	0.42%	0.72%
MSS-D:Open	3	0	—	2.35%	0.05%	0.10%	0.24%
MSS-E:Closed	2	0	—	0.18%	0.53%	0.55%	0.93%
MSS-U:Annual Spp	0	1	0.0	0.25%	39.80%	37.70%	22.44%
MSS-U:Bare Ground	0	1	0.0	0.02%	0.04%	0.04%	0.04%
MSS-U:Depleted	0	1	0.0	14.37%	2.13%	2.49%	5.94%
MSS-U:Early-Shrub	0	0	0.0	0.10%	7.16%	7.10%	4.41%
MSS-U:Exotic Forb	0	0	0.0	0.00%	1.22%	1.26%	0.85%
MSS-U:SA	0	1	0.0	2.20%	0.76%	0.84%	1.85%
MSS-U:SA+	0	1	0.0	0.00%	0.00%	0.01%	0.02%
MSS-U:SAP	0	0	0.0	0.95%	0.20%	0.25%	0.67%
MSS-U:SAP+	0	1	0.0	0.00%	0.00%	0.01%	0.08%
MSS-U:SAP-A	0	0	0.0	0.96%	0.01%	0.01%	0.00%
MSS-U:Seeded Native	0	0	22.0	0.00%	0.00%	0.00%	0.00%
MSS-U:SI-A	0	0	13.2	0.92%	5.16%	4.41%	0.97%
MSS-U:SI-A+AG	0	0	0.0	2.92%	0.96%	0.85%	0.40%
MSS-U:SI-B	0	0	20.4	2.30%	2.95%	2.91%	1.51%
MSS-U:SI-B+AG	0	0	0.0	2.27%	0.52%	0.63%	0.49%
MSS-U:SI-C	0	0	24.0	1.78%	1.52%	2.10%	4.75%
MSS-U:SI-C+AG	0	0	0.0	1.17%	0.64%	0.91%	2.98%
MSS-U:SI-D	0	0	1.8	0.69%	0.46%	0.45%	0.91%
MSS-U:SI-D+AG	0	0	0.0	0.95%	0.21%	0.19%	0.77%
MSS-U:TEA	0	1	0.0	65.15%	33.53%	35.03%	48.17%

Problems or Concerns

2017: The UED for montane sagebrush steppe was 100%, thus highly departed from NRV (Table 17). The primary source of departure was 65% of the system acres being in the uncharacteristic tree-encroached with or without non-native annual species class (MSS-U:TEA). Depleted sagebrush (MSS-U:Depleted) at 14% of the system's area was the second dominant source of departure. Barely any areas were found in reference condition.

After 60 years of MINIMUM MANAGEMENT: The area of tree-encroached sagebrush with or without annual species (MSS-U:TEA) decreased by about 48% for the HISTORIC Climate scenario, by 46% for the CCSM4 LOCA scenario, and by 26% for the ACCESS1 LOCA after 60 years (Table 17). These decreases resulted, presumably after fire, in large increases in non-native annual species (MSS-U:Annual Spp) area on former MSS-U:TEA acres. The depleted sagebrush class (MSS-U:Depleted) decreased by about 85% for the HISTORIC Climate scenario, by 82% for the CCSM4 LOCA scenario, and by 58% for the ACCESS1 LOCA after 60 years. The reduction of depleted sagebrush primarily caused the increase of the early shrub class (MSS-U:Early-Shrub). Decreases for both the MSS-U:TEA and MSS-U:Depleted classes were least under the drier ACCESS1 LOCA, because there was less fire under this climate than under the HISTORIC Climate and CCSM4 LOCA.

Objective(s) for Management Actions

The primary objectives were to improve greater sage-grouse habitat by: (1) reducing the area covered by trees, especially in uncharacteristic classes; (2) reducing the area of depleted sagebrush (MSS-U:Depleted) before it burned and converted to less-desirable classes for sage-grouse; and (c) rehabilitating older seedings dominated by crested wheatgrass by reseeding them with native forb and grass species.

Treatment Rates and Costs

Five actions were used, of which Masticate+Seed was the only one to reduce the area of the tree encroached class (MSS-U:TEA; Table 18). Small tree lopping was used to fell small-diameter trees in older shrubland classes not yet dominated by conifers, such as depleted sagebrush (MSS-U:Depleted), shrub with annual and perennial grasses (MSS-U:SAP), shrubs with only annual grasses (MSS-U:SA), and reference late-successional open class (MSS-D:Open). Prescribed fire (RxFire) was only used in reference late-successional wooded classes (MSS-E:Closed), and sparingly so. The combined chaining and native seeding treatment was used to restore depleted sagebrush and the non-native annual species class (MSS-U:Annual Spp). Finally, the supplemental seeding of native species of forbs and grasses was deployed to improve sage-grouse habitat and was only implemented in existing seedings.

The primary period of implementation was from years 2035 to 2044. The final period, from 2045 to 2077, was mostly used to control the non-native annual species class that increased during the last period of simulation. Within the first time period (2018-2034), minor

differences were seen among climate scenarios in funding and implementation rates of prescribed fire. However, no budget differences were observed among climate scenarios in the second and third periods. The single greatest cost in montane sagebrush steppe, representing a high proportion of the total budget, was for Masticate+Seed.

Table 18. Realized rates and costs of management actions implemented in the Montane Sagebrush Steppe ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period's cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred + Historic	Chaining+Native-Seed	\$205.00	0.0	3,389.0	10,009.3	
	Forb+Grass-Native-Seeding+Chaining	\$160.00	0.0	3,360.3	0.0	
	Masticate+Seed	\$577.50	0.0	5,715.2	0.0	
	RxFire	\$100.00	445.7	110.4	181.5	
	Small-Tree-Lopping	\$150.00	0.0	1,041.4	757.0	
	Cost →		\$44,566 a	\$4,700,184 a	\$2,183,596 a	\$6,928,346
Preferred + CCSM4	Chaining+Native-Seed	\$205.00	0.0	3,289.0	10,500.0	
	Forb+Grass-Native-Seeding+Chaining	\$160.00	0.0	3,453.0	0.0	
	Masticate+Seed	\$577.50	0.0	6,404.8	0.0	
	RxFire	\$100.00	401.6	110.7	191.2	
	Small-Tree-Lopping	\$150.00	0.0	1,172.3	766.6	
	Cost →		\$40,164 a	\$5,112,428 a	\$2,286,606 a	\$7,439,198
Preferred + ACCESS1	Chaining+Native-Seed	\$205.00	0.0	2,456.6	8,298.2	
	Forb+Grass-Native-Seeding+Chaining	\$160.00	0.0	3,256.2	0.0	
	Masticate+Seed	\$577.50	0.0	6,189.8	0.0	
	RxFire	\$100.00	184.1	118.2	125.3	
	Small-Tree-Lopping	\$150.00	0.0	1,009.4	991.1	
	Cost →		\$18,405 b	\$4,762,458 a	\$1,862,329 a	\$6,643,193

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	100 ± 0	84 ± 6
In 2077 under CCSM4 LOCA	100 ± 0	82 ± 3
In 2077 under ACCESS1 LOCA	100 ± 0	88 ± 4

Charts of Relevant Vegetation Classes

Classes of vegetation affected by management actions are shown in treated classes (Figure 13) and recipient/outcome classes (result of treatments, Figure 14). Five treated vegetation classes were visibly affected (Figure 13): tree encroached with or without annual species (MSS-U:TEA), non-native annual species (MSS-U:Annual Spp), depleted sagebrush (MSS-U:Depleted), shrubs with annual species (MSS-U:SA), and reference late-successional closed (MSS-E:Closed). By the end of the 2035-2044 period, there were about 6,000-8,000 acres less of the tree encroached shrubland, and about 2,000+ acres less of depleted sagebrush, in the PREFERRED MANAGEMENT scenarios than the MINIMUM MANAGEMENT scenarios. The area of depleted sagebrush was eliminated by year 2060. While climate differences among scenarios were important for these classes with MINIMUM MANAGEMENT scenarios (i.e., more area remaining under the drier ACCESS1 LOCA), climate differences were very small for PREFERRED MANAGEMENT scenarios.

For the third period of implementation, where the focus was on control of the non-native annual species class, the combined chaining and native seeding action reduced the area of annual species by about 11,000 acres under both HISTORIC Climate and the CCSM4 LOCA, but by only 4,000 acres under the ACCESS1 LOCA, compared to their respective climates under MINIMUM MANAGEMENT. About 7,000 fewer acres of non-native annual species were present in 2077 with the ACCESS1 LOCA than with the HISTORIC Climate and CCSM4 LOCA.

The reference late-successional wooded class (MSS-E:Closed) was represented by a small area. Chronic prescribed fire progressively reduced the area of MSS-E:Closed, which caused a 100- to 150-acre difference by year 2077, with an effect appearing in 2050. It is debatable whether this action should be used at all, given that cost of deployment would be very high for small areas, and the inherent risk that prescribed fire could escape.

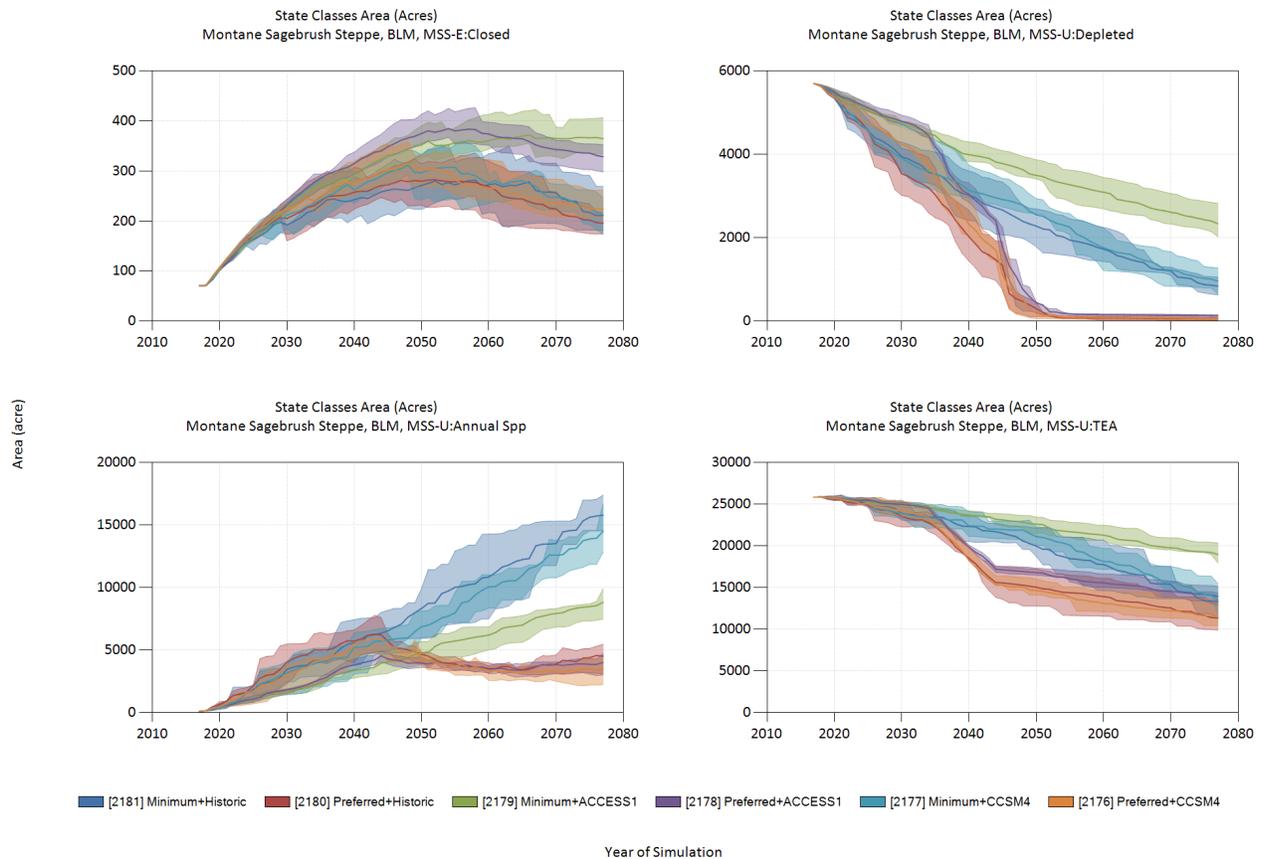


Figure 13. Dominant treated vegetation classes in the Montane Sagebrush Steppe ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Both native seedings and mixed native/introduced species seedings increased rapidly due to restoration actions starting in year 2035 (Figure 14). From 2035 to 2044, early-successional mixed native and introduced species seedings (MSS-U:SI-A) increased from about 1,000 acres (existing seedings) to 5,000 acres. Following the cessation of mastication and seeding, the area of this class progressively dropped as succession to the mid-successional class (MSS-U:SI-B) occurred. Recruitment to the late-successional seeded class (MSS-U:SI-C) also happened after year 2060. The mid-successional and late-successional seedings can be used by sage-grouse. Climate differences were not seen. Over time, the drier ACCESS1 LOCA caused a greater retention of late-successional seeding due to reduced fire activity. Native species seedings (MSS-U:Seeded Native) were not present in the landscape at the time of mapping. Therefore, the area of native seedings increased from 0 acres to about 3,500 acres by year 2050 and remained at that level until the end of simulations.

Increased area of the early shrub class (MSS-U:Early-Shrub) was not a desirable outcome of restoration, but resulted from fires in depleted sagebrush and partial failure of management that caused a 3,000-acre increase of the class. The area of early shrub class created with only

natural fires was about 1,500 to 2,000 acres, as indicated by all MINIMUM MANAGEMENT scenarios. Partial treatment failure rates under PREFERRED MANAGEMENT scenarios accounted for the additional 1,000 to 1,500 acres.

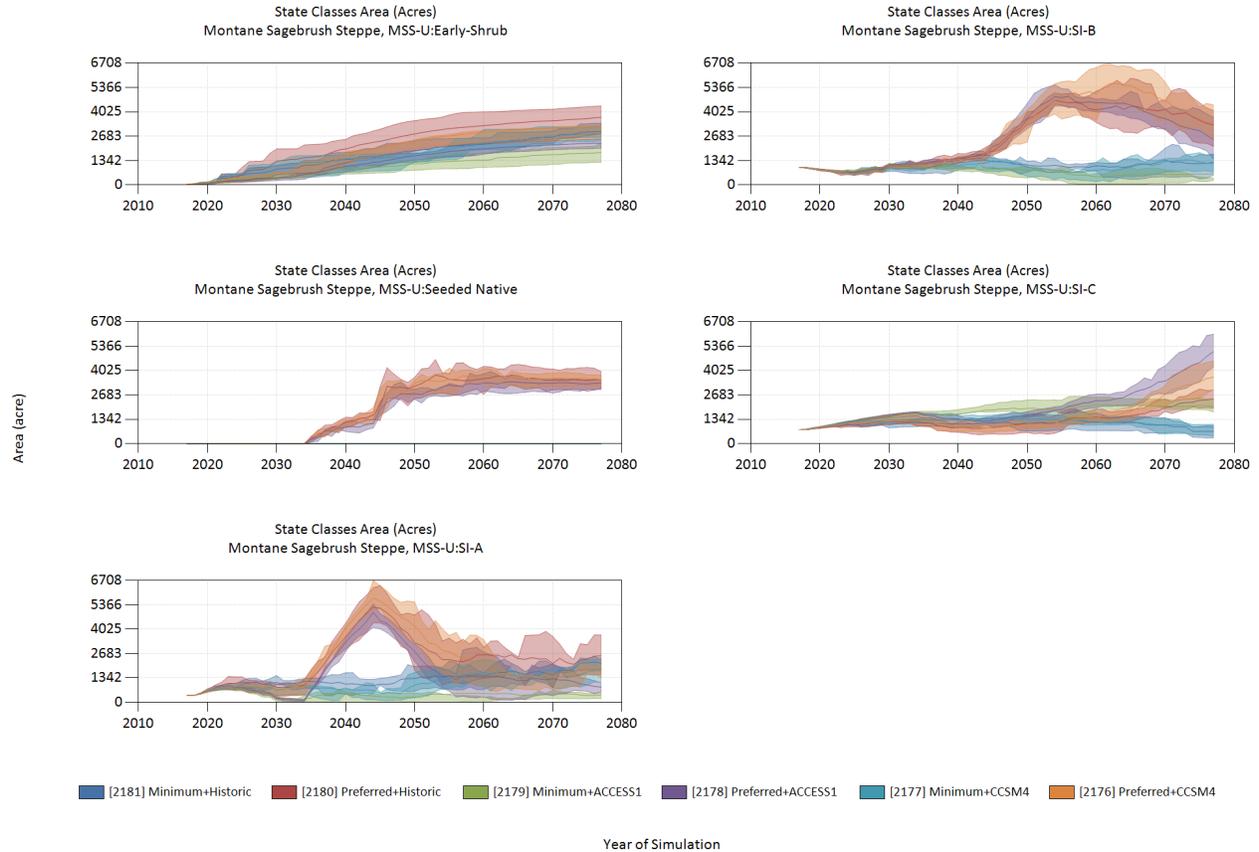


Figure 14. Dominant recipient vegetation classes in the Montane Sagebrush Steppe ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Pinyon-Juniper Woodland Ecological System

Current System Acres: 19,874

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

35
30 ± 5
25 ± 4
13 ± 2

Vegetation Classes

Table 19. Vegetation classes of the Pinyon-Juniper ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
PJ-A:All	3	0	—	0.28%	12.26%	11.77%	2.82%
PJ-B:Open	8	0	—	0.20%	16.18%	13.56%	6.55%
PJ-C:Open	25	0	—	0.50%	17.72%	17.49%	18.36%
PJ-D:Open	64	0	—	97.82%	43.88%	48.67%	65.81%
PJ-U:Annual Spp	0	1	0.0	0.01%	3.23%	2.51%	1.31%
PJ-U:Bare Ground	0	1	0.0	0.00%	0.14%	0.13%	0.08%
PJ-U:Exotic Forb	0	1	0.0	0.00%	2.55%	1.98%	0.30%
PJ-U:SAP	0	0	0.0	0.09%	0.13%	0.08%	0.03%
PJ-U:SI	0	0	60.0	0.00%	0.24%	0.24%	0.25%
PJ-U:SI+AG	0	0	0.0	0.28%	0.00%	0.01%	0.00%
PJ-U:TEA	0	0	0.0	0.82%	3.67%	3.57%	4.47%

Problems or Concerns

2017: The UED for pinyon and/or juniper woodland was only slightly departed from the natural range of variability at 35% (Table 19). While a small proportion of total acreage was in uncharacteristic classes, the primary source of departure was the overrepresentation (97%) of the reference late-successional class (PJ-D:Open), compared to its reference proportion of 64%.

After 60 years of MINIMUM MANAGEMENT: Simulated wildfires favored the redistribution of areas among all the reference classes, which reduced UED to a low level of departure. The proportion of the reference late-successional class (PJ-D:Open) ranged from 44% under HISTORIC Climate to 66% under the ACCESS1 LOCA; greater retention of older classes occurred under drier climate. As a result, the MINIMUM+ACCESS1 scenario achieved the lowest UED.

Objective(s) for Management Actions

The management objectives were only cultural and social. The cultural objective was to protect or enhance pine nut production by thinning younger pinyon between older trees. The social objective was to reduce fire risk associated with dense stands by thinning them and promoting gap recruitment into younger classes.

Treatment Rates and Costs

Two actions were used in pinyon-juniper woodlands (Table 20): (1) Chainsaw thinning was focused on the reduction of stem density in dense, older stands of pinyon (PJ-D:Open and PJ-U:TEA) from year 2020 to 2034; and (2) small areas of mastication combined with native seeding were used to create gaps of early-successional reference class (PJ-A:All) in the late-successional canopy (PJ-D:Open) from years 2035 to 2044. To compensate for the drier climate of the ACCESS1 LOCA, significantly more acres of mastication and native seeding, which is expensive per unit area, were deployed because reduced fire activity resulted in more trees standing compared to the HISTORIC Climate and CCSM4 LOCA scenarios.

Table 20. Realized rates and costs of management actions implemented in the Pinyon-Juniper Woodland ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period’s cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred	Chainsaw-Thinning	\$150.00	2,247.0	0.0	0.0	
+ Historic	Masticate+Native-Seed	\$617.50	0.0	323.3	0.0	
	Cost →		\$337,048 a	\$199,607 a	\$0	\$536,655
Preferred	Chainsaw-Thinning	\$150.00	2,092.8	0.0	0.0	
+ CCSM4	Masticate+Native-Seed	\$617.50	0.0	326.5	0.0	
	Cost →		\$313,923 a	\$201,640 a	\$0	\$515,563
Preferred	Chainsaw-Thinning	\$150.00	2,107.6	0.0	0.0	
+ ACCESS1	Masticate+Native-Seed	\$617.50	0.0	419.9	0.0	
	Cost →		\$316,135 a	\$259,318 b	\$0	\$575,452

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	30 ± 5	21 ± 4
In 2077 under CCSM4 LOCA	25 ± 4	16 ± 4
In 2077 under ACCESS1 LOCA	13 ± 2	10 ± 1

Charts of Relevant Vegetation Classes

The area of trees increased by 150 to 180 acres in the tree-encroached with annual species class (PJ-U:TEA) after chainsaw thinning (Figure 15). The effect of chainsaw thinning was to suppress the likelihood of fires for 30 years without causing a transition to another class compared to MINIMUM MANAGEMENT; therefore, chainsaw thinning protected trees for a period of time. In the late-successional reference class (PJ-D:Open), chainsaw thinning and mastication with seeding were both employed, which resulted in both actions cancelling out their effects. However, by 2077 about 2,500 acres less of the PJ-D:Open class were present under HISTORIC Climate and the CCSM4 LOCA than under the ACCESS1 LOCA, regardless of management level and despite greater rates of mastication deployed for the ACCESS1 LOCA.

Climate differences were also evident for the early (PJ-A:All) and mid-successional (PJ-B:Open) reference classes. Areas of these classes were lower in the ACCESS1 LOCA than in other climates; less fire in older classes under the drier ACCESS1 LOCA resulted in less recruitment to early and mid-successional classes.

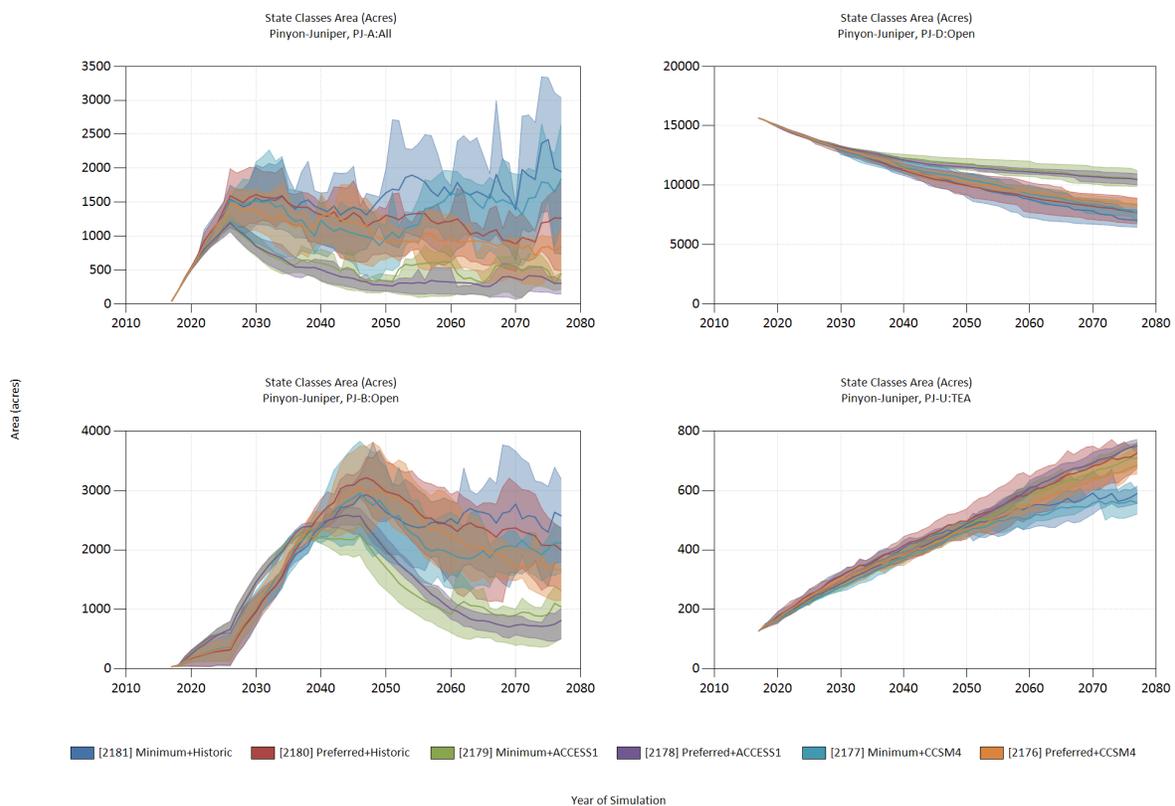


Figure 15. Dominant treated and recipient vegetation classes in the Pinyon-Juniper Woodland ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Ponderosa Pine Ecological System

Current System Acres: 3,839

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

50
29 ± 1
28 ± 2
36 ± 3

Vegetation Classes

Table 21. Vegetation classes of the Ponderosa Pine ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
PP-A:All	10	0	—	2.35%	22.07%	16.07%	10.04%
PP-B:Closed	11	0	—	0.38%	10.62%	10.60%	13.53%
PP-B:Open	32	0	—	44.40%	26.16%	29.27%	25.29%
PP-C:Closed	3	0	—	0.22%	4.71%	5.24%	7.80%
PP-C:Open	44	0	—	19.92%	23.79%	24.07%	19.88%
PP-U:Annual Spp	0	1	0.0	0.00%	1.22%	0.87%	0.60%
PP-U:Bare Ground	0	1	0.0	0.00%	0.07%	0.06%	0.04%
PP-U:FIC-B-Closed	0	1	0.0	10.74%	1.31%	1.83%	4.36%
PP-U:FIC-B-Open	0	0	0.0	19.97%	3.78%	4.95%	9.52%
PP-U:FIC-C-Closed	0	1	0.0	0.73%	1.12%	1.41%	2.12%
PP-U:FIC-C-Open	0	0	0.0	0.99%	2.72%	3.27%	4.28%
PP-U:SI	0	0	0.0	0.00%	0.00%	0.00%	0.00%
PP-U:SI+AG	0	0	0.0	0.31%	0.00%	0.00%	0.00%
PP-U:TEA	0	0	0.0	0.00%	2.45%	2.37%	2.55%

Problems or Concerns

2017: Ponderosa pine was moderately departed (50%) from NRV for two reasons (Table 21): (1) too few acres were present in the older open-canopied class (PP-C:Open) – 20% now vs. 44% in the NRV; and (2) the area of mid-successional fire-intolerant conifer classes mostly devoid of ponderosa pine (PP-U:FIC-B-Closed and PP-U:FIC-B-Open) represented about 32% of the system acres. Both problems were likely the result of historic logging and practices that caused fire exclusion.

After 60 years of MINIMUM MANAGEMENT: Fire and severe drought were the main disturbances to affect ponderosa pine MINIMUM MANAGEMENT scenarios. Fire especially reduced the total area of fire-intolerant conifer classes from a combined class total of 32% (now), to 9%, 12%, and 20%,

respectively, for the HISTORIC Climate, CCSM4 LOCA, and ACCESS1 LOCA. It was assumed in model dynamics that burned fire-intolerant conifer classes transitioned to the reference early-successional class (PP-A:All) because vegetation is native and the creation of mineral soil by fire could favor ponderosa pine seed to germinate given that some trees might be close enough to colonize the historic habitat. This process and additional tree mortality in the reference mid-successional open class created the reference early-successional class. Furthermore, 60 years of succession would also increase the proportion of reference mid-successional classes. Therefore, after 60 years the distribution of ponderosa pine vegetation classes was closer to the NRV. However, this result was highly dependent on the assumption that fire causes a transition from fire-intolerant conifers to the reference early-successional class, which needs to be verified. If the assumption is wrong, which would require a model modification, then the most likely outcome of fire in the fire-intolerant conifer classes would be conversion to montane sagebrush steppe.

Simulations with the drier ACCESS1 LOCA, which supported the least amount of fire, were the most departed from NRV after 60 years compared to HISTORIC Climate or CCSM4 LOCA. Under the ACCESS1 LOCA, closed-canopied ponderosa pine accumulated more, and a greater area of fire-intolerant conifer classes persisted due to suppressed surface fire and mixed severity fire.

Objective(s) for Management Actions

Two management objectives were to: (1) reduce the future expansion of reference mid- and late-successional closed-canopied classes and, consequently, favor open-canopied classes; and (2) restore the fire-intolerant conifer classes to the reference condition using ponderosa pine seedling planting. The method to recover the area of fire-intolerant conifer classes to functional ponderosa pine communities was expensive, and the budget was very limited for this ecological system. Greater value was thus assigned to regaining “lost” ponderosa pine communities, so the use of chainsaw thinning to open up closed-canopied ponderosa pine became a secondary maintenance objective.

Treatment Rates and Costs

Chainsaw thinning was used to thin the reference closed-canopied classes (PP-B:Closed and PP-C:Closed). Mastication reduced the area of fire-intolerant conifer classes, and treated areas were planted with ponderosa pine plugs. The primary period of implementation and funding was from years 2035 to 2044, because ponderosa pine was not a sage-grouse habitat restoration priority (Table 22). Additional chainsaw thinning was used in the third period from years 2045 to 2077 as trees aged under a custodial regime of fire suppression management that would favor closed-canopied classes. About \$200,000 more was spent on mastication and planting for the ACCESS1 LOCA than other climates. This was because the ACCESS1 LOCA supported less fire, thus more of the fire-intolerant conifer classes that required restoration (mastication and planting) remained intact.

Table 22. Realized rates and costs of management actions implemented in the Ponderosa Pine ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period's cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred	Chainsaw-Thinning	\$112.50	0.0	125.0	159.7	
+ Historic	Masticate+PIPO-Planting	\$1,120.00	0.0	748.9	0.0	
	Cost →		\$0	\$855,057 a	\$39,936 a	\$894,993
Preferred	Chainsaw-Thinning	\$112.50	0.0	136.2	152.9	
+ CCSM4	Masticate+PIPO-Planting	\$1,120.00	0.0	750.6	0.0	
	Cost →		\$0	\$859,675 a	\$38,213 a	\$897,888
Preferred	Chainsaw-Thinning	\$112.50	0.0	107.4	148.2	
+ ACCESS1	Masticate+PIPO-Planting	\$1,120.00	0.0	945.0	0.0	
	Cost →		\$0	\$1,066,298 b	\$37,062 a	\$1,103,360

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	29 ± 1	46 ± 4
In 2077 under CCSM4 LOCA	28 ± 2	43 ± 3
In 2077 under ACCESS1 LOCA	36 ± 3	38 ± 2

Charts of Relevant Vegetation Classes

Six vegetation classes were treated (Figure 16). Chainsaw thinning was conducted in both reference mid- and late-successional closed-canopied classes (PP-B:Closed and PP-C:Closed) to cause transitions to open-canopied classes of the same age; and the mastication and ponderosa pine planting treatment applied to all four possible fire-intolerant conifer classes to increase the area of the reference early-successional class. While mastication and planting accomplished the goal of reducing fire-intolerant conifer classes within a limited budget (funding was cut from ponderosa pine to favor sagebrush system restoration within total budget constraints), the same type of success deceptively was not observed for the reduction of reference closed-canopied classes by chainsaws. The areas of closed-canopied and open-canopied classes, respectively, were greater and lower in PREFERRED MANAGEMENT scenarios. This was the opposite of the intended objective.

Chainsaw thinning had nothing to do with these counter-intuitive results (which would have been even less desirable without the thinning), that were caused by the combination of recruitment into the reference early-successional class after mastication, and insufficient mixed severity and surface fire (Figure 17). As the area of reference early-successional classes increased after mastication and ponderosa plug planting, succession at the end of the early-

succession class could follow two distinct pathways. The normal pathway was towards open-canopied structure. However, if no fire occurred for 38 consecutive years, succession directed vegetation toward a closed-canopied pathway, which was what happened. Lack of sufficient fire was built into the model with an assumed 90% agency fire suppression success. To compensate for the build-up of closed canopies, about 600-800 acres more of chainsaw thinning would have been required in the third period from years 2045 to 2077; however, the budget could not maintain this added activity.

Differences among climate scenarios were evident for MINIMUM MANAGEMENT scenarios, but not for PREFERRED MANAGEMENT scenarios. The reduced amount of fire in the MINIMUM+ACCESS1 scenario compared to other climates caused greater areas of closed-canopied reference classes and more fire-intolerant conifer classes (Figure 16) compared to more open-canopied classes (Figure 17).

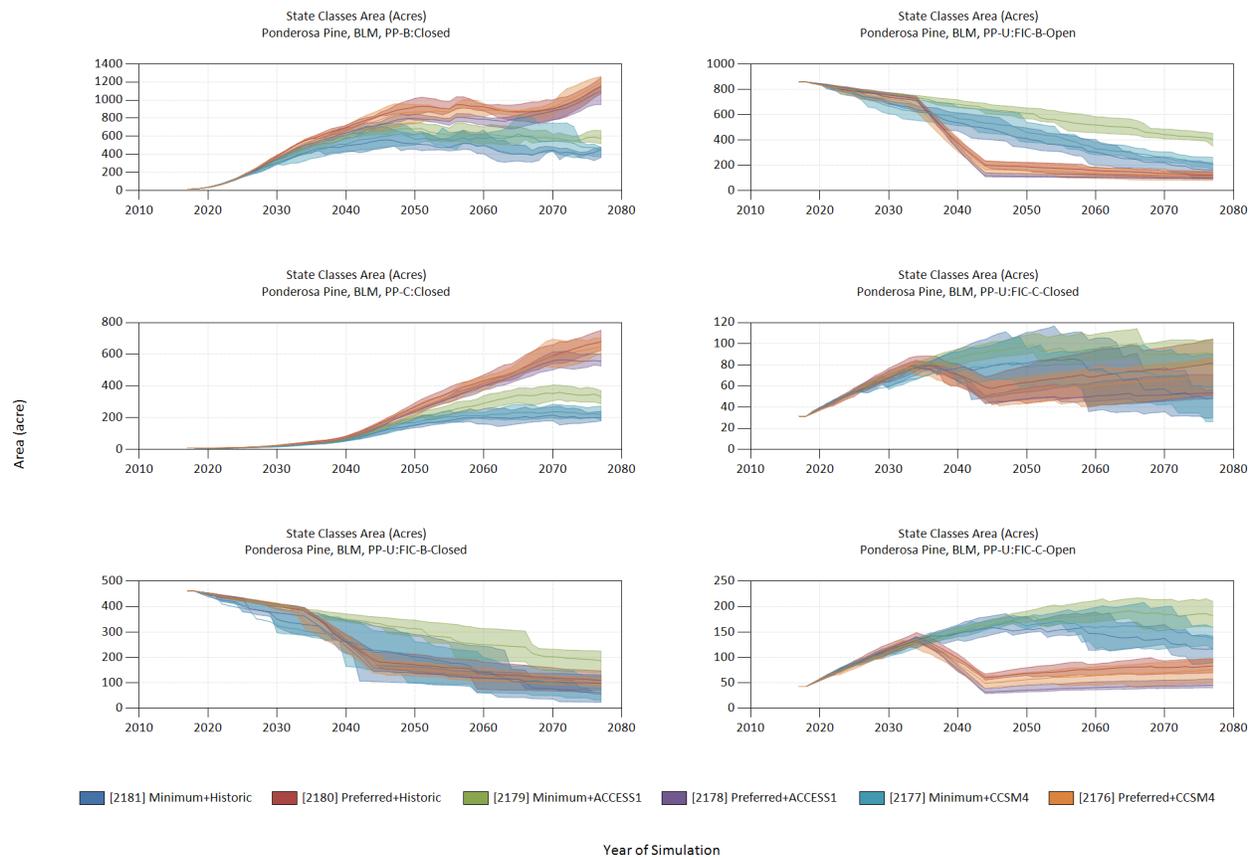


Figure 16. Dominant treated vegetation classes in the Ponderosa Pine ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

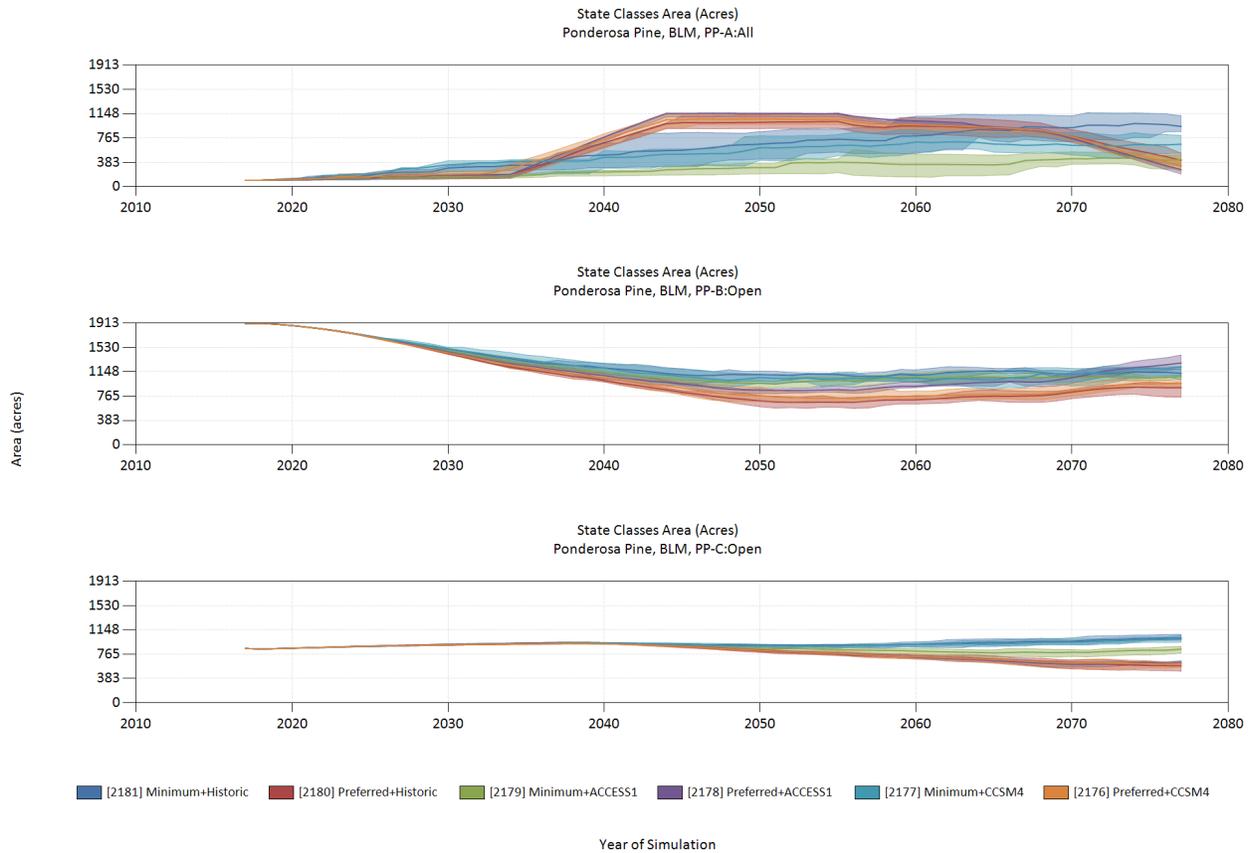


Figure 17. Dominant treated and recipient vegetation classes in the Ponderosa Pine ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Semi-Desert Grassland Ecological System

Current System Acres: 3,254

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

100
100 ± 0
100 ± 0
100 ± 0

Vegetation Classes

Table 23. Vegetation classes of the Semi-Desert Grassland ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
SDG-A:Open	18	0	—	0.00%	4.57%	7.14%	2.13%
SDG-B:Closed	82	0	—	17.64%	11.15%	8.61%	13.73%
SDG-U:Bare Ground	0	1	0.0	0.00%	1.15%	1.18%	1.20%
SDG-U:Depleted	0	1	0.0	67.21%	45.22%	45.46%	41.83%
SDG-U:Early-Shrub	0	0	0.0	10.09%	15.13%	16.47%	21.45%
SDG-U:SAP	0	0	0.0	5.06%	10.93%	9.24%	14.23%
SDG-U:SAP+	0	1	0.0	0.00%	11.70%	11.73%	4.81%
SDG-U:Seeded Native	0	0	18.0	0.00%	0.00%	0.00%	0.00%
SDG-U:SI	0	0	60.0	0.00%	0.00%	0.02%	0.01%
SDG-U:SI+AG	0	0	0.0	0.00%	0.00%	0.01%	0.00%
SDG-U:TEA	0	1	0.0	0.00%	0.15%	0.15%	0.60%

Problems or Concerns

2017: The semi-desert grassland system was completely departed from NRV (Table 23). While this departure was not desirable, the source of departure was tolerable because the dominant uncharacteristic depleted grassland class (SDG-U:Depleted) and subdominant early shrub class (SDG-U:Early-Shrub) were native and supported ≤10% grass cover. This situation is analogous to that observed for the Calcareous Grassland. About 17% of the semi-desert grassland system’s area was in the very desirable mid-successional class (SDG-B:Closed).

After 60 years of MINIMUM MANAGEMENT: The depleted class remained the dominant class but decreased to 41%-45% of the system’s area. The early shrub class increased from 10% (now) to a range of 15% (HISTORIC Climate) to 21% (ACCESS1 LOCA). Severe drought and grazing were two causes of increased early shrub class area at the expense of the depleted class. The loss of the depleted class area was also caused by invasion of non-native annual species that caused a transition to the shrub with annual and perennial species class (SDG-U:SAP), ranging from 9% to

14% of the system's area. A few wetter years toward the end of the 60-year simulation increased the cover of non-native annual species within the class, therefore forcing a transition to the shrub with annual and perennial species class with more than 15% cover of non-native annual species (SDG-U:SAP+). This last class was considered a greater fire risk.

Sixty years of fire and grazing redistributed the area of the reference mid-successional class (SDG-B:Closed), which decreased from about 18% of the area (now) to a range of 9% (CCSM4 LOCA) to 14% (ACCESS1 LOCA). While the reference early-successional class (SDG-A:Open) increased to about 7% (CCSM4 LOCA) and 2% (ACCESS1 LOCA) due to fire, bare ground (SDG-U:Bare-Ground), which is only caused by the small proportion of severe grazing, increased to about 1% at the expense of reference classes.

Objective(s) for Management Actions

Objectives were to reduce the areas of the depleted grassland class (SDG-U:Depleted) and the early shrub class (SDG-U:Early-Shrub). Because *status quo* fire and grazing management were predicted to continue in this system in the long term (except for three-year regulatory suspension of grazing in new seedings), and sandy soils supporting this grassland would be less productive than loamy soils, managers opted for a hardier and more grazing-resistant seeding of mixed natives (for example, thickspike wheatgrass, Indian ricegrass, and needle-and-thread) and introduced species (crested wheatgrass)

Treatment Rates and Costs

Only one restoration action was undertaken that was implemented during the second period of implementation from years 2035 to 2044: Thinning woody species cover, herbicide application to reduce the cover of competitive woody species (snakeweed and low rabbitbrush), and grass seeding (Table 24). The cost of implementation was lower for the ACCESS1 LOCA than other climates, because the area of the depleted class was lower in the MINIMUM+ACCESS1 scenario.

Table 24. Realized rates and costs of management actions implemented in the Semi-Desert Grassland ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period's cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred + Historic	Thin+Herbicide+Seed	\$115.00	0.0	2,508.3	0.0	
	Cost →		\$0	\$288,454 a	\$0	\$288,454
Preferred + CCSM4	Thin+Herbicide+Seed	\$115.00	0.0	2,182.3	0.0	
	Cost →		\$0	\$250,966 a	\$0	\$250,966
Preferred + ACCESS1	Thin+Herbicide+Seed	\$115.00	0.0	1,533.7	0.0	
	Cost →		\$0	\$176,381 b	\$0	\$176,381

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	100 ± 0	80 ± 6
In 2077 under CCSM4 LOCA	100 ± 0	83 ± 3
In 2077 under ACCESS1 LOCA	100 ± 0	88 ± 2

Charts of Relevant Vegetation Classes

While UED remained highly departed from NRV at 80% (HISTORIC Climate) to 88% (ACCESS1 LOCA) after 60 years of management, the improvement from 100% in 2017 was notable because the seeded class was uncharacteristic (with an allowable no-penalty management area), thus did not count towards UED reduction.

Three of the four classes shown in Figure 18 were directly impacted by the single treatment (Thin+Herbicide+Seed): depleted (SDG-U:Depleted), early shrub (SDG-U:Early-Shrub), and early-successional mixed native and introduced species seeding (SDG-U:SI). The shrub with annual

and perennial species class (SDG-U:SAP) was expected to be indirectly reduced by treatments, because a smaller area of depleted grassland would be invadable by non-native annual species.

Treatments reduced by less than 50% the depleted and early shrub classes by year 2044. The budget was insufficient to eliminate these classes. Climate scenario differences were small for the depleted class in the PREFERRED MANAGEMENT scenario, but more area of the early shrub class (SDG-U:Early-Shrub) was observed in the ACCESS1 LOCA than other climate scenarios. The seeded class (SDG-U:SI) rapidly increased from zero in 2035 to about 900 acres for the ACCESS1 LOCA scenario, and about 1,700 acres in the other climate scenarios, by year 2044. It was noticeable that the area of the SDG-U:SAP class was slightly less for the PREFERRED MANAGEMENT than MINIMUM MANAGEMENT scenarios.

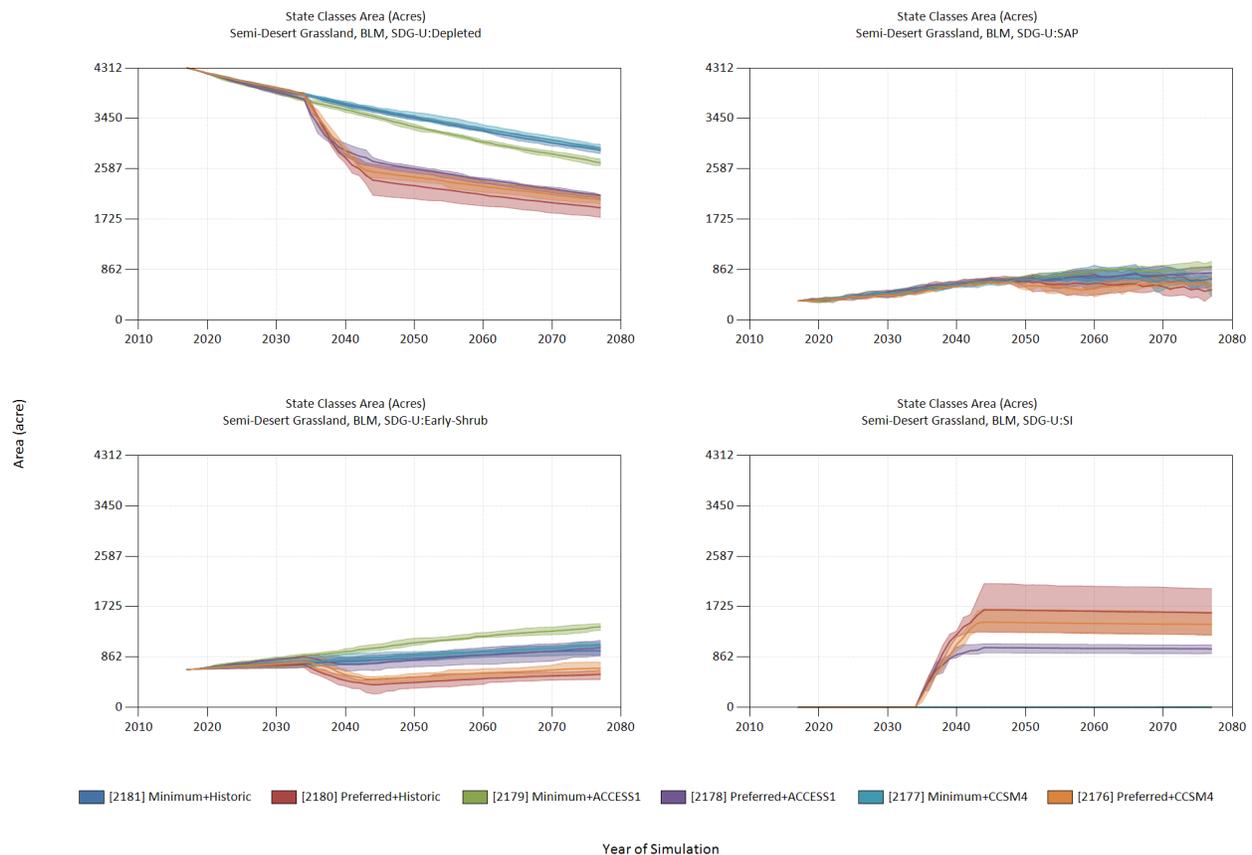


Figure 18. Dominant treated and recipient vegetation classes in the Semi-Desert Grassland ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Stansbury Cliffrose Ecological System

Current System Acres: 11

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

36

53 ± 8

50 ± 6

52 ± 5

Vegetation Classes

Table 25. Vegetation classes of the Stansbury Cliffrose ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
SC-A:All	10	0	—	0.00%	12.76%	27.56%	7.00%
SC-B:Closed	37	0	—	11.49%	36.90%	35.37%	28.14%
SC-C:Open	53	0	—	88.51%	23.91%	18.49%	31.35%
SC-U:Annual Spp	0	1	0.0	0.00%	5.06%	4.28%	1.18%
SC-U:Bare Ground	0	1	0.0	0.00%	0.46%	0.21%	0.29%
SC-U:Depleted	0	1	0.0	0.00%	0.11%	0.00%	0.05%
SC-U:Early-Shrub	0	0	0.0	0.00%	0.92%	0.59%	2.01%
SC-U:SAP	0	0	0.0	0.00%	5.52%	3.47%	5.93%
SC-U:SAP+	0	1	0.0	0.00%	2.76%	0.87%	1.35%
SC-U:Seeded Native	0	0	9.0	0.00%	0.00%	0.00%	0.00%
SC-U:SI-A	0	0	6.0	0.00%	0.00%	0.00%	0.00%
SC-U:SI-A+AG	0	0	0.0	0.00%	0.00%	0.00%	0.00%
SC-U:SI-B	0	0	26.4	0.00%	0.00%	0.00%	0.00%
SC-U:SI-B+AG	0	0	0.0	0.00%	0.00%	0.00%	0.00%
SC-U:SI-C	0	0	28.2	0.00%	0.00%	0.00%	0.00%
SC-U:SI-C+AG	0	0	0.0	0.00%	0.00%	0.00%	0.00%
SC-U:TEA	0	1	0.0	0.00%	11.61%	9.16%	22.69%

Problems or Concerns

2017: Stansbury cliffrose was moderately departed from NRV at 36% UED, which is only 3% above the threshold of the low-departure category (Table 25). Estimates of UED, however, can be biased for small systems with long intervals between stand-replacing events, such as Stansbury cliffrose, because the entire area of the system can be impacted by a single event. About 89% of this system was in the reference late-successional open class (SC-C:Open), with the rest being in the reference mid-successional closed class (SC-B:Closed).

After 60 years of MINIMUM MANAGEMENT: The distribution of area among classes 60 years later was illustrative of the effect of disturbances in a small system. UED increased from 36% in 2017 to 50%-53% in year 2077. From 89% of area in the SC-C:Open class in 2017, only 18% to 31% remained in 2077 (NRV for this class is 53%). Fire caused transitions to the reference early-successional and mid-successional classes: About 7% and 28%, respectively, became SC-A:All, with the ACCESS1 LOCA at the lower value and the CCSM4 LOCA at the higher value. About 28%, 36%, and 37%, respectively, transitioned to the SC-B:Closed class for the ACCESS1 LOCA, CCSM4 LOCA, and HISTORIC Climate scenarios.

Other classes also increased due mostly to non-native annual species invasion. The tree encroached with or without non-native annual species class (SC-U:TEA) replaced some areas of the reference late-successional class following annual species invasion. The SC-U:TEA class was converted by fire to the non-native annual species class (SC-U:Annual Spp), and to the shrub with annual and perennial grass classes (SC-U:SAP and SC-U:SAP+). Not surprisingly, the area of unburned SC-U:TEA was twice as large for the ACCESS1 LOCA (23%), which supported less fire, than for the HISTORIC Climate (12%) or CCSM4 LOCA (9%).

Objective(s) for Management Actions

The only objective was to increase the area of younger successional reference classes (SC-A:ALL and SC-B:Closed) for wildlife use by reducing the area of the older reference successional class (SC-C:Open). Palatability of browse for mule deer decreases with shoot age (Cox et al. 2009).

Treatment Rates and Costs

Only chainsaw thinning was used from years 2035 to 2044 to reduce the area of the reference late-successional class (Table 26). The rates and expenses were small, and significantly smaller for the ACCESS1 LOCA than other climates.

Table 26. Realized rates and costs of management actions implemented in the Stansbury Cliffrose ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period's cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018-2034	2035-2044	2045-2077	
Preferred + Historic	Chainsaw-Thinning	\$112.50	0.0	14.4	0.0	
	Cost →		\$0	\$1,616 a	\$0	\$1,616
Preferred + CCSM4	Chainsaw-Thinning	\$112.50	0.0	13.5	0.0	
	Cost →		\$0	\$1,521 a	\$0	\$1,521
Preferred + ACCESS1	Chainsaw-Thinning	\$112.50	0.0	10.5	0.0	
	Cost →		\$0	\$1,186 b	\$0	\$1,186

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	53 ± 8	62 ± 3
In 2077 under CCSM4 LOCA	50 ± 6	59 ± 2
In 2077 under ACCESS1 LOCA	52 ± 5	63 ± 5

Charts of Relevant Vegetation Classes

Chainsaw thinning decreased to zero the area of the reference late-successional class (SC-C:Open) by year 2036 (Figure 19). Climate differences were not observed. It is noteworthy that the area of this class also progressively decreased in all MINIMUM MANAGEMENT scenarios, although less in the ACCESS1 LOCA after year 2060. The main beneficiary class was reference mid-successional SC-B:Closed, which increased rapidly.

The mid-successional SC-B:Closed class also showed a special climate effect only for the CCSM4 LOCA: The area of this class exceeded the initial area of 11 acres in 2017 because of range shifts from the little-leaf mountain mahogany ecological system. The range shift was presumably caused by fire in the very extensive little-leaf mountain mahogany system, causing a shift to early-successional cliffrose (stand-replacing events were the hypothetical mechanism

that facilitates range shifts experienced at the seedling level), which then matured to mid-successional age. The CCSM4 LOCA caused far more fire activity than the ACCESS1 LOCA. A few fires in a large system (little-leaf mountain mahogany) would have disproportionately contributed to a very small system (Stansbury cliffrose) with even a minor amount of range shifts.

The shrub with annual and perennial grass class (SC-U:SAP) was the undesirable outcome of chainsaw thinning when the seedbank of non-native annual species became expressed, which occurred in small numbers. While chainsaw thinning was not applied to the tree-encroached with or without non-native annual species class (SC-U:TEA), this class nonetheless decreased in the PREFERRED MANAGEMENT scenarios simply because there would have been less of the wooded reference class for annual species to invade.

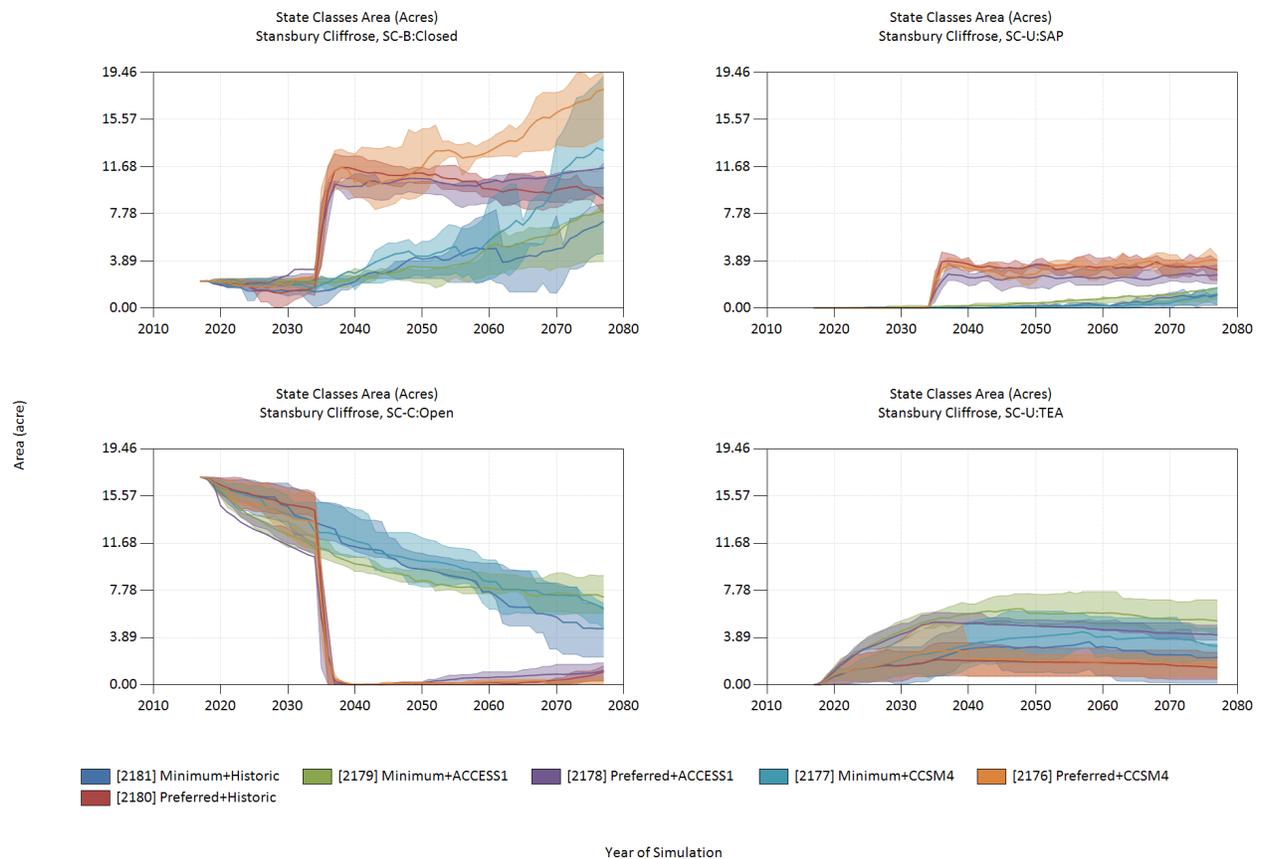


Figure 19. Dominant treated and recipient vegetation classes in the Stansbury Cliffrose ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Utah Serviceberry Ecological System

Current System Acres: 737

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

97

53 ± 8

62 ± 7

77 ± 8

Vegetation Classes

Table 27. Vegetation classes of the Utah Serviceberry ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
US-A:All	9	0	—	0.00%	4.65%	16.27%	1.25%
US-B:Closed	29	0	—	6.57%	28.75%	17.66%	10.06%
US-C:Closed	60	0	—	0.39%	29.13%	25.71%	28.87%
US-D:Open	3	0	—	77.58%	2.68%	2.53%	3.86%
US-U:Annual Spp	0	1	0.0	0.00%	19.30%	22.22%	10.38%
US-U:Bare Ground	0	1	0.0	0.00%	0.09%	0.11%	0.06%
US-U:Depleted	0	1	0.0	0.00%	0.05%	0.04%	0.09%
US-U:Early-Shrub	0	0	0.0	0.00%	0.61%	0.99%	3.18%
US-U:SAP	0	0	0.0	0.18%	8.47%	8.32%	12.35%
US-U:SAP+	0	1	0.0	0.00%	0.85%	0.51%	0.87%
US-U:SI-A	0	0	5.4	0.00%	0.00%	0.00%	0.00%
US-U:SI-A+AG	0	0	0.0	0.00%	0.00%	0.00%	0.00%
US-U:SI-B	0	0	16.8	0.00%	0.00%	0.00%	0.00%
US-U:SI-B+AG	0	0	0.0	0.00%	0.00%	0.00%	0.00%
US-U:SI-C	0	0	36.0	0.00%	0.00%	0.00%	0.00%
US-U:SI-C+AG	0	0	0.0	0.00%	0.00%	0.00%	0.00%
US-U:SI-D	0	0	1.2	0.00%	0.00%	0.00%	0.00%
US-U:SI-D+AG	0	0	0.0	0.00%	0.00%	0.00%	0.00%
US-U:TEA	0	1	0.0	15.28%	5.42%	5.65%	29.03%

Problems or Concerns

2017: The Utah serviceberry ecological system was highly departed from NRV (97%) for three reasons: (1) about 78% of the system was in the reference late-successional open-canopied class (US-D:Open), compared to an NRV value of 3%; (2) 15% of the total area was in the uncharacteristic tree-encroached with or without non-native annual species class (US-U:TEA); and (3) both reference mid-successional classes (US-B:Closed and US-C:Closed) were highly

under-represented compared to NRV (Table 27). As with Stansbury cliffrose, Utah serviceberry was a small system for which the estimate of UED can be biased. However, the fire return interval of Utah serviceberry is shorter than that of cliffrose, thus improving the estimation.

After 60 years of MINIMUM MANAGEMENT: UED decreased from 97% to 53%, 62% and 77%, respectively, for the HISTORIC Climate, CCSM4 LOCA, and ACCESS1 LOCA.

The area of the reference late-successional open-canopied class (US-D:Open) decreased from about 78% to about 3% for all scenarios, which was at the NRV value (Table 27). However, all similarities among different climates of the MINIMUM MANAGEMENT scenario ceased for other classes. A large fraction of the area lost from the reference late-successional open-canopied class (US-D:Open) transitioned to other reference classes (US-A:All, US-B:Closed, and US-C:Closed). The least area of reference classes combined was for the ACCESS1 LOCA, perhaps because its reduced fire activity also allowed for a longer period for non-native annual species to invade the reference late-successional class (US-D:Open), and thus increase the tree-encroached with or without annual species class (US-U:TEA) to 29% of the area. Other climates only supported 5.4% - 5.6% of the US-U:TEA class. By the same process, any stand-replacing or thinning disturbances in US-U:TEA would have caused a transition to the non-native annual species class (US-U:Annual Spp), or to the shrub with annual and perennial grass class (US-U:SAP). These classes were also created by annual species invasion of the reference early-successional (US-A:All) and mid-successional (US-B:Closed) classes. As a rule of thumb, any classes earlier in succession became large under the HISTORIC Climate or CCSM4 LOCA (more fire), whereas classes later in succession became smaller in the drier ACCESS1 LOCA (less fire).

Objective(s) for Management Actions

The primary objective was to recruit into younger successional classes for the benefit of mule deer browse palatability by reducing conifer dominance in Utah serviceberry (Cox et al. 2009).

Treatment Rates and Costs

Chainsaw thinning and prescribed fire were used in the wooded classes (US-D:Open and US-U:TEA) (Table 28), although the original intention was to use only chainsaw thinning. Prescribed fire was only allowed in the reference late-successional class (US-D:Open). Chainsaw thinning was used from years 2035 to 2044, and significantly more was deployed in the ACCESS1 LOCA to make up for the larger wooded area that did not burn under that drier LOCA. Prescribed fire was used in small amounts in all periods, although most acres were burned from 2020 to 2034. Significantly less area was treated with prescribed fire in the ACCESS1 LOCA than in the other climates.

Table 28. Realized rates and costs of management actions implemented in the Utah Serviceberry ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period's cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018-2034	2035-2044	2045-2077	
Preferred + Historic	Chainsaw-Thinning	\$112.50	0.0	457.1	0.0	
	RxFire	\$100.00	742.1	25.3	0.1	
	Cost →		\$74,211 a	\$53,958 a	\$9 a	\$128,178
Preferred + CCSM4	Chainsaw-Thinning	\$112.50	0.0	508.5	0.0	
	RxFire	\$100.00	634.2	42.1	0.0	
	Cost →		\$63,416 a	\$61,417 a	\$2 a	\$124,835
Preferred + ACCESS1	Chainsaw-Thinning	\$112.50	0.0	711.6	0.0	
	RxFire	\$100.00	312.1	36.0	1.2	
	Cost →		\$31,213 b	\$83,656 b	\$122 b	\$114,991

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	53 ± 8	45 ± 7
In 2077 under CCSM4 LOCA	62 ± 7	45 ± 4
In 2077 under ACCESS1 LOCA	77 ± 8	59 ± 6

Charts of Relevant Vegetation Classes

Both the reference late-successional open (US-D:Open) and tree-encroached wooded (US-U:TEA) classes rapidly decreased during the 2035 to 2044 period (Figure 20). Chainsaw thinning was the primary action applied during that period, but fire also contributed to the decline as seen in the MINIMUM MANAGEMENT scenarios. Treated areas in the reference late-successional open class (US-D:Open) transitioned to the reference mid-successional closed (US-B:Closed) and late-successional closed (US-C:Closed) classes. Treated areas in the tree-encroached class

(US-U:TEA) transitioned to the non-native annual species class (US-U:Annual Spp) and shrub with annual and perennial grass class (US-U:SAP). The US-U:SAP recipient class showed higher areas in PREFERRED MANAGEMENT scenarios than MINIMUM MANAGEMENT scenarios, whereas the three other recipient classes had more muted, but noticeable responses. The clearest climate effect was in the US-U:SAP class where area was greater in the ACCESS1 LOCA than in other climate scenarios. Reduced fire activity in the ACCESS1 LOCA maintained shrub cover more than in other, more fire-active climates.

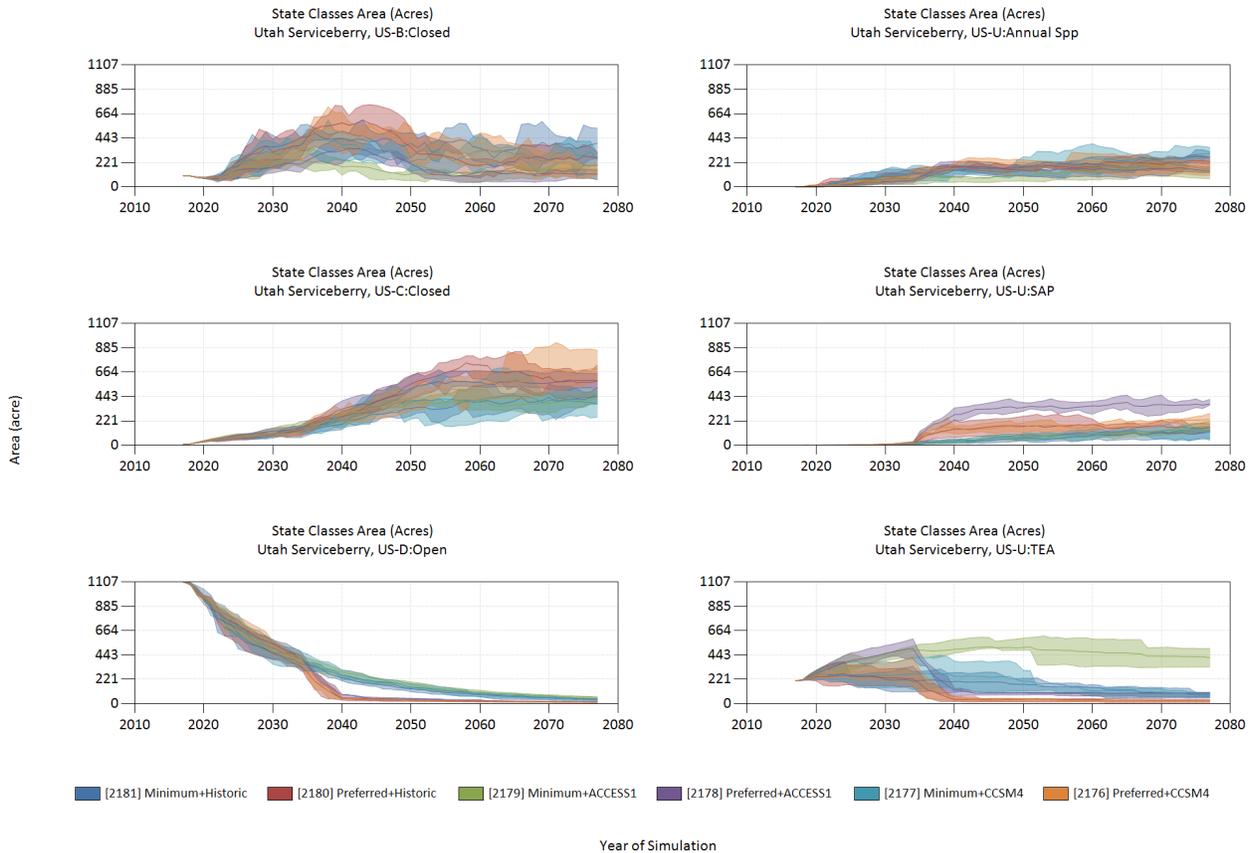


Figure 20. Dominant treated and recipient vegetation classes in the Utah Serviceberry ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Wet Meadow-montane Ecological System

Current System Acres: 63

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

100

100 ± 0

100 ± 0

99 ± 0

Vegetation Classes

Table 29. Vegetation classes of the Wet Meadow-Montane ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
WM-A:Open	5	0	—	0.83%	1.66%	2.00%	0.05%
WM-B:Closed	90	0	—	0.00%	13.22%	10.16%	7.88%
WM-C:Open	5	0	—	22.59%	0.67%	1.62%	4.53%
WM-U:Annual Spp	0	1	0.0	0.00%	4.05%	3.78%	2.34%
WM-U:Bare Ground	0	1	0.0	0.50%	0.38%	0.50%	0.48%
WM-U:Desertified	0	1	0.0	4.65%	5.80%	6.10%	5.92%
WM-U:Early-Shrub	0	1	0.0	1.16%	1.48%	1.53%	1.82%
WM-U:Exotic Forb	0	2	0.0	4.98%	16.43%	19.49%	17.94%
WM-U:Hummocked	0	1	0.0	2.82%	3.09%	2.00%	2.07%
WM-U:Inset	0	0	0.0	8.80%	1.40%	1.34%	0.78%
WM-U:Inset-EF	0	0	0.0	0.00%	8.83%	8.94%	8.82%
WM-U:Inset-Hummocked	0	0	0.0	0.00%	0.00%	0.05%	0.03%
WM-U:SA	0	1	0.0	0.00%	0.12%	0.14%	0.31%
WM-U:SFE	0	0	0.0	37.22%	31.60%	30.63%	33.11%
WM-U:SI	0	0	0.0	9.80%	9.80%	10.15%	10.02%
WM-U:TEA	0	1	0.0	6.64%	1.48%	1.57%	3.90%

Problems or Concerns

2017: The wet meadow-montane system was highly departed from NRV (100%) for three reasons (Table 29): (1) Nearly all the area of reference classes was concentrated in the late-successional WM-C:Open class (about 23% of the total 24%), for which NRV is 5%; thus 20% of the total 24% should have been in the reference mid-successional class (WM-B:Closed), considering that uncharacteristic classes occupied the rest of the area. (2) While the exotic forb class (WM-U:Exotic Forb) was only 5% of the area, it disproportionately increased UED because it has the maximum undesirability level of 2. (3) About 76% of the area was found in uncharacteristic classes, of which the hummocked class (WM-U:Hummocked) and several

incised classes were assigned an intermediate undesirability level of 1 for the calculation of UED. The shrub and forb encroached class (WM-U:SFE) was the dominant uncharacteristic class, but it received the minimum undesirability level of zero because it was not incised and supported native species, albeit unpalatable ones selected through a century of grazing.

Again, wet meadows were represented by a small area. Therefore, UED estimates should be considered with caution, although the dominant disturbance was soil moisture saturation that had a shorter return interval of wet years (about 10 years) than the mean return interval of fire for sagebrush systems (>50 years).

After 60 years of MINIMUM MANAGEMENT: The areas of the shrub and forb encroached class (WM-U:SFE), the desertified class (WM-U:Desertified), and the hummocked class (WM-U:Hummocked) were comparable to the 2017 proportions. Major differences by 2077 were large increases of two classes with exotic forbs (WM-U:Exotic Forb and WM-U:Inset-EF), and the shift of area from the reference late-successional class (WM-C:Open) to the reference mid-successional class (WM-B:Closed). The build-up of the exotic forb class (WM-U:Exotic Forb) appeared to match the loss of area from all reference classes. UED remained at or near 100%.

Objective(s) for Management Actions

Three management objectives were to: (1) control exotic noxious species forbs or keep them in check; (2) elevate the water table to counter the drying effects of incision, which lowered the water table; and (3) allow natural recovery of vegetation from uncharacteristic classes (hummocked and dominated by unpalatable shrubs and forbs) to reference classes by preventing continuous herbivory.

Treatment Rates and Costs

Four actions were taken to meet the three objectives (Table 30), although exotic control and weed inventory supported by herbicide spot treatment were used in combination for exotic forb and tree control. Exotic control methods were used as maintenance actions, and therefore were implemented in all periods. In particular, weed inventory periodically covered all wet meadows whether noxious exotic species were found or not.

Fencing of wet meadows containing hummocked (WM-U:Hummocked) and shrub and forb encroached (WM-U:SFE) classes caused 20 years of rest from herbivory, and a transition to the reference early-successional class (WM-A:Open) after 10 years of continuous lack of ungulate herbivory. Due to its very high cost per unit area, fencing was distributed over all years, although implementation rates were greater from years 2020 to 2034, and then from years 2045 to 2077. Also noteworthy was that when fencing was directed toward certain classes, the reality of implementation was that the whole meadow needed to be temporarily fenced as a riparian pasture (not just the hummocked part), therefore all classes would rest from herbivory.

Lifting the water table could be achieved using any of several inexpensive and likely temporary methods (for example, small rock dam) applied to incision areas. It was assumed that an elevated water table would hydrate all classes previously dried by incisions in a wet meadow. This action was implemented only from 2035 to 2077, and at low rates.

There were no statistical or noticeable differences among climate scenarios.

Table 30. Realized rates and costs of management actions implemented in the Wet Meadow-montane ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period’s cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred + Historic	Exotic-Control	\$360.00	26.6	47.8	207.7	
	Fence	\$8,000.00	94.8	21.9	52.5	
	Water-Table-Uplift	\$500.00	0.0	25.1	10.8	
	Weed-InVENTORY+Treat	\$253.00	201.5	136.4	525.6	
	Cost →		\$269,041 a	\$112,517 a	\$328,586 a	\$710,144
Preferred + CCSM4	Exotic-Control	\$360.00	27.6	40.3	219.2	
	Fence	\$8,000.00	94.9	23.6	51.3	
	Water-Table-Uplift	\$500.00	0.0	23.4	11.3	
	Weed-InVENTORY+Treat	\$253.00	204.0	145.0	511.6	
	Cost →		\$270,346 a	\$114,784 a	\$326,863 a	\$711,993
Preferred + ACCESS1	Exotic-Control	\$360.00	25.2	44.3	221.5	
	Fence	\$8,000.00	96.2	21.2	51.1	
	Water-Table-Uplift	\$500.00	0.0	22.7	10.3	
	Weed-InVENTORY+Treat	\$253.00	218.5	121.8	500.7	
	Cost →		\$276,037 a	\$104,857 a	\$323,903 a	\$704,797

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	100 ± 0	68 ± 5
In 2077 under CCSM4 LOCA	100 ± 0	69 ± 6
In 2077 under ACCESS1 LOCA	99 ± 0	82 ± 5

Charts of Relevant Vegetation Classes

The reference mid-successional class (WM-B:Closed) substantially increased from 2035 to 2045 (Figure 21). This class was considered the most desirable for greater sage-grouse. About 60-80 more acres were found in the PREFERRED MANAGEMENT scenarios than the MINIMUM MANAGEMENT scenarios. Very few acres moved to the reference late-successional class (WM-C:Open), except

under the PREFERRED+ACCESS1 scenario because drier conditions would allow the drought periods needed for woody vegetation establishment.

While the area of the exotic forb class (WM-U:Exotic Forb) decreased from years 2020 to 2034, it then increased in area to the same level as the MINIMUM MANAGEMENT scenarios (Figure 21). This was perplexing because examination of transition results (not shown here) showed treatments were consistently used after 2034 at a higher level than previously. Therefore, these results suggest increased invasion by exotic forbs and insufficient treatment rates for both actions. Furthermore, if an area invaded by noxious exotic forbs and trees was not successfully treated for 20 consecutive years, the class became permanently untreatable with the standard methods. This may have happened in a few meadows.

Fencing appeared to have the most substantial effect of all treatments on all classes compared to MINIMUM MANAGEMENT, because it was the only treatment used during the first period from 2020 to 2034. These improvements were the primary causes of increased area of the reference mid-successional class. The following classes all decreased during this period: shrub and forb encroached (WM-U:SFE), desertified (WM-U:Desertified), inset (not shown; WM-U:Inset), and hummocked (WM-U:Hummocked).

Because fencing was even effective at resting incised classes, the role of lifting the water table was cryptic, although implemented. The hydrologic characteristics of the soil were maintained by lifting the water table and preventing more incision.

Overall, UED was reduced by treatments by about 30% for the PREFERRED+HISTORIC and PREFERRED+CCSM4 scenarios, and 17% for the PREFERRED+ACCESS1 scenario. The latter and poorer result was primarily caused by the recruitment of the reference late-successional class (WM-C:Open) under drier conditions. Therefore, wet meadows remained highly departed from reference conditions, although improved from what they would have been under MINIMUM MANAGEMENT.

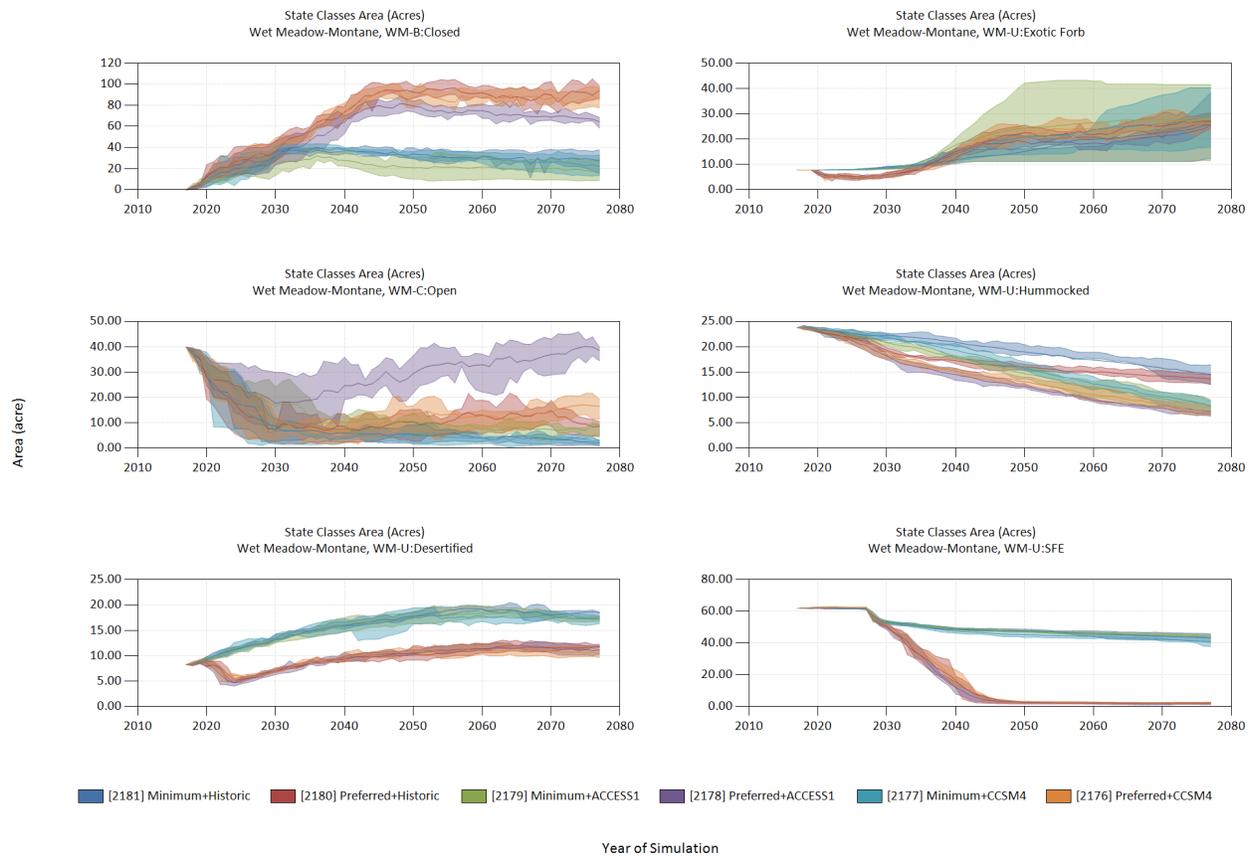


Figure 21. Dominant treated and recipient vegetation classes in the Wet Meadow-montane ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Wyoming Big Sagebrush-upland Ecological System

Current System Acres: 51,769

Condition: Unified Ecological Departure

In 2017:

In 2077 under MINIMUM MANAGEMENT & HISTORIC Climate:

In 2077 under MINIMUM MANAGEMENT & CCSM4 LOCA:

In 2077 under MINIMUM MANAGEMENT & ACCESS1 LOCA:

100

100 ± 0

100 ± 0

100 ± 0

Vegetation Classes

Table 31. Vegetation classes of the Wyoming Big Sagebrush-upland ecological system at the current time (2017), and after 60 years of MINIMUM MANAGEMENT (2077) under three climate scenarios.

Vegetation Class	Ref NRV%	Undesir. Level	Allow. Thresh%	Current (2017)	MINIMUM MANAGEMENT (2077)		
				Class %	HISTORIC Class %	CCSM4 Class %	ACCESS1 Class %
WSup-A:All	16	0	—	0.00%	1.08%	1.31%	0.45%
WSup-B:Open	28	0	—	2.20%	1.20%	0.78%	0.67%
WSup-C:Closed	42	0	—	1.05%	1.22%	1.71%	2.46%
WSup-D:Open	6	0	—	2.58%	0.33%	0.41%	0.46%
WSup-E:Closed	8	0	—	0.02%	1.50%	1.46%	1.40%
WSup-U:Annual Spp	0	1	0.0	0.20%	26.75%	26.11%	16.23%
WSup-U:Bare Ground	0	1	0.0	0.01%	0.07%	0.06%	0.08%
WSup-U:Depleted	0	1	0.0	27.02%	8.30%	9.41%	15.88%
WSup-U:Early-Shrub	0	0	0.0	15.35%	24.96%	23.22%	20.15%
WSup-U:Exotic Forb	0	2	0.0	0.04%	1.86%	2.00%	1.80%
WSup-U:SA	0	1	0.0	0.00%	1.98%	2.06%	4.27%
WSup-U:SA+	0	1	0.0	0.00%	0.04%	0.04%	0.20%
WSup-U:SAP	0	0	0.0	17.72%	2.12%	2.50%	6.21%
WSup-U:SAP+	0	1	0.0	0.00%	0.11%	0.09%	0.49%
WSup-U:SAP-A	0	0	0.0	0.21%	1.30%	1.18%	1.14%
WSup-U:Seeded Native	0	0	16.0	0.00%	0.00%	0.00%	0.00%
WSup-U:SI-A	0	0	9.6	1.40%	1.63%	2.06%	0.40%
WSup-U:SI-A+AG	0	0	0.0	5.12%	0.38%	0.45%	0.17%
WSup-U:SI-B	0	0	16.8	4.29%	1.76%	1.10%	0.74%
WSup-U:SI-B+AG	0	0	0.0	1.65%	0.39%	0.45%	0.54%
WSup-U:SI-C	0	0	27.0	0.82%	4.11%	4.60%	6.02%
WSup-U:SI-C+AG	0	0	0.0	1.34%	1.20%	1.42%	2.25%
WSup-U:SI-D	0	0	5.4	0.35%	1.06%	1.06%	0.96%
WSup-U:SI-D+AG	0	0	0.0	0.49%	0.50%	0.59%	0.63%
WSup-U:TEA	0	1	0.0	18.13%	16.17%	15.90%	16.39%

Problems or Concerns

2017: Wyoming big sagebrush on upland soils was highly departed from NRV (100%). Less than 6% of the total area of the system was in any reference class (Table 31). The uncharacteristic classes that dominated were typical of this system in the Great Basin ecoregion: 27% for depleted sagebrush class (WSup-U:Depleted), 15% for early shrub class (WSup-U:Early-Shrub), 18% for shrubs with annual and perennial grasses class (WSup-U:SAP), 18% for the tree-encroached with or without non-native annual grass class (WSup-U:TEA), and about 12% for various introduced species seeding classes (WSup-U:SI-A, WSup-U:SI-B, and others). Very few acres were in the annual species class (WSup-U:Annual Spp).

After 60 years of MINIMUM MANAGEMENT: While the reference classes and the tree-encroached class (WSup-U:TEA) did not appreciably change over 60 years, other classes did (Table 31). The non-native annual species class (WSup-U:Annual Spp) increased from 0.2% of the area (now) to about 26% under both the HISTORIC Climate and the CCSM4 LOCA, and to about 16% under the ACCESS1 LOCA. These areas were apparently the result of fire burning in several classes (including WSup-U:TEA), but primarily the shrub with annual and perennial grass class (WSup-U:SAP). The WSup-U:SAP class decreased from 18% to about 2% under the HISTORIC Climate and the CCSM4 LOCA, and to about 6% under the ACCESS1 LOCA. The other main temporal change after 60 years was the decrease of depleted sagebrush (WSup-U:Depleted) from 27% in 2017 to 8%-9% under both the HISTORIC Climate and the CCSM4 LOCA, and to about 16% under the ACCESS1 LOCA. Because fire and drought were the agents of this change, the early shrub class (WSup-U:Early-Shrub) increased from about 15% in 2017 to 25% in the HISTORIC Climate, 23% in the CCSM4 LOCA, and 20% in the ACCESS1 LOCA. Finally, the few areas occupied by different introduced species seedings, which are more resistant to fire than reference classes of sagebrush, matured into the late-successional seeded closed class (WSup-U:SI-C).

Objective(s) for Management Actions

The most obvious overriding objective was to reestablish a successional pattern of shrublands that could support greater sage-grouse and sagebrush-dependent wildlife species. Specific objectives tied to the overall sage-grouse habitat improvement are listed below:

1. A first specific objective was to decrease the area of tree-encroached shrubland (WSup-U:TEA) and create seedings that would eventually age with sagebrush. Cutting or lopping saplings and young conifers in many classes was deemed as an inexpensive action to prevent future conifer encroachment of Wyoming big sagebrush.
2. Other objectives were to decrease the areas of the depleted sagebrush (WSup-U:Depleted) and shrubs with non-native annual grass (WSup-U:SA) classes, which were a source for future annual grassland if they burned.
3. A general goal of BLM also was to test at small scale the seeding of pure native herbaceous and woody species, which was more expensive and generally less successful, than seeding

introduced species. Classes receiving this treatment were depleted sagebrush (WSup-U:Depleted), tree-encroached sagebrush with or without annual species (WSup-U:TEA), and even non-native annual species (WSup-U:Annual Spp).

4. Another special objective was to seed native forbs and grasses experimentally into older introduced species seedings, to increase those seedings' native species content and their nutritional value for sage-grouse.
5. An objective for future years was to control the non-native annual species class (WSup-U:Annual Spp) as it increased after fire in uncharacteristic classes.

Treatment Rates and Costs

Nearly all the funding was spent from years 2020 to 2034 (Table 32), because Wyoming big sagebrush was closer to leks in Pine Valley than higher elevation montane sagebrush steppe, thus making Wyoming big sagebrush a BLM restoration priority – as is also the case for black sagebrush. Six actions were used to achieve objectives:

1. Remove mature pinyon and juniper encroaching into shrubland. Masticate+Herbicide+Seed was the most expensive action used, supplemented during the first period (2020-2034) with a small amount of Chaining+Native-Seed;
2. Cut young saplings and immature trees starting to occupy shrublands (Small-Tree-Lopping) in all periods as saplings became available;
3. Restore depleted sagebrush (WSup-U:Depleted) by reducing woody cover and competition for soil moisture, thus allowing seeding of native herbaceous and sagebrush species (Chaining+Native-Seed) to take during the first period;
4. Restore sagebrush shrubland invaded by non-native annual species by reducing woody shrub cover to facilitate seeding with mixed native and introduced species; this was followed, if needed, by Imazapic (Plateau™) spraying to prevent further non-native annual species germination (Chaining+Plateau+Seed) during the first and last (2045-2077) periods;
5. Control of the non-native annual species class (WSup-U:Annual Spp) as it increased with future fires by seeding mixed native and introduced species, mechanically incorporating the seed into the soil, and spraying Imazapic to inhibit germination of annual species (Chaining+Plateau+Seed) during the first and last (2045-2077) periods; and
6. Supplemental seeding of native forbs and grasses into older pure seedings of introduced grass species, followed by running a chain to incorporate native seed in the ground and provide mineral soil to reduce competition from established plants (Forb+Grass-Native-Seeding+Chaining), especially sagebrush, during the first period.

The money spent was only significantly different among climate scenarios in the last period, where about \$220,000 more money was spent in the HISTORIC Climate than in both LOCAs, which did not show spending differences. The significant difference was entirely caused by a one-order of magnitude greater use of Chaining+Plateau+Seed. The range of total 60-year spending was from \$5.6 million (ACCESS1 LOCA) to \$6 million (HISTORIC Climate).

Table 32. Realized rates and costs of management actions implemented in the Wyoming Big Sagebrush-upland ecological system during three time periods in the PREFERRED+HISTORIC, PREFERRED+CCSM4 and PREFERRED+ACCESS1 climate scenarios. Letters adjacent to each period’s cost should only be compared vertically; different letters indicate statistically different means.

Scenario	Treatment or Mgmt Action	Cost/Ac	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
			2018 -2034	2035 -2044	2045 -2077	
Preferred + Historic	Chaining+Native-Seed	\$205.00	1,258.3	0.0	0.0	
	Chaining+Plateau+Seed	\$192.50	3,869.6	0.0	2,078.8	
	Chaining+Seed	\$165.00	4,331.5	0.0	0.0	
	Forb+Grass-Native-Seeding+Chaining	\$160.00	4,862.6	0.0	0.0	
	Masticate+Herbicide+Seed	\$605.00	4,017.2	0.0	0.0	
	Small-Tree-Lopping	\$75.00	5,236.4	820.5	2,564.1	
	Cost →		\$5,318,719 a	\$61,541 a	\$592,477 a	\$5,972,737
Preferred + CCSM4	Chaining+Native-Seed	\$205.00	1,140.4	0.0	0.0	
	Chaining+Plateau+Seed	\$192.50	3,423.1	0.0	975.8	
	Chaining+Seed	\$165.00	4,399.1	0.0	0.0	
	Forb+Grass-Native-Seeding+Chaining	\$160.00	4,983.7	0.0	0.0	
	Masticate+Herbicide+Seed	\$605.00	3,958.2	0.0	0.0	
	Small-Tree-Lopping	\$75.00	4,927.0	853.1	2,547.7	
	Cost →		\$5,180,255 a	\$63,983 a	\$378,918 b	\$5,623,156
Preferred + ACCESS1	Chaining+Native-Seed	\$205.00	1,257.1	0.0	0.0	
	Chaining+Plateau+Seed	\$192.50	3,042.3	0.0	708.2	
	Chaining+Seed	\$165.00	3,803.5	0.0	0.0	
	Forb+Grass-Native-Seeding+Chaining	\$160.00	4,751.3	0.0	0.0	
	Masticate+Herbicide+Seed	\$605.00	4,183.3	0.0	0.0	
	Small-Tree-Lopping	\$75.00	5,473.7	819.9	2,598.5	
	Cost →		\$5,172,524 a	\$61,496 a	\$331,222 b	\$5,565,243

Results of Simulated Management Actions (PREFERRED MANAGEMENT)

Unified Ecological Departure	MINIMUM MANAGEMENT	PREFERRED MANAGEMENT
In 2077 under HISTORIC Climate	100 ± 0	81 ± 3
In 2077 under CCSM4 LOCA	100 ± 0	83 ± 2
In 2077 under ACCESS1 LOCA	100 ± 0	86 ± 1

Charts of Relevant Vegetation Classes

Compared to 100% UED departure with MINIMUM MANAGEMENT scenarios in 2077, UED was reduced to 81% (HISTORIC Climate), 83% (CCSM4 LOCA), and 86% (ACCESS1 LOCA) after 60 years with the PREFERRED MANAGEMENT scenarios. The 95% C.I.s suggest that the ACCESS1 LOCA might have been significantly more departed from NRV than other climate scenarios.

The most visible result was reducing the area of tree-encroached shrublands (WSup-U:TEA) by about 6,000 acres in 2035, and by 4,000 acres in 2077 (Figure 22). Differences among climates were not apparent.

The Chaining+Plateau+Seed action was effective at controlling the non-native annual species class (WSup-U:Annual Spp) to very low levels, compared to the progressive increase of area in the MINIMUM MANAGEMENT scenarios reaching about 12,000 acres in the HISTORIC Climate and CCSM4 LOCA, and 8,000 acres in the ACCESS1 LOCA. The same treatment also reduced the shrub with annual species class (WSup-U:SA) by about 800 acres at the end of the first implementation period (2034), compared to MINIMUM MANAGEMENT scenarios. By year 2077, the Chaining+Plateau+Seed action had lost its effectiveness, as fires reduced the area of the WSup-U:SA class in the MINIMUM MANAGEMENT scenarios, except in the drier ACCESS1 LOCA.

Small tree lopping in the reference late-successional open class (WSup-D:Open) and late-successional seeded class (WSup-U:SI-D) produced different results. Removing young trees and saplings was more effective in the seeded class (~150 acres difference between PREFERRED and MINIMUM MANAGEMENT scenarios) than in the reference late-successional class, where differences were small and overshadowed by larger climate differences.

The more surprising result was the lack of treatment differences in the depleted sagebrush class (WSup-U:Depleted). Differences in climate were more pronounced, although not strong, but the implementation rates for the Chaining+Native-Seed were very small and shared among different classes. Increasing the treatment rate for the depleted sagebrush class would have considerably increased the budget because this class, while large, was not a threat to sage-grouse.

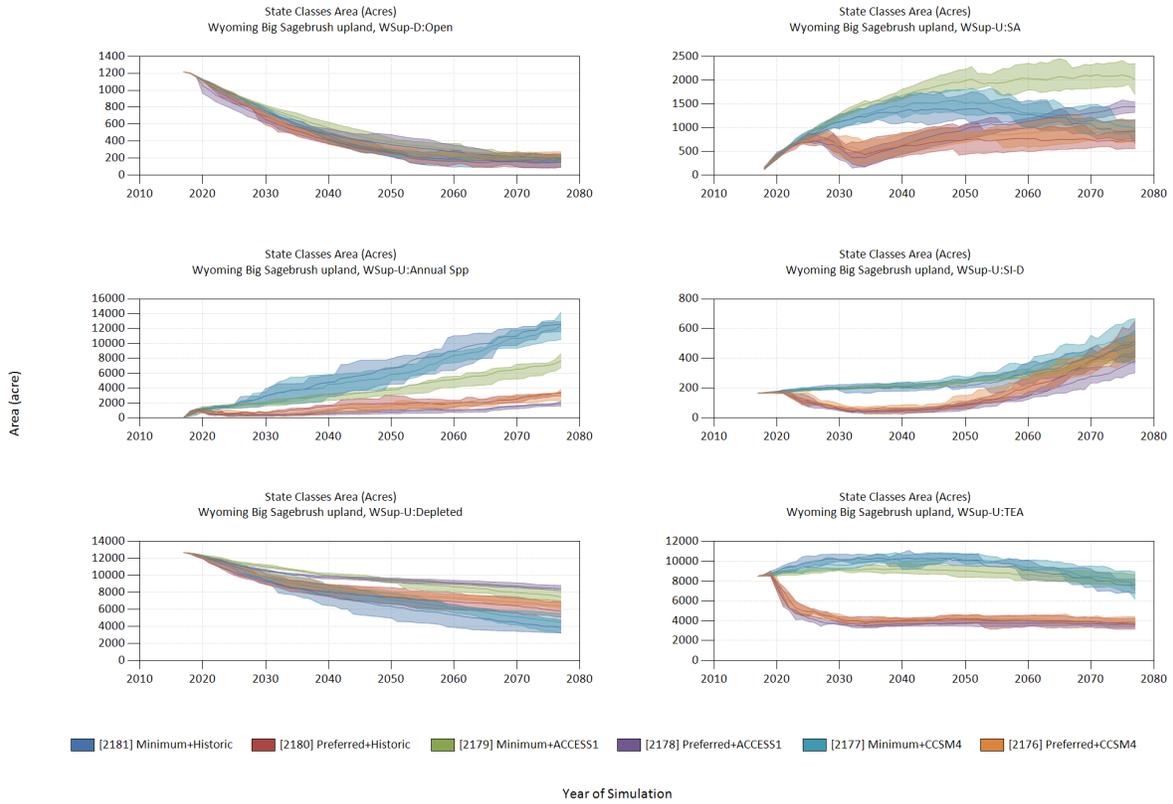


Figure 22. Dominant treated vegetation classes in the Wyoming Big Sagebrush-upland ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

All treatments that included seedings caused an increase of about 6,000 acres of mixed native and introduced species seedings compared to MINIMUM MANAGEMENT scenarios (Figures 23). Existing seedings in MINIMUM MANAGEMENT scenarios established a baseline. With succession, the seeded areas matured into mid-successional (WSup-U:SI-B) and late-successional (WSup-U:SI-C) seedings. The success of the mixed native and introduced species seedings was lower in the drier ACCESS1 LOCA than other climates during early and middle succession, because droughts increased seeding failure. However, the area of the late-successional seeded class was greater for the ACCESS1 LOCA than other climates because reduce fire activity preserved shrubs.

The native species seeding represented a minor contributor to restoration, but should be viewed as an important component of the increased effort to move towards native species seedings. The area of native species seedings increased steadily over the first 15 years, then slowly decreased as successful seedings converted to reference classes or were invaded by non-native annual species.

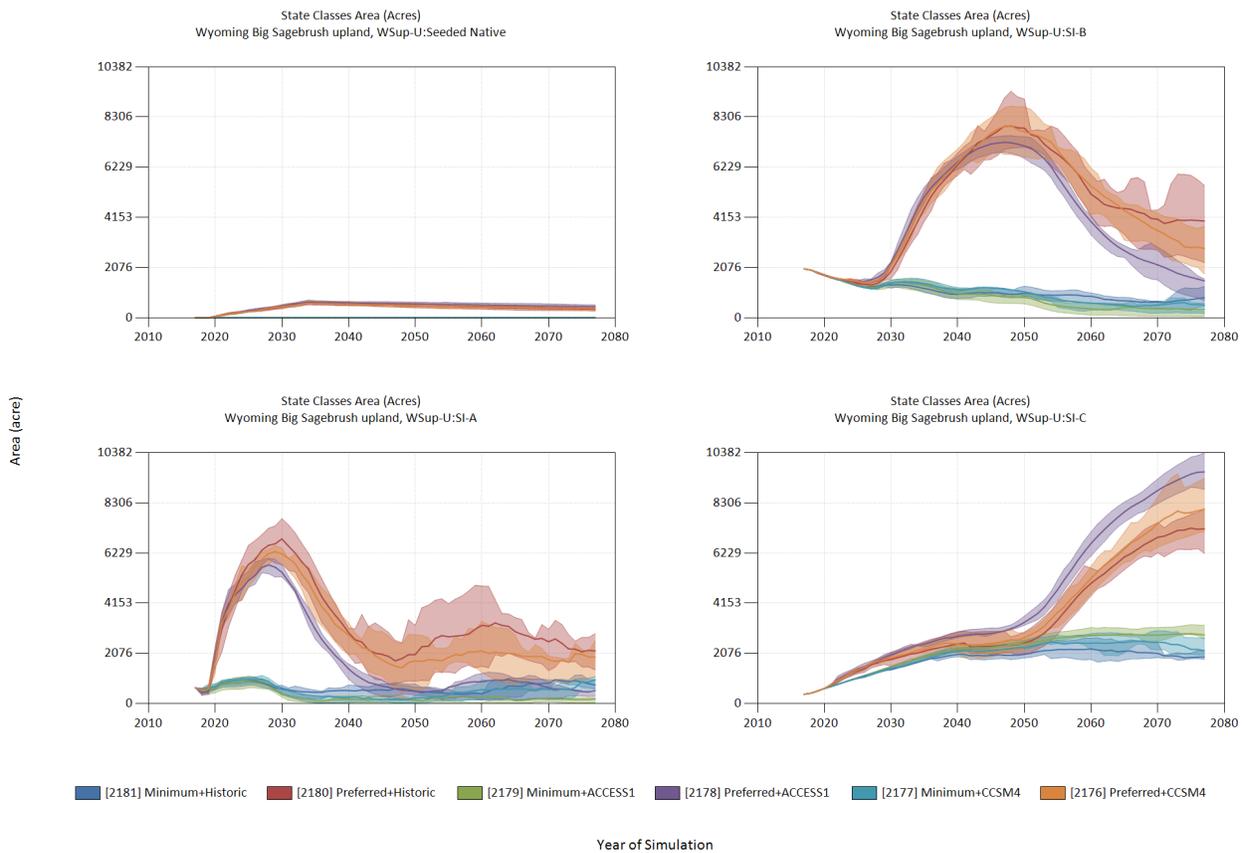


Figure 23. Dominant recipient vegetation classes in the Wyoming Big Sagebrush-upland ecological system. Sample size = 10 per scenario. The line is the mean, and the colored interval around each line contains observations in the 25% and 75% percentiles. MINIMUM = minimum management; PREFERRED = preferred management; HISTORIC = forecasted HISTORIC Climate; ACCESS1 and CCSM4 = forecasted ACCESS1 and CCSM4 LOCAs, respectively.

Future Condition – PREFERRED MANAGEMENT

Table 33 shows a side-by-side summary comparison of future condition, per the measure of Unified Ecological Departure, for the twelve analyzed ecological systems after 60 years of MINIMUM MANAGEMENT versus 60 years of active PREFERRED MANAGEMENT. While active management generally reduced UED, it did not for ponderosa pine and Stansbury cliffrose.

Stansbury cliffrose was a very small system where UED was very sensitive to changes in class proportions. Restoration resulted in the targeted reduction of one abundant class to increase a more desirable class, which resulted in new class proportions that were not close to NRV, but acceptable for management.

Ponderosa pine was trickier because great effort was made to plant plugs of ponderosa pine in areas where the species was absent due to historic logging. This created a pulse of the reference early-successional class (PP-A:All) that, unfortunately, followed the closed-canopied succession pathway with insufficient fire. While efforts were made to convert closed canopies to open canopies with chainsaws, stands rapidly transition to closed canopies without the contribution of prescribed fire or natural low severity fire. It would be a challenge to conduct prescribed burns in isolated stands on often steep terrain and surrounded by dangerous fuels. That prescription was not chosen here. With more funding, more chainsaw thinning of closed stands should be conducted after the plugs of seedlings grow to mid-successional age.

Ecological systems whose restoration relies on large areas of seedings, especially of mixed native and introduced species that are uncharacteristic classes, will likely never return to low UED values as shown in Table 33. This strategy improved sage-grouse habitat suitability based on our results, but if the objective is to lower UED to at least the lowest level of moderate UED, then use of pure native species seedings and greater seeding success will need to increase.

Table 33. Unified ecological departure predicted under three climate scenarios in 2077 after 60 years of MINIMUM MANAGEMENT, and of active PREFERRED MANAGEMENT, of ecological systems selected for management analyses in the Pine Valley - Mountain Home Range Project Area.

Ecological System	MINIMUM MANAGEMENT – 2077*			PREFERRED MANAGEMENT – 2077*		
	HISTORIC	CCSM4	ACCESS1	HISTORIC	CCSM4	ACCESS1
Aspen Woodland	61 ± 7	62 ± 5	53 ± 5	49 ± 6	42 ± 4	45 ± 2
Black Sagebrush	100 ± 0	100 ± 0	100 ± 0	55 ± 3	56 ± 4	56 ± 3
Calcareous Grassland	100 ± 0	100 ± 0	100 ± 0	92 ± 4	91 ± 5	98 ± 1
Montane Riparian	76 ± 6	80 ± 10	82 ± 8	74 ± 6	67 ± 6	76 ± 3
Montane Sagebrush Steppe	100 ± 0	100 ± 0	100 ± 0	84 ± 6	82 ± 3	88 ± 4
Pinyon-Juniper Woodland	30 ± 5	25 ± 4	13 ± 2	21 ± 4	16 ± 4	10 ± 1
Ponderosa Pine	29 ± 1	28 ± 2	36 ± 3	46 ± 4	43 ± 3	38 ± 2
Semi-Desert Grassland	100 ± 0	100 ± 0	100 ± 0	80 ± 6	83 ± 3	88 ± 2
Stansbury Cliffrose	53 ± 8	50 ± 6	52 ± 5	62 ± 3	59 ± 2	63 ± 5
Utah Serviceberry	53 ± 8	62 ± 7	77 ± 8	45 ± 7	45 ± 4	59 ± 6
Wet Meadow-montane	100 ± 0	100 ± 0	99 ± 0	68 ± 5	69 ± 6	82 ± 5
Wyoming Big Sagebrush-upland	100 ± 0	100 ± 0	100 ± 0	81 ± 3	83 ± 2	86 ± 1

Code to UED cell colors:

0-33	34-66	67-100
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* Each UED value is the mean of ten model runs (N=10), ± one 95% confidence interval.

Sage-Grouse Habitat Suitability

Current Time (Year 0) Suitability

The spatial distribution of habitat suitability index for greater sage-grouse in the Pine Valley - Mountain Home Range project area in 2017 (Year 0) is shown in Figure 24. The average habitat suitability index represented in Figure 24 is 39.87%.

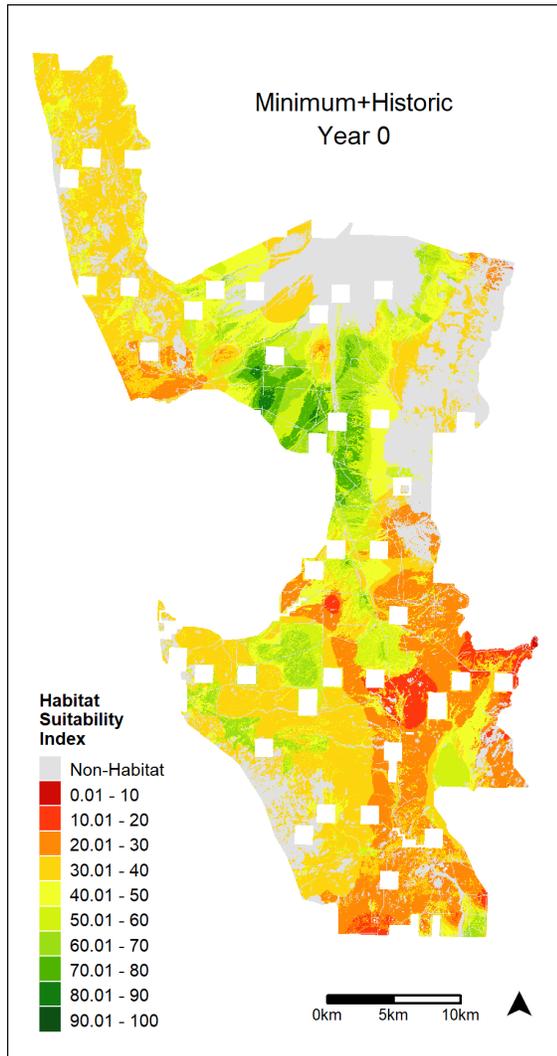


Figure 24. Current (Year 0: 2017) habitat suitability index for greater sage-grouse in the Pine Valley - Mountain Home Range project area. Average habitat suitability for Year 0 of simulation is 39.87%. At Year 0 there is no difference among management scenarios. Darker green indicates higher habitat suitability index, and redder indicates poorer habitat suitability index.

The north-central part of the landscape contained areas of high habitat suitability, being located close to a lek outside to the west of the project-area boundary. It was noteworthy that the southern half of Pine Valley was, at best, moderately suitable, despite containing excellent occurrences of Wyoming big sagebrush and black sagebrush. The lower habitat suitability here was partly caused by greater distance to the closest lek. In addition, while few trees occupy the broader northern Pine Valley, tree encroachment into shrublands was prevalent in the southern half. Therefore, opportunities for restoration exist in the middle of the project area. In the many areas of low sage-grouse habitat suitability, the potential for maintenance or improvement to mule deer habitat might be high. Good examples are found on the steeper slopes of the Indian Peak Range and Mountain Home Range where browse is commonly found.

Future Suitability and Deviations

Future habitat suitability results are presented as deviations from the MINIMUM+HISTORIC scenario for the year of consideration. This presentation helps isolate areas that were forecast to improve or to degrade under different climate and management scenarios.

Average Habitat Suitability Differences Among Scenarios (Non-Spatial)

In 2017, average sage-grouse habitat suitability was 39.87% (Figure 24 above). Thirty and sixty years later, respectively, habitat suitability decreased to about 25.5% and 24.8% without management under any climate scenario (Table 34: Year 2047 and 2077). While management actions significantly increased suitability by about 4% by 2047 and 5% by 2077, different climate scenarios only had significant effects on suitability in year 2047. However, the effect of different climate was small, with suitability increasing with drying climate. The non-significant or marginal effect of climate was partly expected, because variation in the implementation levels of restoration actions was designed to compensate for climate effects on vegetation classes (as noted in the **Project Background** section).

Table 34. Average Habitat Suitability for Greater Sage-Grouse in the Pine Valley - Mountain Home Range project area. Year of vegetation mapping was 2017.

Scenario Name	Year 2047		Year 2077	
	Mean (n=10)	±1 95% C.I.	Mean (n=10)	±1 95% C.I.
MINIMUM+HISTORIC	25.5 ^{a,i}	0.2	24.8 ^{a,i}	0.4
PREFERRED+HISTORIC	30.5 ^{b,i}	0.4	30.8 ^{b,i}	0.6
MINIMUM+ACCESS1	25.9 ^{a,ii}	0.1	25.0 ^{a,i}	0.1
PREFERRED+ACCESS1	31.1 ^{b,ii}	0.3	31.0 ^{b,i}	0.4
MINIMUM+CCSM4	25.6 ^{a,iii}	0.2	24.7 ^{a,i}	0.2
PREFERRED+CCSM4	30.8 ^{b,iii}	0.3	30.9 ^{b,i}	0.3

– Scale of 0-100, where 100 = highest quality habitat.

– Difference between means was analyzed using a 2 × 3 Factorial Analysis of Variance (ANOVA; 2 = management levels, 3 = climate levels).

– Degrees of Freedom (df) for management, climate, interaction factors, and error, respectively, were (2-1) = 1, (3-1) = 2, (2-1) × (3-1) = 2, and 2 × 3 × (10 replicates - 1) = 54.

^{a,i} Different superscripts indicate significant differences based on pre-planned contrasts: Letters a-b and i-iii indicate significantly different means due to management effects and climate effects, respectively. Both the 2047 and 2077 habitat suitability values required square-root transformations to homogenize variances among treatment combinations.

At year 2047, pre-planned contrasts were significant at $p < 0.0001$ for Minimum vs. Preferred and at $p = 0.002338$ for the climate effect. The first contrast between HISTORIC *versus* ACCESS1 and CCSM4 climate was significant at $p = 0.005487$, whereas the second contrast between ACCES1 and CCSM4 was significant at $p = 0.0263$. The Management × Climate interaction effect was not significant at $p = 0.7$; thus, required no contrasts. MSE (based on probabilities ≤ 1) for Management = 3.521, Climate = 0.011, Management × Climate = 0.001, and Error = 0.002.

At year 2077, pre-planned contrasts were significant at $p < 0.0001$ for Minimum vs. Preferred, but non-significant at $p = 0.543281$ for Climate effect and the Management × Climate interaction ($p < 0.76$). MSE for Management = 5.057, Climate 0.002, Management × Climate = 0.001, and Error = 0.003.

Spatial Habitat Suitability Deviations Under MINIMUM MANAGEMENT Scenarios

While non-spatial average differences were small, but significantly different, among climate scenarios in 2047, and absent in 2077, a visual examination of maps showing where habitat improved or degraded in the absence of active management, relative to the MINIMUM+HISTORIC scenario from the same year, was more interesting (Figure 25).

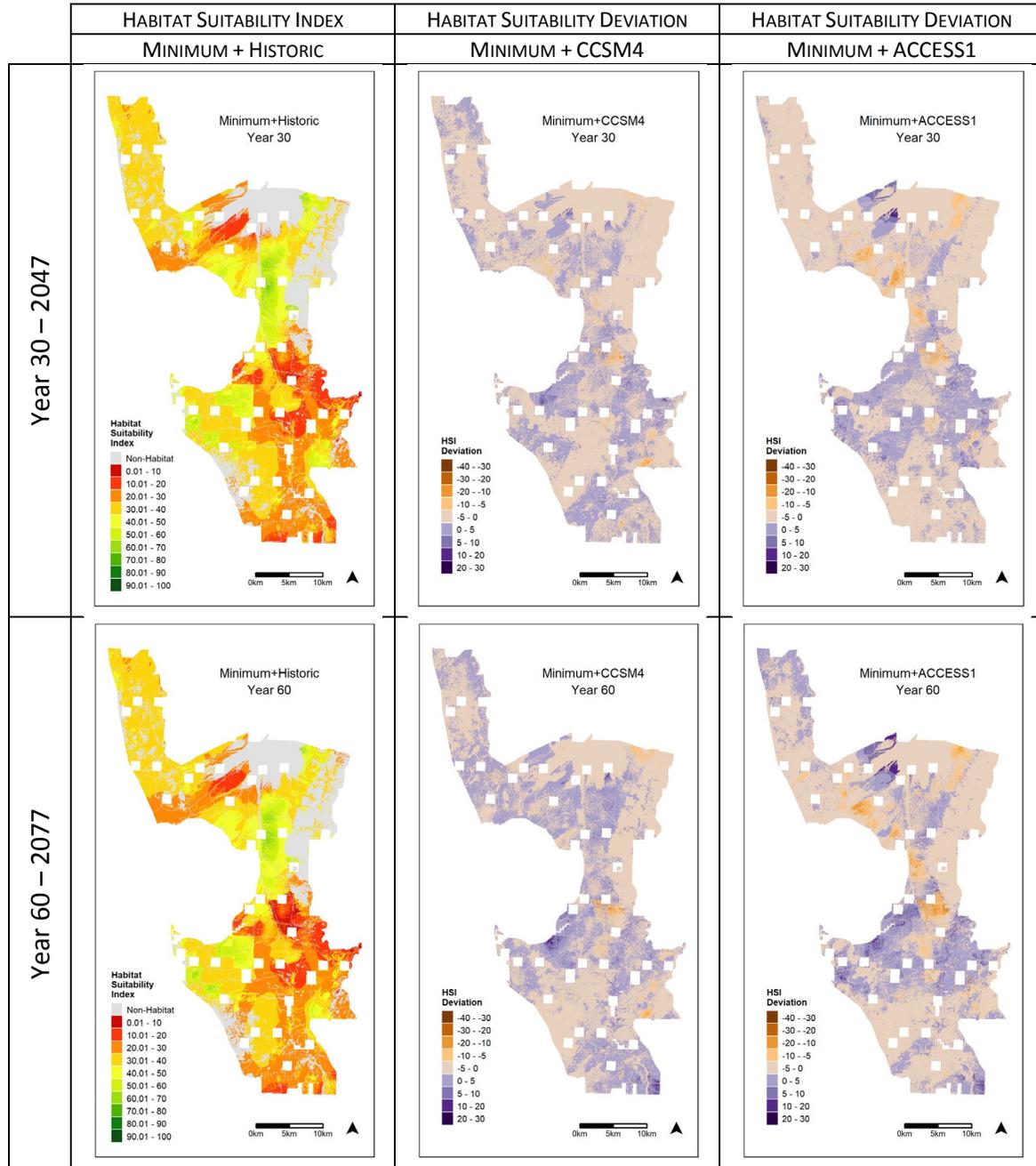


Figure 25. Habitat suitability for greater sage-grouse in the Pine Valley - Mountain Home Range project area in 2047 (Year 30) and 2077 (Year 60) for the MINIMUM+HISTORIC scenario, and deviation from those standards of the MINIMUM+CCSM4 and MINIMUM+ACCESS1 scenarios.

Areas of sage-grouse habitat improvement under MINIMUM MANAGEMENT (purple color palette for deviations in Figure 25) were distributed throughout the project area, although differences were observed between climates and between years 2047 and 2077. Most deviations from HISTORIC Climate were less than 5 in absolute value. The pattern of improvements matched closely the higher frequencies of fire in areas of tree encroachment and lower fire frequencies in areas not already harboring trees (Figure 26). The variation between years 2047 and 2077 appeared to be related to whether the periods of greater fire activity occurred before or after 2047. Habitat suitability improvements were more pronounced for ACCESS1 than CCSM4 in the north-central boundary areas and in the central-western boundary, as fire frequency was generally lower everywhere for ACCESS1. Therefore, preservation of standing sagebrush benefitted sage-grouse habitat.

Conversely, areas of habitat degradation varied between CCSM4 and ACCESS1 LOCAs relative to the HISTORIC Climate. For the ACCESS1 LOCA, areas of degradation were closer to the lek nearest to the Indian Peak Wildlife Management Area (Figure 25). The connection to fire was not obvious, because some degradation was in frequently burned zones, but other areas of degradation were not (Figure 26). For the CCSM4 LOCA, habitat degradation was more diffuse, with more pronounced areas of degradation in the center of already poor habitat according to the HISTORIC Climate, and also apparent in the northeast corner at the base of the Wah Wah Range. While the former is not clearly related to fire, the latter is found in or near the area of more frequent fire activity (Figure 26).

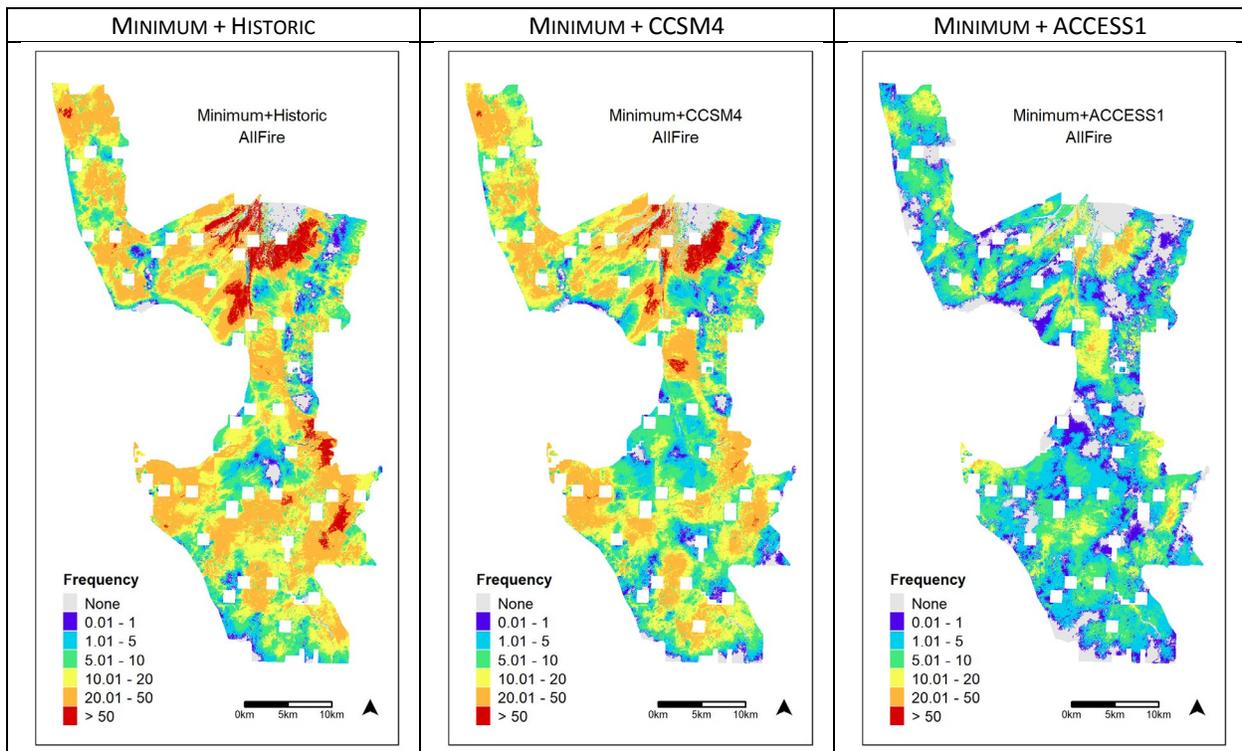


Figure 26. Fire frequency expressed as the number of fire events per pixel out of 600 possible events (10 replicates × 60 years) in all three MINIMUM MANAGEMENT scenarios. Gray areas never burned. Legend: blue is one fire event (i.e., essentially no fire); yellow is 10 to 20 fire events (i.e., about one event per 60-year replicate); and red is >50 fire events.

Spatial Habitat Suitability Deviations Under PREFERRED MANAGEMENT Scenarios

Improvements to sage-grouse habitat suitability achieved with PREFERRED MANAGEMENT scenarios were expressed as deviations from the MINIMUM+HISTORIC scenario, at years 2047 (Figure 27) and 2077 (Figure 28). The patterns of habitat improvement and degradation deviations were nearly opposite between MINIMUM and PREFERRED MANAGEMENT scenarios (Figure 25 above vs. Figures 27 and 28 below). Furthermore, spatial differences among preferred scenarios were barely detectable between PREFERRED+HISTORIC and PREFERRED+CCSM4, but noticeable between PREFERRED+ACCESS1 and the other scenarios as suggested by the statistical result in Table (34).

In both future years, it was noticeable that areas of degradation matched areas of habitat suitability <40 where the habitat suitability dynamic multiplier would have prevented or reduced the likelihood of treatment implementation. Therefore, while fires improved habitat in the absence of active management (previous MINIMUM MANAGEMENT results), further benefits were not accrued in the same general areas of poor value to sage-grouse because additional management actions of intensive tree removal or seeding in non-native annual grasslands were prevented.

Areas of improved habitat suitability were scattered in the central and northern portions of the landscape. The more significant one was in the central part (where Pine Valley Road meets Cougar Spar Road) where the habitat suitability dynamic multiplier would have directed intensive treatment implementation to zones of intermediate habitat suitability. The improvements grew in magnitude as more treatments or treated vegetation matured from 2047 to 2077.

It is noteworthy that areas of improvement in Figures 27 and 28 corresponded to areas of lower fire frequency in the central portion and northeast corner of the project area (Figure 29), perhaps as a result of fire-resistant seedings being aggressively implemented during the first 25 years of simulations, and moderate fire frequency in the north-central boundary area.

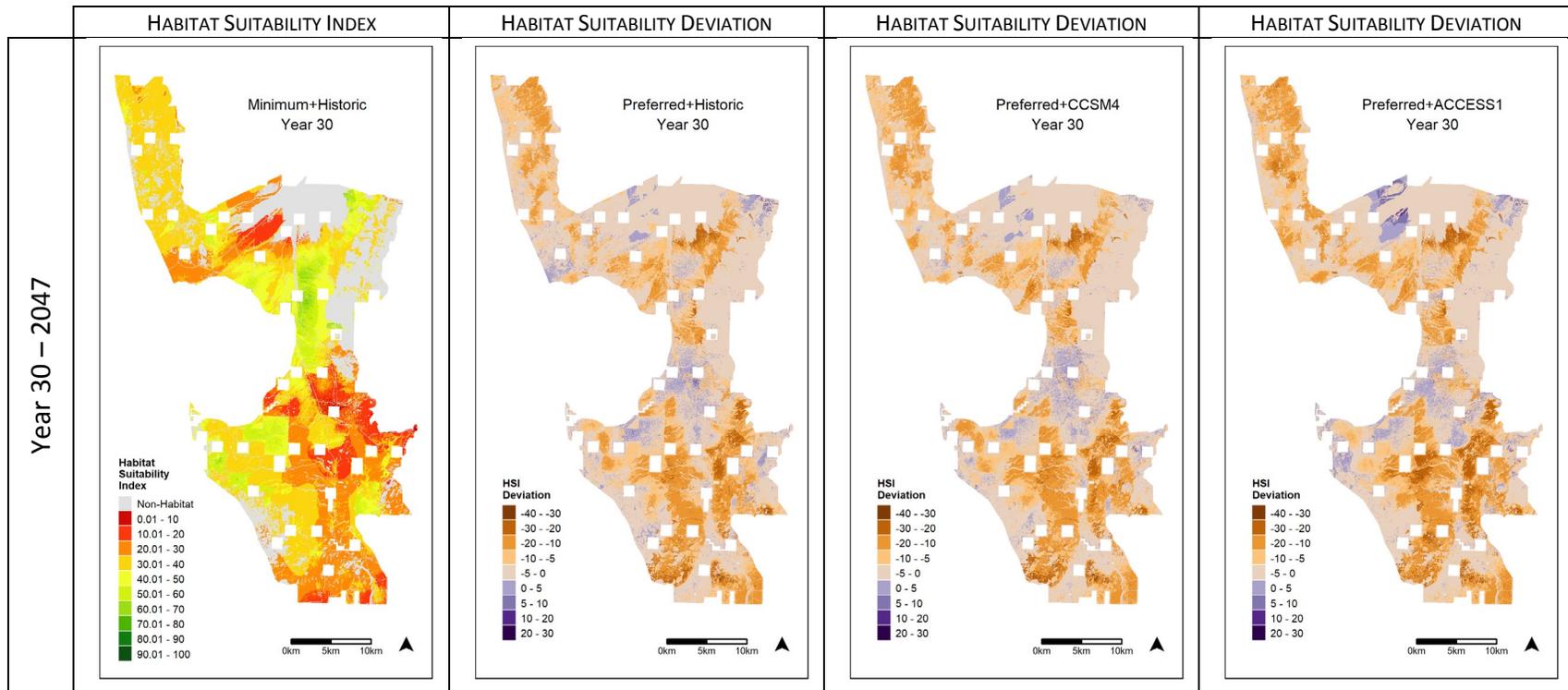


Figure 27. Habitat suitability for greater sage-grouse in the Pine Valley - Mountain Home Range project area in 2047 (Year 30) for the MINIMUM+HISTORIC scenario, and deviation from that standard of the PREFERRED+HISTORIC, PREFERRED+ACCES1, and PREFERRED+CCSM4 scenarios.

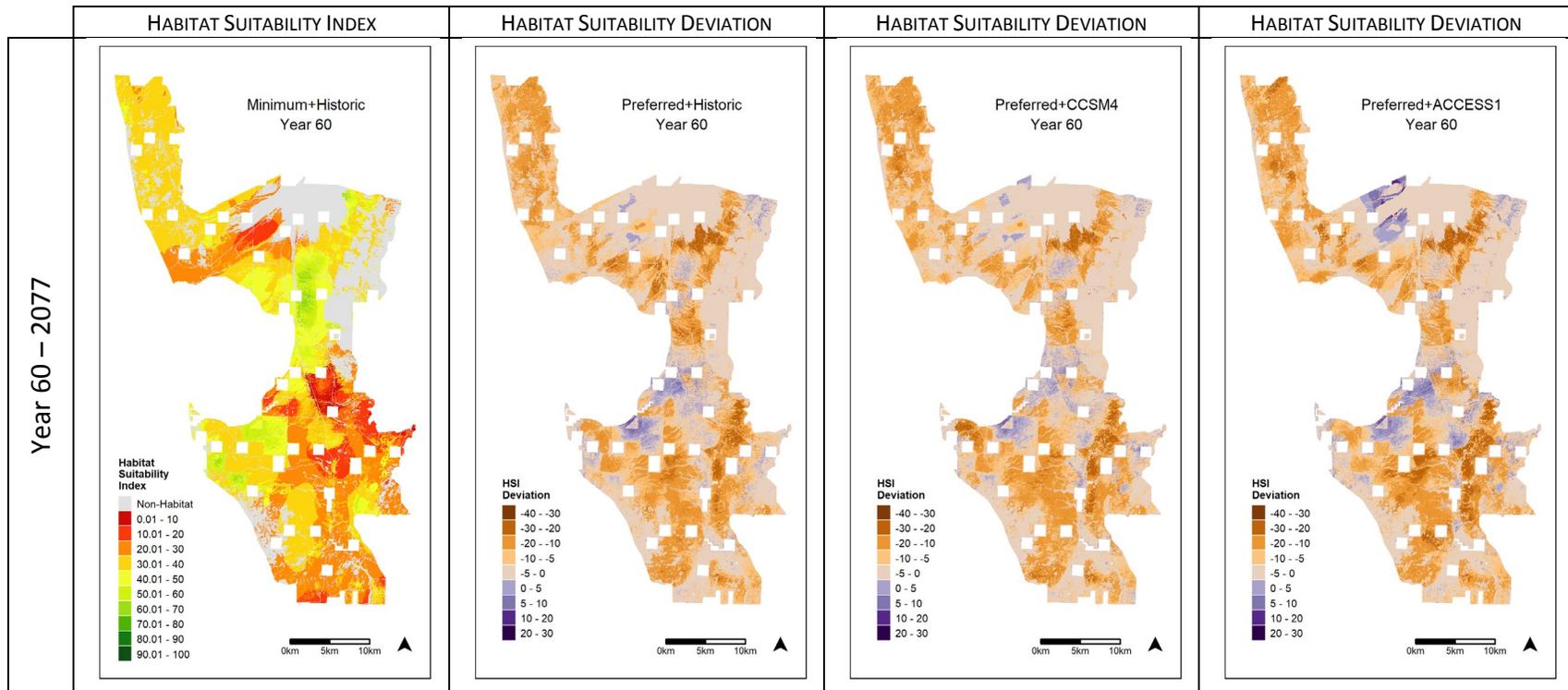


Figure 28. Habitat suitability for greater sage-grouse in the Pine Valley - Mountain Home Range project area in 2077 (Year 60) for the MINIMUM+HISTORIC scenario, and deviation from that standard of the PREFERRED+HISTORIC, PREFERRED+ACCES1, and PREFERRED+CCSM4 scenarios.

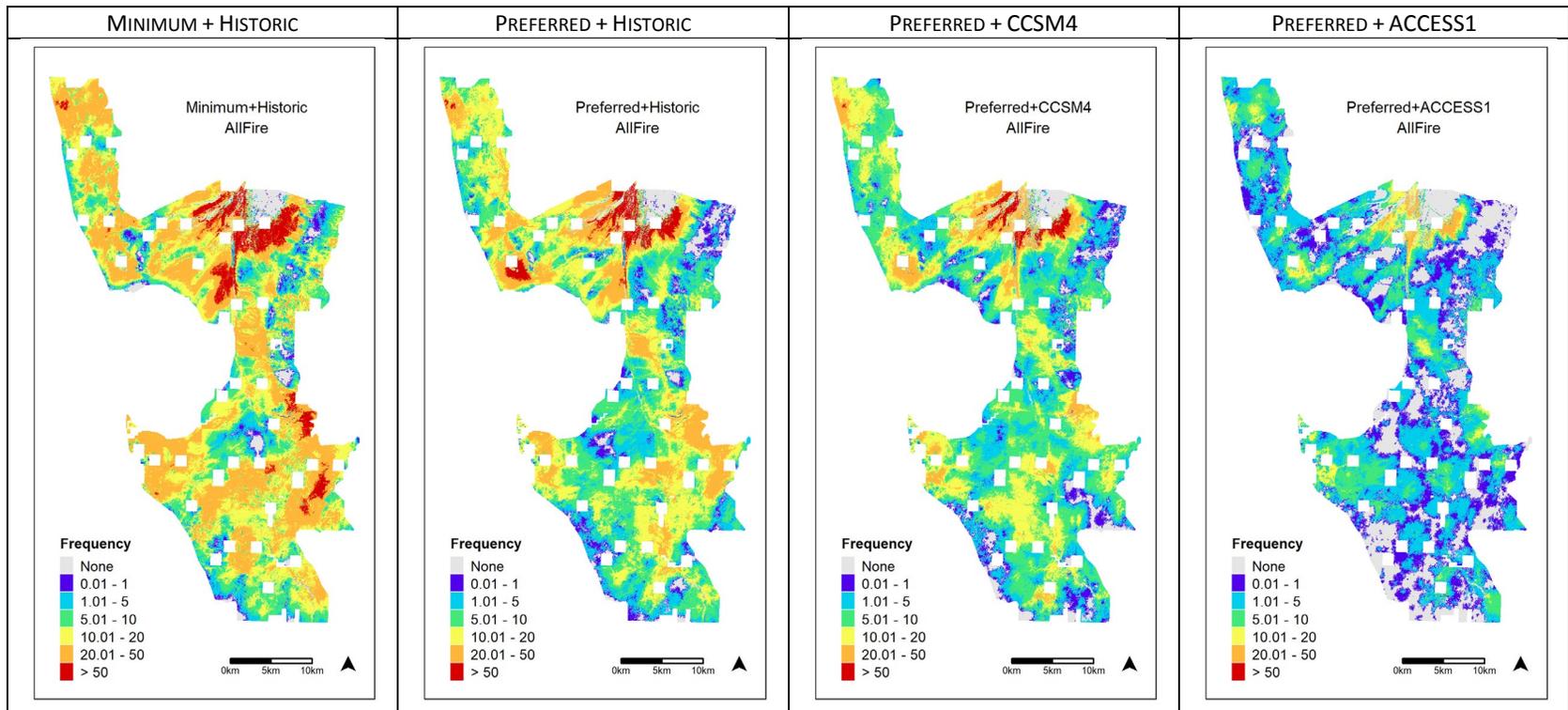


Figure 29. Fire frequency expressed as the number of fire events per pixel out of 600 possible events (10 replicates × 60 years) in the MINIMUM+HISTORIC and all three PREFERRED MANAGEMENT scenarios. Gray areas never burned. Legend: blue is one fire event (i.e., essentially no fire); yellow is 10 to 20 fire events (i.e., about one event per 60-year replicate); and red is >50 fire events.

Land Management Actions

This section displays maps of simulated management actions and the number of times actions were applied out of 600 possible events (60 years per replicate × 10 replicates). While the goal is not to explain the locations of implementation, the treated ecological system and vegetation classes are noted for the benefit of managers. Managers will receive in digital format the geospatial products for these actions.

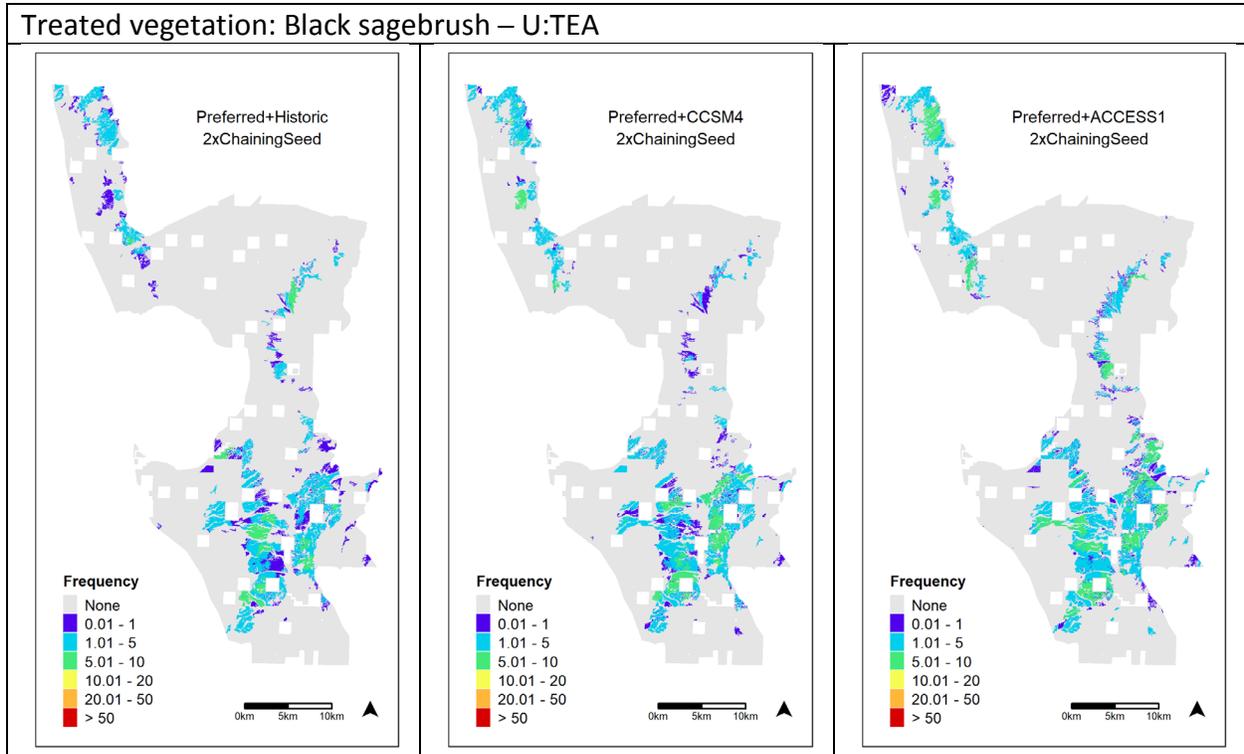


Figure 30. Implementation of chaining, followed by seeding and a second chaining to imprint seed into the ground (2×Chaining+Seed) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Montane sagebrush steppe and Wyoming big sagebrush – U-A:Annual species, E:Closed, and U-C:Depleted

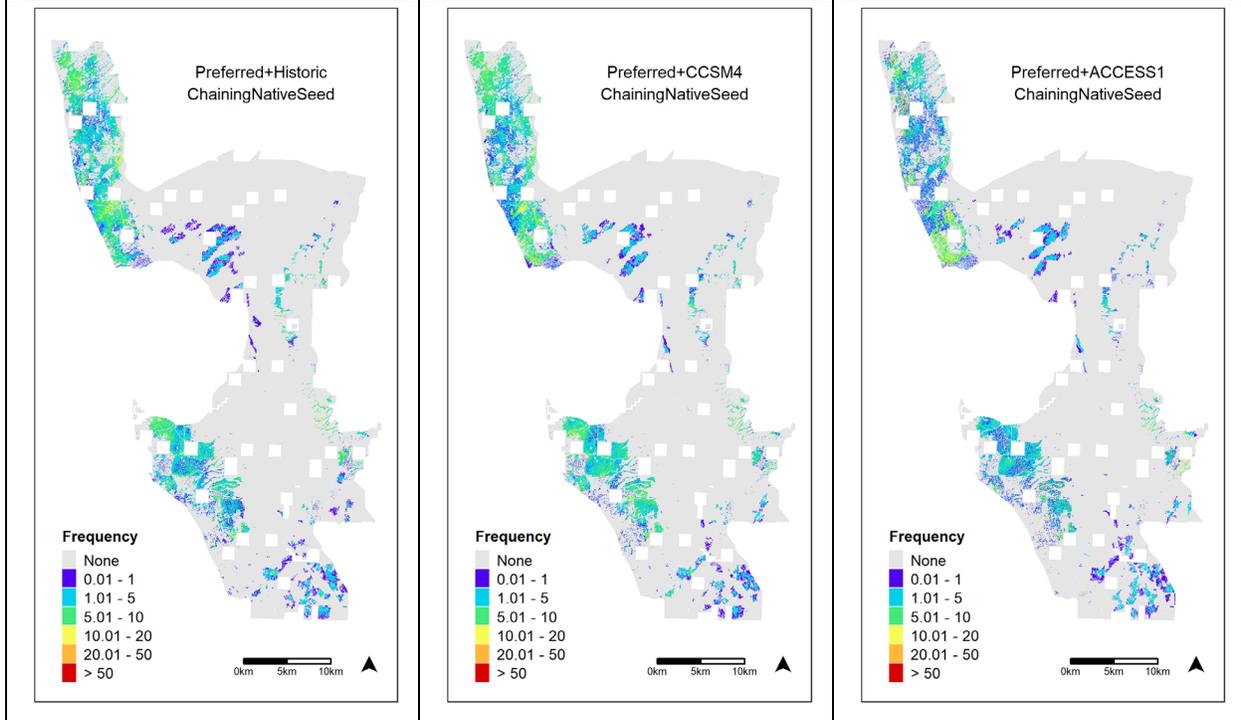


Figure 31. Implementation of native species seeding followed by one-way chaining to imprint seed into the ground (Chaining+Native-Seed) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Black sagebrush and Wyoming big sagebrush – U:Annual-Species, U:SAP-A, U:SAP, and U:SA

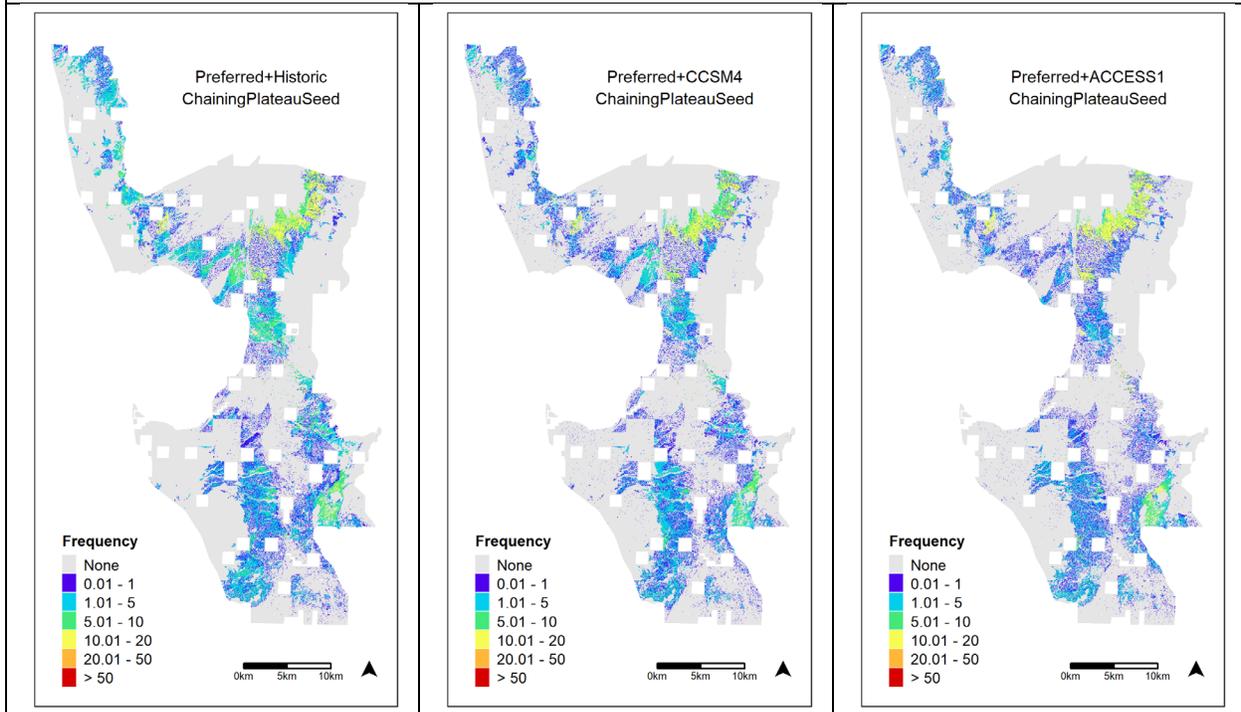


Figure 32. Implementation of chaining, followed by spraying of the herbicide Imazapic (Plateau®), and seeding (Chaining+Plateau+Seed) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated Vegetation: Aspen woodland – C:Closed, D:Open, U:Depleted-D; Black sagebrush – D:Open, U:Depleted, U:SA, U:SAP, U:SI-D, U:SI-D+AG; Pinyon-Juniper – C:Open, D:Open, U:TEA; Ponderosa Pine – B:Closed, C:Closed; Stansbury Cliffrose – C:Open; Utah serviceberry – D:Open, U:SI-D, TEA

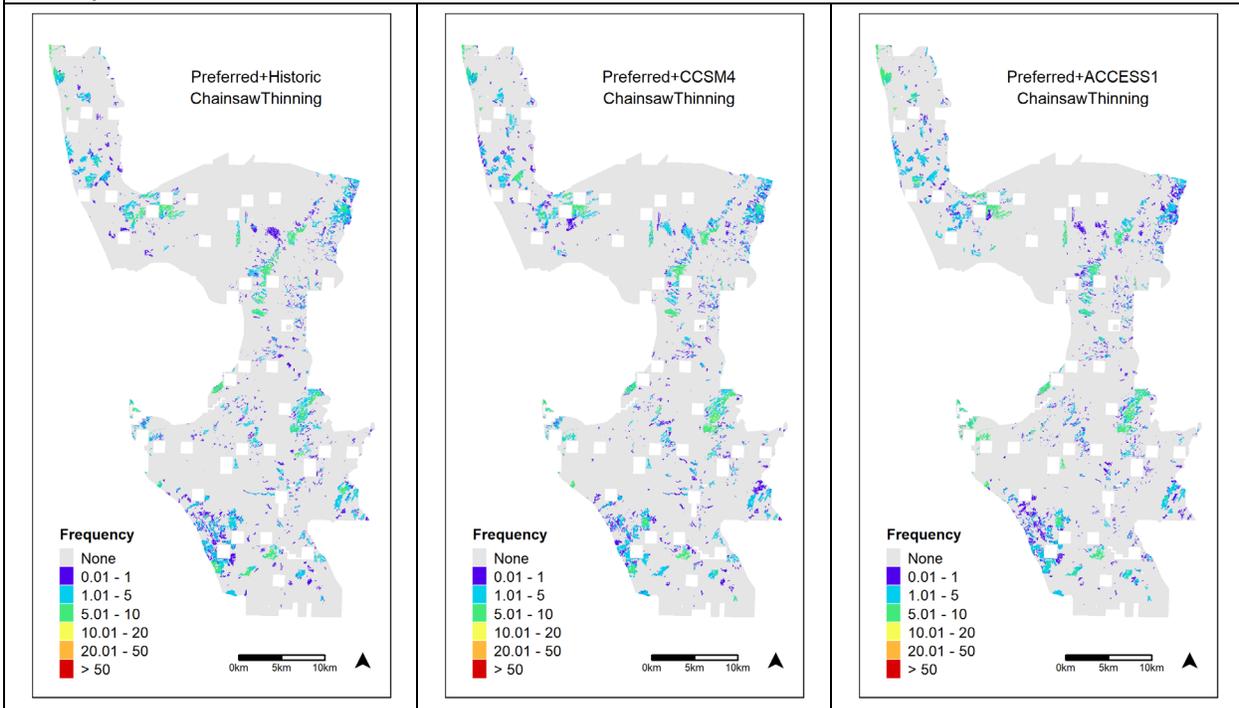


Figure 33. Implementation of chainsaw thinning expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Black sagebrush, Montane sagebrush Steppe, Wyoming big sagebrush – U:SI-A, U:SI-A+AG, U:SI-B, U:SI-B+AG, U:SI-C, U:SI-C+AG

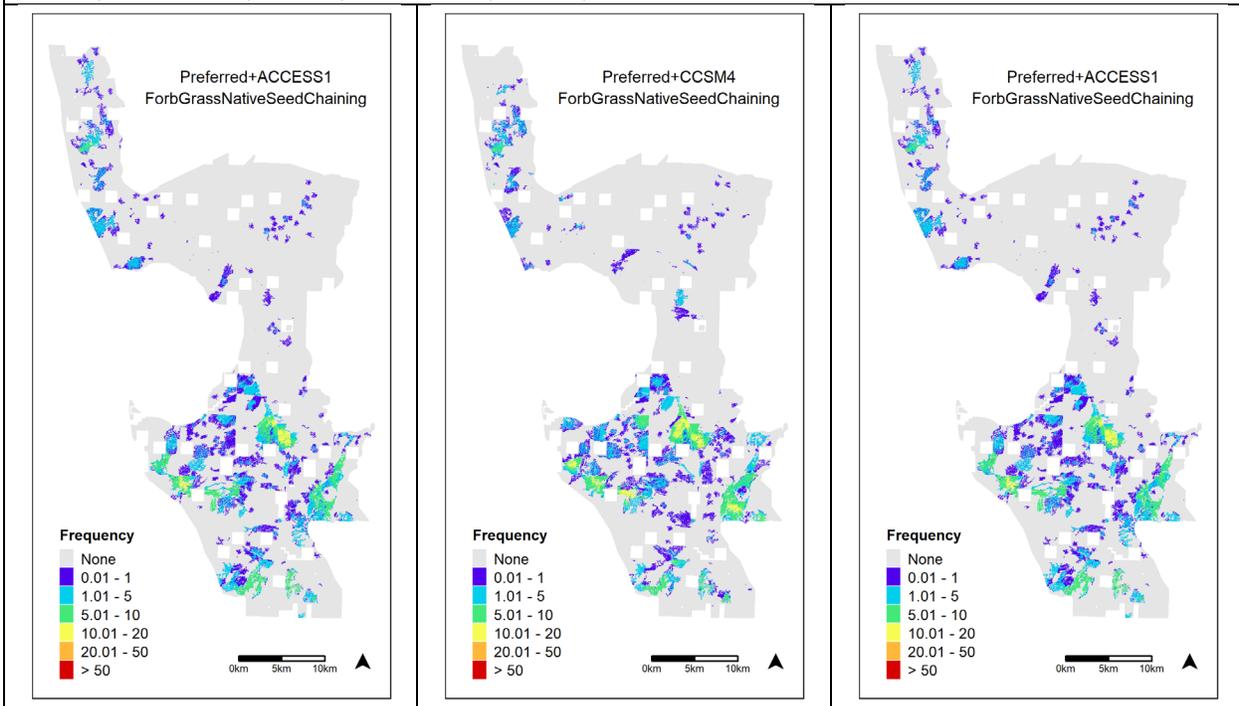


Figure 34. Implementation of native grass and forb species seeding followed by chaining (Forb-Grass-NativeSeed+Chaining) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated Vegetation: Black sagebrush – U:Annual Species

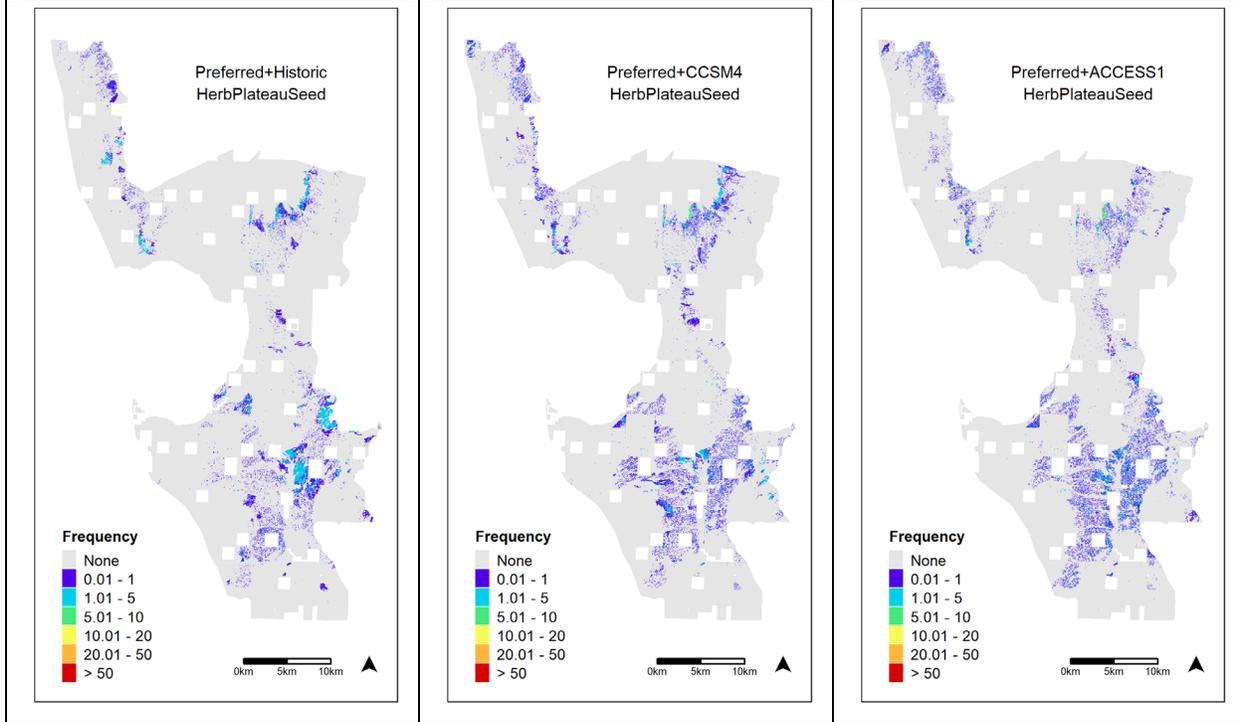


Figure 35. Implementation of spraying of the herbicide Imazapic (Plateau®) followed by seeding (Herbicide+Plateau+Seed) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Wyoming big sagebrush – U:SAP, U:SAP+, U:SI-D+AG, U:TEA

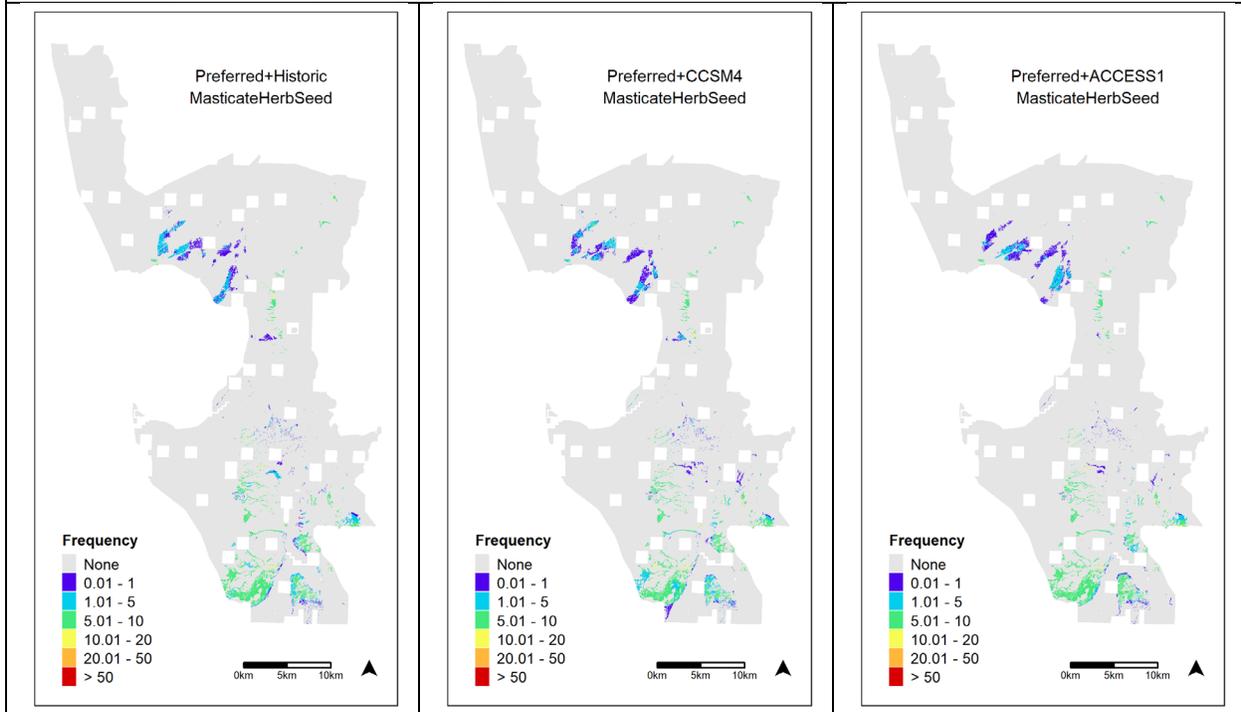


Figure 36. Implementation of mastication followed by spraying of the herbicide Imazapic (Plateau®) and seeding (Masticate+Herbicide+Seed) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Pinyon-Juniper – D:Open

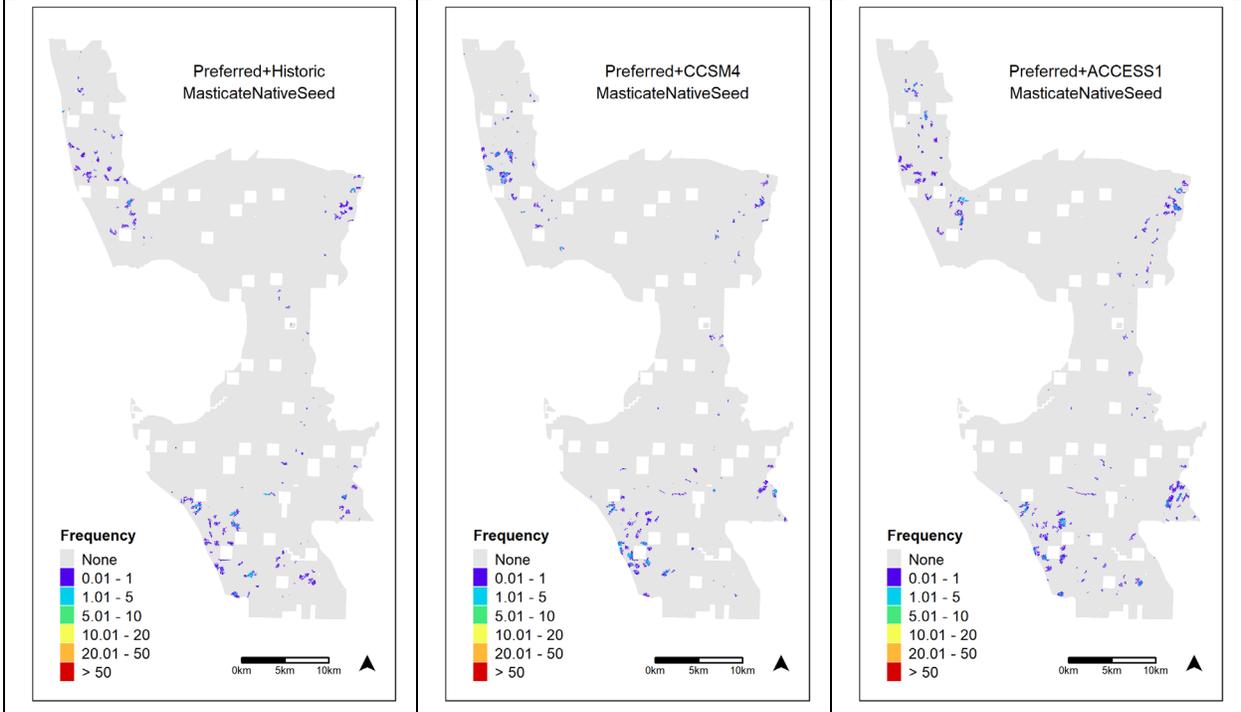


Figure 37. Implementation of mastication followed by native species seeding (Masticate+NativeSeed) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Ponderosa pine – U:FIC-B-Open, U:FIC-B-Closed, U:FIC-C-Closed, U:FIC-C-Open

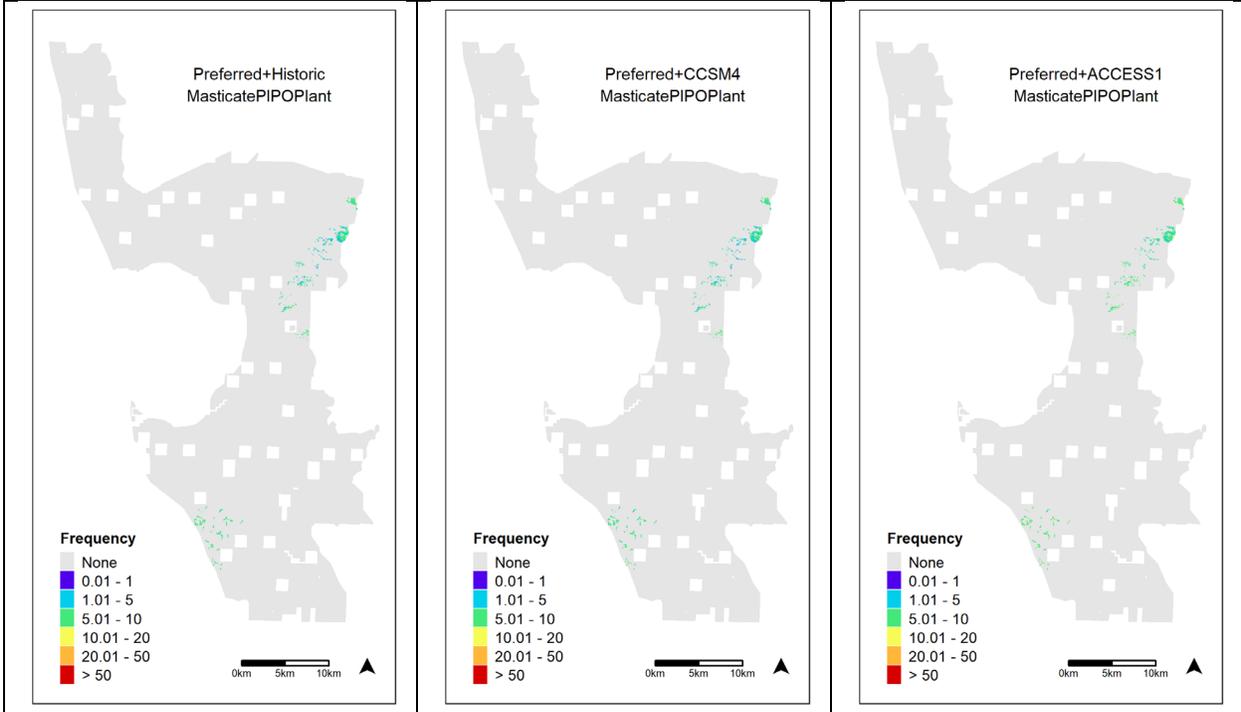


Figure 38. Implementation of mastication of fire-intolerant conifers followed by planting of ponderosa pine seedling plugs (Masticate++PIPO-Planting) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Black sagebrush, Montane sagebrush steppe – U:SI-D, U:SI-D+AG, U:TEA

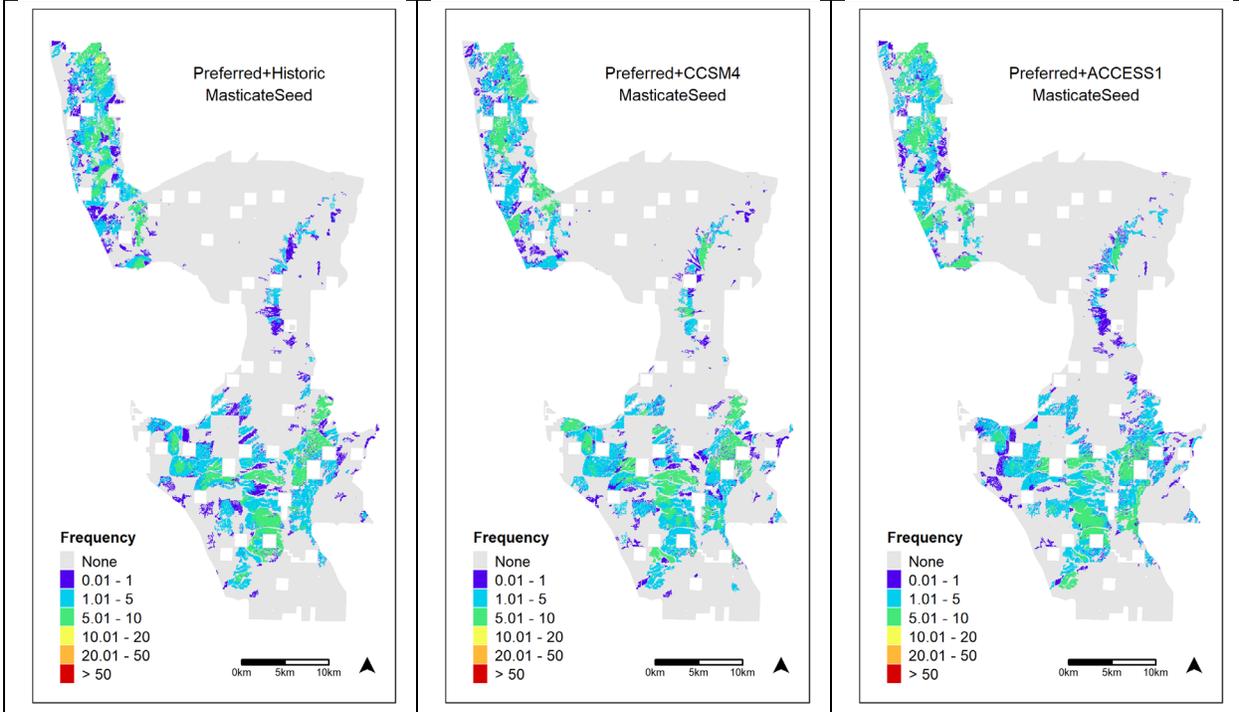


Figure 39. Implementation of mastication followed by seeding (Masticate+ Seed) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Montane sagebrush steppe, Wyoming big sagebrush – D:Open, U:Depleted, U:SA, U:SA+, U:SAP, U:SAP+, U:SI-D, U:SI-D+AG

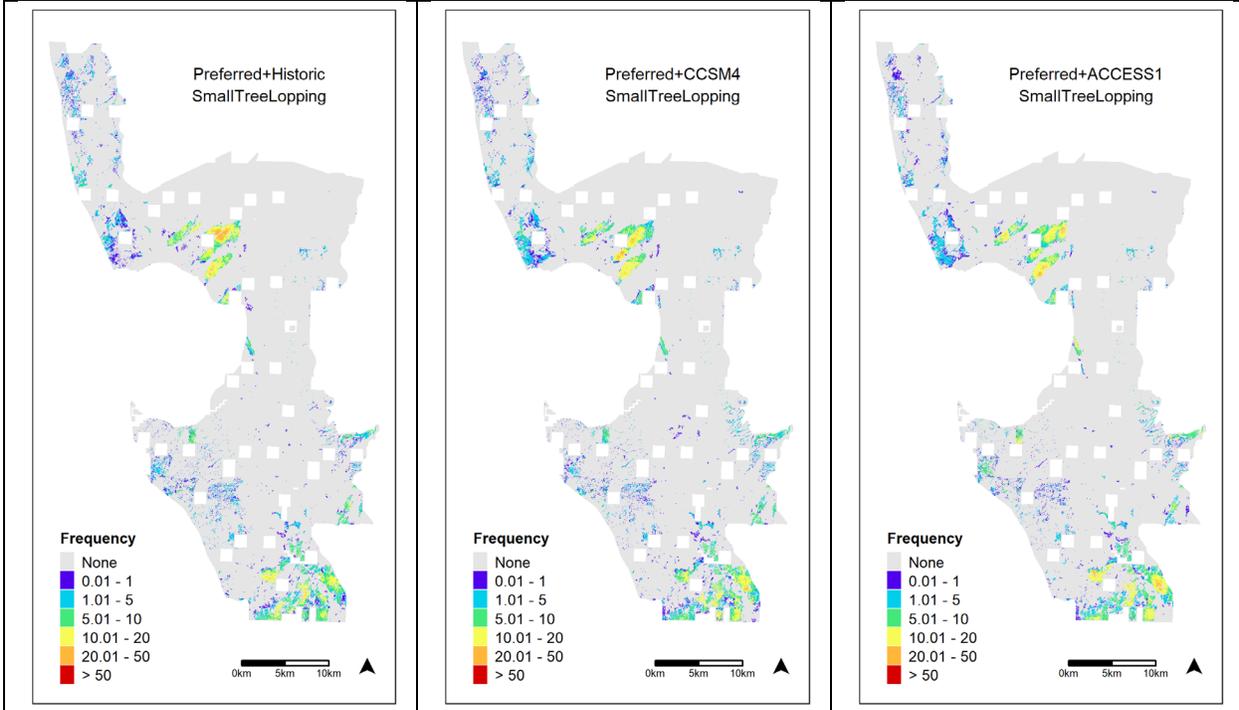


Figure 40. Implementation of small tree cutting with loppers and small chainsaws (Small-Tree-Lopping) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Calcareous grassland – U:SAP

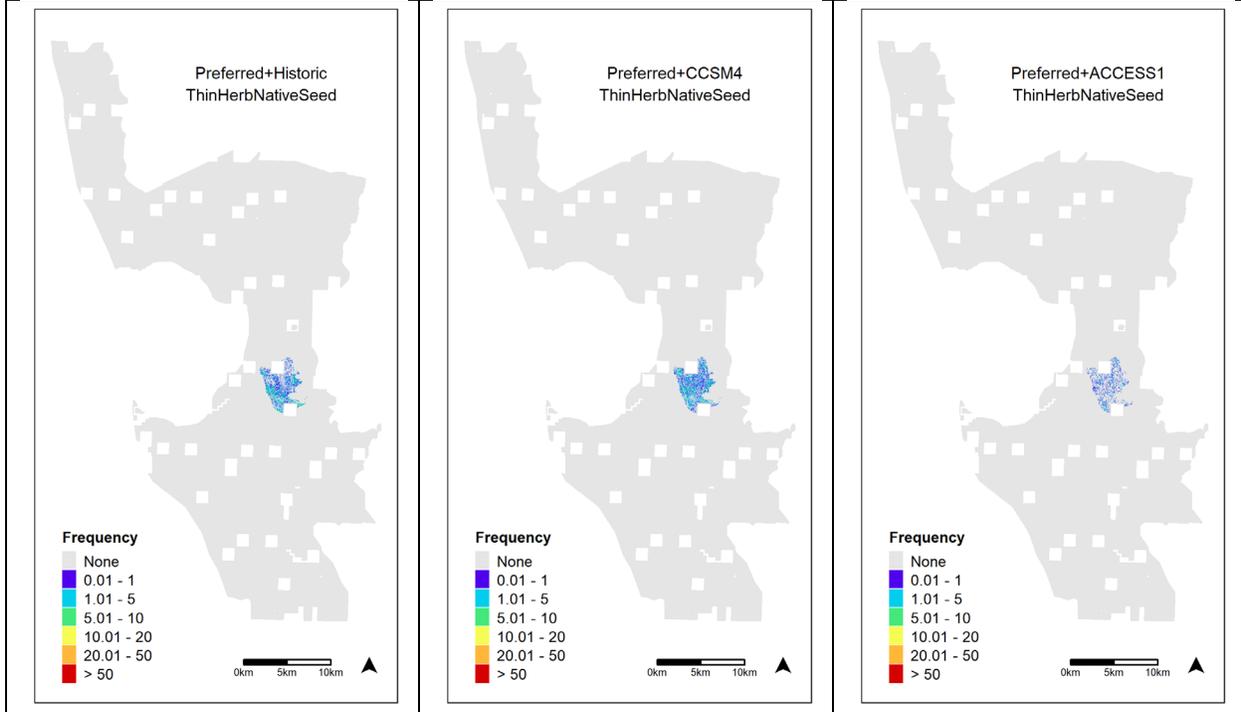


Figure 41. Implementation of mower thinning followed by spraying the herbicide Imazapic (Plateau®) and native species seeding (Thin+Herbicide+Native-Seed) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Treated vegetation: Montane riparian – A:All, B:Open, C:Closed, U:SFE; Wet meadow – A:open, B:Closed, C:Open, U:Hummocked, U:SFE

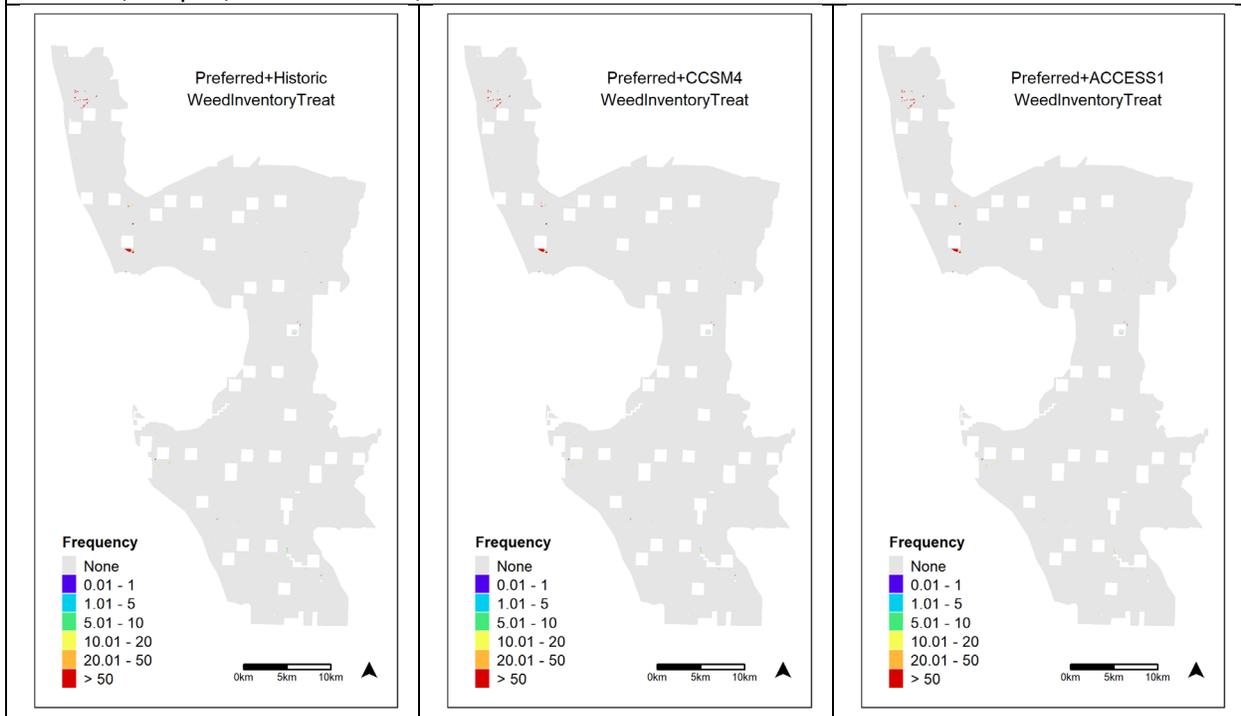


Figure 42. Implementation of periodic weed surveys of wet areas with possible spot-spraying of small weed patches (Weed-Inventory+Spot-Treatment) expressed as the number of events per pixel out of 600 possible events (10 replicates × 60 years).

Key Findings and Conclusions

Two levels of analysis addressed: (1) system-specific vegetation responses to management, and (2) landscape-level estimation of greater sage-grouse habitat suitability. Statistically, management level effects generally were stronger than climate scenario effects. In part, this was caused by our choice to compensate under budget limitations among climate scenarios to maintain key vegetation class results expected under HISTORIC Climate (i.e., forecasted PRISM climate series) for the priority systems on which sage-grouse most depend.

Vegetation

- Twenty-five ecological systems were found and mapped in 2017. The largest was black sagebrush (82,210 acres), and the smallest was Stansbury cliffrose (11 acres). The three largest systems were all sagebrush shrublands: black sagebrush, Wyoming big sagebrush-upland soils (51,760 acres), and montane sagebrush steppe (44,145 acres).
- New models were built for two systems: calcareous grassland (920 acres; tentatively-named unresearched grassland), and little-leaf mountain mahogany (2,328 acres). The calcareous grassland system had never been observed before. The little-leaf mountain mahogany system had been observed before in nearby landscapes, but only as very small occurrences (<10 acres total), and it was previously subsumed in another model. But little-leaf mountain mahogany was found in large areas of the Wah Wah Range and therefore needed its own model in the PV-MH landscape.
- In addition to little-leaf mountain mahogany, the extents of four-wing saltbush (211 acres), semi-desert grassland (3,254 acres; on sandy soils), juniper savanna (400 acres), and winterfat (18,318 acres; on silty soils) were unusually greater than what we had observed elsewhere (with the exception of juniper savanna that is also found in the southern part of the Black Mountains).
- Wet meadows, which are critical to sage-grouse brood rearing, occupied 63 acres. However, several meadows were far from the only lek near the center of the study area west of the Pine Valley Road. As a result, wet meadows distant from the lek could not contribute to chick rearing (Gibson et al. 2017; Kane et al. 2017).
- In 2017, Unified Ecological Departure (UED) calculations showed that eighteen systems were highly departed, six systems were moderately departed, and one system (juniper savanna) was slightly departed from reference conditions (i.e., the natural range of variability, NRV).
- Twelve ecological systems were selected for active management based on future decline without management, wildlife management priority, and cultural/social reasons. The twelve are aspen woodland, black sagebrush, calcareous grassland, montane riparian, montane sagebrush steppe, pinyon-juniper woodland, ponderosa pine, semi-desert grassland, Stansbury cliffrose, Utah serviceberry, wet meadow-montane, and Wyoming big sagebrush. The pinyon-juniper woodland was the only system selected for cultural (pine nut harvesting) and social (fire risk) reasons.

- Without additional active management (i.e., under the MINIMUM MANAGEMENT scenario), all but four systems (aspen woodland, pinyon-juniper woodland, ponderosa pine, and Utah serviceberry) became increasingly departed from reference conditions by 2077.
- Large occurrences of black sagebrush and Wyoming big sagebrush in reference condition were found in the central part of the landscape (from Jackson Wash Road area to Cougar Spar and Jockey Road area).

Ecological System Management

- PREFERRED MANAGEMENT scenarios decreased the departure from reference conditions (reduced UED) for ten of the twelve focal ecological systems. Reduction in departure was counter-intuitively achieved using seedings composed of native and introduced grass species, which are uncharacteristic classes of vegetation that increase departure from reference conditions above a fixed management threshold. Investment in improved native species seeding success would greatly reduce departure from reference conditions. The two systems whose departure from reference conditions increased (greater UED) were ponderosa pine and Stansbury cliffrose.
- In ponderosa pine, restoration of historically logged stands was successful using mastication of fire-sensitive conifers (other than ponderosa pine) and curl-leaf mountain mahogany, followed by planting ponderosa pine plugs. However, the area of chainsaw thinning to open up closed stands was too small compared to the large proportion of new plantings that followed a closed-canopied fire-suppressed succession pathway (by unintentional design). This closed-canopied succession was the cause of greater departure, compounded by an untested key, probably erroneous, model assumption that allowed wildfire to naturally “restore” the fire-sensitive conifer class (thus giving an edge to MINIMUM MANAGEMENT scenarios). This model assumption needs to be revised.
- While Stansbury cliffrose was improved according to its management objective, the estimation of UED for this small system of 11 acres could be biased because a single management action or natural disturbance could shift all the vegetation to a different class, thus causing the scale-dependent departure observed.
- Black sagebrush restoration resulted in the largest expenditure of about \$12 million, mostly incurred from 2020 to 2034. The second and third largest expenditures were for montane sagebrush steppe (about \$7 million, after year 2034), and for Wyoming big sagebrush (about \$5.6 million, mostly in years 2020 to 2034). Successful restoration of tree-encroached shrublands and non-native annual grasslands accounted for most of the area treated and money spent in these three sagebrush systems. Chainsaw thinning and lopping of young conifers, and native species improvements to older seedings, were additional actions that were less extensive and expensive.
- Forecasted tree removal included the use of about 1.5 times more mastication than two-way chaining, compared to using nearly only two-way chaining in Hamlin Valley and the Black Mountains (Provencher et al. 2018). Because mastication is considerably more expensive than chaining, and chaining often provides equal or better ecological outcomes compared to

other mechanical methods (Tausch and Tueller 1977, Provencher and Thompson 2014), this resulted in less restoration for all systems within the budgetary limits.

- Three other systems had moderately sizable expenditures: aspen woodland at \$1.1 million (mostly from 2020 to 2034), ponderosa pine at \$0.9 million (mostly from 2035 to 2044), and wet meadow-montane at \$0.71 million (from 2020 to 2077). Actions in these systems used fencing (aspen and wet meadow) and mastication (ponderosa pine) that had very high costs per area, applied to small areas.
- The smallest amounts of funding were devoted to improving mule deer habitat suitability in the very small Stanbury cliffrose and Utah serviceberry systems. These low-hanging-fruit projects could be achieved with chainsaws in one or a few days.
- The two grasslands (semi-desert and calcareous) shared similar uncharacteristic vegetation classes, probably caused by decades of preferential grazing, that required similar solutions to increase grass content and reduce woody cover of early-successional shrubs. The costs of restoration were modest, and the terrain on which actions would be applied is smooth and on gentle slopes.
- Thinning of conifers in pinyon and juniper stands for cultural and social reasons was surprisingly expensive at about \$515,000. This number may be over-estimated because we found that juniper woodlands (not juniper savanna) were a large fraction of the area of pinyon-juniper woodlands, whereas it was likely that pinyon dominance was targeted. We recommend that land managers inspect stands before taking action because pinyon may be absent, and we rarely found dense stands of true pinyon woodland. Moreover, many pinyon stands were on steep and rocky slopes where only chainsaws can be used.
- Montane riparian should be viewed as a maintenance system where the primary action was to control noxious weeds. The set of actions also included the experimental action “Water-Table-Uplift” that includes substitutable inexpensive actions in the form small rock dams and beaver dam analogs to stop incisions and reconnect the water table to the floodplain (Clothier and Zeedyk, 2014). Inspection of incisions would be important to tailor the needed water-table-uplift action to the severity of the incision and gradient of the stream.
- About 37,000 acres were forecasted to be seeded with a mix of native and introduced species, and 4,000 acres forecasted to be seeded with a mix of only native species. For every acre successfully seeded, about 0.2 - 0.3 acres were seeded but assumed to fail, not including the loss to herbivory and drought. Also, a small fraction of the successfully seeded mixed introduced and native species areas theoretically became invaded, but not dominated, by non-native annual species, especially during wetter years.
- Climate scenarios had strong but different effects among ecological systems on the fate of vegetation classes. The ACCESS1 LOCA was clearly the driest of climate scenarios. As a result, this scenario’s dryness reduced overall fire activity, which caused a greater forecasted retention of tree-encroached shrublands and late-successional shrubland classes without trees, compared to the HISTORIC Climate and the CCSM4 LOCA. In addition, the ACCESS1 LOCA caused greater initial failure of seeding establishment, but greater preservation of late-successional classes of established seedings. For instance, about 5,000 acres less of mixed native and introduced species seedings successfully established in black sagebrush in the ACCESS1 LOCA than in the other climate scenarios.

- The CCSM4 LOCA often showed intermediate effects on vegetation classes between the ACCESS1 LOCA and the HISTORIC Climate. In several cases, the CCSM4 LOCA and the HISTORIC Climate produced indistinguishable outcomes for vegetation classes. Moreover, we compensated with implementation rates of management actions for climate differences. Therefore, as in the previous report (Provencher et al. 2018), we recommend that land managers choose the levels of implementation we forecasted for the CCSM4 scenario as a path for the future. CCSM4 also had spring and summer rains that land managers depend on for successful seeding. The ACCESS1 LOCA represented a worst-case scenario for land managers. Table 35 below summarizes recommended actions for the CCSM4 scenario.

Greater Sage-Grouse

- In 2017, the average sage-grouse habitat suitability index was 39.87%. Without management, the habitat suitability index declined to 25.5% after 30 years (2047), and to 24.8% after 60 years (2077).
- PREFERRED MANAGEMENT significantly increased the average habitat suitability index by about 4% and 5%, respectively, compared to the MINIMUM MANAGEMENT scenario in years 2047 and 2077 (i.e., comparing within the same year).
- Average climate effects on the habitat suitability index were significantly different, but small (<1) compared to management effects, only in year 2047. The ACCESS1 LOCA had the highest suitability value as a result of reduced fire activity, whereas the HISTORIC Climate and CCSM4 LOCA were not different.
- While overall the single area-wide value of the habitat suitability index decreased over time with MINIMUM MANAGEMENT, maps of the index showed large areas of improvement and a few focused areas of degradation within the years 2047 and 2077. Improvement and degradation areas were highest for the ACCESS1 LOCA compared to the other climate scenarios. Variation in frequency of wildfire activity appeared to explain results, with low fire frequencies increasing the index and higher frequencies decreasing the index.
- With additional management (PREFERRED MANAGEMENT) that increased (improved) the average habitat suitability index, maps showed that improvement areas were focused compared to widespread degradation areas where management was not a modeled priority, although still allowed. This pattern for the PREFERRED MANAGEMENT scenarios was the opposite observed for the MINIMUM MANAGEMENT scenarios. The largest area of improvement under management was in the central portion of the landscape near the intersection of the Pine Valley Road and Jackson Wash Road and westward. Important areas of improvement were also observed near the foothills of the Mountain Home Range in the northern portion of the study area. Again, the spatial layout of fire frequencies appeared to explain most patterns.

Table 35. Summary of realized implementation rates and costs of management actions in the 12 focal ecological systems, during 3 time periods under the PREFERRED+CCSM4 scenario.

Ecological System Treatment or Management Action	Cost/Acre	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
		2018-2034	2035-2044	2045-2077	
Aspen Woodland					
Chainsaw-Thinning	\$112.50	58.2	0.0	0.0	
Fence	\$10,000.00	115.7	0.0	0.0	
RxFire	\$300.00	44.6	2.1	50.0	
Cost →		\$1,177,047	\$620	\$14,992	\$1,192,659
Black Sagebrush					
2xChaining+Seed	\$202.50	9,649.5	0.0	0.0	
Chaining+Plateau+Seed	\$160.00	7,617.6	0.0	3,639.4	
Chainsaw-Thinning	\$112.50	2,752.1	0.0	0.0	
Forb+Grass-Native-Seeding+Chaining	\$160.00	1,954.1	0.0	0.0	
Herbicide-Plateau+Seed	\$117.50	2,195.1	0.0	0.0	
Masticate+Seed	\$577.50	12,968.0	0.0	0.0	
Cost →		\$11,542,028	\$0	\$582,311	\$12,124,339
Calcareous Grassland					
Thin+Herbicide+Native-Seed	\$180.00	0.0	591.7	0.0	
Cost →		\$0	\$106,503	\$0	\$106,503
Montane Riparian					
Exotic-Control	\$360.00	0.0	0.0	4.8	
Water-Table-Uplift	\$500.00	0.0	1.4	0.0	
Weed-Inventory+Treat	\$253.00	63.3	46.1	149.6	
Cost →		\$16,019	\$12,387	\$39,560	\$67,966
Montane Sagebrush Steppe					
Chaining+Native-Seed	\$205.00	0.0	3,289.0	10,500.0	
Forb+Grass-Native-Seeding+Chaining	\$160.00	0.0	3,453.0	0.0	
Masticate+Seed	\$577.50	0.0	6,404.8	0.0	
RxFire	\$100.00	401.6	110.7	191.2	
Small-Tree-Lopping	\$150.00	0.0	1,172.3	766.6	
Cost →		\$40,164	\$5,112,428	\$2,286,606	\$7,439,198

Ecological System Treatment or Management Action	Cost/Acre	Sum of Acres/Interval (Avg of 10 runs)			60-Year Total Cost
		2018-2034	2035-2044	2045-2077	
Pinyon-Juniper Woodland					
Chainsaw-Thinning	\$150.00	2,092.8	0.0	0.0	
Masticate+Native-Seed	\$617.50	0.0	326.5	0.0	
Cost →		\$313,923	\$201,640	\$0	\$515,563
Ponderosa Pine					
Chainsaw-Thinning	\$112.50	0.0	136.2	152.9	
Masticate+PIPO-Planting	\$1,120.00	0.0	750.6	0.0	
Cost →		\$0	\$859,675	\$38,213	\$897,888
Semi-Desert Grassland					
Thin+Herbicide+Seed	\$115.00	0.0	2,182.3	0.0	
Cost →		\$0	\$250,966	\$0	\$250,966
Stansbury Cliffrose					
Chainsaw-Thinning	\$112.50	0.0	13.5	0.0	
Cost →		\$0	\$1,521	\$0	\$1,521
Utah Serviceberry					
Chainsaw-Thinning	\$112.50	0.0	508.5	0.0	
RxFire	\$100.00	634.2	42.1	0.0	
Cost →		\$63,416	\$61,417	\$2	\$124,835
Wet Meadow-montane					
Exotic-Control	\$360.00	27.6	40.3	219.2	
Fence	\$8,000.00	94.9	23.6	51.3	
Water-Table-Uplift	\$500.00	0.0	23.4	11.3	
Weed-Inventory+Treat	\$253.00	204.0	145.0	511.6	
Cost →		\$270,346	\$114,784	\$326,863	\$711,993
Wyoming Big Sagebrush-upland					
Chaining+Native-Seed	\$205.00	1,140.4	0.0	0.0	
Chaining+Plateau+Seed	\$192.50	3,423.1	0.0	975.8	
Chaining+Seed	\$165.00	4,399.1	0.0	0.0	
Forb+Grass-Native-Seeding+Chaining	\$160.00	4,983.7	0.0	0.0	
Masticate+Herbicide+Seed	\$605.00	3,958.2	0.0	0.0	
Small-Tree-Lopping	\$75.00	4,927.0	853.1	2,547.7	
Cost →		\$5,180,255	\$63,983	\$378,918	\$5,623,156

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Appendices

Appendix 1

Descriptions of Ecological Systems (Biophysical Settings) and their Vegetation Classes BLM Cedar City Field Office: Pine Valley-Mountain Home Range

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Agriculture 10070	<i>Overview:</i> Agricultural lands and obvious irrigated pastures where soils may have been graded or modified.
U:Agriculture 100070122	Agriculture: Irrigated pastures, crops, alfalfa fields.

Aspen-Mixed Conifer (ASM) 10610	<i>Overview:</i> The Aspen-Mixed Conifer BpS is perhaps the most widespread aspen type in Utah and is commonly called “seral aspen.” <i>Populus tremuloides</i> is the dominant tree species, except in late succession where prolonged fire exclusion and ungulate herbivory allow dominance by mixed conifers, such as white fir and Douglas-fir. The presence of even a single aspen tree in a stand provides strong evidence that the area historically supported aspen clones. This BpS typically occurs on flat to steep terrain (<80%) on all aspects. Elevation generally ranges from 2,135 m to 2,745 m (7,000' to 9,000') in southern Utah. Soils are highly variable, but generally cool. This type occurs above the pinyon-juniper and/or sagebrush zones but below the spruce-fir zone. Aspen stands that are difficult to “see through” are considered healthy. Shrub, forb, and grass species typical of mesic sites are very diverse and plant cover is very high.
A:All 10610010 ¹	Early-all: 10-100% cover aspen <4.9m; mountain snowberry and <i>Ribes</i> common; 0-9 yrs
B:Closed 10610021	Mid1-closed: 40-99% cover aspen 5-9.9m; mountain snowberry and <i>Ribes</i> common; 10-39 yrs
C:Closed 10610030	Mid2-closed: 40-99% cover aspen 10-24m; conifer saplings visible in mid-story; mountain snowberry and <i>Ribes</i> common; 40-79 yrs
D:Open 10610042	Late1-open: 10-39% cover aspen 10-25 m; 10-25% mixed conifer cover 5-10 m; mountain snowberry and <i>Ribes</i> common; >80 yrs
E:Closed 10610050	Late1-closed: 40-80% cover of mixed conifer 10-50m; <40% cover of aspen 10-25m; mountain snowberry and <i>Ribes</i> present; >100 yrs
U-ASM->MC:All (aka: No-ASP) 10610109	Loss of clone: permanent conversion to Mixed Conifer – 1052; >50% white fir and/or limber pine cover; aspen absent or in trace amount; dead aspen boles may be present
U-ASM->MC:All (aka: No-ASP) 10610109	Loss of clone: permanent conversion to Mixed Conifer – 1052; >50% white fir and/or limber pine cover; aspen absent or in trace amount; dead aspen boles may be present

Aspen Woodland (ASP) 10110	<i>Overview:</i> The Aspen Woodland BpS is dominated by <i>Populus tremuloides</i> and is commonly called “stable aspen.” Aspen woodland is a debated BpS as it is assumed, but not proven, that soils prevent encroachment of conifers even with fire exclusion, therefore soils maintain the <u>relative</u> cover of conifers to <25%. Where the BpS is adjacent to conifers, an occasional conifer seedling may occur, but conifers do not drive the fire regime. Elevations generally range from 1,525 to 3,050 m (5,000'-10,000'), but occurrences can be found at lower elevations in some regions. Distribution of this ecological system is limited primarily by adequate soil moisture required to meet its high evapotranspiration demand, and secondarily by the length of the growing season or low temperatures. This BpS occurs commonly as multi-storied stands. Stands are usually closed. Aspen suckers 1.5 m to 4.6 m (5-15') tall will be present in all classes (min. 500 stems/acre). The Aspen Woodland BpS typically occurs above pinyon/juniper and adjacent to mountain big sagebrush. At elevations below 6,500 feet this group grades into black and narrowleaf cottonwood types along riparian corridors. On Great Basin ranges, the BpS is found both on dry sites, but where subsurface water in within rooting depth, and in more mesic areas where fir species are largely absent. Understory consists of abundant herbaceous and shrub components. Often species of tall forbs, perennial grasses and shrubs are found in the understory. The herbaceous layer may be lush and diverse.
A:All 10110010	Early-all: 10-100% cover of aspen <5m; 0-9 yrs

¹ Remote Sensing code (geotiff code)

B:Closed 10110021	Mid1-closed: 40-99% cover of aspen 5-9.9m (this class also includes aspen thickets caused by heavy snow bank deposition); 10-39 yrs
C:Closed 10110030	Late1-closed: 40-99% cover of aspen 10-25m; few conifers in mid-story; 39 -99 yrs
D:Open 10110042	Late1-open: 10-39% cover of aspen 10-25 m; conifers may be present but less than 25% relative cover; >99 yrs
U:Depleted-B (aka: DP) 10110203	Depleted-Mid1-open: 10-39% cover of pole size aspen <5-9.9m; no or little aspen regeneration; mountain big sagebrush common in understory; high visibility through the midstory; at most few conifers in mid-story; 10-39 yrs
U:Depleted-C (aka: DP) 10110303	Depleted-Late1-open: 10-39% cover of aspen 10-25m; no or little aspen regeneration; mountain big sagebrush common in understory; high visibility through the midstory; at most few conifers in mid-story; 39 -99 yrs
U:Depleted-D (aka: DP) 10110403	Depleted-Late2-open: 10-39% cover of older aspen 10-25m; no or little aspen regeneration; mountain big sagebrush common in understory; high visibility through the midstory; at most few conifers in mid-story
U->MSS:All (aka: No-ASP) 10110109	Loss of clone: permanent conversion to montane sagebrush steppe - 1126; dead clone of aspen; very few aspen stems present; dead boles may be visible on the ground; 5-50% cover of mountain big sagebrush/mountain shrub; <50% herbaceous cover

Badland 10002	<i>Overview:</i> Natural badlands formed of barren to very sparsely vegetated soils. Usually associated with erosional lacustrine hills or sumps, or unwelded tuff. Soil is usually highly reflective.
A:Bare Ground 10002101	Bare Ground: >90% mineral soil; <5% cover of shrubs, grasses or forbs

Barren-Rock-Mud (Barren) 10000	<i>Overview:</i> This feature can be present as natural barren areas of soil, rock, or mud, or human-caused barren areas.
A 10000001	Barren: natural barren areas of soil, rock, or mud
U:Bare ground 10000101	Bare Ground: Human-caused barren area (e.g., mine)

Basin Wildrye-montane (Bwm) 10801	<i>Overview:</i> The Basin Wildrye BpS is a Great Basin grassland dominated by basin wildrye (<i>Elymus cinereus</i>). The BpS is found at elevations from about 914 m to 1,829 m (3,000' to 6,000') with extensions to as high as 2,286 m (7,500') in valley bottoms. Typically, soils are deep to very deep with loamy to coarse 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 were formed through alluvial processes and typically form valley bottoms with slopes generally less than 8%, and typically between 0 and 4%. Annual precipitation ranges from 20 to 35 cm (8" to 14"). Many locations 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"). On lower precipitation sites (20 to 25 cm or 8 to 10") these locations may be positioned at the base of slopes such that water may run onto these sites. Not much is written specifically about the dynamics of this BpS. This is a grassland-shrubland mixture dominated by basin wildrye, a deep-rooted cool-season bunchgrass, with basin big sagebrush subdominant (<15% cover) later in succession. Other shrubs generally represent less than 10 % of the overall cover and include various species and subspecies of rabbitbrush. Other grasses are generally cool season bunchgrasses, with the exception of some rhizomatous grasses on the dry meadows with deep soils and high precipitation. Forbs represent less than 10 % of the herbaceous cover.
A:All 10801010	Early: 5-20% cover of basin wildrye; 0-10 yrs

B:Closed 10801021	Mid-closed: 21-80% cover of basin wildrye; <11% shrub cover; 11-75 yrs
C:Open 10801032	Late-open: 11-20% cover of big sagebrush and rabbitbrush; <75% cover of basin wildrye; >75 yrs
U-A:Annual Spp (aka: AS) 10801100	Annual-Spp: 5-40% cover of non-native annual species
U-A:Bare Ground (aka: BAGR) 10801101	Bare-Ground: Mostly bare ground
U:Depleted-C (aka: DP) 10801303	Depleted: >20% cover of native shrubs, especially basin big sagebrush and rabbitbrush; <5% basin wildrye; >20% mineral soil and litter cover
U:Early-Shrub (aka: ES) 10801105	Early-Shrub: >20% cover of rabbitbrush species; native grasses present
U:Exotic Forb (aka: EF) 108012108	Exotic-Forb: 5-100% exotic forbs (knapweed, tall whitetop, purple loosestrife)
U:SAP 10801324	Shrub-Annual-Species-Perennial-Grass: 5-14% cover of non-native annual species; >10% cover of native shrubs; ≥0% basin wildrye
U:SAP+ 10801330	Shrub-Annual-Species-Perennial-Grass+: ≥15% cover of non-native annual species; >10% cover of native shrubs; ≥0% basin wildrye
U:Seeded-Native (aka:SD) 10801135	Seeded-Native: >10% seeded basin wildrye, forbs, and shrubs; <5% non-native annual species (if ≥5 non-native annual species, then ASPG or even AS)
U:SI (aka: SDI) 10801129	Seeded-Introduced: >10% seeded introduced grasses, forbs, and shrubs
U:SI+AG (aka: SDI+AG) 10801138	Seeded-Introduced+Annual-Species: >10% seeded introduced grasses, forbs, and shrubs, ≥5% cover of non-native annual species
U:TEA 10801344	Tree-Encroached-Annual-Species: ≥10% cover of conifers; ≥0% (i.e., absent to common) cover of non-native annual species

<p>Big Sagebrush semi-desert (BSsd) 10802</p>	<p><i>Overview:</i> The Big Sagebrush semi-desert BpS exists in form distinct forms in the general area. (A) In Pine Valley, the Big Sagebrush semidesert BpS occurs on well-drained and/or shallow loamy soils on foothills, terraces, slopes and plateaus. Wyoming and basin big sagebrush characterize the BpS, with basin big sagebrush established on hills with deep soils. Elevation ranges from 1,280 m to 1,981 m (4,200' – 6,500'), which corresponds to annual precipitation zones from 20 cm to 30 cm (8 to 12"). The BpS is found on soil depths as shallow as 25 cm (10") and as deep as 152 cm (60+"). When Wyoming and basin big sagebrush are found on deeper soil, annual precipitation is <25 cm (<10"). The BpS is found just above the low elevation salt desert shrub typically unfavorable to tree establishment. Thus, other site characteristics (e.g. aspect, drainage) should be considered in identifying this BpS. At the precipitation extremes, this BpS generally occurs as small patches and stringers. Shrub canopy cover generally ranges from 5 to 25%, but can exceed 30% at the upper elevations, deeper soils, and precipitation zones. Wyoming big sagebrush sites have fewer understory species relative to other big sagebrush types. Rubber rabbitbrush and spiny hopsage may be co-dominant and basin big sagebrush might occur on concave sites with finer soils. Perennial forb cover is usually <10% and perennial grass cover reaches 40-60% on more productive sites. Thurber's needlegrass may be a dominant species following replacement fires and as a co-dominant after 20 years. Bottlebrush squirreltail, Indian ricegrass, and Sandberg bluegrass are common on more xeric sites. Percent cover and species richness of understory are determined by site limitations.</p> <p>(B) Around the Black Mountains, the Big Sagebrush semidesert BpS is found on clay loam that is similar to Wyoming big sagebrush semi-desert loam, but different from the basin wildrye loamy bottoms. The BpS is found at elevations from about 1,645 m to 1,737 m (5,400' to 5,700') on alluvial fans and flats with slopes between 0% and 2%. Typically soils are very deep (>152 cm or >60") clay loams. Soils are well drained and derived from sedimentary rock. Annual precipitation ranges from 25 to 30.5 cm (10" to 12"). Basin big sagebrush is dominant, but other shrubs, such as winterfat and low rabbitbrush, generally represent less than 10 % of the overall cover. Bottlebrush and Indian ricegrass are the most common grasses, with bottlebrush achieving high cover. Forbs represent a small component of the vegetation.</p>
<p>A:All 10802010</p>	<p>Early-All: ≥20% cover of native grasses (bottlebrush and Indian ricegrass); <10% shrub (various rabbitbrushes, snakeweed, and Wyoming and/or basin big sagebrush) cover; mineral soil abundant; 0-4 yrs</p>
<p>B:Closed 10802022</p>	<p>Mid-closed: 10-19% cover of Wyoming (10-29% cover of basin big sagebrush) and rabbitbrush; ≥20% native grass cover; 5-39 yrs</p>
<p>C:Open 10802030</p>	<p>Late-open: ≥20% cover of Wyoming big sagebrush (≥30% cover of basin big sagebrush), with other shrub (winterfat and low rabbitbrush) present; 5-25% cover of native grasses; pinyon and juniper saplings might be present; >40 yrs</p>
<p>U:Annual Spp (aka: AG) 10802100</p>	<p>Annual-Species: >10% non-native annual species cover; <10% shrubs, especially rabbitbrush and snakeweed; native grasses may be present</p>
<p>U-A:Bare Ground (aka: BAGR) 10082101</p>	<p>Bare Ground: primarily bare ground due primarily to anthropogenic disturbances</p>
<p>U:Depleted-C (aka: DP) 10802303</p>	<p>Depleted: ≥20% cover of Wyoming big sagebrush (≥30% cover of basin big sagebrush), rabbitbrush, and rabbitbrush; <5% native grass cover; >20% mineral soil and litter cover</p>
<p>U:Early-Shrub (aka: ES) 10802105</p>	<p>Early-Shrub: >20% cover of rabbitbrush and snakeweed species; native grasses present</p>
<p>U:Exotic Forb (aka: EF) 10802108</p>	<p>Exotic-Forb-early: 5-100% exotic forbs (thistles, halogeton, knapweed); <10% cover of rabbitbrush species; <10% cover of big sagebrush; native grass and forbs may be present</p>
<p>U:SA 10802321</p>	<p>Shrub-Annual-Species: 5-14% cover of non-native annual species; >10% cover of big sagebrush and other shrubs; <5% native grasses</p>
<p>U:SA+ 10802325</p>	<p>Shrub-Annual-Species: ≥15% cover of non-native annual species; >10% cover of big sagebrush and other shrubs; <5% native grasses</p>

U:SAP 10802324	Shrub-Annual-Species-Perennial-Grass: 5-14% cover of non-native annual species; >10% cover of big sagebrush and other shrubs; ≥5% native grasses
U:SAP+ 10802330	Shrub-Annual-Species-Perennial-Grass+: ≥15% cover of non-native annual species; >10% cover of big sagebrush and other shrubs; ≥5% native grasses
U:Seeded Native (aka: SD) 10802135	Seeded-Native: >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover
U:SI-A (aka: SDI-A) 10802129	Seeded-Introduced-Early: >10% seeded introduced grasses and shrubs; <10% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; <5% non-native annual species cover
U:SI-B (aka: SDI-B) 10802229	Seeded-Introduced-Mid: >10% seeded introduced grasses and shrubs; 10-29% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; <5% non-native annual species cover
U:SI-C (aka: SDI-C) 10802329	Seeded-Introduced-Late: >10% seeded introduced grasses and shrubs; ≥30% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; <5% non-native annual species cover
U:SI-A+AG 10802138	Seeded-Introduced-Early+Annual-Species: >10% seeded introduced grasses and shrubs; <10% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; ≥5% cover of non-native annual species;
U:SI-B+AG 10802238	Seeded-Introduced-Mid+Annual-Species: >10% seeded introduced grasses and shrubs; 10-29% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; ≥5% cover of non-native annual species
U:SI-C+AG 10802338	Seeded-Introduced-Late+Annual-Species: >10% seeded introduced grasses and shrubs; ≥30% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; ≥5% cover of non-native annual species
U:TEA 10802344	Tree-Encroached-Annual-Species: ≥10% cover of conifers; <20% cover of shrubs; either <5% non-native annual species cover AND <5% native grass cover OR ≥5% non-native annual species cover AND ≥5% native grass cover

Black Sagebrush (BS) 10791	<i>Overview:</i> The Black Sagebrush BpS is found throughout the project area. Artemisia nova is the dominant species. Black sagebrush tends to grow where there is a calcite-based root-limiting layer in the soil profile. Wyoming big sagebrush and basin big sagebrush generally occur with black sagebrush on moderately deep to deep soils that are well-drained. Elevations range from 1,500 m to 2,600 m (4,920' to 6,530'), although the BpS is sometimes found as high as 2,743 m (9,000'). The BpS mostly occurs on Great Basin alluvial fans, piedmonts, bajadas, rolling hills and mountain slopes. The BpS can also be found on flats and plains. Black sagebrush generally has relatively low fuel loads with low-growing and cushion forbs and scattered bunchgrasses such as Thurber needlegrass (Achnatherum thurberianum), Sandberg's bluegrass (Poa secunda), Indian ricegrass (Achnatherum hymenoides), and bluebunch wheatgrass (Pseudoroegneria spicata) at higher elevations. Forbs often include buckwheats (Eriogonum spp.), fleabanes (Erigeron spp.), phloxes (Phlox spp.), paintbrushes (Castilleja spp.), globemallows (Sphaeralcea spp.), and lupines (Lupinus spp.).
A:All 10791010	Early-all: <10% cover rabbitbrush; 10-40% cover of grass; <50% cover mineral soil; 0-25 yrs
B:Open 10791022	Mid-open: 10-19% cover of black sagebrush and rabbitbrush; 10-30% grass cover; <40% cover of mineral soil; 25-119 yrs
C:Closed 10791030	Late-closed: 1-10% pinyon-juniper sapling cover; 20-30% cover of black sagebrush; 10-30% cover of grasses; 120-194 yrs
D:Open 10791042	Late-open: 10-40% cover of pinyon or juniper 3-8m tall; <10% black sagebrush cover; <10% grass cover; >195 yrs
U:Annual Spp (aka: AG) 10791100	Annual-Species: >10% cover of non-native annual species; <10% cover of shrubs

U-A:Bare Ground (aka: BAGR) 10082101	Bare Ground: primarily bare ground due primarily to anthropogenic disturbances
U:Depleted-C (aka:DP) 10791303	Depleted: 20-50% cover of black sagebrush; <5% herbaceous cover; <10% pinyon or juniper sapling cover
U:Exotic Forb (aka: EF) 10791108	Exotic-Forbs: 5-100% exotic forbs (thistles, halogeton, knapweed); cover of rabbitbrush and black sagebrush increases with successional age; native grasses may be present
U:Early-Shrub (aka: ES) 10791105	Early-Shrub: 10-40% cover rabbitbrush species
U:SA 10791321	Shrub-Annual-Species: 5-14% non-native annual species cover; 10-50% cover of black sagebrush; <5% cover of native grass; <10% pinyon or juniper sapling cover
U:SA+ 10791325	Shrub-Annual-Species+: ≥15% non-native annual species cover; 10-50% cover of black sagebrush; <5% cover of native grass; <10% pinyon or juniper sapling cover
U:SAP-A (aka: ASPG) 10791124	Shrub-Annual-Species-Perennial-Grass-early: 5-14% cover of non-native annual species; ≥5% native grasses; <10% cover of shrubs
U:SAP 10791324	Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species cover; 20-50% cover of black sagebrush; >5% cover of native grass; <10% pinyon or juniper sapling cover
U:SAP-A (aka: ASPG) 10791124	Shrub-Annual-Species-Perennial-Grass+early: ≥15% cover of non-native annual species; ≥5% native grasses; <10% cover of shrubs
U:SAP+ 10791330	Shrub-Annual-Species-Perennial-Grass+: ≥15% non-native annual species cover; 20-50% cover of black sagebrush; >5% cover of native grass; <10% pinyon or juniper sapling cover
U:Seeded Native (aka: SD) 10791135	Seeded: >5% seeded native
U-SI-A (aka: SDI-A) 10791129	Seeded-Introduced-Early: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; <5% non-native annual species cover
U-SI-B (aka: SDI-B) 10791229	Seeded-Introduced-Mid: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of black sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover
U-SI-C (aka: SDI-C) 1079329	Seeded-Introduced-Late: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 1-10% pinyon-juniper sapling cover; 20-30% cover of black sagebrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover
U-D:SI (aka: SDI-D) 10791429	Seeded-Introduced-Late: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-40% cover of pinyon or juniper 3-8m tall; <10% black sagebrush cover; native grasses and forbs may be present to abundant; <5% non-native annual species cover
U-SI-A+AG 10791138	Seeded-Introduced-Early+Annual-Species: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover
U:SI-B+AG 10791238	Seeded-Introduced-Mid+Annual-Species: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of black sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover
U-SI-C+AG 10791338	Seeded-Introduced-Late+Annual-Species: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 1-10% pinyon-juniper sapling cover; 20-30% cover of black sagebrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover.

U-D:SI+AG (aka: SI-D+AG) 10791438	Seeded-Introduced-Late+Annual-Species: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-40% cover of pinyon or juniper 3-8m tall; <10% black sagebrush cover; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover
U-TEA 10791444	Tree-Encroached-Annual-Species: >10% mature pinyon or juniper cover 3-8m tall; <5% shrub cover; either <5% native herbaceous cover and <5% non-native annual species; OR ≥5% non-native annual species and >0% native herbaceous cover

Calcareous Grassland (CG) 11351	<i>Overview:</i> The Calcareous Grassland BpS is undescribed by NRCS in Beaver County, UT. The system is localized and found at and north of the intersection of Pine Valley Road and Jockey Road. The current description is inspired by the semi-desert grassland system occurring on sandy soil. The calcareous grassland occupies soil derived from limestone and tuff on west-facing alluvial fans and bajadas of the Wah Wah Range and is found at 1,060m to 1,980m (6,150-6,600') of elevation in Pine Valley. A carbonate root-restricting layer is suspected but would need to be verified. Slope are <10%. These grasslands are surrounded by black sagebrush (<i>Artemisia nova</i>) and juniper savannas whose understories have the same grass composition. Common cool season grasses, such as needle-and-tread (<i>Stipa comata</i>), bottlebrush squirreltail (<i>Elymus elymoides</i>), Indian ricegrass (<i>Stipa hymenoides</i>), and Sandberg's bluegrass (<i>Poa secunda</i>), codominate. Snakeweed (<i>Gutierrezia</i> spp.) and various low rabbitbrushes (<i>Chrysothamnus</i> spp.), and occasional black sagebrush can be found in areas with greater grazing pressure or more advanced succession. 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.
A:All 11351010	Early-all: <5% shrub cover (snakeweed, rabbitbrush); ≥10% cover of grasses (Indian ricegrass, needle-and-tread, bottlebrush squirreltail, Indian ricegrass, and Sandberg's bluegrass); soil cover may be high; 0-19 yrs
B:Closed 11351021	Mid-closed: ≥5% shrub cover (mostly snakeweed and rabbitbrush, and occasional sagebrush); ≥10% cover of grasses (Indian ricegrass, needle-and-tread, bottlebrush squirreltail, Indian ricegrass, and Sandberg's bluegrass); soil cover may be high; ≥20 yrs
U-A:Bare Ground (aka: BAGR) 11351101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Depleted-B (aka: DP) 11351203	Depleted: <10% shrub (mostly snakeweed and rabbitbrush, and occasional sagebrush) cover; <10% cover of grasses; <5% cover of non-native annual species; 10-30% bare ground cover; soil cover may be high; conifers are absent, although a few seedlings or saplings may be observed in the ecotone to juniper savannas.
U:Early-Shrub (aka:ES) 11351105	Early-Shrub: ≥10% cover of snakeweed and rabbitbrush; 10-30% bare ground cover; <10% native grass cover; <5% cover of non-native annual species; soil cover may be high
U:SAP-A (aka: ASPG) 11351124	Shrub-Annual-Perennial-Grass: 5-14% cover of non-native annual species; <5% shrub (mostly snakeweed and rabbitbrush, and occasional sagebrush) cover; native grasses may be present to common; juniper saplings absent; soil cover may be high
U:SAP 11351224	Shrub-Annual-Perennial-Grass: 5-14% cover of non-native annual species; ≥5% shrub (mostly snakeweed and rabbitbrush, and occasional sagebrush) cover; native grasses may be present to common; conifers are absent, although a few seedlings or saplings may be observed in the ecotone to juniper savannas; soil cover may be high
U:SAP+ 11351230	Shrub-Annual-Perennial-Grass+: ≥15% cover of non-native annual grasses; ≥5% shrub (mostly rabbitbrush, sagebrush) cover; native grasses may be present to common; conifers are absent, although a few seedlings or saplings may be observed in the ecotone to juniper savannas; soil cover may be high
U:Seeded Native (aka: SD) 11351135	Seeded-Native: >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover.

U:SI (aka: SDI) 11351129	Seeded-Introduced: >10% cover of introduced seeded grass species; <5% cover of non-native annual species; sagebrush and other shrubs may be present; soil cover may be moderately high
U:SI+AG (aka: SDI+AG) 11351138	Seeded-Introduced+Annual-Species: >10% cover of introduced seeded grass species; ≥5% cover of non-native annual grasses; sagebrush and other shrubs may be present; soil cover may be moderately high

Curl-leaf Mountain Mahogany (CMM) 10620	<i>Overview:</i> The Curl-leaf Mountain Mahogany BpS is usually found on upper slopes and ridges between 2,133 m to 3,200 m (7,000' to 10,500') elevation. Most stands occur on rocky shallow soils and outcrops. Stands are assumed to reach old age, >1,000 years, without fire. The BpS is present in two distinct forms due to soil differences: 1) savannas of old and well-dispersed trees form open and often grassy woodlands (with mature stand cover between 10-55%) with a diverse understory on soils with a large proportion of boulders above and below ground; and 2) dense thickets of old shrubs (56% to 100% cover) with thick litter and little understory cover form on soils without bouldering. Curlleaf mountain mahogany (<i>Cercocarpus ledifolius</i>) is both a primary early successional colonizer rapidly occupying bare mineral soils after disturbance and the dominant long-lived species. Seedlings require mineral soil without plant competition to reestablish after fire. Reproduction often appears dependent upon geographic variables (slope, aspect, and elevation) more than biotic factors. Where curl-leaf mountain mahogany has reestablished quickly after fire, rabbitbrush (<i>Chrysothamnus nauseosus</i>) may co-dominate. Litter and shading by woody plants inhibits establishment of curl-leaf mountain mahogany. Mountain big sagebrush is the most common codominant with curlleaf mountain mahogany, although chaparral species such as manzanita (<i>Arctostaphylos patula</i>), tobaccobrush (<i>Ceanothus velutinus</i>), and green ephedra (<i>Ephedra viridis</i>) often codominate on some sites. Snowberry, Utah serviceberry, and currant are present on cooler sites, with more moisture. Singleleaf and Colorado pinyon, western juniper, Douglas-fir, white fir, Rocky Mountain juniper, ponderosa pine, and limber pine may be present, with less than 10% total cover. In old, closed canopy stands, understory may consist largely of prickly phlox (<i>Leptodactylon pungens</i>).
A:All 10620010	Early: <70% cover of mountain mahogany; other shrubs (snowberry, rabbitbrush) and grasses may be present; 0-20 yrs
B:Open 10620022	Mid-open: 10-30% cover mountain mahogany and other shrubs; 20-60 yrs
C:Closed 10620030	Mid-closed: 30-70% cover of mountain mahogany, other shrubs (snowberry, rabbitbrush, big sagebrush, bitterbrush, black sagebrush) abundant; 60-150 yrs
D:Open (aka: D) 10620042	Late-open: 10-30% cover of mountain mahogany; big sagebrush, black sagebrush, bitterbrush; grasses abundant; occasional ponderosa pine possible; 150+ yrs
D:Closed (aka: E) 10620040	Late-closed: >30% cover of mountain mahogany; 5-10% cover of pinyon-juniper; snowberry may be common; occasional ponderosa pine possible; 150+ yrs
U:Annual Spp (aka: AG) 10620100	Annual-Species: ≥10% non-native annual species cover; mountain mahogany largely absent; ≤80% cover of mineral soil, bedrock, and rock
U:SI-A (aka: SDI) 10620129	Seeded-Introduced-Early: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; <5% non-native annual species cover
U:SI-A+AG (aka: SDI+AG) 10620138	Seeded-Introduced-Early+Annual-Species: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover
U:TEA (aka: TA) 10620444	Tree-Encroached or with Annual-Species: >5% non-native annual species cover; >10% cover of mountain mahogany; 40% cover of mineral soil, bedrock, and rock

Desert Wash (DWA) 11544	<i>Overview:</i> The Desert Wash BpS comprises intermittent to dry desert drainages with mostly deeper subsurface flow whose banks can be deeply incised, but usually on one side of meanders. Flash-flooding is the major disturbance in this BpS. Gravels and desert shrub species dominate the system with shrub cover increasing with time since last flood. Common species include burrobrush, big sagebrush, snakeweed, rabbitbrush, Indian ricegrass, squirreltail, and bush muhly.
A:All 11544010	Early-all: 30-50% cover may be gravel, sands, and/or flood debris; 10-19% cover of burrobrush, rabbitbrush, snakeweed, and desert willows present; ≥5% cover of grasses (bush muhly, Indian ricegrass, squirreltail); forbs present to abundant; 0-5 yrs
B:Closed 11544021	Mid-closed: 10-30% of gravel and rocks; 20-50% cover of big sagebrush, burrobrush, and rabbitbrush; 5-10% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); forbs present to abundant; 5-19 yrs
C:Closed 11544030	Late-closed: <10% of gravel and rocks; 30-50% cover of big sagebrush, burrobrush, rabbitbrush, Woods Rose, and other tall shrubs; 5-10% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); forbs present to abundant; >20 yrs
Bare Ground (aka: BAGR) 11544101	Bare-Ground: mineral soil exposed by human-caused disturbances
U:Early-Shrub (aka: ES) 11544105	Early-Shrub: 20-50% cover of snakeweed, burrobrush, or rabbitbrush species
U-EFT 11544106	Exotic-Forb-Tree: >5% cover of salt cedar, Russian olive, or exotic forbs (knapweed, tall whitetop); ≥10% cover of burrobrush, big sagebrush, rabbitbrush, and sagebrush. Gravel and rocks common to abundant
U-SA 11544221	Shrub-Annual-Species: 5-14% non-native annual species (Bromus tectorum, Bromus rubens, Erodium cicutarium) cover; 0-50% small trees and shrubs; <5% cover of native grasses; mineral soil may be common
U-SA+ 11544225	Shrub-Annual-Species+: ≥15% non-native annual species (Bromus tectorum, Bromus rubens, Erodium cicutarium) cover; 0-50% small trees and shrubs; <5% cover of native grasses; mineral soil may be common
U-SAP 11544224	Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species (Bromus tectorum, Bromus rubens, Erodium cicutarium) cover; 0-50% small trees and shrubs, ≥5% cover of grasses (bush muhly, Indian ricegrass, squirreltail); mineral soil may be common
U-SAP+ 11544230	Shrub-Annual-Species-Perennial-Grass+: ≥15% non-native annual species (Bromus tectorum, Bromus rubens, Erodium cicutarium) cover; 0-50% small trees and shrubs, ≥5% cover of grasses (bush muhly, Indian ricegrass, squirreltail); mineral soil may be common

Four-Wing Saltbush (FWS) 10811	<i>Overview:</i> The Four-Wing Saltbush BpS occurs from 1,524 – 1,585 m (5,000 – 5,200'). It is part of the Mixed Salt Desert community, but the high stature and high density of four-wing saltbush (Atriplex canescens) makes it stand apart. Soils are alkaline, made of loamy fine sand, highly permeable, and very deep (>152 cm or >60"). Many soils are derived from eolian deposits and often associated with dunes. Average annual precipitation ranges from 0-25.4 cm (0 to 10"). This system generally occurs as small patches and stringers. Summers are hot and dry with many days reaching 30 degrees C (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. Four-wing saltbush are tall shrubs found at high density (3-5 plants per sq. m) interspersed with low to mid-height bunch grasses. Other shrubs include basin big sagebrush (Artemisia tridentata ssp. tridentata) and rubber rabbitbrush (Ericameria nauseosa). Common bunch grass species are Indian ricegrass (Achnatherum hymenoides), needle-and-thread (Hesperostipa comata), and, where monsoonal influences are present, rhizomatous/sod forming grasses such as galleta grass (Pleuraphis jamesii) and sand dropseed (Sporobolus cryptandrus). The biophysical setting has not evolved with fire and fire is absent from the reference condition.
A:All 10811010	Early-all: ≥10% Indian ricegrass, galleta grass, needle-and-thread, or bottlebrush cover; <5% young four-wing saltbush or rubber rabbitbrush cover; mineral soil common to abundant; 0-5 yrs

B:Open 10811022	Mid1-open: 5-20% four-wing saltbush, basin big sagebrush, or rabbitbrush cover; >10% Indian ricegrass, galleta grass, needle-and-thread, or bottlebrush cover; mineral soil common to abundant; 6-19 yrs
C:Closed 10811030	Late1-closed: >20% four-wing saltbush and basin big sagebrush cover >1m tall; 10-20% Indian ricegrass, galleta grass, needle-and-thread, or bottlebrush cover; ≥20 years
U:Annual Grass (aka: AG) 10811100	Annual-Species: ≥10% non-native annual species cover; <5% shrub cover; native grass may be present to common
U-A:Bare Ground (aka: BAGR) 10811101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Depleted (aka: DP) 10811303	Depleted: 5-20% cover of four-wing saltbush, basin big sagebrush, or rabbitbrush; <10% native grass; <5% non-native annual species cover
U:Early-Shrub (aka: ES) 10811105	Early-Shrub: 10-40% cover rabbitbrush and snakeweed species
U:SAP 10811324	Shrub-Annual-Species: 5-14% non-native annual species cover; ≥5% cover of four-wing saltbush, basin big sagebrush, or rabbitbrush; native grass may be present to common
U:SAP+ 10811330	Shrub-Annual-Species+: ≥15% non-native annual species cover; ≥5% cover of four-wing saltbush, basin big sagebrush, or rabbitbrush; native grass may be present to common
U:Seeded Native (aka: SD) 10811135	Seeded-Native: >10% native grass and four-wing saltbush seed mix cover; <5% non-native annual species cover
U:SI (aka: SDI) 10811129	Seeded-Introduced: >10% seeded introduced grasses and shrub species (crested wheatgrass and forage kochia); <5% non-native annual species cover; native shrubs may be present to common
U:SI+AG (aka: SDI+AG) 10811138	Seeded-Introduced+Annual-Species: >10% seeded introduced grasses and shrub species (crested wheatgrass and forage kochia); ≥5% non-native annual species cover; native shrubs may be present to common

Gambel Oak-Mountain Shrub (GOMS) 11070	<i>Overview:</i> The Gambel Oak-Mountain Shrub BpS is one of four mountain shrub types, although it is not expected in the Pine Valley-Mountain Home Range-Hamlin Valley area. It is found on a variety of soil types, often rocky and potentially erosive, and on slopes that range from gentle to steep, on all aspects. Elevations range from 915 m to 2,438 m (3,000' to 8,000'), typically on mountain foothills and lower slopes. The BpS exists in two sub-types based on aspect and soils. The patchy form of the BpS is characterized by Gambel oak covering ≤60% of the area and generally occurs on sites less than 1,676 m (5,500 ') in elevation, more often on south- or west-facing slopes, and on shallower soils than the continuous form that has >60% Gambel oak cover and more often occupies higher elevations and northern and eastern slopes. There is, of course, overlap in the gradients for these two sub-types. The BpS is dominated by Gambel oak, often with serviceberry, big sagebrush, chokecherry, bitterbrush, and snowberry. Oak and most other associated shrubs will sprout readily after disturbance.
A: All 11070010	Early-all: 5-40% cover of Gambel oak sprouts ≤ 2 m (6.6') tall; <5% cover of sagebrush and other shrubs; grass and forb cover low in oak patches but abundant between patches; 0-4 years
B:Closed 11070021	Mid1-closed: >40% cover with patches of Gambel oak with stems 2-3+m tall; low herbaceous cover in oak patches; 5-20% cover of grass/herb/sagebrush/mountain shrub in interspaces between clones; 5-19 years
C:Closed 11070030	Late-closed: 40-80% cover of Gambel oak (greater at the periphery than center of patches due to self-thinning) with trees reaching 3+-8m tall; herbaceous understory low; 20-30% cover of sagebrush and mountain shrubs (and other low shrubs) in interspaces between clones; in older patches (>50 yrs), Gambel oak adopts a tree form in southern Utah; >20 yrs

U-SAP 11070324	Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species cover between oak patches; >5% cover of Gambel oak; native herbaceous cover usually present to abundant between oak patches
U-SAP+ 11070330	Shrub-Annual-Species-Perennial-Grass+: ≥15% non-native annual species cover between oak patches; >5% cover of Gambel oak; native herbaceous cover usually present to abundant between oak patches.

Greasewood-Basin Big Sagebrush (GW) 11530	<i>Overview:</i> The Greasewood-Basin Big Sagebrush BpS occurs on alluvial flats or lake plains usually adjacent to playas. Sites typically have saline to sodic soils, shallow water table, and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations. Slope gradients of less than 2 percent are most typical. Elevations range from 1,158 to 1,768 m (3,800 to 5,800'). Average annual precipitation is 13 to 20 cm (5 to 8"); mean temperature is 45 to 50 degrees F; average growing season is 100 to 120 days. The surface layer normally crusts over, inhibiting water infiltration and seedling emergence. This BpS sometimes occurs as a mosaic of multiple communities, with open to moderately-dense shrublands dominated or co-dominated by <i>Sarcobatus vermiculatus</i> (greasewood). <i>Atriplex confertifolia</i> (shadscale) and basin big sagebrush (<i>Artemisia tridentata</i> spp. <i>tridentata</i>) may be present or co-dominant. An herbaceous layer, if present, is usually dominated by salt-tolerant graminoids. There may be inclusions of <i>Sporobolus airoides</i> (alkali sacaton), <i>Distichlis spicata</i> (saltgrass), and basin wildrye (<i>Elymus cinereus</i>). Vegetation on this site is normally restricted to coppice mound areas that are surrounded by playa-like depressions or nearly level, usually barren, inner spaces. In eastern Nevada and Utah, this BPS also occurs along creek floodplains and in washes with fine saline to sodic soils. As ecological condition declines, herbaceous understory is reduced or eliminated, and the site becomes a community of halophytic shrubs dominated by greasewood.
A:All 11530010	Early-all: >5% herbaceous cover of inland salt grass, alkali sacaton, or basin wildrye; ≤5% young or resprouting greasewood; >25% mineral soil; flood debris may be abundant; 0-4 years
B:Closed 11530021	Mid-closed: >5% cover of mature greasewood with other shrubs possible (basin big sagebrush and shadscale); >5% herbaceous cover of inland salt grass, alkali sacaton, or basin wildrye; mineral soil may be common; >4 years
U:Annual Spp (aka: AG) 11530100	Annual-Species: >10% cover of non-native annual species; <5% cover of mature greasewood and other shrubs
U-A:Bare Ground (aka: BAGR) 11530101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:SAP 11530224	Shrub-Annual-Perennial-Grass: 5-14% non-native annual species cover; >5% cover of mature greasewood or basin big sagebrush; native grasses may be present to common; >4 years
U:SAP+ 11530230	Shrub-Annual-Perennial-Grass+: >15% non-native annual species cover; >5% cover of mature greasewood or basin big sagebrush; native grasses may be present to common; >4 years
U:SI (aka: SDI) 11530129	Seeded-Introduced: >10% seeded introduced grasses (usually Russian wheatgrass), forbs, and shrubs; greasewood and other shrubs may be present to common; <5% non-native annual species cover
U:SI+AG (aka: SDI+AG) 11530138	Seeded-Introduced+Annual-Species: >10% seeded introduced grasses (usually Russian wheatgrass), forbs, and shrubs; greasewood and other shrubs may be present to common; ≥5% non-native annual species cover.

Juniper Savanna (JUN) 11150	<i>Overview:</i> The Juniper Savanna BpS was historically noted by the first explorers on the Spanish Trail south of the Black Mountains, which is about 50 miles southeast from locations in Pine Valley. This ecological system is typically found at elevations ranging from 1,500-2,300 m (4,920 – 7,550 ft). Occurrences are found on lower mountain slopes, hills, plateaus, basins and flats. The Juniper savanna ecotype generally occurs in local, geologically confined environments with poor soils and is limited in its distribution. This system occurs at the lower altitudinal limits for tree species, below the pinyon-juniper woodland type but at or above sagebrush semidesert and salt desert shrubland in locations where soil moisture is limiting. In Pine Valley, the juniper savanna is located immediately uphill of the undescribed calcareous grassland (11351) and share the same understory species. The vegetation is typically open savanna with many old trees, although there may be inclusions of more dense juniper woodlands. This savanna is typically dominated by Juniperus osteosperma trees with sparse cover of black sagebrush and Wyoming big sagebrush. Perennial bunchgrass cover can be abundant creating a grassland aspect below the canopy of juniper. Most common grass species are Elymus elymoides, Achnatherum hymenoides (= Oryzopsis hymenoides), Hesperostipa comata (= Stipa comata), Poa secunda, and Pleuraphis jamesii (= Hilaria jamesii) being most common. Pinyon trees are typically not present because sites are outside the ecological or geographic range of Pinus monophylla and Pinus edulis.
A:All 11150010	Early-all: ≤10% herbaceous cover; charred stumps and trunks should be visible; 0-9 yrs.
B:Open 11150022	Mid1-open: 10-20% herbaceous cover; 5-10% cover big sagebrush, black sagebrush, or bitterbrush <1.0m, 10-29 yrs.
C:Open 11150032	Mid2-open: 11-20% cover of young (<100 yrs old) juniper; >10% herbaceous cover; 10-20% shrub cover; 30-99 yrs.
D:Open 1150042	Late-open: ≥20% cover of older junipers; >10% herbaceous cover; 5-10% shrub cover; ≥100 yrs.
U:Annual Spp (aka: AG) 11150100	Annual-Species: >10% non-native annual species cover; dead juniper visible.
U-A:Bare Ground (aka: BAGR) 11530101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Early-Shrub (aka: ES) 11150105	Early-Shrub: ≥10% cover rabbitbrush and snakeweed species.
U:SAP 11150224	Shrub-Annual-Perennial-Grass: >5% non-native annual species; 5-20% cover big sagebrush, black sagebrush, or bitterbrush <1.0m, <40% herbaceous cover.
U-TEA (aka: TA) 11150444	Tree-Annual-Species: ≥20% cover of juniper <5m-9m, 5-10% shrub cover, >5% non-native annual species cover; ≥30 yrs.

Limber-Bristlecone Pine (LB) 10200	<i>Overview:</i> The Limber-Bristlecone Pine BpS is often the highest subalpine forest type. Elevation ranges from 2,438 m to 3,505 m (8,000' to 11,500') on mid to upper slopes. The areas are typically in rain shadows, and are the dry and cold extent of tree cover. Stands occur on thin, stony soils, high windswept ridges and open slopes with minimal ground cover. Pinus longaeva and Pinus flexilis can exist separately or as mixed stands. Picea engelmannii and Pseudotsuga menziesii may occur incidentally with Pinus longaeva. Sparse forbs, grasses and short shrubs form an understory.
A:All 10200010	Early-all: 0-10% limber and bristlecone pine cover 0-5m tall; abundant mineral soil or talus cover; sparse ground cover; 0-99 yrs
B:Open 10200022	Mid1-open: 11-30% limber and bristlecone pine cover 5-10m tall; abundant mineral soil or talus cover; sparse ground cover; 100-249 yrs
C:Open 10200032	Late1-open: very old trees; 11-30% limber and bristlecone pine cover 5-25m tall; abundant mineral soil or talus cover; sparse ground cover; >250 yrs

Little-leaf Mountain Mahogany (LLMM) 10862	<i>Overview:</i> The Little-leaf Mountain Mahogany BpS is one of four mountain shrub types, where little-leaf mountain mahogany (<i>Cercocarpus intricatus</i>) is the indicator species. Elevation ranges from 1,219 m to 2,580 m (4,000' to 8,500'). The BpS is typically found on limestone ridges and cliff ledges with very shallow carbonate and dry unproductive soils over bedrock. On the Wah Wah Range, this system can be extensive, which is unusual for this normally patchy system. Pinyon and/or juniper can co-dominate in communities that have not burned for a long time.
A:All 10862010	Early-all: 0-10% canopy of little-leaf mountain mahogany; ≥5% grass and forb cover; mineral soil and bedrock cover high; 0-12 yrs
B:Open 10862022	Mid-open: 11-20% cover of little-leaf mountain mahogany; ≥10% herbaceous cover; <10% conifer sapling cover; 13-79 yrs
C:Closed 10862030	Late-closed: 10-20% pinyon pine-juniper cover; >21% cover of little-leaf mountain mahogany; <10% herbaceous cover; 80-129 yrs
U:Annual Spp (aka: AG) 10862100	Annual-Species: >10% cover of non-native annual grasses; snakeweed or rabbitbrush may be present; dead standing stems of little-leaf mountain mahogany often present.
U:SAP 10862224	Shrub-Annual-Species-Perennial-Grass: ≥5% non-native annual species cover; >10% cover of little-leaf mountain mahogany; native herbaceous cover usually present; tree samplings may be present
U:TEA 10862344	Tree-Encroached-Annual-Species: >10% mature pinyon-juniper cover; IF ≥5% cover of non-native annual grasses and forbs THEN >0% cover of little-leaf mountain mahogany OR IF <5% cover of non-native annual grasses and forbs THEN <10% cover of little-leaf mountain mahogany AND <5% native herbaceous cover.

Low Sagebrush (LS) 10790	<i>Overview:</i> Low sagebrush (<i>Artemisia arbuscula</i>) is the dominant species. Low sagebrush tends to grow where there is a clay-based root-limiting layer in the soil profile. Big sagebrush species generally occur on deeper loamy soils. Elevations range from 1,500 m to 2,600 m (4,920' to 6,530'), although the BpS is sometimes found as high as 2,743 m (9,000'). The BpS mostly occurs on Great Basin alluvial fans, piedmonts, bajadas, rolling hills and mountain slopes. The BpS can also be found on flats and plains. Low sagebrush generally has relatively low fuel loads with low-growing and cushion forbs and scattered bunchgrasses such as Thurber needlegrass (<i>Achnatherum thurberianum</i>), Sandberg's bluegrass (<i>Poa secunda</i>), Indian ricegrass (<i>Achnatherum hymenoides</i>), and bluebunch wheatgrass (<i>Pseudoroegneria spicata</i>) at higher elevations. Forbs often include buckwheats (<i>Eriogonum</i> spp.), fleabanes (<i>Erigeron</i> spp.), phloxes (<i>Phlox</i> spp.), paintbrushes (<i>Castilleja</i> spp.), globemallows (<i>Sphaeralcea</i> spp.), and lupines (<i>Lupinus</i> spp.). Utah juniper (<i>Juniperus osteosperma</i>), more than singleleaf pinyon (<i>Pinus monophylla</i>), may occasionally establish in low sagebrush's harsh soils; however, low sagebrush does not generally support trees.
A:All 10790010	Early-all: <10% cover rabbitbrush and other shrubs; >10% cover of grass; <50% cover mineral soil; 0-24 yrs
B:Open 10790022	Mid-open: 10-19% cover of low sagebrush and rabbitbrush; >10% grass cover; <40% cover of mineral soil; 25-119 yrs
C:Closed 10790030	Late-closed: >20% cover of low sagebrush; <3% mature juniper (maybe pinyon) cover; ≤5% juniper (maybe pinyon) sapling cover; >5% cover of grasses; >120 yrs
U:Annual Spp (aka: AG) 10790100	Annual-Species: >10% cover of non-native annual species; <10% cover of shrubs (primarily rabbitbrush and snakeweed)
U-A:Bare Ground (aka: BAGR) 10790101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Depleted (aka: DP) 10790303	Depleted: >20% cover of low sagebrush; <5% herbaceous cover; <3% mature juniper (maybe pinyon) cover; ≤5% pinyon or juniper sapling cover
U:Early-Shrub (aka: ES) 10790105	Early-Shrub: 10-40% cover rabbitbrush species

U:SA 10790321	Shrub-Annual-Species: 5-14% non-native annual species cover; >10% cover of low sagebrush; <5% cover of native grass; <3% mature juniper (maybe pinyon) cover; ≤5% pinyon or juniper sapling cover
U:SA+ 10790325	Shrub-Annual-Species+: ≥15% non-native annual species cover; >10% cover of low sagebrush; <5% cover of native grass; <3% mature juniper (maybe pinyon) cover; ≤5% pinyon or juniper sapling cover
U:SAP-A (aka: AGPG) 10790124	Shrub-Annual-Species-Perennial-Grass-early: 5-14% cover of non-native annual species; ≥5% native grasses; <10% cover of shrubs; trees absent
U:SAP 10790324	Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species cover; >10% cover of low sagebrush; >5% cover of native grass; <3% mature juniper (maybe pinyon) cover; <5% pinyon or juniper sapling cover
U:SAP+ 10790230	Shrub-Annual-Species-Perennial-Grass+: ≥15% non-native annual species cover; >10% cover of low sagebrush; >5% cover of native grass; <3% mature juniper (maybe pinyon) cover; ≤5% pinyon or juniper sapling cover
U:Seeded Native (aka: SD) 10790135	Seeded-Native: >5% seeded native grass and forb species; <10% cover of shrubs; <5% non-native annual species cover.
U:SI-A (aka: SDI-A) 10790129	Seeded-Introduced-Early: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; <5% non-native annual species cover
U:SI-B (aka: SDI-B) 10790229	Seeded-Introduced-Mid: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of low sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover
U:SI-C (aka: SDI-C) 10790329	Seeded-Introduced-Late: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <3% mature juniper (maybe pinyon) cover; ≤5% pinyon or juniper sapling cover; >20% cover of low sagebrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover
U:SI-A+AG 10790138	Seeded-Introduced-Early+Annual-Species: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover
U:SI-B+AG 10790238	Seeded-Introduced-Mid+Annual-Species: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of low sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover
U:SI-C+AG 10790338	Seeded-Introduced-Late+Annual-Species: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <3% mature juniper (maybe pinyon) cover; ≤5% pinyon or juniper sapling cover; >20% cover of low sagebrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover.
U-TEA (aka: TE or TA) 10790344	Tree- Encroached or with Annual-Species: ≥3% mature pinyon or juniper cover; <10% low sagebrush and other shrub cover; ≥5% non-native annual species; >0% native herbaceous cover OR <5% low sagebrush and other shrub cover; <5% non-native annual species; <5% native herbaceous

Mixed Conifer (MC) 10520	<i>Overview:</i> The Mixed Conifer BpS is found at elevations ranging from 1,200 m to 2,743 m (4,000'-9,000'). Sites include lower and middle slopes of ravines, along stream terraces, moist concave topographic positions, and north- and east-facing slopes which burn somewhat infrequently. White fir (<i>Abies concolor</i>) and Douglas-fir (<i>Pseudotsuga menziesii</i>) are most common canopy dominants, but ponderosa pine (<i>Pinus ponderosa</i>), Engelmann spruce (<i>Picea engelmannii</i>), limber pine (<i>Pinus flexilis</i>), and bristlecone pine (<i>Pinus longeava</i>) may be occasional. Many cold-deciduous shrub, graminoid, and forbs species can occur, although litter is often the dominant understory cover. Aspen is absent and there is no evidence of remnant aspen boles.
A:All 10520010	Early-all: 0-15% cover of young trees/shrub/grass; <5m; 0-29 yrs
B:Closed (aka: B) 10520021	Mid1-closed: 35-100% cover of pole-sized conifers <24m; 30-99 yrs

B:Open (aka: C) 10520022	Mid1-open: 0-35% cover of pole-sized conifers <24m; 30-99 yrs
C:Open (aka: D) 10520032	Late1-open: 0-35% cover of mature conifers 25-49m; >100 yrs
C:Closed (aka: E) 10520030	Late1-closed: 35-100% cover of mature conifers 25-49m; >100 yrs
U:Annual Spp (aka: AG) 10520100	Annual-Species: saplings plus >10% non-native annual grass cover
U-TEA (aka: TA) 10520344	Tree-Annual-Species: any mid- to late-successional class plus >5% non-native annual grass cover

Mixed Salt Desert (MSD) 10810	<p><i>Overview:</i> The Mixed Salt Desert BpS occurs from lower slopes to valley bottoms ranging in elevation from 1,158 – 1981m (3,800 - 6,500'). 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 7.5-25.4cm (3 to 10"); however, this system is in 12.7-30.3 cm (5-8") of effective moisture within this broader range. Thus, other site characteristics (e.g. aspect, drainage, soil type) should be considered in identifying this biophysical setting. At the precipitation extremes, this system generally occurs as small patches and stringers. Summers are hot and dry with many days reaching 30 degrees C (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. Mixed Salt Desert generally lies above playas, lakes, and greasewood communities. Up slope the BpS is bordered by low elevation big sagebrush groups, commonly Wyoming big sagebrush, low sagebrush, and black sagebrush communities. Mixed Salt Desert includes low (<0.91 m or 3') and medium-sized shrubs found widely scattered (often 6.1-9.1 m [20-30'] apart) to high density (3-5 plants per sq. m) shrubs interspersed with low to mid-height bunch grasses. 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 bunchgrass species are Indian ricegrass, needle-and-thread, purple three-awn, and bottlebrush squirreltail, and where monsoonal influences are present one may find common rhizomatous/sod forming grasses such as galleta grass, sand dropseed, and blue grama. Globemallows 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 precipitation 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 bud sagebrush dominance. The biophysical setting has not evolved with fire and fire is absent from the reference condition.</p>
A:All 10810010	Early-all: 0-5% cover of young Atriplex spp. or other shrubs; Indian ricegrass and squirreltail common; 0-5 yrs
B:Open 10810022	Late1-open: >5% cover Atriplex spp. or other shrubs; Indian ricegrass and squirreltail present to common; ≥6 yrs
C:Open 10810032	Late2-open: >5% cover budsage <0.25m; Indian ricegrass and squirreltail present to common; ≥6 years

U:Annual Spp (aka: AG) 10810100	Annual-Species: ≥5% non-native annual species cover; <5% shrub cover
U:Bare Ground (aka: BAGR) 10810101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U-Early-Shrub (aka: ES) 10810105	Early-Shrub: ≥10% cover rabbitbrush and snakeweed species.
U:SAP 10810224	Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species cover; ≥5% cover of Atriplex spp. or other shrubs; native grasses may be present to common.
U-SAP+ 10810230	Shrub-Annual-Species-Perennial-Grass+: ≥15% non-native annual species cover; ≥5% cover of Atriplex spp. or other shrubs; native grasses may be present to common.
U:Seeded Native (aka: SD) 10810135	Seeded-Native: >10% native seed mix, including shadscape, cover; <5% non-native annual species cover
U-SI (aka: SDI) 10810129	Seeded-Introduced: >10% seeded introduced grasses, forbs, and shrubs; <5% non-native annual species cover; shrubs may be present to common
U-SI+AG (aka: SDI+AG) 10810138	Seeded-Introduced+Annual-Species: >10% seeded introduced grasses and shrubs; ≥5% non-native annual species cover; shrubs may be present to common.

Montane Riparian (MR) 11540	<i>Overview:</i> The Montane Riparian BpS is found within a broad elevation range above 1,220 m (4,000'). Riparian forests and woodlands require flooding and gravel for reestablishment. The BpS is found in low- to mid-elevation canyons and draws, on floodplains, in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff, although summer flash floods can have dramatic effects on succession. Underlying gravels, which are favored substrates for cottonwood and willow germination, may keep the water table just below ground surface. 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. Codominant and diagnostic species include willow, buffaloberry, cottonwood, velvet ash, and conifers. Vegetation is very heterogeneous and diverse along river reaches. The description below corresponds to an older version when willow and cottonwood successional pathways were not separated.
A: All 11540010	Early-All: 0-40% cover of shrub—willow dominates after fire, whereas cottonwood and willow co-dominate after flooding; grass may co-dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs
B:Open 11540022	Mid-open: <30% cover of small trees (velvet ash, conifers) and small cottonwood trees; 31-100% cover of tall shrubs (willows, buffaloberry) and; <20% gravel, rock, and boulders; 5-19yrs
C:Closed 11540030	Late-closed: ≥31% cover of cottonwood, willow, conifers and other trees 10-24m; <20% gravel, rock, and boulders; >20 yrs
U:Annual Spp (aka: AG) 11540100	Annual-Species: >10% cover of non-native annual species on dry <u>incised</u> banks; < 10% shrub cover
U:Bare Ground (aka: BAGR) 11540101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances on either incised (most common case) or un-incised banks
U:Desertified (aka: DES) 11540304	Desertified: <u>Incised</u> river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush, snakeweed, rabbitbrush); <5% native grass cover

U:EFT 11540106	Exotic-Forb-Tree: >10% cover of exotic forb or tree species (knapweed, tall whitetop, thistles, purple loosestrife, salt cedar, or Russian olive)
U:Hummocked 11540110	Hummocked: Trampled by ungulates; graminoids and shrubs present to common in and out of holes created by ungulate hoofs.
U-SAP 11540324	Shrub-Annual-Species-Perennial-Grass: <u>Incised</u> river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush); >5% non-native annual species cover; >5% native grass cover; ≤20% cover of pinyon-juniper
U:Seeded Native (aka: SD) 11540135	Seeded-Native: >10% seeded basin wildrye, other grasses native to deep loamy soils, forbs, and shrubs; <5% non-native annual species (if ≥5 non-native annual species, then SAP or even AS)
U-SI+AG (aka: SDA) 11540138	Seeded-Introduced-Species-Annual-Species: Incised river/creek with >20% introduced grass species cover; >0% non-native annual species cover (this class lumps the SI and SI+AG classes); pinyon-juniper may be present
U-SFE 11540337	Shrub-Forb-Encroached: 10-50% cover of Wood's rose, sumac, or other unpalatable forbs and shrubs in open areas or under tree canopy
U-TEA (aka: TE) 11540344	Tree-Encroached or with Annual-Species: <u>Incised</u> river/creek with >20% cover of pinyon or juniper; highly variable cover of riparian shrubs and cottonwood; degree of incision is highly variable; non-native annual species may be present

Montane Sagebrush Steppe-upland (MSS) 11260	<i>Overview:</i> The Montane Sagebrush Steppe BpS (a.k.a., mountain big sagebrush) is found above and intergrades with the mesic sites of the Wyoming Big Sagebrush BpS. Elevation is generally above 2,134 m (6,500') in the southern Great Basin. 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 ridge tops, and mountain slopes. Vegetation types are usually dominated by <i>Artemisia tridentata</i> ssp. <i>vaseyana</i> , but other high-elevation sagebrush species can be present, even dominant if they are big sagebrush species (e.g., Bonneville big sagebrush). A variety of other shrubs can be found in some occurrences, but these are seldom dominant. Abundant forbs are an indicator of good range condition. Grasses are abundant, sometimes very abundant, and often diverse.
A:All 11260010	Early-all: 10-80% grass and forb cover; 0-10% canopy of mountain sagebrush, mountain brush; 0-12 yrs
B:Open 11260022	Mid-open: 11-30% cover of mountain sagebrush, mountain shrub; >50% herbaceous cover; 13-38 yrs
C:Closed 11260030	Mid-closed: >30% cover of mountain sagebrush (dominant) and mountain brush; 25-50% herbaceous cover; <10% conifer sapling cover; 39+ yrs
D:Open 11260042	Late-open: 10-30% cover of young pinyon-juniper; 25-40% cover of mountain sagebrush (dominant) and mountain brush; >10% herbaceous cover; 80-129 yrs
E:Closed 11260050	Late-closed: >30% older pinyon-juniper (>100 years) cover; 6-20% shrub cover; >10% herbaceous cover; 130+ yrs
U:Annual Spp (aka: AG) 11260100	Annual-Species: >10% cover of non-native annual species; snakeweed or rabbitbrush may be present
U:Bare Ground (aka: BAGR) 11260101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Depleted (aka: DP) 11260303	Depleted: >20% cover of mountain sagebrush (dominant) and mountain brush; <5% herbaceous cover; <30% conifer sapling cover; litter and mineral soil common
U:Early-Shrub (aka: ES) 11260105	Early-Shrub: >20% cover of snakeweed or rabbitbrush species

U:Exotic Forb (aka: EF) 11260108	Exotic-Forb-early: 5-100% exotic forbs (primarily thistles); <10% cover of rabbitbrush species; <10% cover of big sagebrush; native grass and forbs may be present
U:SA 11260321	Shrub-Annual-Species: 5-14% non-native annual species cover; >10% cover of mountain sagebrush (dominant) and mountain brush; ≤5% cover of native grass; <30% conifer sapling cover
U:SA+ 11260325	Shrub-Annual-Species+: ≥15% non-native annual species cover; >10% cover of mountain sagebrush (dominant) and mountain brush; ≤5% cover of native grass; <30% conifer sapling cover
U:SAP-A (aka:AGPG) 11260124	Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species cover; ≤10% cover of mountain sagebrush (dominant) and mountain brush; >5% cover of native grass; no conifers
U:SAP 11260224	Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species cover; 11-50% cover of mountain sagebrush (dominant) and mountain brush; occasional blackbrush above Mojave Desert slopes; >5% cover of native grass; <30% conifer sapling covers
U:SAP+ 11260230	Shrub-Annual-Species-Perennial-Grass+: ≥15% non-native annual species cover; >10% cover of mountain sagebrush (dominant) and mountain brush; >5% cover of native grass; <30% conifer sapling cover
U:Seeded Native (aka: SD) 11260135	Seeded-Native: >10% seeded native grasses, forbs, and shrubs
U:SI-A (aka: SDI-A) 11260129	Seeded-Introduced-Early: >10% seeded introduced grasses and shrubs; 0-10% canopy of mountain sagebrush, mountain brush; native grasses present to common; <5% cover of non-native annual species
U:SI-B (aka: SDI-B) 11260229	Seeded-Introduced-Mid-open: >10% seeded introduced grasses and shrubs; 11-30% cover of mountain sagebrush and mountain shrub; native grasses present to common; <5% cover of non-native annual species
U:SI-A (aka: SDI-C) 11260329	Seeded-Introduced-Mid-Closed: >5% seeded introduced grasses and shrubs; >30% cover of mountain sagebrush and mountain shrub; native grasses present to common; <10% conifer sapling cover; <5% cover of non-native annual species
U:SI-D (aka: SDI-D) 11260429	Seeded-Introduced-Late-Open: >5% seeded introduced grasses and shrubs; 10-30% conifer cover; 25-40% cover of mountain sagebrush and mountain shrub; native grasses present to common; <5% cover of non-native annual species
U-SI-A+AG (aka: SDI-A+AG) 11260138	Seeded-Introduced-Early+Annual-Species: >10% seeded introduced grasses and shrubs; 0-10% canopy of mountain sagebrush, mountain brush; native grasses present to common; ≥5% cover of non-native annual species
U-SI-B+AG (aka: SDI-B+AG) 11260238	Seeded-Introduced-Mid-Open+Annual-Species: >10% seeded introduced grasses and shrubs; 11-30% cover of mountain sagebrush and mountain shrub; native grasses present to common; ≥5% cover of non-native annual species
U-SI-C+AG (aka: SDI-C+AG) 11260338	Seeded-Introduced-Mid-Closed+Annual-Species: >5% seeded introduced grasses and shrubs; >30% cover of mountain sagebrush and mountain shrub; native grasses present to common; <10% conifer sapling cover; ≥5% cover of non-native annual species
U-SI-D+AG (aka: SDI-D+AG) 11260438	Seeded-Introduced-Late-Open+Annual-Species: >5% seeded introduced grasses and shrubs; 10-30% conifer cover; 25-40% cover of mountain sagebrush and mountain shrub; native grasses present to common; ≥5% cover of non-native annual species.
U-TEA (aka: TE or TA) 11260544	Tree-Encroached-Annual-Species: >20% pinyon-juniper cover 3-8m tall; <5% shrub cover; <5% herbaceous cover; <5% non-native annual species cover OR >20% pinyon-juniper cover 3-8m tall; ≥5% non-native annual species cover; ≥5% shrub cover; ≥5% herbaceous cover
Pickleweed (PW) 11531	<i>Overview:</i> The pickleweed (<i>Salicornia</i> spp.) ecological system is found at the transition between playa and greasewood, often forming a “bathtub ring” around playas. <i>Salicornia</i> spp. is often the only species present, although grasses found in greasewood flats can also be found in this system depending on soil moisture.
A:All 11531010	Early-all: ≥5% pickleweed; <5% herbaceous cover of inland salt grass, alkali sacaton, or basin wildrye; >25% mineral soil; flood debris may be present

Pinyon-Juniper Woodland (PJ) 10190	<i>Overview:</i> The Pinyon-Juniper Woodland BpS is typically found from 1,675-2,440 m (5,500-8,000') above the black sagebrush and Wyoming big sagebrush zones. This BpS generally occurs on most soils and landforms, especially fire-safe sites of steep and rocky slopes. Soils supporting this system vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. Woodlands comprising this system can be dominated by a mix of Pinus monophylla, Pinus edulis, and Juniperus osteosperma; by pure or nearly pure occurrences of Pinus monophylla or Pinus edulis; or solely by Juniperus osteosperma. Understory layers are variable. Grass and shrub species are often diverse and common, although not abundant.
A:All 10190010	Early-all: 5-20% herbaceous cover; charred stumps and trunks; 0-9 yrs
B:Open 10190022	Mid1-open: 11-30% cover big sagebrush, black sagebrush, or bitterbrush <1.0m, 10-40% herbaceous cover; 10-29 yrs
C:Open 10190032	Mid2-open: 11-20% cover of young (<100 yrs old) pinyon and/or juniper <5m, 10-20% shrub cover, <20% herbaceous cover; 30-99 yrs
D:Open 10190042	Late-open: 21-60% cover of pinyon and/or juniper <5m-9m, 10-40% shrub cover, <20% herbaceous cover; ≥100 yrs
U:Annual Spp (aka:AG) 10190100	Annual-Species: >10% non-native annual species cover; dead pinyon or juniper visible.
U:Bare Ground (aka: BAGR) 10190101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Exotic Forb (aka: EF) 10190108	Exotic-Forb: 5-100% exotic forbs (e.g., thistles, knapweed).
U:SAP 10190224	Shrub-Annual-Species-Perennial-Grass: >5% non-native annual species; 11-30% cover big sagebrush, black sagebrush, or bitterbrush <1.0m, <40% herbaceous cover
U:Seeded Native (aka: SD) 10190135	Seeded-Native: >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover.
U-SI (aka: SDI) 10190129	Seeded-Introduced: >10% seeded introduced grass and forbs; <5% cover of non-native annual species
U-SI+AG (aka: SDI+AG) 10190138	Seeded-Introduced+Annual-Species: >10% seeded introduced grass and forbs; ≥5% cover of non-native annual species.
U-TEA (aka: TA) 10190444	Tree-Encroached or with Annual-Species: ≥20% pinyon-juniper cover 3-8m tall; <5% shrub cover; <5% herbaceous cover; <5% non-native annual species cover OR ≥20% pinyon-juniper cover 3-8m tall; ≥5% non-native annual species cover; ≥5% shrub cover; ≥5% herbaceous cover; ≥30 yrs
Playa (PL) 10001	<i>Overview:</i> Dry salt flats of high reflectance that may be inundated during wetter years, especially during the winter and spring.
Barren 10001001	Barren: Salt flat with high reflectance that are usually dry but can be temporally inundated.

Ponderosa Pine (PP) 10540	<i>Overview:</i> The Ponderosa Pine BpS is found at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites. Occurrences are found on all slopes and aspects, though moderately steep to very steep slopes or ridge tops are most common. The BpS 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. <i>Pinus ponderosa</i> is the predominant conifer; <i>Pseudotsuga menziesii</i> , <i>Pinus edulis</i> , <i>Pinus monophylla</i> , and <i>Juniperus</i> spp. may be present in the tree canopy. The understory is usually shrubby, with <i>Artemisia nova</i> , <i>Artemisia tridentata</i> , <i>Arctostaphylos patula</i> , <i>Arctostaphylos uva-ursi</i> , <i>Cercocarpus montanus</i> , <i>Cercocarpus ledifolius</i> , <i>Purshia stansburiana</i> , <i>Purshia tridentata</i> , <i>Quercus gambelii</i> , <i>Symphoricarpos oreophilus</i> , <i>Prunus virginiana</i> , <i>Amelanchier alnifolia</i> , and <i>Rosa</i> spp. common species. <i>Pseudoroegneria spicata</i> and species of <i>Hesperostipa</i> , <i>Achnatherum</i> , <i>Festuca</i> , <i>Muhlenbergia</i> , and <i>Bouteloua</i> are some of the common grasses. <i>Pinus ponderosa</i> / <i>Arctostaphylos patula</i> represents the extreme with typically a high percentage of rock and bare soil present.
A:All	Early-all: 5-60% cover of shrub/grass; conifer seedlings can be abundant <5m; 0-39yrs
B:Closed (aka: B) 10540021	Mid-closed: 31-60% cover of ponderosa pine, pinyon, juniper, Douglas-fir, and white fir 5-10m; dense shrub cover possible; 40-159 yrs
B:Open (aka: C) 10540022	Mid-open: 5-30% cover of ponderosa pine (dominant), Douglas-fir, pinyon, juniper, and white fir 5-10m; abundant shrub and grass cover; 40-159 yrs
C:Open (aka: D) 10540032	Late-open: 5-30% cover of ponderosa pine (dominant), Douglas-fir, pinyon, juniper, and white fir 11-50m; abundant shrub and grass cover; ≥160 yrs
C:Closed (aka: E) 10540030	Late-closed: 31-80% cover of ponderosa pine, Douglas-fir, pinyon, juniper, and white fir 11-50m; mountain snowberry common; ≥160 yrs
U:Annual Spp (aka: AG)	Annual-Species: >10% non-native annual grass cover; ponderosa pine saplings may be present
U:Bare Ground (aka: BAGR) 10190101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:FIC-B-Closed 10540251	Fire-Intolerant-Conifer-Mid-closed: ≥30% cover of young pinyon, juniper, or curl-leaf mountain mahogany; occasional older and sapling of ponderosa pine may be present; herbaceous cover highly variable but generally <10% cover
U:FIC-B-Open 10540252	Fire-Intolerant-Conifer-Mid-open: <30% cover of young pinyon, juniper, or curl-leaf mountain mahogany; occasional older and sapling of ponderosa pine may be present; herbaceous cover highly variable but generally <20% cover
U:FIC-C-Open 10540352	Fire-Intolerant-Conifer-Late-open: <30% cover of older, but not ancient pinyon, juniper, or curl-leaf mountain mahogany; occasional older and sapling of ponderosa pine may be present; herbaceous cover highly variable but generally <20% cover
U:FIC-C-Closed 10540351	Fire-Intolerant-Conifer-Late-closed: ≥30% cover of older, but not ancient pinyon, juniper, or curl-leaf mountain mahogany; occasional older and sapling of ponderosa pine may be present; herbaceous cover highly variable but generally <10% cover
U:SI (aka: SDI) 10540129	Seeded-Introduced-Early: >10% seeded introduced grasses (smooth brome, intermediate wheatgrass); 0-10% canopy of mountain sagebrush, mountain brush; native grasses present to common; occasional ponderosa pine saplings or isolated large trees may be present; <5% cover of non-native annual species
U:SI+AG (aka: SDI+AG) 10540138	Seeded-Introduced-Early: >10% seeded introduced grasses (smooth brome, intermediate wheatgrass); 0-10% canopy of mountain sagebrush, mountain brush; native grasses present to common; occasional ponderosa pine saplings or isolated large trees may be present; ≥5% cover of non-native annual species

U:TEA (aka: TA) 10540344	Tree-Encroached or with Annual-Species: Any class B,C,D, or E plus >5% non-native annual grass cover
Roads-Local 10032	<i>Overview:</i> County-maintained dirt roads and larger unmaintained dirt roads, but not two-tracks.
U:Bare Ground 10032101	Bare-Ground: Local dirt road bigger than two-track roads
Roads-Paved 10031	<i>Overview:</i> Paved roads.
U:Paved 10031120	Paved: Paved road
Saline Meadow (SM) 11451	<i>Overview:</i> The Saline Meadow BpS is wetted by an elevated water table or is spring-fed. Saturated soils support graminoid dominance. Soils are deep and saline. These wet meadows are found at the bottom of broad valleys and on alluvial flats at elevations of 1,630 m to 1,676 m (5,350 to 5,500') with slopes between 0-2%, usually surrounded by salt tolerant plant communities. Average annual precipitation ranges from 20 to 25 cm (8" to 10"). Alkali sacaton (<i>Sporobolus airoides</i>) dominates, although inland saltgrass (<i>Distichlis spicata</i>) may co-dominate on some soils. Black greasewood and four-wing saltbush may be present at low abundance.
A:Open 11451012	Early-open: 10-60% alkali sacaton or inland saltgrass cover; 0-2 yrs
B:Closed 11451021	Mid-closed: 61-100% alkali sacaton or inland saltgrass cover; 3-22 yrs
C:Open 11451032	Late-open: 5-10% shrub (greasewood and four-wing saltbush) cover; 60-80% alkali sacaton or inland saltgrass cover; >22 yrs
U:Annual Spp (aka: AG) 11451100	Annual-Species: >10% cover of non-native annual species; <10% alkali sacaton or inland saltgrass cover; <10% shrub cover; >10% mineral soil cover
U:Bare Ground (aka: BAGR) 11451101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Depleted (aka: DP) 11451303	Depleted: ≥10% shrub cover (greasewood and other shrubs); <60% of inland saltgrass and Baltic rush cover; 10-30% cover of bare ground.
U:Exotic Forb (aka: EF) 11451108	Exotic-Forb: >5% exotic forbs (tall whitetop, knapweed, purple loosestrife, Russian thistle)
U:SAP-A (aka: AGPG) 11451124	Annual-Species-Perennial-Grass-early: <10% cover of native shrubs; ≥10% alkali sacaton or inland saltgrass cover; ≥5 non-native annual species cover; >10% mineral soil cover
U:SAP 11451324	Shrub-Annual-Species-Perennial-Grass: ≥10% cover of native shrubs; >10% alkali sacaton or inland saltgrass cover; ≥5 non-native annual species cover; >10% mineral soil cover

Semi-Desert Grassland (SDG) 11350	<i>Overview:</i> The Semi-Desert Grassland BpS occupies sandy soil and is found at approximately 1,450m to 2,320 m (4,750'-7,610') of elevation. Indian ricegrass (<i>Stipa hymenoides</i>) is often the diagnostic and dominant grass species. These grasslands occur in lowland and upland areas and may occupy swales, playas, mesa tops, plateau parks, alluvial flats, and plains, but sites are typically xeric. Substrates are often 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. Where they occur near foothill grasslands, they will be at lower elevations. These grasslands occur on a variety of aspects and slopes. Sites may range from flat to moderately steep. Annual precipitation is usually from 20-40 cm (7.9"-15.7"). Grasslands within this system are typically characterized by a sparse to moderately dense herbaceous layer dominated by medium-tall and short bunch grasses, often in a sod-forming growth. The dominant perennial bunch grasses and shrubs within this system are all very drought-resistant plants.
A:All 11350010	Early-all: <5% shrub cover (rabbitbrush); >10% cover of grasses (Indian ricegrass, big galleta, bush muhly, desert needlegrass); sandy soil cover may be high; 0-19 yrs
B:Closed 11350021	Mid-closed: ≥5% shrub cover (rabbitbrush, sagebrush); >25% cover of grasses (Indian ricegrass, big galleta, bush muhly, desert needlegrass); sandy soil cover may be high; ≥20 yrs
U:Bare Ground (aka: BAGR) 11350101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Depleted-C (aka: DP) 11350303	Depleted: ≥5% shrub (mostly rabbitbrush, sagebrush) cover; <10% cover of grasses; 10-30% bare ground cover; <20% cover of pinyon or juniper saplings; sandy soil cover may be high
U:Early-Shrub (aka: ES) 11350105	Early Shrub: 10-30% cover of rabbitbrush; 10-30% bare ground cover; <10% native grass cover; sandy soil cover may be high
U:SAP 11350224	Shrub-Annual-Perennial-Grass: 5-14% cover of non-native annual grasses; ≥5% shrub (mostly rabbitbrush, sagebrush) cover; native grasses may be present to common; <20% cover of pinyon or juniper saplings; sandy soil cover may be high
U:SAP+ 11350230	Shrub-Annual-Perennial-Grass+: ≥15% cover of non-native annual grasses; ≥5% shrub (mostly rabbitbrush, sagebrush) cover; native grasses may be present to common; <20% cover of pinyon or juniper saplings; sandy soil cover may be high
U:Seeded Native (aka: SD) 11350135	Seeded-Native: >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover.
U:SI (aka: SDI) 11350129	Seeded-Introduced: >10% cover of introduced seeded grass species; <5% cover of non-native annual species; sagebrush and other shrubs may be present; sandy soil cover may be moderately high
U-SI+AG (aka: SDI+AG) 11350138	Seeded-Introduced+Annual-Species: >10% cover of introduced seeded grass species; ≥5% cover of non-native annual grasses; sagebrush and other shrubs may be present; sandy soil cover may be moderately high
U:TEA 11350344	Tree-Encroached or with Annual-Species: >20% mature pinyon-juniper cover; <5% cover of shrubs; either <5% cover native grasses AND <5% cover of non-native annual species OR ≥5% cover of non-native annual species AND ≥5% cover native grasses; sandy soil cover may be moderately high.
Stansbury Cliffrose (SC) 10861	<i>Overview:</i> The Stansbury Cliffrose BpS is one of three mountain shrub types, where Stansbury cliffrose (<i>Purshia mexicana</i>) is the indicator species. Elevation ranges from 915 m to 2,438 m (3,000' to 8,000'), typically on mountain foothills and lower slopes. The BpS is found in small patches on different montane landforms with shallow unproductive soils. This cliffrose form of mountain shrub is usually at lower elevations and adjacent or imbedded in the montane zone adjacent to pinyon - juniper woodlands on moderate to steep slopes, and often follows linear geologic features (rock ledges).
A:All 10861010	Early-all: 0-10% canopy of Stansbury cliffrose or desert bitterbrush (often resprouting); 10-80% grass and forb cover; 0-12 yrs

B:Closed 10861021	Mid-closed: 11-20% cover of Stansbury cliffrose or desert bitterbrush; >25% herbaceous cover;<10% conifer sapling cover; 13-79 yrs
C:Open 10861032	Late-open: 10-20% pinyon pine-juniper cover 3-8m; >21% cover of Stansbury cliffrose or desert bitterbrush; <30% herbaceous cover; 80-129 yrs
U:Annual Spp (aka: AG) 10861100	Annual-Species: >10% cover of non-native annual grasses; snakeweed or rabbitbrush may be present; dead standing stems of Stansbury cliffrose or desert bitterbrush often present, with desert bitterbrush resprouts if the species is present.
U:Bare Ground (aka: BAGR) 10861101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Depleted (aka: DP) 10861303	Depleted: >20% cover of Stansbury cliffrose or desert bitterbrush; <5% herbaceous cover; <10% conifer sapling cover
U:Early-Shrub (aka: ES) 10861105	Early-Shrub: >10% snakeweed or rabbitbrush; <5% non-native annual species cover; native grass may be present; Stansbury cliffrose or desert bitterbrush may be present
U:SAP 10861224	Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species cover; >5% cover of Stansbury cliffrose or desert bitterbrush; native herbaceous cover usually present; trees may be present
U:SAP+ 10861230	Shrub-Annual-Species-Perennial-Grass+: ≥15% non-native annual species cover; >5% cover of Stansbury cliffrose or desert bitterbrush; native herbaceous cover usually present; trees may be present
U:Seeded Native (aka: SD) 10861135	Seeded-Native: >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover.
U:SI-A (aka: SDI-A) 10861129	Seeded-Introduced-Early: >10% seeded introduced grass and shrubs; 0-10% canopy of Stansbury cliffrose or desert bitterbrush (often resprouting); 10-80% grass and forb cover; <5% cover of non-native annual species
U:SI-B (aka: SDI-B) 10861229	Seeded-Introduced-Mid-open: >10% seeded introduced grass and shrubs; 11-20% cover of Stansbury cliffrose or desert bitterbrush; >25% herbaceous cover; <10% conifer sapling cover; <5% cover of non-native annual species
U:SI-C (aka: SDI-C) 10861329	Seeded-Introduced-Late-open: >10% seeded introduced grass and shrubs; 10-20% pinyon pine-juniper cover 3-8m; >21% cover of Stansbury cliffrose or desert bitterbrush; <30% herbaceous cover; <5% cover of non-native annual species
U:SI-A+AG (aka:SDI-A+AG) 10861138	Seeded-Introduced-Early+Annual-Species: >10% seeded introduced grass and shrubs; 0-10% canopy of Stansbury cliffrose or desert bitterbrush (often resprouting); 10-80% grass and forb cover; ≥5% cover of non-native annual species
U:SI-B+AG (aka:SDI-B+AG) 10861238	Seeded-Introduced-Mid-open+Annual-Species: >10% seeded introduced grass and shrubs; 11-20% cover of Stansbury cliffrose or desert bitterbrush; >25% herbaceous cover; <10% conifer sapling cover; ≥5% cover of non-native annual species
U:SI-C+AG (aka:SDI-C+AG) 10861338	Seeded-Introduced-Late-open+Annual-Species: >10% seeded introduced grass and shrubs; 10-20% pinyon pine-juniper cover 3-8m; >21% cover of Stansbury cliffrose or desert bitterbrush; <30% herbaceous cover; ≥5% cover of non-native annual species
U:TEA 10861344	Tree-Encroached-Annual-Species: >10% mature pinyon-juniper cover 3-8m; IF ≥5% cover of non-native annual grasses and forbs THEN >0% cover of Stansbury cliffrose or desert bitterbrush OR >0% native herbaceous cover; IF <5% cover of non-native annual grasses and forbs THEN <5% cover of Stansbury cliffrose AND <5% native herbaceous cover.

<p>Utah Serviceberry (US) 10860</p>	<p><i>Overview:</i> The Utah Serviceberry BpS is one of three mountain shrub types, where Utah serviceberry (<i>Amelanchier utahensis</i>) is the diagnostic shrub in the absence of Gambel oak. The BpS occupies the same elevation band as pinyon-juniper woodlands and big sagebrush steppe. These shrublands occur between 1,500-2,900 m (4,921-9,515') elevation and are usually associated with exposed sites, rocky substrates, and dry conditions, which limit tree growth. Scattered trees or inclusions of grassland patches or sagebrush steppe may be present, but the vegetation is typically dominated by a variety of shrubs including <i>Amelanchier utahensis</i>, <i>Cercocarpus montanus</i>, <i>Purshia tridentata</i>, <i>Rhus trilobata</i>, <i>Ribes cereum</i>, <i>Symphoricarpos oreophilus</i>, or <i>Yucca glauca</i>. In Utah, true mountain mahogany (<i>Cercocarpus montanus</i>) is a resprouting shrub that sometimes dominates this ecological system, whereas <i>Ribes</i>, <i>Acer</i>, mountain ash (<i>Sorbus scopulina</i>), and <i>Chrysothamnus</i> are less common. <i>Artemisia tridentata</i> ssp. <i>vaseyana</i> and <i>Holodiscus</i> are more common shrubs on dry sites in Utah and the Great Basin. Grasses are represented as species of <i>Muhlenbergia</i> spp., <i>Bouteloua</i> spp., <i>Stipa</i> spp., and <i>Elymus spicatus</i>. Fire plays an important role in this system as the dominant shrubs are usually affected by severe die-back, although some plants will stump sprout. <i>Cercocarpus montanus</i> requires a disturbance such as fire to reproduce, either by seed sprout or root crown sprouting. Fire suppression may have allowed an invasion of trees into some of these shrublands, but in many cases sites are too xeric for tree growth. When trees are present, they include pinyon pine, juniper, and limber pine. Douglas-fir and white fir may be found on more mesic sites.</p>
<p>A:All 10860010</p>	<p>Early-all: 0-10% canopy of serviceberry, antelope bitterbrush, or true mountain mahogany; 10-80% grass and forb cover; 0-4 yrs</p>
<p>B:Closed 10860021</p>	<p>Mid-closed: 11-30% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; >50% herbaceous cover; 5-19 yrs</p>
<p>C:Closed 10860030</p>	<p>Mid-closed: 31-50% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; 25-50% herbaceous cover; <10% conifer sapling cover; 20-79 yrs</p>
<p>D:Open 10860042</p>	<p>Late-open: 10-20% pinyon pine-juniper cover <5m; 25-40% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; ≥5% herbaceous cover; ≥80 yrs</p>
<p>U:Annual Spp (aka: AG) 10860100</p>	<p>Annual-Species: ≥10% cover of non-native annual species; snakeweed or rabbitbrush may be present.</p>
<p>U:Bare Ground (aka: BAGR) 10860101</p>	<p>Bare-Ground: Mostly mineral soil due to anthropogenic disturbances</p>
<p>U:Depleted (aka: DP) 10860303</p>	<p>Depleted: 31-50% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; <5% herbaceous cover; <10% conifer sapling cover</p>
<p>U:Early-Shrub (aka: ES) 10860105</p>	<p>Early-Shrub: 20-50% cover rabbitbrush species</p>
<p>U:SAP 10860324</p>	<p>Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species cover; 5-40% cover of mountain shrubs; native herbaceous cover usually present; trees may be present</p>
<p>U-SAP+ 10860330</p>	<p>Shrub-Annual-Species-Perennial-Grass+: ≥15% non-native annual species cover; 5-40% cover of mountain shrubs; native herbaceous cover usually present; trees may be present</p>
<p>U-SI-A (aka: SDI-A) 10860129</p>	<p>Seeded-Introduced-Early: >10% seeded introduced grass and shrubs; 0-10% canopy of serviceberry, antelope bitterbrush, or true mountain mahogany; 10-80% grass and forb cover; <5% cover of non-native annual species</p>
<p>U-SI-B (aka: SDI-B) 10860229</p>	<p>Seeded-Introduced-Mid-open: >10% seeded introduced grass and shrubs; 11-30% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; >50% herbaceous cover; <5% cover of non-native annual species</p>
<p>U-SI-C (aka: SDI-C) 10860329</p>	<p>Seeded-Introduced-Mid-closed: >10% seeded introduced grass and shrubs; 31-50% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; 25-50% herbaceous cover; <10% conifer sapling cover; <5% cover of non-native annual species</p>

U-SI-D (aka: SDI-D) 10860429	Seeded-Introduced-Late-open: >10% seeded introduced grass and shrubs; 10-20% pinyon pine-juniper cover <5m; 25-40% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; ≥5% herbaceous cover; <5% cover of non-native annual species
U-SI-A+AG (aka: SDI-A+AG) 10860138	Seeded-Introduced-Early+Annual-Species: >10% seeded introduced grass and shrubs; 0-10% canopy of serviceberry, antelope bitterbrush, or true mountain mahogany; 10-80% grass and forb cover; ≥5% cover of non-native annual species
U-SI-B+AG (aka: SDI-B+AG) 10860238	Seeded-Introduced-Mid-open+Annual-Species: >10% seeded introduced grass and shrubs; 11-30% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; >50% herbaceous cover; ≥5% cover of non-native annual species
U-SI-C+AG (aka: SDI-C+AG) 10860338	Seeded-Introduced-Mid-closed+Annual-Species: >10% seeded introduced grass and shrubs; 31-50% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; 25-50% herbaceous cover; <10% conifer sapling cover; ≥5% cover of non-native annual species
U-SI-D+AG (aka: SDI-D+AG) 10860438	Seeded-Introduced-Late-open+Annual-Species: >10% seeded introduced grass and shrubs; 10-20% pinyon pine-juniper cover <5m; 25-40% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; ≥5% herbaceous cover; ≥5% cover of non-native annual species
U-TEA (aka: TA, TE) 108660444	Tree-Encroached or with Annual-Species: >21% pinyon pine-juniper cover 3-8m; <5% shrub cover; <5% native herbaceous cover; <5% cover of non-native annual species OR >21% pinyon pine-juniper cover 3-8m; ≥5% cover of non-native annual grasses and forbs; ≥5% cover of snowberry, antelope bitterbrush, or true mountain mahogany; <30% herbaceous cover

Water 10040	<i>Overview:</i> Consists of both natural water bodies and human-made ones.
Water 10040011	Water: natural waterway
U:Water 10040148	Anthropogenic Water: water in reservoirs, impoundment, or irrigation ditch

Wet Meadow-Montane (WM) 11450	<i>Overview:</i> The Wet Meadow-Montane BpS is wetted by an elevated water table adjacent to creeks or rivers, or is spring-fed. Saturated soils support graminoid dominance. Rushes and sedges dominate with tufted hairgrass and Sandberg bluegrass common. The presence of shrubs (aspen, willow, Wood's rose, sagebrush) at the meadow's edge increases during consecutive drought years and decreases during consecutive high water years.
A:All 11450010	Early-all: 10-60% herbaceous cover – mostly graminoids; 0-2 yrs
B:Closed 11450021	Mid-closed: 61-100% herbaceous cover – mostly graminoids; 3-22 yrs
C:Open 11450032	Late-open: 5-10% tree-shrub (willow, Wood's rose, sagebrush, aspen) cover; 60-80% herbaceous cover – mostly graminoids; >22 yrs
U:Annual Spp (aka: AG) 11450100	Annual-Species (on incised meadow): >5% cover of non-native annual species; < 10% shrub cover
U:Bare Ground (aka: BAGR) 11450101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Desertified (aka: DES) 11450304	Desertified (= incised): Entrenched water table with 10-50% cover of sagebrush
U:Exotic Forb (aka: EF) 11450108	Exotic-Forb: >5% exotic forbs (knapweed, purple loosestrife, thistles)
U:Hummocked (aka: HUM) 11450110	Hummocked: Trampled by ungulates; graminoids present to common in and out of holes created by ungulate hoofs.

U:Inset 11450113	Inset-Floodplain: Functional wet meadow dominated by graminoids has formed on a new floodplain at the bottom of a widened incision.
U:Inset-EF 11450116	Inset-Floodplain-Exotic-Forb: Functional wet meadow dominated by graminoids has formed on a new floodplain at the bottom of a widened incision; >5% exotic forbs (knapweed, purple loosestrife, thistles)
U:Inset-Hummocked 11450117	Inset-Floodplain-Hummocked: Functional wet meadow has formed on a new floodplain at the bottom of a widened incision that has been trampled by ungulates; graminoids present to common in and out of holes created by ungulate hoofs.
U:SA 11450121	Shrub-Annual-Species (on incised meadow): >10% cover of native shrubs; <5% native grass cover; 5-30% cover of non-native annual species
U:SFE 11450337	Shrub-Forb-Encroached: >10% cover of less palatable grasses and forbs (e.g., Iris missouriensis) OR >10% shrub cover (willow, Wood's rose, sagebrush, aspen); 10-30% cover of bare ground
U:SI (aka: SDI) 11450129	Seeded-Introduced: ≥10% cover of introduced forage species (e.g., smooth brome, intermediate wheatgrass); >10% native graminoid cover
U:TEA 11450344	Tree-Encroached-Annual-Species (on incised meadow): >20% conifer cover 10-25m; <5% shrub cover; <5% native herbaceous cover; ≥0% cover of non-native annual species

Winterfat (WF) 10812	<i>Overview:</i> The Winterfat BpS is generally considered part of the mixed salt desert scrub communities. Winterfat communities occupy saline silty or gravelly silty soils on shallow slopes between 1,158 – 1981m (3,800 - 6,500'). Such sites are often found in shallow washes. Average annual precipitation ranges from 7.5-25.4cm (3 to 10"); however, this system is in 12.7-30.3cm (5-8") of effective moisture within this broader range. Winterfat (<i>Krascheninnikovia lanata</i>) is the dominant shrub, often monotypic. Snakeweed and rabbitbrush also can be common shrubs. Common grasses are Indian ricegrass, squirreltail, and needle-and-thread.
A:All 10812010	Early-all: >10% Indian ricegrass, squirreltail, other native grasses; ≤5% cover of rabbitbrush, snakeweed, and other salt desert shrubs; <60% mineral soil <0.5m; 0-49 yrs
B:Open 10812022	Mid1-open: 5-20% cover winterfat, rabbitbrush, and other desert shrubs <0.5m; >10% native grass cover; 50-149 yrs
C:Closed 10812030	Late1-closed: >20% cover winterfat, rabbitbrush, and other salt desert shrubs; >5% grass cover; >150 yrs
U:Annual Spp (aka: AG) 10812100	Annual-Species: >10% non-native annual species (non-native annual species, mustards) cover; <5% cover of native shrubs
U:Bare Ground (aka: BAGR) 108120101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Depleted (aka: DP) 10812303	Depleted: >5% cover of winterfat or other shrubs; ≤5% native grass cover; ≤5% non-native annual species cover; ≤5% exotic forb cover
U:Exotic Forb (aka: EF) 10812108	Exotic-Forb: >5% cover halogeton or exotic mustards; <10% cover of non-native annual species; >50% mineral soil
U-SA 10812321	Shrub-Annual-Species: 5-14% non-native annual species cover; >5% cover of winterfat or other shrubs; ≤5% native grass cover
U:SA+ 10812325	Shrub-Annual-Species+: ≥15% non-native annual species cover; >5% cover of winterfat or other shrubs; ≤5% native grass cover
U:SAP-A (aka: AGPG) 10812124	Shrub-Annual-Species-Perennial-Grass-early: >5% non-native annual species cover; ≤5% cover of winterfat or other shrubs; >5% native grass cover
U:SAP 10812324	Shrub-Annual-Species-Perennial-Grass: 5-14% non-native annual species cover; >5% cover of winterfat or other shrubs; >5% native grass cover

U-SAP+ 10812330	Shrub-Annual-Species-Perennial-Grass+: ≥15% non-native annual species cover; >5% cover of winterfat or other shrubs; >5% native grass cover
U:Seeded Native (aka: SD) 10812135	Seeded-Native: ≥10% native grass species seed mix cover; <5% non-native annual species cover
U-SI (aka: SDI) 10812129	Seeded-Introduced: ≥5% introduced species (crested wheatgrass, forage kochia) seed mix cover; <5% non-native annual species cover
U:SI+AG (aka: SDI-A+AG) 10812138	Seeded-Introduced+Annual-Species: ≥5% introduced species (crested wheatgrass, forage kochia) seed mix cover; ≥5% non-native annual species cover

Wyoming Big Sagebrush-upland soils (WSup) 10804	<i>Overview:</i> The Wyoming Big Sagebrush upland BpS is common in the Basin and Range province. It ranges from 1,219 m to 2,132 m (4,000' - 7,000') in elevation, and occurs on well-drained soils on foothills, terraces, slopes and plateaus. It is found on soil depths greater than 45 cm (18") and up to 152 cm (60+"). The BpS is found between low elevation salt desert shrub typically unfavorable to tree establishment and higher elevation mountain big sagebrush zones where pinyon and juniper can establish. The BpS occurs from 10 cm to 35 cm (4 to 14") precipitation zones; however, Wyoming big sagebrush requires 20-30 cm (8-12") of effective moisture within this broader range. Thus, other site characteristics (e.g. aspect, drainage) should be considered in identifying this BpS. At the precipitation extremes, this BpS generally occurs as small patches and stringers. Shrub canopy cover generally ranges from 5 to 25%, but can exceed 30% at the upper elevation and precipitation zones. Wyoming big sagebrush sites have fewer understory species relative to other big sagebrush types. Rubber rabbitbrush may be co-dominant and basin big sagebrush might occur on concave sites with finer soils. Perennial forb cover is usually <10% and perennial grass cover reaches 20 - 25% on more productive sites. Bluebunch wheatgrass may be a dominant species following replacement fires and as a co-dominant after 20 years, but only in precipitation zones above 25 cm (10"). Bottlebrush squirreltail and Indian ricegrass are common on more xeric sites. Percent cover and species richness of understory are determined by site limitations. Pinyon pine (<i>Pinus monophyla</i> and <i>Pinus edulis</i>) and juniper (generally <i>Juniperus osteosperma</i>) are present, occasionally reaching 50% canopy cover in areas that have escaped fire.
A:All 10804010	Early-all: 10-25% herbaceous cover; <10% cover of rabbitbrush species; <10% cover of Wyoming big sagebrush; 0-20 yrs
B:Open 10804022	Mid-open: 11-20% cover of Wyoming big sagebrush; 10-25% herbaceous cover; 20-60 yrs
C:Closed 10804030	Late1-closed: >20% cover of Wyoming big sagebrush; 10-20% native herbaceous cover; 60-100 yrs;
D:Open 10804042	Late2-open: 0-15% pinyon or juniper sapling <5m tall; 10-25% cover of Wyoming big sagebrush; <15% native herbaceous cover; 100-150 yrs;
E:Closed 10812050	Late2-closed: >20% pinyon or juniper cover <10m tall; <10% cover of Wyoming big sagebrush; ~5% native herbaceous cover; 150+ yrs
U:Annual Spp (aka: AG) 10804100	Annual-Species: >10% cover of non-native annual species
U:Bare Ground (aka: BAGR) 10804101	Bare-Ground: Mostly mineral soil due to anthropogenic disturbances
U:Depleted (aka: DP) 10804303	Depleted: >20% cover of big sage (dominant); <5% herbaceous cover; <30% conifer sapling cover; litter and mineral soil common
U:Early-Shrub (aka: ES) 10804105	Early-Shrub: >10% cover rabbitbrush species

U:SA 10804321	Shrub-Annual-Species: 5-14% cover non-native annual species; ≥10% Wyoming big sagebrush <0.5m; scattered pinyon-juniper saplings may be present; native grasses rare
U:SA+ 10804325	Shrub-Annual-Species+: ≥15% cover non-native annual species; ≥10% Wyoming big sagebrush <0.5m; scattered pinyon-juniper saplings may be present; native grasses rare
U:SAP-A (aka: AGPG) 10804124	Shrub-Annual-Species-Perennial-Grass: 5-14% cover non-native annual species; <10% Wyoming big sagebrush <0.5m; ≥5% cover native grasses; pinyon-juniper absent
U:SAP 108042324	Shrub-Annual-Species-Perennial-Grass: 5-14% cover non-native annual species; ≥10% Wyoming big sagebrush <0.5m; ≥5-20% cover native grasses; scattered pinyon-juniper saplings may be present
U:SAP+ (aka: SAP) 1084230	Shrub-Annual-Species-Perennial-Grass+: ≥15% cover non-native annual species; ≥10% Wyoming big sagebrush <0.5m; 5-20% cover native grasses; scattered pinyon-juniper saplings may be present
U:Seeded Native (aka: SD) 10804135	Seeded-Native: >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover.
U:SI-A (aka: SDI-A) 10804129	Seeded-Introduced-Early: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of rabbitbrush species; <10% cover of Wyoming big sagebrush; native grass may be present to common; <5% cover of non-native annual species
U:SI-B (aka: SDI-B) 10804229	Seeded-Introduced-Mid-open: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 11-20% cover of Wyoming big sagebrush; native grass may be present to common; <5% cover of non-native annual species
U:SI-C (aka: SDI-C) 10804329	Seeded-Introduced-Late1-closed: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 20-40% cover of Wyoming big sagebrush; native grass may be present to common; <5% cover of non-native annual species
U:SI-D (aka: SDI-D) 10804429	Seeded-Introduced-Late2-open: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 0-15% pinyon or juniper sapling <5m tall; 10-25% cover of Wyoming big sagebrush; native grass may be present to common; <5% cover of non-native annual species
U:SI-A+AG 10804138	Seeded-Introduced-Early+Annual-Species: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of rabbitbrush species; <10% cover of Wyoming big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species
U:SI-B+AG 10804238	Seeded-Introduced-Mid-open+Annual-Species: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 11-20% cover of Wyoming big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species
U:SI-C+AG 10804338	Seeded-Introduced-Late1-closed+Annual-Species: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 20-40% cover of Wyoming big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species
U:SI-D+AG 10804438	Seeded-Introduced-Late2-open+Annual-Species: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 0-15% pinyon or juniper sapling <5m tall; 10-25% cover of Wyoming big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species
U:TEA 10804544	Tree-Encroached-Annual-Species: 11-60% cover of trees 5-9m; non-native annual species may be present to abundant; native grasses absent or trace amounts

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Aspen Woodland	ASP-A:All	Aspen Woodland	ASP-A:All	Wild-Horse-Grazing	0.0400	0.9990				Yes		
Aspen Woodland	ASP-A:All	Aspen Woodland	ASP-A:All	Cattle+Sheep-Grazing	0.0400	0.9995	3		1	Yes	12	
Aspen Woodland	ASP-A:All	Aspen Woodland	ASP-A:All	Fence	1.0000					No	12	
Aspen Woodland	ASP-A:All	Aspen Woodland	ASP-A:All	NativeGrazing	0.0020					Yes		
Aspen Woodland	ASP-A:All	Aspen Woodland	ASP-A:All	ReplacementFire	0.0200	0.2000				Yes		
Aspen Woodland	ASP-A:All	Aspen Woodland	ASP-U->MSS:All	Cattle+Sheep-Grazing	0.0400	0.0005	3		1	Yes	12	
Aspen Woodland	ASP-A:All	Aspen Woodland	ASP-U->MSS:All	Wild-Horse-Grazing	0.0100	0.0010				Yes		
Aspen Woodland	ASP-A:All	Montane Sagebrush Steppe	MSS-A:All	Range Shift	0.0714	0.7500		1	1	No	60	
Aspen Woodland	ASP-A:All	Utah Serviceberry	US-A:All	Range Shift	0.0714	0.2500		1	1	No	60	
Aspen Woodland	ASP-B:Closed	Aspen Woodland	ASP-A:All	ReplacementFire	0.0200	0.2000				Yes		
Aspen Woodland	ASP-B:Closed	Aspen Woodland	ASP-B:Closed	Cattle+Sheep-Grazing	0.0400	0.9995			1	No	12	
Aspen Woodland	ASP-B:Closed	Aspen Woodland	ASP-U:Depleted-B	Cattle+Sheep-Grazing	0.0400	0.0005			1	No	12	
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-A:All	Chainsaw-Thinning	1.0000					Yes		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-A:All	Insect/Disease	0.0050	0.2000				Yes		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-A:All	ReplacementFire	0.0200	0.5000				Yes		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-A:All	RxFire	1.0000	0.7000				Yes		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-C:Closed	Cattle+Sheep-Grazing	0.0400	0.9995			1	No	12	
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-C:Closed	Insect/Disease	0.0050	0.8000			-1	No		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-C:Closed	RxFire	1.0000	0.3000				No		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-U:Depleted-C	Cattle+Sheep-Grazing	0.0400	0.0005			1	No	12	
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-A:All	Chainsaw-Thinning	1.0000					Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-A:All	Senescence	0.0100		150			Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-D:Open	Small-Tree-Lopping	1.0000					Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-A:All	ReplacementFire	0.0200	0.5000				Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-A:All	RxFire	1.0000	0.7000				Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-C:Closed	Insect/Disease	0.0030					Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-D:Open	Cattle+Sheep-Grazing	0.0400	0.9995			1	No	12	
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-D:Open	MixedFire	0.0020					Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-D:Open	RxFire	1.0000	0.3000				No		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-U:Depleted-D	Cattle+Sheep-Grazing	0.0400	0.0005			1	No	12	
Aspen Woodland	ASP-U:Depleted-B	Aspen Woodland	ASP-A:All	ReplacementFire	0.0200	0.9000						
Aspen Woodland	ASP-U:Depleted-B	Aspen Woodland	ASP-B:Closed	Natural-Recovery	1.0000					No	9	
Aspen Woodland	ASP-U:Depleted-B	Aspen Woodland	ASP-U:Depleted-D	Cattle+Sheep-Grazing	0.0400				1	No		
Aspen Woodland	ASP-U:Depleted-B	Aspen Woodland	ASP-U:Depleted-D	Fence	1.0000					No	12	
Aspen Woodland	ASP-U:Depleted-B	Aspen Woodland	ASP-U->MSS:All	ReplacementFire	0.0200	0.1000						
Aspen Woodland	ASP-U:Depleted-C	Aspen Woodland	ASP-A:All	Insect/Disease	0.0033	0.1000						
Aspen Woodland	ASP-U:Depleted-C	Aspen Woodland	ASP-A:All	ReplacementFire	0.0200	0.4000						
Aspen Woodland	ASP-U:Depleted-C	Aspen Woodland	ASP-B:Closed	Natural-Recovery	1.0000					No	9	
Aspen Woodland	ASP-U:Depleted-C	Aspen Woodland	ASP-U:Depleted-C	Cattle+Sheep-Grazing	0.0400				1	No		
Aspen Woodland	ASP-U:Depleted-C	Aspen Woodland	ASP-U:Depleted-C	Fence	1.0000					No	12	
Aspen Woodland	ASP-U:Depleted-C	Aspen Woodland	ASP-U:Depleted-C	Insect/Disease	0.0033	0.8000				No		
Aspen Woodland	ASP-U:Depleted-C	Aspen Woodland	ASP-U->MSS:All	Insect/Disease	0.0033	0.1000			20			
Aspen Woodland	ASP-U:Depleted-C	Aspen Woodland	ASP-U->MSS:All	ReplacementFire	0.0200	0.1000						
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-A:All	Insect/Disease	0.0033	0.0500				Yes		
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U->MSS:All	LosingClone	0.0001		250	299	40	Yes	12	
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U->MSS:All	LosingClone	0.0010		300	499	40	Yes	12	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U->MSS:All	LosingClone	0.0100		500			Yes		
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-A:All	Chainsaw-Thinning	1.0000					Yes	12	
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-A:All	ReplacementFire	0.0200	0.4500				Yes		
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-A:All	RxFire	1.0000	0.7000				Yes	12	
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-A:All	Severe Drought	0.0070	0.1000				Yes		
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-D:Open	Natural-Recovery	1.0000					Yes	9	
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U:Depleted-D	Cattle+Sheep-Grazing	0.0400				1	No	12	
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U:Depleted-D	Fence	1.0000					No	12	
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U:Depleted-D	Insect/Disease	0.0033	0.9000				Yes		
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U:Depleted-D	RxFire	1.0000	0.3000				No	12	
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U:Depleted-D	Severe Drought	0.0070	0.8000				Yes		
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U->MSS:All	Insect/Disease	0.0033	0.0500			20	Yes		
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U->MSS:All	ReplacementFire	0.0200	0.0500				Yes		
Aspen Woodland	ASP-U:Depleted-D	Aspen Woodland	ASP-U->MSS:All	Severe Drought	0.0070	0.1000			20	Yes		
Aspen Woodland	ASP-U->MSS:All	Aspen Woodland	ASP-U->MSS:All	ReplacementFire	0.0100		150			Yes		
Aspen Woodland	ASP-U->MSS:All	Aspen Woodland	ASP-U->MSS:All	ReplacementFire	0.0125		0	12		Yes		
Aspen Woodland	ASP-U->MSS:All	Aspen Woodland	ASP-U->MSS:All	ReplacementFire	0.0200		30	149		Yes		
Aspen Woodland	ASP-U->MSS:All	Aspen Woodland	ASP-U->MSS:All	ReplacementFire	0.0250		13	29		Yes		
Aspen Woodland	ASP-U->MSS:All	Montane Sagebrush Steppe	MSS-A:All	Range Shift	0.0714	0.7500		1	1	No	60	
Aspen Woodland	ASP-U->MSS:All	Utah Serviceberry	US-B:Closed	Range Shift	0.0714	0.2500		1	1	No	60	
Aspen-Mixed Conifer	ASM-A:All	Aspen-Mixed Conifer	ASM-A:All	Fence	1.0000					No	12	
Aspen-Mixed Conifer	ASM-A:All	Aspen-Mixed Conifer	ASM-A:All	ReplacementFire	0.0200	0.1000				Yes		
Aspen-Mixed Conifer	ASM-A:All	Aspen-Mixed Conifer	ASM-A:All	Wild-Horse-Grazing	0.0100	0.9990				Yes		
Aspen-Mixed Conifer	ASM-A:All	Aspen-Mixed Conifer	ASM-A:All	Cattle+Sheep-Grazing	0.0100	0.9995	3		1	No	12	
Aspen-Mixed Conifer	ASM-A:All	Aspen-Mixed Conifer	ASM-A:All	NativeGrazing	0.0020	0.0500				Yes		
Aspen-Mixed Conifer	ASM-A:All	Aspen-Mixed Conifer	ASM-A:All	NativeGrazing	0.0020	0.9500				Yes		
Aspen-Mixed Conifer	ASM-A:All	Aspen-Mixed Conifer	ASM-U->MC:All	Cattle+Sheep-Grazing	0.0100	0.0005	3			No	12	
Aspen-Mixed Conifer	ASM-A:All	Aspen-Mixed Conifer	ASM-U->MC:All	Wild-Horse-Grazing	0.0000	0.0010				Yes		
Aspen-Mixed Conifer	ASM-A:All	Mixed Conifer	MC-A:All	Range Shift	0.0714	0.5000		1	1	No	60	
Aspen-Mixed Conifer	ASM-A:All	Montane Sagebrush Steppe	MSS-A:All	Range Shift	0.0714	0.2500		1	1	No	60	
Aspen-Mixed Conifer	ASM-A:All	Ponderosa Pine	PP-A:All	Range Shift	0.0714	0.2500		1	1	No	60	
Aspen-Mixed Conifer	ASM-B:Closed	Aspen-Mixed Conifer	ASM-A:All	ReplacementFire	0.0200	0.2500				Yes		
Aspen-Mixed Conifer	ASM-B:Closed	Aspen-Mixed Conifer	ASM-B:Closed	Cattle+Sheep-Grazing	0.0100	0.0005			1	No	12	
Aspen-Mixed Conifer	ASM-B:Closed	Aspen-Mixed Conifer	ASM-B:Closed	Cattle+Sheep-Grazing	0.0100	0.9995				No	12	
Aspen-Mixed Conifer	ASM-C:Closed	Aspen-Mixed Conifer	ASM-C:Closed	Cattle+Sheep-Grazing	0.0100	0.0005			1	No	12	
Aspen-Mixed Conifer	ASM-C:Closed	Aspen-Mixed Conifer	ASM-C:Closed	Cattle+Sheep-Grazing	0.0100	0.9995				No	12	
Aspen-Mixed Conifer	ASM-C:Closed	Aspen-Mixed Conifer	ASM-A:All	Insect/Disease	0.0050	0.2000				Yes		
Aspen-Mixed Conifer	ASM-C:Closed	Aspen-Mixed Conifer	ASM-A:All	ReplacementFire	0.0200	0.5000				Yes		
Aspen-Mixed Conifer	ASM-C:Closed	Aspen-Mixed Conifer	ASM-B:Closed	Insect/Disease	0.0050	0.8000				Yes		
Aspen-Mixed Conifer	ASM-C:Closed	Aspen-Mixed Conifer	ASM-C:Closed	MixedFire	0.0150					Yes		
Aspen-Mixed Conifer	ASM-D:Open	Aspen-Mixed Conifer	ASM-D:Open	Competition	0.0010				-10	No		
Aspen-Mixed Conifer	ASM-D:Open	Aspen-Mixed Conifer	ASM-D:Open	Insect/Disease	0.0050				1	No		
Aspen-Mixed Conifer	ASM-D:Open	Aspen-Mixed Conifer	ASM-A:All	ReplacementFire	0.0219					Yes		
Aspen-Mixed Conifer	ASM-D:Open	Aspen-Mixed Conifer	ASM-A:All	RxFire	1.0000	0.7000				Yes		
Aspen-Mixed Conifer	ASM-D:Open	Aspen-Mixed Conifer	ASM-C:Closed	Chainsaw-Thinning	1.0000					Yes		
Aspen-Mixed Conifer	ASM-D:Open	Aspen-Mixed Conifer	ASM-D:Open	RxFire	1.0000	0.3000				No		
Aspen-Mixed Conifer	ASM-D:Open	Aspen-Mixed Conifer	ASM-D:Open	SurfaceFire	0.0024					No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-D:Open	Severe Drought	0.0070					Yes		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-E:Closed	SurfaceFire	0.0014					Yes		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-U->MC:All	LosingClone	0.0010		300	499		No		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-U->MC:All	LosingClone	0.0100		500			No		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-A:All	Chainsaw-Thinning	1.0000	0.1000	150			Yes		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-A:All	ReplacementFire	0.0200					Yes		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-A:All	RxFire	1.0000	0.7000				Yes		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-C:Closed	Chainsaw-Thinning	1.0000	0.9000	150			Yes		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-D:Open	Insect/Disease	0.0056					Yes		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-E:Closed	RxFire	1.0000	0.3000				No		
Aspen-Mixed Conifer	ASM-E:Closed	Aspen-Mixed Conifer	ASM-U->MC:All	LosingClone	0.0001		250	299		No		
Aspen-Mixed Conifer	ASM-U->MC:All	Aspen-Mixed Conifer	ASM-U->MC:All	ReplacementFire	0.0100		30	99		Yes		
Aspen-Mixed Conifer	ASM-U->MC:All	Aspen-Mixed Conifer	ASM-U->MC:All	ReplacementFire	0.0100		100			Yes		
Aspen-Mixed Conifer	ASM-U->MC:All	Aspen-Mixed Conifer	ASM-U->MC:All	ReplacementFire	0.0080			29		Yes		
Aspen-Mixed Conifer	ASM-U->MC:All	Mixed Conifer	MC-A:All	Range Shift	0.0714	0.5000		1	1	No	60	
Aspen-Mixed Conifer	ASM-U->MC:All	Montane Sagebrush Steppe	MSS-A:All	Range Shift	0.0714	0.2500		1	1	No	60	
Aspen-Mixed Conifer	ASM-U->MC:All	Ponderosa Pine	PP-A:All	Range Shift	0.0714	0.2500		1	1	No	60	
Barren	Barren:Barren	Barren	Barren:Barren	ReplacementFire	0.0001					Yes		
Basin Wildrye	BW-A:All	Basin Wildrye	BW-A:All	Wild-Horse-Grazing	0.1000	0.9990				2	No	
Basin Wildrye	BW-A:All	Basin Wildrye	BW-U:Bare Ground	Cattle+Sheep-Grazing	0.1000	0.0005	2			Yes		
Basin Wildrye	BW-A:All	Basin Wildrye	BW-U:Bare Ground	Wild-Horse-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-A:All	Basin Wildrye	BW-U:Early-Shrub	Wild-Horse-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-A:All	Basin Wildrye	BW-A:All	Cattle+Sheep-Grazing	0.1000	0.9990	2		1	No		
Basin Wildrye	BW-A:All	Basin Wildrye	BW-A:All	ReplacementFire	0.0200					Yes		
Basin Wildrye	BW-A:All	Basin Wildrye	BW-A:All	Weed-Inventory+Treat	1.0000					No	3	
Basin Wildrye	BW-A:All	Basin Wildrye	BW-U:Early-Shrub	Cattle+Sheep-Grazing	0.1000	0.0005	2			No		
Basin Wildrye	BW-A:All	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0001		5			Yes	5	
Basin Wildrye	BW-A:All	Four-Wing Saltbush	FWS-A:All	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-A:All	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-A:All	Wyoming Big Sagebrush upland	WSup-A:All	Range Shift	0.0620	0.2000		1	1	No	60	
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-B:Closed	Wild-Horse-Grazing	0.1000	0.9990				2	No	
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-U:Bare Ground	Cattle+Sheep-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-U:Bare Ground	Wild-Horse-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-U:Early-Shrub	Wild-Horse-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-A:All	ReplacementFire	0.0250					Yes		
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-A:All	Severe Drought	0.0070					5	Yes	
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-B:Closed	Cattle+Sheep-Grazing	0.1000	0.9990				1	No	
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-B:Closed	Weed-Inventory+Treat	1.0000					No	3	
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-U:Early-Shrub	Cattle+Sheep-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0001					Yes	5	
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-U:SAP	2xChaining+Seed	1.0000					No		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-A:All	Masticate+Native-Seed	1.0000	0.9500				Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-A:All	Thin	1.0000					Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-C:Open	Wild-Horse-Grazing	0.1000	0.9990				2	No	
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:Bare Ground	Cattle+Sheep-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:Bare Ground	Wild-Horse-Grazing	0.1000	0.0005				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:Depleted-C	Wild-Horse-Grazing	0.1000	0.0005			2	No		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:Early-Shrub	Masticate+Native-Seed	1.0000	0.0500				Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-A:All	ReplacementFire	0.0150					Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-A:All	RxFire	1.0000					Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-B:Closed	Severe Drought	0.0070	0.1000				Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-C:Open	Cattle+Sheep-Grazing	0.1000	0.9990			1	No		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-C:Open	Severe Drought	0.0070	0.9000				Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-C:Open	Small-Tree-Lopping	1.0000		100			Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-C:Open	Weed-Inventory+Treat	1.0000					No	3	
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:Depleted-C	Cattle+Sheep-Grazing	0.1000	0.0005			1	No		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0001					Yes	5	
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:SAP	AG-Invasion	0.0010					No		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:TEA	Tree-Encroachment	0.0071		150			Yes		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:Annual Spp	Cattle+Sheep-Grazing	0.1000				1	No		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:Annual Spp	Chaining+Native-Seed	1.0000	0.2000		5		Yes		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.0500		5		Yes		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:Annual Spp	Wild-Horse-Grazing	0.1000				2	No		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:Seeded Native	Chaining+Native-Seed	1.0000	0.8000		5		Yes		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:SI	Chaining+Plateau+Seed	1.0000	0.9000		5		Yes		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:SI+AG	Chaining+Plateau+Seed	1.0000	0.0500		5		Yes		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:SI+AG	Herbicide-Plateau+Seed	1.0000	0.1000		5		Yes		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:Annual Spp	Herbicide-Plateau+Seed	1.0000	0.1000		5		Yes		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:Annual Spp	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0001	1.0000				Yes	5	
Basin Wildrye	BW-U:Annual Spp	Basin Wildrye	BW-U:SI	Herbicide-Plateau+Seed	1.0000	0.8000		5		Yes		
Basin Wildrye	BW-U:Annual Spp	Four-Wing Saltbush	FWS-U:Annual Spp	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Range Shift	0.0620	0.2000		1	1	No	60	
Basin Wildrye	BW-U:Bare Ground	Basin Wildrye	BW-U:Annual Spp	AG-Invasion	0.0050					Yes		
Basin Wildrye	BW-U:Bare Ground	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0005					Yes	5	
Basin Wildrye	BW-U:Bare Ground	Four-Wing Saltbush	FWS-U:Bare Ground	Range Shift	0.0620	0.4000	1	1		No	60	
Basin Wildrye	BW-U:Bare Ground	Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Range Shift	0.0620	0.4000	1	1		No	60	
Basin Wildrye	BW-U:Bare Ground	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Range Shift	0.0620	0.2000	1	1		No	60	
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Depleted-C	Small-Tree-Lopping	1.0000		75			Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Early-Shrub	Spyke+Native-Seed	1.0000	0.2000				Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Early-Shrub	Thin+Native-Seed	1.0000	0.1000				Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Seeded Native	Spyke+Native-Seed	1.0000	0.8000				Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Seeded Native	Thin+Native-Seed	1.0000	0.9000				Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Depleted-C	Severe Drought	0.0070	0.9000				Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Depleted-C	Weed-Inventory+Treat	1.0000					No	3	
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Early-Shrub	Masticate+Native-Seed	1.0000	0.2000				Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Early-Shrub	ReplacementFire	0.0100					Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Early-Shrub	Severe Drought	0.0070	0.1000				Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0001					Yes	5	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:SAP	AG-Invasion	0.0050					No		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:Seeded Native	Masticate+Native-Seed	1.0000	0.8000				Yes		
Basin Wildrye	BW-U:Depleted-C	Basin Wildrye	BW-U:TEA	Tree-Invasion	0.0050		75			Yes		
Basin Wildrye	BW-U:Early-Shrub	Basin Wildrye	BW-U:Early-Shrub	ReplacementFire	0.0100					Yes		
Basin Wildrye	BW-U:Early-Shrub	Basin Wildrye	BW-U:Early-Shrub	Thin+Herbicide+Native-Seed	1.0000	0.3000				Yes		
Basin Wildrye	BW-U:Early-Shrub	Basin Wildrye	BW-U:Seeded Native	Thin+Herbicide+Native-Seed	1.0000	0.7000				Yes		
Basin Wildrye	BW-U:Early-Shrub	Four-Wing Saltbush	FWS-U:Early-Shrub	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:Early-Shrub	Greasewood-Basin Big Sagebrush	GW-B:Closed	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:Early-Shrub	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Range Shift	0.0620	0.2000		1	1	No	60	
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-U:Exotic Forb	Wild-Horse-Grazing	0.1000				2	No		
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-U:Seeded Native	Exotic-Control+Native-Seed	1.0000	0.6000	10			Yes		20
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-A:All	Exotic-Control+Native-Seed	1.0000	0.6000		9		Yes		20
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-U:Exotic Forb	Cattle+Sheep-Grazing	0.1000		3		1	No		
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-U:Exotic Forb	Exotic-Control+Native-Seed	1.0000	0.4000				Yes		20
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-U:Exotic Forb	ReplacementFire	0.0150	1.0000				Yes		
Basin Wildrye	BW-U:Exotic Forb	Four-Wing Saltbush	FWS-U:Annual Spp	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:Exotic Forb	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:Exotic Forb	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Range Shift	0.0620	0.2000		1	1	No	60	
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Annual Spp	Cattle+Sheep-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Annual Spp	Wild-Horse-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Cattle+Sheep-Grazing	0.1000	0.9995	1			No		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Small-Tree-Lopping	1.0000		100			Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Wild-Horse-Grazing	0.1000	0.9995	2			No		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-A:All	ReplacementFire	0.0225	0.0500				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Annual Spp	ReplacementFire	0.0225	0.9500				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Early-Shrub	Masticate+Herbicide+Native-Seed	1.0000	0.1000	75			Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0001					Yes	5	
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Masticate+Herbicide+Native-Seed	1.0000	0.1000	75			Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Severe Drought	0.0070	0.9000				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Weed-Inventory+Treat	1.0000					No	3	
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP+	Wet-Year	0.1000					No		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Seeded Native	Masticate+Herbicide+Native-Seed	1.0000	0.8000	75			Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:TEA	Tree-Invasion	0.0050		100			Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Spp	Wild-Horse-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP+	Small-Tree-Lopping	1.0000		100			Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP+	Wild-Horse-Grazing	0.1000	0.9995			2	No		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SI+AG	Masticate+Herbicide+Seed	1.0000	0.1000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Spp	Cattle+Sheep-Grazing	0.1000	0.0005				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Spp	Masticate+Herbicide+Seed	1.0000	0.1000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Spp	ReplacementFire	0.0375					Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0001					Yes	5	
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP	FineFuelDecomp	0.3300					No	2	
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP+	Cattle+Sheep-Grazing	0.1000	0.9995			1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP+	Severe Drought	0.0070	0.9000				No		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP+	Weed-Inventory+Treat	1.0000					No	3	
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP+	Wet-Year	0.1000				1	No		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SI	Masticate+Herbicide+Seed	1.0000	0.8000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:TEA	Tree-Invasion	0.0050		100			Yes		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-A:All	Natural-Recovery	0.3300	1.0000		9		No	5	
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-B:Closed	Natural-Recovery	0.3300	1.0000	10	74		No	5	
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-C:Open	Natural-Recovery	0.3300	1.0000	75			No	5	
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Annual Spp	AG-Invasion	0.0010	1.0000		74		No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Bare Ground	Cattle+Sheep-Grazing	0.1000	0.0010	6			No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Bare Ground	Wild-Horse-Grazing	0.1000	0.0010	6			No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Early-Shrub	Cattle+Sheep-Grazing	0.1000		3	5		No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Early-Shrub	Severe Drought	0.0070	0.1000	4			Yes		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Early-Shrub	Wild-Horse-Grazing	0.1000			5		No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:SAP	AG-Invasion	0.0010	1.0000	75			No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Seeded Native	Cattle+Sheep-Grazing	0.1000	0.9990	6		1	No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Seeded Native	ReplacementFire	0.0020	1.0000				Yes		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Seeded Native	Severe Drought	0.0070	0.9000	4			Yes		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Seeded Native	Wild-Horse-Grazing	0.1000	0.9990	6		2	No		
Basin Wildrye	BW-U:Seeded Native	Four-Wing Saltbush	FWS-U:Seeded Native	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:Seeded Native	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Range Shift	0.0620	0.2000		1	1	No	60	
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:Early-Shrub	Wild-Horse-Grazing	0.1000			2		Yes		
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:SI	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:SI	Severe Drought	0.0070	0.1000	3			Yes		
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:SI	Severe Drought	0.0070	0.9000	3		-1	No		
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:SI	Thin	1.0000		74			Yes		
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:SI	Wild-Horse-Grazing	0.1000		3		2	No		
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-A:All	Natural-Recovery	0.0001	1.0000	5	9		No	10	
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-B:Closed	Natural-Recovery	0.0010	1.0000	10	74		No	10	
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-C:Open	Natural-Recovery	0.0100	1.0000	75			No	10	
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0001	1.0000	5			No	5	
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:SI	Cattle+Sheep-Grazing	0.1000		3		1	No		
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:SI	ReplacementFire	0.0010	1.0000				Yes		
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:SI	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Basin Wildrye	BW-U:SI	Basin Wildrye	BW-U:SI+AG	AG-Invasion	0.0010	1.0000				No		
Basin Wildrye	BW-U:SI	Four-Wing Saltbush	FWS-U:SI	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:SI	Greasewood-Basin Big Sagebrush	GW-U:SI	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:SI	Wyoming Big Sagebrush upland	WSup-U:SI-A	Range Shift	0.0620	0.2000		1	1	No	60	
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:Annual Spp	Wild-Horse-Grazing	0.1000			2		Yes		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Severe Drought	0.0071	0.1000	3			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Thin	1.0000		74			Yes		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	WaterWithdrawal	0.0020	0.9990			1	No		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Wild-Horse-Grazing	0.1000		3		2	No		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0001					No	5	
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI	Competition	0.2000			9		Yes	3	
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI	Competition	0.3000		10	74		No	3	
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI	Competition	0.3300		75			No	3	
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI	Masticate+Herbicide+Seed	1.0000	0.9500	75			Yes		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Cattle+Sheep-Grazing	0.1000		3		1	No		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Masticate+Herbicide+Seed	1.0000	0.0500	75			Yes		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	ReplacementFire	0.0020					Yes		
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Weed-Inventory+Treat	1.0000					No	3	
Basin Wildrye	BW-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Wet-Year	0.1000					No		
Basin Wildrye	BW-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Range Shift	0.0620	0.4000		1	1	No	60	
Basin Wildrye	BW-U:SI+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Range Shift	0.0620	0.2000		1	1	No	60	
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Annual Spp	Masticate+Herbicide+Native-Seed	1.0000	0.1000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Annual Spp	Masticate+Herbicide+Seed	1.0000	0.1000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Annual Spp	ReplacementFire	0.0075	0.5000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Annual Spp	Severe Drought	0.0070	0.0500	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Early-Shrub	Masticate+Herbicide+Native-Seed	1.0000	0.1000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Early-Shrub	ReplacementFire	0.0075	0.5000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Early-Shrub	Severe Drought	0.0070	0.0500	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Seeded Native	Masticate+Herbicide+Native-Seed	1.0000	0.8000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:SI	Masticate+Herbicide+Seed	1.0000	0.8000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:SI+AG	Masticate+Herbicide+Seed	1.0000	0.1000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:TEA	Severe Drought	0.0070	0.9000	75			Yes		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-A:All	Wild-Horse-Grazing	0.0130	0.9990			2	No		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-U:Bare Ground	Cattle+Sheep-Grazing	0.0130	0.0005	3			Yes		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-U:Bare Ground	Wild-Horse-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Wild-Horse-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-A:All	Cattle+Sheep-Grazing	0.0130	0.9990	3		1	No		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-A:All	ReplacementFire	0.0040					Yes		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-U:Annual Spp	AG-Invasion	0.0025					No		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Cattle+Sheep-Grazing	0.0130	0.0005	3			Yes		
Big Sagebrush semi-desert	BSsd-A:All	Mixed Salt Desert	MSD-A:All	Range Shift	0.0040		1	1		No	60	
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-A:All	Severe Drought	0.0070	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-B:Open	Wild-Horse-Grazing	0.0130	0.9990			1	No		
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-U:Bare Ground	Cattle+Sheep-Grazing	0.0130	0.0005	3			Yes		
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-U:Bare Ground	Wild-Horse-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Wild-Horse-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-A:All	ReplacementFire	0.0083					Yes		
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-B:Open	Cattle+Sheep-Grazing	0.0130	0.9990	3		1	No		
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-B:Open	Severe Drought	0.0070	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Cattle+Sheep-Grazing	0.0130	0.0005	3			No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Big Sagebrush semi-desert	BSsd-B:Open	Big Sagebrush semi-desert	BSsd-U:SAP	AG-Invasion	0.0010					No		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-A:All	ReplacementFire	0.0083					Yes		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-A:All	Spyke	1.0000					Yes		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-A:All	Thin	1.0000					Yes		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-A:All	Thin+Herbicide+Native-Seed	1.0000					Yes		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-A:All	Thin+Native-Seed	1.0000					Yes		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-B:Open	Severe Drought	0.0070	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-C:Closed	Cattle+Sheep-Grazing	0.0130	0.9990			1	No		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-C:Closed	Severe Drought	0.0070	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-C:Closed	Wild-Horse-Grazing	0.0130	0.9990			2	No		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-U:Bare Ground	Cattle+Sheep-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-U:Bare Ground	Wild-Horse-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-U:Depleted	Cattle+Sheep-Grazing	0.0130	0.0005			1	No		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-U:Depleted	Wild-Horse-Grazing	0.0130	0.0005			2	No		
Big Sagebrush semi-desert	BSsd-C:Closed	Big Sagebrush semi-desert	BSsd-U:SAP	AG-Invasion	0.0010					No		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Cattle+Sheep-Grazing	0.0130		3		1	No		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Chaining+Native-Seed	1.0000	0.5000		5		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.1000		5		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Herbicide-Plateau+Seed	1.0000	0.1500		5		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:Annual Spp	ReplacementFire	0.1000	1.0000		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Wild-Horse-Grazing	0.0130				1	No		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Chaining+Native-Seed	1.0000	0.5000		5		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:SI-A	Chaining+Plateau+Seed	1.0000	0.7500		5		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:SI-A	Herbicide-Plateau+Seed	1.0000	0.7000		5		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Chaining+Plateau+Seed	1.0000	0.1500		5		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Herbicide-Plateau+Seed	1.0000	0.1500		5		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	Range Shift	0.0040			1	1	No	60	
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Depleted	Severe Drought	0.0070	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	2xChaining+Native-Seed	1.0000	0.2000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	ReplacementFire	0.0083					Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Severe Drought	0.0070	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Spyke+Native-Seed	1.0000	0.4000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Thin+Native-Seed	1.0000	0.2000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:SA	AG-Invasion	0.0050					No		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Seeded Native	2xChaining+Native-Seed	1.0000	0.8000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Chaining+Native-Seed	1.0000	0.6000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Spyke+Native-Seed	1.0000	0.6000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Thin+Native-Seed	1.0000	0.8000				Yes		
Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	ReplacementFire	0.0083					Yes		
Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Mixed Salt Desert	MSD-U:Early-Shrub	Range Shift	0.0040			1	1	No	60	
Big Sagebrush semi-desert	BSsd-U:Exotic Forb	Mixed Salt Desert	MSD-U:Exotic Forb	Range Shift	0.0040		1	1		No	60	
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-C:Closed	2xChaining+Plateau+Seed	1.0000	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Cattle+Sheep-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:Annual Spp	ReplacementFire	0.0125	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Wild-Horse-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SA	Cattle+Sheep-Grazing	0.0130	0.9995			1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SA	Severe Drought	0.0070	0.9000			1	Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SA	Wild-Horse-Grazing	0.0130	0.9995			2	No		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SI-A	2xChaining+Plateau+Seed	1.0000	0.8000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	2xChaining+Plateau+Seed	1.0000	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SA	Wet-Year	0.1000	1.0000				No		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	2xChaining+Plateau+Seed	1.0000	0.1500				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Cattle+Sheep-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	ReplacementFire	0.0187					Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Wild-Horse-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SA+	Cattle+Sheep-Grazing	0.0130	0.9995			1	No		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SA+	Severe Drought	0.0070	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SA+	Wild-Horse-Grazing	0.0130	0.9995			2	No		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SI-A	2xChaining+Plateau+Seed	1.0000	0.7000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	2xChaining+Plateau+Seed	1.0000	0.1500				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SA	FineFuelDecomp	0.3300					No	2	
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SA+	Wet-Year	0.1000				1	No		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Cattle+Sheep-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Wild-Horse-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SA	Cattle+Sheep-Grazing	0.0130	0.0005			1	No		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SA	Wild-Horse-Grazing	0.0130	0.0005			2	No		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SAP	Cattle+Sheep-Grazing	0.0130	0.9990			1	No		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SAP	Wild-Horse-Grazing	0.0130	0.9990			2	No		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:Annual Spp	ReplacementFire	0.0125	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SAP	Severe Drought	0.0070	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SAP+	Wet-Year	0.1000	1.0000				No		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	2xChaining+Plateau+Seed	1.0000	0.1500				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Cattle+Sheep-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Wild-Horse-Grazing	0.0130	0.0005				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SA+	Cattle+Sheep-Grazing	0.0130	0.0005			1	No		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SA+	Wild-Horse-Grazing	0.0130	0.0005			2	No		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SAP+	Cattle+Sheep-Grazing	0.0130	0.9990			1	No		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SAP+	Wild-Horse-Grazing	0.0130	0.9990			2	No		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SI-A	2xChaining+Plateau+Seed	1.0000	0.7000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	2xChaining+Plateau+Seed	1.0000	0.1500				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	ReplacementFire	0.0187	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SAP	FineFuelDecomp	0.3300	1.0000				No	2	
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SAP+	Severe Drought	0.0070	0.9000			1	Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SAP+	Wet-Year	0.1000	1.0000				No		
Big Sagebrush semi-desert	BSsd-U:SAP-A	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Cattle+Sheep-Grazing	0.0130	0.0010			1	No		
Big Sagebrush semi-desert	BSsd-U:SAP-A	Big Sagebrush semi-desert	BSsd-U:Annual Spp	ReplacementFire	0.0125					Yes		
Big Sagebrush semi-desert	BSsd-U:SAP-A	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Wild-Horse-Grazing	0.0130	0.0010			2	No		
Big Sagebrush semi-desert	BSsd-U:SAP-A	Big Sagebrush semi-desert	BSsd-U:SAP-A	Cattle+Sheep-Grazing	0.0130	0.9990			1	No		
Big Sagebrush semi-desert	BSsd-U:SAP-A	Big Sagebrush semi-desert	BSsd-U:SAP-A	Severe Drought	0.0070				-1	No		
Big Sagebrush semi-desert	BSsd-U:SAP-A	Big Sagebrush semi-desert	BSsd-U:SAP-A	Wild-Horse-Grazing	0.0130	0.9990			2	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Big Sagebrush semi-desert	BSsd-U:SAP-A	Mixed Salt Desert	MSD-U:Annual Spp	Range Shift	0.0040		1	1			60	
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-A:All	Natural-Recovery	0.3300	1.0000	3	9		No	5	
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-B:Open	Natural-Recovery	0.3300	1.0000	10	39		No	5	
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-C:Closed	Natural-Recovery	0.3300	1.0000	40			No	5	
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Bare Ground	Cattle+Sheep-Grazing	0.0130	0.0005	3			Yes		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Bare Ground	Wild-Horse-Grazing	0.0130	0.0005	6			Yes		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Cattle+Sheep-Grazing	0.0130	0.0005	3			Yes		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Severe Drought	0.0070	0.1000	4			No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Wild-Horse-Grazing	0.0130			5		Yes		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Wild-Horse-Grazing	0.0130	0.0005	6			Yes		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:SAP	AG-Invasion	0.0010					No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Cattle+Sheep-Grazing	0.0130	0.9990	3		1	No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Seeded Native	ReplacementFire	0.0020	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Severe Drought	0.0070	0.9000	4		-1	No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Wild-Horse-Grazing	0.0130	0.9990	6		2	No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Range Shift	0.0040			1	1	No	60	
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-A:All	Natural-Recovery	0.0000	1.0000	5			No	10	
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Wild-Horse-Grazing	0.0130			2		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-U:SI-A	Cattle+Sheep-Grazing	0.0130		3		1	No		
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-U:SI-A	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-U:SI-A	ReplacementFire	0.0010					Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-U:SI-A	Severe Drought	0.0070	0.1000	3			Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-U:SI-A	Severe Drought	0.0070	0.9000	3		-1	No		
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-U:SI-A	Wild-Horse-Grazing	0.0130		3		2	No		
Big Sagebrush semi-desert	BSsd-U:SI-A	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	AG-Invasion	0.0010					No		
Big Sagebrush semi-desert	BSsd-U:SI-A	Mixed Salt Desert	MSD-U:SI	Range Shift	0.0040			1	1	No	60	
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Severe Drought	0.0125			2		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Wild-Horse-Grazing	0.0130			2		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A	Competition	0.3330	1.0000				No	3	
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Cattle+Sheep-Grazing	0.0130		3		1	No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	ReplacementFire	0.0020	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Severe Drought	0.0070	0.1000	3			Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Severe Drought	0.0070	0.9000	3		-1	No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Wet-Year	0.1000	1.0000				No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Wild-Horse-Grazing	0.0130		3		2	No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Mixed Salt Desert	MSD-U:SI+AG	Range Shift	0.0040			1	1	No	60	
Big Sagebrush semi-desert	BSsd-U:SI-B	Big Sagebrush semi-desert	BSsd-B:Open	Natural-Recovery	0.0000	1.0000	9	39		No	10	
Big Sagebrush semi-desert	BSsd-U:SI-B	Big Sagebrush semi-desert	BSsd-U:SI-A	ReplacementFire	0.0010		9	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-B	Big Sagebrush semi-desert	BSsd-U:SI-A	Severe Drought	0.0070	0.1000	9	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-B	Big Sagebrush semi-desert	BSsd-U:SI-B	Cattle+Sheep-Grazing	0.0130				1	No		
Big Sagebrush semi-desert	BSsd-U:SI-B	Big Sagebrush semi-desert	BSsd-U:SI-B	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Big Sagebrush semi-desert	BSsd-U:SI-B	Big Sagebrush semi-desert	BSsd-U:SI-B	Severe Drought	0.0070	0.9000	9	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-B	Big Sagebrush semi-desert	BSsd-U:SI-B	Wild-Horse-Grazing	0.0130				2	No		
Big Sagebrush semi-desert	BSsd-U:SI-B	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	AG-Invasion	0.0010		9	39		No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	ReplacementFire	0.0020	1.0000	10	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Severe Drought	0.0070	0.1000	10	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-B	Competition	0.3300	1.0000	10	39		No	3	
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Cattle+Sheep-Grazing	0.0130				1	No		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Severe Drought	0.0070	0.9000	10	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Wet-Year	0.1000	1.0000	10	39		No		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Wild-Horse-Grazing	0.0130				2	No		
Big Sagebrush semi-desert	BSsd-U:SI-C	Big Sagebrush semi-desert	BSsd-C:Closed	Natural-Recovery	0.0000	1.0000				No	10	
Big Sagebrush semi-desert	BSsd-U:SI-C	Big Sagebrush semi-desert	BSsd-U:SI-A	ReplacementFire	0.0010	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C	Big Sagebrush semi-desert	BSsd-U:SI-A	Thin	1.0000					Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C	Big Sagebrush semi-desert	BSsd-U:SI-B	Severe Drought	0.0070	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C	Big Sagebrush semi-desert	BSsd-U:SI-C	Cattle+Sheep-Grazing	0.0130				1	No		
Big Sagebrush semi-desert	BSsd-U:SI-C	Big Sagebrush semi-desert	BSsd-U:SI-C	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Big Sagebrush semi-desert	BSsd-U:SI-C	Big Sagebrush semi-desert	BSsd-U:SI-C	Severe Drought	0.0070	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C	Big Sagebrush semi-desert	BSsd-U:SI-C	Wild-Horse-Grazing	0.0130				2	No		
Big Sagebrush semi-desert	BSsd-U:SI-C	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	AG-Invasion	0.0010	0.1590				No		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Thin	1.0000					Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Severe Drought	0.0070	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C	Competition	0.2000	1.0000				No	3	
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Cattle+Sheep-Grazing	0.0130				1	No		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	ReplacementFire	0.0020	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Severe Drought	0.0070	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Wet-Year	0.1000	1.0000				No		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Wild-Horse-Grazing	0.0130				2	No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-A:All	Cattle+Sheep-Grazing	0.0100	0.9990	3		1	No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-A:All	Wild-Horse-Grazing	0.0100	0.9990			2	No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-U:Bare Ground	Cattle+Sheep-Grazing	0.0100	0.0005	3			Yes		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-U:Bare Ground	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0005	3			Yes		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-A:All	ReplacementFire	0.0040					Yes		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-A:All	Severe Drought	0.0070				-1	No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-U:SAP	AG-Invasion	0.0025		10			No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-U:SAP-A	AG-Invasion	0.0025			9		No		
Black Sagebrush	BS-A:All	Mixed Salt Desert	MSD-A:All	Range Shift	0.0102			1	1	No	60	
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-B:Open	Cattle+Sheep-Grazing	0.0100	0.9990			1	No		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-B:Open	Thin	1.0000					Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-B:Open	Wild-Horse-Grazing	0.0100	0.9990			2	No		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-U:Bare Ground	Cattle+Sheep-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-U:Bare Ground	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0005				No		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-A:All	ReplacementFire	0.0083					Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-A:All	Severe Drought	0.0070	0.1000				Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-B:Open	Severe Drought	0.0070	0.9000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-U:SAP	AG-Invasion	0.0010					No		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-A:All	Thin	1.0000					Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-C:Closed	Cattle+Sheep-Grazing	0.0100	0.9990			1	No		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-C:Closed	Wild-Horse-Grazing	0.0100	0.9990			2	No		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-U:Bare Ground	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-U:Depleted	Cattle+Sheep-Grazing	0.0100	0.0050			1	No		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-U:Depleted	Wild-Horse-Grazing	0.0100	0.0005			2	No		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0050				Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-A:All	ReplacementFire	0.0067					Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-B:Open	Severe Drought	0.0070	0.1000				Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-C:Closed	Severe Drought	0.0070	0.9000				Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-C:Closed	Small-Tree-Lopping	1.0000					Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-D:Open	Tree-Invasion	0.0050		120			Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-U:SAP	AG-Invasion	0.0010					No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-B:Open	Chaining+Native-Seed	1.0000	0.7000				Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-D:Open	Cattle+Sheep-Grazing	0.0100	0.9990			1	No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:Early-Shrub	Chaining+Native-Seed	1.0000	0.3000				Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:TEA	Cattle+Sheep-Grazing	0.0100	0.0010				No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:TEA	Tree-Encroachment	0.0071		500			No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:TEA	Tree-Encroachment	0.0071	0.0100	250	399		No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:TEA	Tree-Encroachment	0.0071	0.1000	400	499		No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-A:All	Masticate+Native-Seed	1.0000	0.2000				Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-A:All	ReplacementFire	0.0067					Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-B:Open	Masticate+Native-Seed	1.0000	0.8000				Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-B:Open	Severe Drought	0.0070	0.1000				Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-C:Closed	Chainsaw-Thinning	1.0000					Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-D:Open	Severe Drought	0.0070	0.9000			1	No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:TEA	AG-Invasion	0.0010					No		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Cattle+Sheep-Grazing	0.0100		3		1	No		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Chaining+Native-Seed	1.0000	0.5000		5		Yes		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Herbicide-Plateau+Seed	1.0000	0.1000		5		Yes		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Wild-Horse-Grazing	0.0100				2	No		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:Seeded Native	Chaining+Native-Seed	1.0000	0.5000		5		Yes		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:SI-A	Herbicide-Plateau+Seed	1.0000	0.8000		5		Yes		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:SI-A+AG	Herbicide-Plateau+Seed	1.0000	0.1000		5		Yes		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.1500		5		Yes		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:SI-A	Chaining+Plateau+Seed	1.0000	0.7000		5		Yes		
Black Sagebrush	BS-U:Annual Spp	Black Sagebrush	BS-U:SI-A+AG	Chaining+Plateau+Seed	1.0000	0.1500		5		Yes		
Black Sagebrush	BS-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	Range Shift	0.0102			1	1	No	60	
Black Sagebrush	BS-U:Bare Ground	Black Sagebrush	BS-U:Annual Spp	AG-Invasion	0.0050							
Black Sagebrush	BS-U:Bare Ground	Black Sagebrush	BS-U:Exotic Forb	Exotic-Invasion	0.0005					Yes		
Black Sagebrush	BS-U:Bare Ground	Mixed Salt Desert	MSD-U:Bare Ground	Range Shift	0.0102			1	1	No	60	
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Depleted	2xChaining+Native-Seed	1.0000	0.1000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Depleted	Chaining+Native-Seed	1.0000	0.4000						
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Depleted	Spyke+Native-Seed	1.0000	0.1500				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	2xChaining+Native-Seed	1.0000	0.1000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	Spyke+Native-Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	Thin+Native-Seed	1.0000	0.3000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Seeded Native	2xChaining+Native-Seed	1.0000	0.8000						
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Seeded Native	Chaining+Native-Seed	1.0000	0.6000						
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Depleted	Chainsaw-Thinning	1.0000		120			Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Depleted	Severe Drought	0.0070	0.9000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	ReplacementFire	0.0067					Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	Severe Drought	0.0070	0.1000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:SA	AG-Invasion	0.0050					No		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Seeded Native	Spyke+Native-Seed	1.0000	0.7000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Seeded Native	Thin+Native-Seed	1.0000	0.7000	120			Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:TEA	Tree-Invasion	0.0050		120			Yes		
Black Sagebrush	BS-U:Early-Shrub	Black Sagebrush	BS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Black Sagebrush	BS-U:Early-Shrub	Black Sagebrush	BS-U:Early-Shrub	ReplacementFire	0.0067					Yes		
Black Sagebrush	BS-U:Early-Shrub	Mixed Salt Desert	MSD-U:Early-Shrub	Range Shift	0.0102			1	1	No	60	
Black Sagebrush	BS-U:Exotic Forb	Black Sagebrush	BS-U:Exotic Forb	Cattle+Sheep-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:Exotic Forb	Black Sagebrush	BS-U:Exotic Forb	ReplacementFire	0.0067							
Black Sagebrush	BS-U:Exotic Forb	Black Sagebrush	BS-U:Exotic Forb	Wild-Horse-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:Exotic Forb	Mixed Salt Desert	MSD-U:Exotic Forb	Range Shift	0.0102			1	1	No	60	
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Annual Spp	Cattle+Sheep-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Annual Spp	Wild-Horse-Grazing	0.0005					Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SA	Cattle+Sheep-Grazing	0.0100	0.9995			1	No		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SA	Wild-Horse-Grazing	0.9995				2	No		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SI-A+AG	Chaining+Plateau+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Annual Spp	ReplacementFire	0.0100					Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SA	Chainsaw-Thinning	1.0000		120			Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SA	Severe Drought	0.0070	0.9000				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SA+	Wet-Year	0.1000					No		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SI-A	Chaining+Plateau+Seed	1.0000	0.7000				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:TEA	Tree-Invasion	0.0050		120			Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:Annual Spp	Cattle+Sheep-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.2000				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:Annual Spp	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA	FineFuelDecomp	0.3300					No	2	
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Cattle+Sheep-Grazing	0.0100	0.9995			1	No		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Hypo-Hatchet-Spyke	1.0000	0.1000	150			No		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Hypo-Hatchet-Spyke	1.0000	0.9000	150			Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Mastication	1.0000		150			Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Wet-Year	0.1000					No		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Wild-Horse-Grazing	0.0100	0.9995			2	No		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SI-A	Chaining+Plateau+Seed	1.0000	0.7000				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SI-A+AG	Chaining+Plateau+Seed	1.0000	0.1000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:Annual Spp	ReplacementFire	0.0150					Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Severe Drought	0.0070	0.9000			-1	No		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Small-Tree-Lopping	1.0000		120			Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:TEA	Tree-Invasion	0.0050		120			Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Annual Spp	Cattle+Sheep-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Annual Spp	ReplacementFire	0.0100	0.0500				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Annual Spp	Severe Drought	0.0070	0.0100				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Annual Spp	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SA	Cattle+Sheep-Grazing	0.0100	0.0005			1	No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SA	Wild-Horse-Grazing	0.0100	0.0005			2	No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Cattle+Sheep-Grazing	0.0100	0.9990			1	No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Hypo-Hatchet-Spyke	1.0000	0.1000	120			No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Hypo-Hatchet-Spyke	1.0000	0.9000	120		11	Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Wild-Horse-Grazing	0.0100	0.9990			2	No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SI-A	Chaining+Plateau+Seed	1.0000	0.7000				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SI-A+AG	Chaining+Plateau+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Chainsaw-Thinning	1.0000		120			Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Severe Drought	0.0070	0.9000				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP+	Wet-Year	0.1000					No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP-A	ReplacementFire	0.0100	0.9500				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP-A	Severe Drought	0.0070	0.0900				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:TEA	Tree-Invasion	0.0050		120			Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:Annual Spp	Cattle+Sheep-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:Annual Spp	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SA+	Cattle+Sheep-Grazing	0.0100	0.0005			1	No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SA+	Wild-Horse-Grazing	0.0100	0.0005			2	No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP	FineFuelDecomp	0.3300					No	2	
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Cattle+Sheep-Grazing	0.0100	0.9990			1	No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Exotic-Invasion	0.0005					No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Hypo-Hatchet-Spyke	1.0000	0.1000	150			No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Hypo-Hatchet-Spyke	1.0000	0.9000	150			Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Mastication	1.0000	0.2000	150			No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Mastication	1.0000	0.8000	150			Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Wet-Year	0.1000					No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Wild-Horse-Grazing	0.0100	0.9990			2	No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:Annual Spp	ReplacementFire	0.0150					Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Severe Drought	0.0070	0.9000			-1	No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Small-Tree-Lopping	1.0000		120			Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:TEA	Tree-Invasion	0.0050		120			Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-A:All	Severe Drought	0.0070	0.0900				Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:Annual Spp	Cattle+Sheep-Grazing	0.0100	0.0010				Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.1500		4		Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:Annual Spp	ReplacementFire	0.0100	0.9500				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:Annual Spp	Severe Drought	0.0070	0.0100				Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:Annual Spp	Wild-Horse-Grazing	0.0100	0.0010	6			Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:Bare Ground	Wild-Horse-Grazing	0.0100			5		Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:SAP-A	Cattle+Sheep-Grazing	0.0100	0.9990			1	No		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:SAP-A	ReplacementFire	0.0100	0.0500				Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:SAP-A	Severe Drought	0.0070	0.9000				Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:SAP-A	Wild-Horse-Grazing	0.0100	0.9990	6		2	No		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:SI-A	Chaining+Plateau+Seed	1.0000	0.7000		4		Yes		
Black Sagebrush	BS-U:SAP-A	Black Sagebrush	BS-U:SI-A+AG	Chaining+Plateau+Seed	1.0000	0.1500		4		Yes		
Black Sagebrush	BS-U:SAP-A	Mixed Salt Desert	MSD-U:Annual Spp	Range Shift	0.0102			1	1	No	60	
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Bare Ground	Cattle+Sheep-Grazing	0.0100	0.0005	6			Yes		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Bare Ground	Wild-Horse-Grazing	0.0100	0.0005	6			Yes		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100		3	5		No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0005	6			No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Early-Shrub	Severe Drought	0.0071	0.1000	4			Yes		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Early-Shrub	Wild-Horse-Grazing	0.0100			5		No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0005	6			No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Exotic Forb	Exotic-Invasion	0.0005			24		No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Seeded Native	Cattle+Sheep-Grazing	0.0100	0.9990	6		1	No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Seeded Native	Wild-Horse-Grazing	0.0100	0.9990	6		2	No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-A:All	Natural-Recovery	1.0000	1.0000	3	24		No	5	
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-B:Open	Natural-Recovery	1.0000	1.0000	25	119		No	5	
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-C:Closed	Natural-Recovery	1.0000	1.0000	120			No	5	
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Annual Spp	AG-Invasion	0.0010			24		No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:SAP	AG-Invasion	0.0010		25			No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Seeded Native	ReplacementFire	0.0020	1.0000				Yes		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Seeded Native	Severe Drought	0.0070	0.9000	4		-1	No		
Black Sagebrush	BS-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Range Shift	0.0102			1	1	No	60	
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-U:Early-Shrub	Wild-Horse-Grazing	0.0100			2		Yes		
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-U:SI-A	Cattle+Sheep-Grazing	0.0100		3		1	No		
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-U:SI-A	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-U:SI-A	Severe Drought	0.0071	0.1000	3			Yes		
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-U:SI-A	Wild-Horse-Grazing	0.0100		3		2	No		
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-A:All	Natural-Recovery	0.0001		5			No	10	
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-U:SI-A	ReplacementFire	0.0010					Yes		
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-U:SI-A	Severe Drought	0.0071	0.9000	3		-1	No		
Black Sagebrush	BS-U:SI-A	Black Sagebrush	BS-U:SI-A+AG	AG-Invasion	0.0010					No		
Black Sagebrush	BS-U:SI-A	Mixed Salt Desert	MSD-U:SI	Range Shift	0.0102			1	1	No	60	
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:Annual Spp	Wild-Horse-Grazing	0.0100			2		Yes		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Cattle+Sheep-Grazing	0.0100		3		1	No		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Severe Drought	0.0071	0.9000	3			Yes		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Wild-Horse-Grazing	0.0100		3		2	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A	Competition	1.0000	1.0000				No	3	
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	ReplacementFire	0.0020	1.0000				Yes		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Severe Drought	0.0070	0.1000	3		-1	No		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Wet-Year	0.1000	1.0000				No		
Black Sagebrush	BS-U:SI-A+AG	Mixed Salt Desert	MSD-U:SI+AG	Range Shift	0.0102			1	1	No	60	
Black Sagebrush	BS-U:SI-B	Black Sagebrush	BS-U:SI-B	Cattle+Sheep-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:SI-B	Black Sagebrush	BS-U:SI-B	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Black Sagebrush	BS-U:SI-B	Black Sagebrush	BS-U:SI-B	Wild-Horse-Grazing	0.0100				2	No		
Black Sagebrush	BS-U:SI-B	Black Sagebrush	BS-B:Open	Natural-Recovery	0.0010					No	10	
Black Sagebrush	BS-U:SI-B	Black Sagebrush	BS-U:SI-A	ReplacementFire	0.0010					Yes		
Black Sagebrush	BS-U:SI-B	Black Sagebrush	BS-U:SI-B	Severe Drought	0.0070				-1	No		
Black Sagebrush	BS-U:SI-B	Black Sagebrush	BS-U:SI-B+AG	AG-Invasion	0.0010					No		
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B+AG	Cattle+Sheep-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B+AG	Wild-Horse-Grazing	0.0100				2	No		
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-A+AG	ReplacementFire	0.0020	1.0000	25	199		Yes		
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B	Competition	1.0000	1.0000	25	119		No	3	
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B+AG	Severe Drought	0.0070	1.0000	25	119	-1	No		
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B+AG	Wet-Year	0.1000	1.0000	25	119		No		
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-U:SI-A	Thin	1.0000					Yes		
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-U:SI-C	Cattle+Sheep-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-U:SI-C	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-U:SI-C	Wild-Horse-Grazing	0.0100				2	No		
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-U:SI-D	Tree-Invasion	0.0050		120					
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-C:Closed	Natural-Recovery	0.0100					No	10	
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-U:SI-A	ReplacementFire	0.0010					Yes		
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-U:SI-C	Severe Drought	0.0070				-1	No		
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-U:SI-C	Small-Tree-Lopping	1.0000		150			Yes		
Black Sagebrush	BS-U:SI-C	Black Sagebrush	BS-U:SI-C+AG	AG-Invasion	0.0010					No		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-A+AG	Thin	1.0000					Yes		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Cattle+Sheep-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Wild-Horse-Grazing	0.0100				2	No		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-D+AG	Tree-Invasion	0.0050		120					
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-A+AG	ReplacementFire	0.0020	1.0000				Yes		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C	Competition	1.0000	1.0000				No	3	
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Severe Drought	0.0070	1.0000			-1	No		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Small-Tree-Lopping	1.0000	1.0000	150			Yes		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Wet-Year	0.1000	1.0000				No		
Black Sagebrush	BS-U:SI-D	Black Sagebrush	BS-D:Open	Natural-Recovery	0.0100					No	10	
Black Sagebrush	BS-U:SI-D	Black Sagebrush	BS-U:SI-A	Masticate+Seed	1.0000	0.1000			5	Yes		
Black Sagebrush	BS-U:SI-D	Black Sagebrush	BS-U:SI-A	ReplacementFire	0.0010					Yes		
Black Sagebrush	BS-U:SI-D	Black Sagebrush	BS-U:SI-B	Masticate+Seed	1.0000	0.9000				Yes		
Black Sagebrush	BS-U:SI-D	Black Sagebrush	BS-U:SI-C	Chainsaw-Thinning	1.0000					Yes		
Black Sagebrush	BS-U:SI-D	Black Sagebrush	BS-U:SI-D	Cattle+Sheep-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:SI-D	Black Sagebrush	BS-U:SI-D	Severe Drought	0.0070				-1	No		
Black Sagebrush	BS-U:SI-D	Black Sagebrush	BS-U:SI-D	Wild-Horse-Grazing	0.0100				2	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Black Sagebrush	BS-U:SI-D	Black Sagebrush	BS-U:SI-D+AG	AG-Invasion	0.0010					No		
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-A	Masticate+Seed	1.0000	0.0250				Yes		
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-A+AG	Masticate+Seed	1.0000	0.0250				Yes		
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-A+AG	ReplacementFire	0.0020							
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-B	Masticate+Seed	1.0000	0.9000				Yes		
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-B+AG	Masticate+Seed	1.0000	0.0250				Yes		
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-C+AG	Chainsaw-Thinning	1.0000					Yes		
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-D+AG	Cattle+Sheep-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-D+AG	Competition	1.0000	1.0000				No	3	
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-D+AG	Severe Drought	0.0070				-1	No		
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-D+AG	Wet-Year	0.1000					No		
Black Sagebrush	BS-U:SI-D+AG	Black Sagebrush	BS-U:SI-D+AG	Wild-Horse-Grazing	0.0100				2	No		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Spp	2xChaining+Plateau+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Spp	2xChaining+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Spp	Masticate+Seed	1.0000	0.2000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Spp	RxFire+Seed+Chain	1.0000	0.1000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A	2xChaining+Plateau+Seed	1.0000	0.7000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A	2xChaining+Seed	1.0000	0.7000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A	Masticate+Seed	1.0000	0.7000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A	RxFire+Seed+Chain	1.0000	0.5000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	2xChaining+Plateau+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	2xChaining+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	Masticate+Herbicide+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	Masticate+Seed	1.0000	0.2000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	RxFire+Seed+Chain	1.0000	0.1000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:TEA	RxFire+Seed+Chain	1.0000	0.3000				No		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Spp	Masticate+Herbicide+Seed	1.0000	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Spp	ReplacementFire	0.0075	1.0000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Spp	Severe Drought	0.0070	0.0500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Early-Shrub	Severe Drought	0.0070	0.0500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A	Masticate+Herbicide+Seed	1.0000	0.7000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:TEA	Severe Drought	0.0070	0.9000				Yes		
Calcareous Grassland	CG-A:Open	Calcareous Grassland	CG-A:Open	Cattle+Sheep-Grazing	0.0160	0.9990	3		1	No		
Calcareous Grassland	CG-A:Open	Calcareous Grassland	CG-A:Open	NativeGrazing	0.0100	1.0000			-1	No		
Calcareous Grassland	CG-A:Open	Calcareous Grassland	CG-A:Open	ReplacementFire	0.0083	1.0000				Yes		
Calcareous Grassland	CG-A:Open	Calcareous Grassland	CG-A:Open	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Calcareous Grassland	CG-A:Open	Calcareous Grassland	CG-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Calcareous Grassland	CG-A:Open	Calcareous Grassland	CG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160	0.0005	3			Yes		
Calcareous Grassland	CG-A:Open	Calcareous Grassland	CG-U:Early-Shrub	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Calcareous Grassland	CG-A:Open	Calcareous Grassland	CG-U:SAP-A	AG-Invasion	0.0025					No		
Calcareous Grassland	CG-A:Open	Calcareous Grassland	CG-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005	3			Yes		
Calcareous Grassland	CG-A:Open	Mixed Salt Desert	MSD-A:All	Range Shift	0.0040		1	1		No	60	
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-A:Open	ReplacementFire	0.0100	1.0000				Yes		
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-A:Open	Severe Drought	0.0070	0.1000				Yes		
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-B:Closed	Cattle+Sheep-Grazing	0.0160	0.9990			1	No		
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-B:Closed	NativeGrazing	0.0100	1.0000				Yes		
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-B:Closed	Severe Drought	0.0070	0.9000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-B:Closed	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005				No		
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-U:Depleted	Cattle+Sheep-Grazing	0.0160	0.0005				No		
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-U:Depleted	Wild-Horse-Grazing	0.0160	0.0005			2	No		
Calcareous Grassland	CG-B:Closed	Calcareous Grassland	CG-U:SAP	AG-Invasion	0.0010					No		
Calcareous Grassland	CG-U:Bare Ground	Calcareous Grassland	CG-U:SAP-A	AG-Invasion	0.0050							
Calcareous Grassland	CG-U:Bare Ground	Mixed Salt Desert	MSD-U:Bare Ground	Range Shift	0.0040		1	1			60	
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-B:Closed	Thin+Herbicide+Native-Seed	1.0000	0.6000				Yes		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005	3			Yes		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Depleted	Cattle+Sheep-Grazing	0.0160	0.9990	3		1	No		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Depleted	ReplacementFire	0.0083			59		Yes		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Depleted	Severe Drought	0.0070	0.9000			-1	No		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Depleted	Severe Drought	0.0071	0.1000				Yes		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Depleted	Thin+Herbicide+Native-Seed	1.0000	0.2000				Yes		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Depleted	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160	0.0005	3			Yes		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Early-Shrub	ReplacementFire	0.0083							
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Early-Shrub	Thin+Herbicide+Native-Seed	1.0000	0.2000				Yes		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:Early-Shrub	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Calcareous Grassland	CG-U:Depleted	Calcareous Grassland	CG-U:SAP	AG-Invasion	0.0010					No		
Calcareous Grassland	CG-U:Depleted	Mixed Salt Desert	MSD-U:Early-Shrub	Range Shift	0.0040		1	1		No	60	
Calcareous Grassland	CG-U:Early-Shrub	Calcareous Grassland	CG-A:Open	Thin+Herbicide+Native-Seed	0.6000					Yes		
Calcareous Grassland	CG-U:Early-Shrub	Calcareous Grassland	CG-U:Early-Shrub	ReplacementFire	0.0100					Yes		
Calcareous Grassland	CG-U:Early-Shrub	Calcareous Grassland	CG-U:Early-Shrub	Thin+Herbicide+Native-Seed	0.4000					Yes		
Calcareous Grassland	CG-U:Early-Shrub	Mixed Salt Desert	MSD-U:Early-Shrub	Range Shift	0.0040		1	1		No	60	
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	Cattle+Sheep-Grazing	0.0160	0.9990	3		1	No		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	Chaining+Native-Seed	1.0000	0.5000		3		Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	Chaining+Plateau+Seed	1.0000	0.2000		3		Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	NativeGrazing	0.0100				2	Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	ReplacementFire	0.0130		20			Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	Severe Drought	0.0070	0.1000				Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	Severe Drought	0.0070	0.9000			2	Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	Thin+Herbicide+Native-Seed	1.0000	0.2500	20			Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	Thin+Herbicide+Seed	1.0000	0.2000	20			No		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP-A	Cattle+Sheep-Grazing	0.0160	0.0010	3			Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP-A	Thin+Herbicide+Native-Seed	1.0000	0.2500	20			Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SAP-A	Wild-Horse-Grazing	0.0160	0.0010				Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:Seeded Native	Chaining+Native-Seed	1.0000	0.5000		3		Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:Seeded Native	Thin+Herbicide+Native-Seed	1.0000	0.5000	20			Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SI	Chaining+Plateau+Seed	1.0000	0.6000		3		Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SI	Thin+Herbicide+Seed	1.0000	0.6000	20			No		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SI+AG	Chaining+Plateau+Seed	1.0000	0.2000		3		Yes		
Calcareous Grassland	CG-U:SAP	Calcareous Grassland	CG-U:SI+AG	Thin+Herbicide+Seed	1.0000	0.2000	20			Yes		
Calcareous Grassland	CG-U:SAP-A	Calcareous Grassland	CG-U:SAP-A	Cattle+Sheep-Grazing	0.0160	0.0010	3			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Calcareous Grassland	CG-U:SAP-A	Calcareous Grassland	CG-U:SAP-A	Cattle+Sheep-Grazing	0.0160	0.9990	3		1	No		
Calcareous Grassland	CG-U:SAP-A	Calcareous Grassland	CG-U:SAP-A	ReplacementFire	0.0130					Yes		
Calcareous Grassland	CG-U:SAP-A	Calcareous Grassland	CG-U:SAP-A	Wild-Horse-Grazing	0.0160	0.0010				Yes		
Calcareous Grassland	CG-U:SAP-A	Calcareous Grassland	CG-U:SAP-A	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Calcareous Grassland	CG-U:SAP-A	Mixed Salt Desert	MSD-U:SAP	Range Shift	0.0040		1	1			60	
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-A:Open	Natural-Recovery	0.3330	1.0000		19		No	5	
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-B:Closed	Natural-Recovery	0.3330	1.0000	20			No	5	
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Bare Ground	Wild-Horse-Grazing	0.0160			5		Yes		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005	6			Yes		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160		3	3		No		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160	0.0010	4			No		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Early-Shrub	Severe Drought	0.0071	0.1000	4			Yes		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Early-Shrub	Wild-Horse-Grazing	0.0160	0.0005	6			Yes		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:SAP	AG-Invasion	0.0010					No		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Seeded Native	Cattle+Sheep-Grazing	0.0160	0.9990	4		1	No		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Seeded Native	ReplacementFire	0.0083	1.0000		19		Yes		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Seeded Native	ReplacementFire	0.0100	1.0000	20					
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Seeded Native	Severe Drought	0.0071	0.9000	4		-1	No		
Calcareous Grassland	CG-U:Seeded Native	Calcareous Grassland	CG-U:Seeded Native	Wild-Horse-Grazing	0.0160	0.9990	6		2	No		
Calcareous Grassland	CG-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Range Shift	0.0040			1	1	No	60	
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-A:Open	Natural-Recovery	0.0000		5	19		No	10	
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-B:Closed	Natural-Recovery	0.0000		20			No	10	
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:Bare Ground	Wild-Horse-Grazing	0.0160			2		Yes		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:SI	Cattle+Sheep-Grazing	0.0160		3		1	No		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:SI	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:SI	ReplacementFire	0.0010					Yes		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:SI	Severe Drought	0.0071	0.1000	3	19		Yes		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:SI	Severe Drought	0.0071	0.1000	20			Yes		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:SI	Severe Drought	0.0071	0.9000	3	19	-1	No		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:SI	Severe Drought	0.0071	0.9000	20		2	Yes		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:SI	Wild-Horse-Grazing	0.0160		3		2	No		
Calcareous Grassland	CG-U:SI	Calcareous Grassland	CG-U:SI+AG	AG-Invasion	0.0010					No		
Calcareous Grassland	CG-U:SI	Mixed Salt Desert	MSD-U:SI	Range Shift	0.0040			1	1	No	60	
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SAP	Drought_36mo(t+2)	0.0071			2		Yes		
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SAP	Wild-Horse-Grazing	0.0160			2		Yes		
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SI	Competition	0.3330	1.0000				No	3	
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SI+AG	Cattle+Sheep-Grazing	0.0160		3		1	No		
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SI+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SI+AG	ReplacementFire	0.0050					Yes		
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SI+AG	Severe Drought	0.0071	0.1000	3			Yes		
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SI+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SI+AG	Wet-Year	0.1000	1.0000				No		
Calcareous Grassland	CG-U:SI+AG	Calcareous Grassland	CG-U:SI+AG	Wild-Horse-Grazing	0.0160		3		2	No		
Calcareous Grassland	CG-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	Range Shift	0.0040			1	1	No	60	
Curl-leaf Mountain Mahogany	CMM-A:All	Black Sagebrush	BS-A:All	Range Shift	0.0451	0.4000		1	1	No	60	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Curl-leaf Mountain Mahogany	CMM-A:All	Curl-leaf Mountain Mahogany	CMM-A:All	NativeGrazing	1.0000	0.0200		19		Yes		
Curl-leaf Mountain Mahogany	CMM-A:All	Curl-leaf Mountain Mahogany	CMM-A:All	ReplacementFire	0.0020	1.0000	5	19		Yes		
Curl-leaf Mountain Mahogany	CMM-A:All	Pinyon-Juniper	PJ-A:All	Range Shift	0.0451	0.4000		1	1	No	60	
Curl-leaf Mountain Mahogany	CMM-A:All	Wyoming Big Sagebrush upland	WSup-A:All	Range Shift	0.0451	0.2000		1	1	No	60	
Curl-leaf Mountain Mahogany	CMM-B:Open	Curl-leaf Mountain Mahogany	CMM-A:All	ReplacementFire	0.0070	1.0000	20	59		Yes		
Curl-leaf Mountain Mahogany	CMM-B:Open	Curl-leaf Mountain Mahogany	CMM-B:Open	NativeGrazing	0.0100	1.0000	20	59	-1	No		
Curl-leaf Mountain Mahogany	CMM-C:Closed	Curl-leaf Mountain Mahogany	CMM-A:All	ReplacementFire	0.0070					Yes		
Curl-leaf Mountain Mahogany	CMM-C:Closed	Curl-leaf Mountain Mahogany	CMM-D:Open	Alternate-Succession1	0.0070					No		
Curl-leaf Mountain Mahogany	CMM-D:Closed	Curl-leaf Mountain Mahogany	CMM-A:All	ReplacementFire	0.0020	1.0000	150			Yes		
Curl-leaf Mountain Mahogany	CMM-D:Closed	Curl-leaf Mountain Mahogany	CMM-U:TEA	AG-Invasion	0.0010	1.0000	150			No		
Curl-leaf Mountain Mahogany	CMM-D:Open	Curl-leaf Mountain Mahogany	CMM-A:All	ReplacementFire	0.0030	1.0000	60			Yes		
Curl-leaf Mountain Mahogany	CMM-D:Open	Curl-leaf Mountain Mahogany	CMM-U:TEA	AG-Invasion	0.0010	1.0000	60			No		
Curl-leaf Mountain Mahogany	CMM-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Range Shift	0.0451	0.4000		1	1	No	60	
Curl-leaf Mountain Mahogany	CMM-U:Annual Spp	Curl-leaf Mountain Mahogany	CMM-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Curl-leaf Mountain Mahogany	CMM-U:Annual Spp	Pinyon-Juniper	PJ-U:Annual Spp	Range Shift	0.0451	0.4000		1	1	No	60	
Curl-leaf Mountain Mahogany	CMM-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Range Shift	0.0451	0.2000		1	1	No	60	
Curl-leaf Mountain Mahogany	CMM-U:TEA	Curl-leaf Mountain Mahogany	CMM-U:Annual Spp	ReplacementFire	0.0045	1.0000	60			Yes		
Desert Wash	DWA-A:All	Desert Wash	DWA-A:All	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Desert Wash	DWA-A:All	Desert Wash	DWA-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-A:All	Desert Wash	DWA-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-A:All	Desert Wash	DWA-U:Early-Shrub	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-A:All	Desert Wash	DWA-A:All	Cattle+Sheep-Grazing	0.0160	0.9990			1	No		
Desert Wash	DWA-A:All	Desert Wash	DWA-A:All	Flash-Flood	0.0070					Yes		
Desert Wash	DWA-A:All	Desert Wash	DWA-A:All	Weed-Inventory+Treat	1.0000					No	3	
Desert Wash	DWA-A:All	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-A:All	Desert Wash	DWA-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-A:All	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0001					Yes	5	
Desert Wash	DWA-A:All	Desert Wash	DWA-U:SAP	AG-Invasion	0.0025					No		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-B:Closed	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:Early-Shrub	Wild-Horse-Grazing	0.0160	0.0005			2	No		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-A:All	Flash-Flood	0.0075					Yes		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-A:All	ReplacementFire	0.0010					Yes		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-B:Closed	Cattle+Sheep-Grazing	0.0160	0.9990			1	No		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-B:Closed	Weed-Inventory+Treat	1.0000					No	3	
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160	0.0005			1	No		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0001					Yes	5	
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:SAP	AG-Invasion	0.0010					No		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-C:Closed	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:Early-Shrub	Wild-Horse-Grazing	0.0160	0.0005			2	No		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-A:All	Flash-Flood	0.0075				1	Yes		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-A:All	ReplacementFire	0.0001					Yes		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-C:Closed	Cattle+Sheep-Grazing	0.0160	0.9990			1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Desert Wash	DWA-C:Closed	Desert Wash	DWA-C:Closed	Weed-Inventory+Treat	1.0000					No	3	
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160	0.0005			1	No		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0001					Yes	5	
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:SAP	AG-Invasion	0.0010					No		
Desert Wash	DWA-U:Bare Ground	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-U:Bare Ground	Desert Wash	DWA-U:Bare Ground	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Desert Wash	DWA-U:Bare Ground	Desert Wash	DWA-U:Early-Shrub	Alternate-Succession2	0.1000	1.0000	20			Yes		
Desert Wash	DWA-U:Bare Ground	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0001	1.0000				Yes	5	
Desert Wash	DWA-U:Bare Ground	Desert Wash	DWA-U:SA	AG-Invasion	0.0050	1.0000				Yes		
Desert Wash	DWA-U:Early-Shrub	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-U:Early-Shrub	Desert Wash	DWA-U:Early-Shrub	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Desert Wash	DWA-U:Early-Shrub	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0001	1.0000				Yes	5	
Desert Wash	DWA-U:EFT	Desert Wash	DWA-A:All	Exotic-Control	1.0000	0.6000		4		No		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-A:All	Tamarisk-Beetle	0.2500	0.9000		4		No		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-B:Closed	Exotic-Control	1.0000	0.6000	5	19		No		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-B:Closed	Tamarisk-Beetle	0.2500	0.9000	5	19		No		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-C:Closed	Exotic-Control	1.0000	0.6000	20			No		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-C:Closed	Tamarisk-Beetle	0.2500	0.9000	20			No		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-U:EFT	Exotic-Control	1.0000	0.4000				Yes		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-U:EFT	Flash-Flood	0.0075	1.0000				Yes		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-U:EFT	ReplacementFire	0.0010	1.0000				Yes		
Desert Wash	DWA-U:EFT	Desert Wash	DWA-U:EFT	Tamarisk-Beetle	0.2500	0.1000				No		
Desert Wash	DWA-U:SA	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-U:SA	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0001	1.0000				No	5	
Desert Wash	DWA-U:SA	Desert Wash	DWA-U:SA	Flash-Flood	0.0075	1.0000				Yes		
Desert Wash	DWA-U:SA	Desert Wash	DWA-U:SA	ReplacementFire	0.0010	1.0000				Yes		
Desert Wash	DWA-U:SA	Desert Wash	DWA-U:SA	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Desert Wash	DWA-U:SA	Desert Wash	DWA-U:SA+	Wet-Year	0.1000	1.0000				No		
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:SA	FineFuelDecomp	0.3300	1.0000				No	2	
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:SA+	Severe Drought	0.0070	0.1000				Yes		
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:SA+	Wet-Year	0.1000	1.0000				No		
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0001	1.0000				Yes	5	
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:SA+	Flash-Flood	0.0075	1.0000				Yes		
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:SA+	ReplacementFire	0.0100	1.0000				Yes		
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:SA+	Severe Drought	0.0070	0.9000			-1	No		
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:SA+	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SA	Cattle+Sheep-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SA	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SA	Wild-Horse-Grazing	0.0160	0.0005			2	No		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SAP	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0001	1.0000				Yes	5	
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SA	Cattle+Sheep-Grazing	0.0160	0.0005			1	No		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SAP	Cattle+Sheep-Grazing	0.0160	0.9990			1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SAP	Flash-Flood	0.0075	1.0000				Yes		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SAP	ReplacementFire	0.0010	1.0000				Yes		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SAP	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SAP+	Wet-Year	0.1000	1.0000				No		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SA+	Cattle+Sheep-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SA+	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SA+	Wild-Horse-Grazing	0.0160	0.0005			2	No		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP	FineFuelDecomp	0.3300	1.0000				No	2	
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP+	Severe Drought	0.0070	0.1000				Yes		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP+	Wet-Year	0.1000	1.0000				No		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP+	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001				Yes		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0001	1.0000				Yes	5	
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SA+	Cattle+Sheep-Grazing	0.0160	0.0005			1	No		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP	Flash-Flood	0.0075	1.0000				Yes		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP+	Cattle+Sheep-Grazing	0.0160	0.9990			1	No		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP+	ReplacementFire	0.0100	1.0000				Yes		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP+	Severe Drought	0.0070	0.9000			-1	No		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP+	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Four-Wing Saltbush	FWS-A:All	Four-Wing Saltbush	FWS-A:All	Cattle+Sheep-Grazing	0.0080	0.9995	3		1	No		
Four-Wing Saltbush	FWS-A:All	Four-Wing Saltbush	FWS-A:All	NativeGrazing	0.0500				1	Yes		
Four-Wing Saltbush	FWS-A:All	Four-Wing Saltbush	FWS-A:All	Very-Wet-Year	0.0181					Yes		
Four-Wing Saltbush	FWS-A:All	Four-Wing Saltbush	FWS-A:All	Wild-Horse-Grazing	0.0080	0.9990			2	No		
Four-Wing Saltbush	FWS-A:All	Four-Wing Saltbush	FWS-U:Annual Spp	AG-Invasion	0.0025					No		
Four-Wing Saltbush	FWS-A:All	Four-Wing Saltbush	FWS-U:Bare Ground	Cattle+Sheep-Grazing	0.0080	0.0005	3			Yes		
Four-Wing Saltbush	FWS-A:All	Four-Wing Saltbush	FWS-U:Bare Ground	Wild-Horse-Grazing	0.0080	0.0010				Yes		
Four-Wing Saltbush	FWS-A:All	Mixed Salt Desert	MSD-A:All	Range Shift	0.0040			1	1	No	60	
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-A:All	ReplacementFire	0.0001					Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-A:All	Severe Drought	0.0070	0.1000			1	Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-A:All	Very-Wet-Year	0.0181					Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-B:Open	Cattle+Sheep-Grazing	0.0080	0.9995			1	No		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-B:Open	NativeGrazing	0.0500				-1	No		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-B:Open	Severe Drought	0.0070	0.9000				Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-B:Open	Wild-Horse-Grazing	0.0080	0.9990			2	No		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-U:Bare Ground	Cattle+Sheep-Grazing	0.0080	0.0005				Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-U:Bare Ground	Wild-Horse-Grazing	0.0080	0.0005				Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-U:Depleted	Wild-Horse-Grazing	0.0080	0.0005			2	No		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-U:SAP	AG-Invasion	0.0010					No		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-A:All	ReplacementFire	0.0010					Yes		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-A:All	Severe Drought	0.0070	0.1000			1	Yes		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-A:All	Very-Wet-Year	0.0181					Yes		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-B:Open	Severe Drought	0.0070	0.9000				Yes		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-C:Closed	Cattle+Sheep-Grazing	0.0080	0.9990			1	No		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-C:Closed	NativeGrazing	0.0500				-1	No		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-C:Closed	Wild-Horse-Grazing	0.0080	0.9990			2	No		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-U:Bare Ground	Cattle+Sheep-Grazing	0.0080	0.0005				Yes		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-U:Bare Ground	Wild-Horse-Grazing	0.0080	0.0005				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-U:Depleted	Wild-Horse-Grazing	0.0080	0.0005			2	No		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-U:SAP	AG-Invasion	0.0010					No		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:Annual Spp	Cattle+Sheep-Grazing	0.0080		3		1	No		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:Annual Spp	Chaining+Native-Seed	1.0000	0.6000		5		Yes		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.2500		5		Yes		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:Annual Spp	Herbicide-Plateau+Seed	1.0000	0.2500		5		Yes		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:Annual Spp	Wild-Horse-Grazing	0.0080				2	No		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:SAP	Alternate-Succession2	0.3330	1.0000	9			No	9	
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:Seeded Native	Chaining+Native-Seed	1.0000	0.4000		5		Yes		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:SI	Chaining+Plateau+Seed	1.0000	0.5000		5		Yes		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:SI	Herbicide-Plateau+Seed	1.0000	0.2500		5		Yes		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:SI	Herbicide-Plateau+Seed	1.0000	0.5000		5		Yes		
Four-Wing Saltbush	FWS-U:Annual Spp	Four-Wing Saltbush	FWS-U:SI+AG	Chaining+Plateau+Seed	1.0000	0.2500		5		Yes		
Four-Wing Saltbush	FWS-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	Range Shift	0.0040			1	1	No	60	
Four-Wing Saltbush	FWS-U:Bare Ground	Four-Wing Saltbush	FWS-U:Annual Spp	AG-Invasion	0.0050							
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:Bare Ground	Cattle+Sheep-Grazing	0.0080	0.0005				Yes		
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:Depleted	Cattle+Sheep-Grazing	0.0080	0.9995			-1	No		
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:Depleted	Thin+Native-Seed	1.0000	0.4000				Yes		
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:Early-Shrub	Very-Wet-Year	0.0181	1.0000				Yes		
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:SAP	AG-Invasion	0.0050	1.0000				No		
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:Seeded Native	Thin+Native-Seed	1.0000	0.6000				Yes		
Four-Wing Saltbush	FWS-U:Early-Shrub	Four-Wing Saltbush	FWS-U:Early-Shrub	ReplacementFire	0.0001	1.0000				Yes		
Four-Wing Saltbush	FWS-U:Early-Shrub	Four-Wing Saltbush	FWS-U:Early-Shrub	Very-Wet-Year	0.0181	1.0000				Yes		
Four-Wing Saltbush	FWS-U:Early-Shrub	Mixed Salt Desert	MSD-U:Early-Shrub	Range Shift	0.0040			1	1	No	60	
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:Annual Spp	Cattle+Sheep-Grazing	0.0080	0.0005	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:Annual Spp	ReplacementFire	0.0100	1.0000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:Annual Spp	Thin+Herbicide+Seed	1.0000	0.2000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:Annual Spp	Very-Wet-Year	0.0181	1.0000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:Annual Spp	Wild-Horse-Grazing	0.0080	0.0010	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:SAP	Cattle+Sheep-Grazing	0.0080	0.9995	6		1	No		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:SAP	Wild-Horse-Grazing	0.0080	0.9990	6		2	No		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:SAP+	Wet-Year	0.1000	1.0000	6			No		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:SI	Thin+Herbicide+Seed	1.0000	0.6000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:SI+AG	Thin+Herbicide+Seed	1.0000	0.2000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:Annual Spp	Cattle+Sheep-Grazing	0.0080	0.0005				Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:Annual Spp	ReplacementFire	0.0150	1.0000				Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:Annual Spp	Thin+Herbicide+Seed	1.0000	0.2500				Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:Annual Spp	Very-Wet-Year	0.0181	1.0000				Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:Annual Spp	Wild-Horse-Grazing	0.0080	0.0005				Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:SAP	FineFuelDecomp	0.3300	1.0000				No	2	
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:SAP+	Cattle+Sheep-Grazing	0.0080	0.9995			1	No		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:SAP+	Wet-Year	0.1000	1.0000				No		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:SAP+	Wild-Horse-Grazing	0.0080	0.9995			2	No		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:SI	Thin+Herbicide+Seed	1.0000	0.5000				Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:SI+AG	Thin+Herbicide+Seed	1.0000	0.2500				Yes		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-A:All	Natural-Recovery	0.3300	1.0000	3	5		No	5	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-B:Open	Natural-Recovery	0.3300	1.0000	6	19		No	5	
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-C:Closed	Natural-Recovery	0.3300	1.0000	20			No	5	
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Bare Ground	Cattle+Sheep-Grazing	0.0080	0.0005	3			Yes		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Bare Ground	Wild-Horse-Grazing	0.0080	0.0005	20			Yes		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Bare Ground	Wild-Horse-Grazing	0.0080	0.0010	3	19		Yes		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Depleted	Wild-Horse-Grazing	0.0080	0.0005	20			No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Early-Shrub	Wild-Horse-Grazing	0.0080			2		No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:SAP	AG-Invasion	0.0010	1.0000				No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Seeded Native	Cattle+Sheep-Grazing	0.0080	0.9995	3		1	No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Seeded Native	Severe Drought	0.0071	0.1000	4			Yes		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Seeded Native	Severe Drought	0.0071	0.9000	4		-1	No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Seeded Native	Very-Wet-Year	0.0181	1.0000				Yes		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Seeded Native	Wild-Horse-Grazing	0.0080	0.9990	3		2	No		
Four-Wing Saltbush	FWS-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Range Shift	0.0040			1	1	No	60	
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-B:Open	Natural-Recovery	0.0000	1.0000	6	19		No	10	
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-C:Closed	Natural-Recovery	0.0000	1.0000	20			No	10	
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-U:Bare Ground	Wild-Horse-Grazing	0.0080			2		Yes		
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-U:Early-Shrub	Drought 36mo(t+2)	0.0071			2		Yes		
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-U:Early-Shrub	Severe Drought	0.0071	0.1000	3			Yes		
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-U:SI	Cattle+Sheep-Grazing	0.0080		3		1	No		
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-U:SI	Severe Drought	0.0071	0.9000	3		-1	No		
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-U:SI	Very-Wet-Year	0.0181	1.0000				Yes		
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-U:SI	Wild-Horse-Grazing	0.0080		3		2	No		
Four-Wing Saltbush	FWS-U:SI	Four-Wing Saltbush	FWS-U:SI+AG	AG-Invasion	0.0010	1.0000				No		
Four-Wing Saltbush	FWS-U:SI	Mixed Salt Desert	MSD-U:SI	Range Shift	0.0040			1	1	No	60	
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:Annual Spp	Drought 36mo(t+2)	0.0071			2		Yes		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:Annual Spp	Wild-Horse-Grazing	0.0080			2		Yes		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI	Competition	0.2000	1.0000	6			Yes	3	
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI	Competition	0.3300	1.0000		5		No	3	
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	Herbicide-Plateau+Seed	1.0000	0.9500				No		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	Cattle+Sheep-Grazing	0.0080		3		1	No		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	Herbicide-Plateau+Seed	1.0000	0.0500				No		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	ReplacementFire	0.0020	1.0000				Yes		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	Severe Drought	0.0071	0.1000	3			Yes		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	Very-Wet-Year	0.0181	1.0000				Yes		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	Very-Wet-Year	0.1000	1.0000				No		
Four-Wing Saltbush	FWS-U:SI+AG	Four-Wing Saltbush	FWS-U:SI+AG	Wild-Horse-Grazing	0.0080		3		2	No		
Four-Wing Saltbush	FWS-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	Range Shift	0.0040			1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-A:All	Greasewood-Basin Big Sagebrush	GW-A:All	Cattle+Sheep-Grazing	0.0030	0.9995	3		1	No		
Greasewood-Basin Big Sagebrush	GW-A:All	Greasewood-Basin Big Sagebrush	GW-A:All	Very-Wet-Year	0.0181					Yes		
Greasewood-Basin Big Sagebrush	GW-A:All	Greasewood-Basin Big Sagebrush	GW-A:All	Wild-Horse-Grazing	0.0003	0.9990			2	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Greasewood-Basin Big Sagebrush	GW-A:All	Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Cattle+Sheep-Grazing	0.0030	0.0005	3			Yes		
Greasewood-Basin Big Sagebrush	GW-A:All	Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Wild-Horse-Grazing	0.0003	0.0010				Yes		
Greasewood-Basin Big Sagebrush	GW-A:All	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	AG-Invasion	0.0025	1.0000		4		No		
Greasewood-Basin Big Sagebrush	GW-A:All	Pickleweed	PW-A:All	Range Shift	0.0010	0.8000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-A:All	Playa	PL-A:Barren	Range Shift	0.0010	0.2000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-B:Closed	Greasewood-Basin Big Sagebrush	GW-A:All	Very-Wet-Year	0.0181					Yes		
Greasewood-Basin Big Sagebrush	GW-B:Closed	Greasewood-Basin Big Sagebrush	GW-B:Closed	Cattle+Sheep-Grazing	0.0030	0.9995			1	No		
Greasewood-Basin Big Sagebrush	GW-B:Closed	Greasewood-Basin Big Sagebrush	GW-B:Closed	Wild-Horse-Grazing	0.0030	0.9990			2	No		
Greasewood-Basin Big Sagebrush	GW-B:Closed	Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Cattle+Sheep-Grazing	0.0030	0.0005				Yes		
Greasewood-Basin Big Sagebrush	GW-B:Closed	Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Wild-Horse-Grazing	0.0030	0.0010				Yes		
Greasewood-Basin Big Sagebrush	GW-B:Closed	Greasewood-Basin Big Sagebrush	GW-U:SAP	AG-Invasion	0.0010	1.0000	5			No		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Cattle+Sheep-Grazing	0.0030		3		1	No		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.2500		5		Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Wild-Horse-Grazing	0.0030				2	No		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:SI	Chaining+Plateau+Seed	1.0000	0.5000		5		Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Chaining+Plateau+Seed	1.0000	0.2500		5		Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Herbicide-Plateau+Seed	1.0000	0.5000		5		Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:SI	Herbicide-Plateau+Seed	1.0000	0.5000		5		Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Pickleweed	PW-A:All	Range Shift	0.0010	0.8000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Playa	PL-A:Barren	Range Shift	0.0010	0.2000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	AG-Invasion	0.0050							
Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Exotic-Invasion	0.0005					Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Pickleweed	PW-A:All	Range Shift	0.0010	0.8000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Playa	PL-A:Barren	Range Shift	0.0010	0.2000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Cattle+Sheep-Grazing	0.0030				1	No		
Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	ReplacementFire	0.0033							
Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Wild-Horse-Grazing	0.0030				2	No		
Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Pickleweed	PW-A:All	Range Shift	0.0010	0.8000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Playa	PL-A:Barren	Range Shift	0.0010	0.2000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Cattle+Sheep-Grazing	0.0030	0.0005				Yes		
Greasewood-Basin Big Sagebrush	GW-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Wild-Horse-Grazing	0.0030	0.0005				Yes		
Greasewood-Basin Big Sagebrush	GW-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Greasewood-Basin Big Sagebrush	GW-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:SAP	Cattle+Sheep-Grazing	0.0030	0.9995			1	No		
Greasewood-Basin Big Sagebrush	GW-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:SAP	Wild-Horse-Grazing	0.0030	0.9995			2	No		
Greasewood-Basin Big Sagebrush	GW-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	ReplacementFire	0.0033					Yes		
Greasewood-Basin Big Sagebrush	GW-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:SAP+	Wet-Year	0.1000					No		
Greasewood-Basin Big Sagebrush	GW-U:SAP+	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Cattle+Sheep-Grazing	0.0030	0.0005				Yes		
Greasewood-Basin Big Sagebrush	GW-U:SAP+	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Wild-Horse-Grazing	0.0030	0.0005				Yes		
Greasewood-Basin Big Sagebrush	GW-U:SAP+	Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Greasewood-Basin Big Sagebrush	GW-U:SAP+	Greasewood-Basin Big Sagebrush	GW-U:SAP	FineFuelDecomp	0.3300	1.0000	5			No	2	
Greasewood-Basin Big Sagebrush	GW-U:SAP+	Greasewood-Basin Big Sagebrush	GW-U:SAP+	Cattle+Sheep-Grazing	0.0030	0.9995			1	No		
Greasewood-Basin Big Sagebrush	GW-U:SAP+	Greasewood-Basin Big Sagebrush	GW-U:SAP+	Wild-Horse-Grazing	0.0030	0.9995			2	No		
Greasewood-Basin Big Sagebrush	GW-U:SAP+	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	ReplacementFire	0.0067	1.0000	5			Yes		
Greasewood-Basin Big Sagebrush	GW-U:SAP+	Greasewood-Basin Big Sagebrush	GW-U:SAP+	Wet-Year	0.1000	1.0000	5			No		
Greasewood-Basin Big Sagebrush	GW-U:SI	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Greasewood-Basin Big Sagebrush	GW-U:SI	Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Wild-Horse-Grazing	0.0030			2		Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Greasewood-Basin Big Sagebrush	GW-U:SI	Greasewood-Basin Big Sagebrush	GW-U:SI	Cattle+Sheep-Grazing	0.0030		3		1	No		
Greasewood-Basin Big Sagebrush	GW-U:SI	Greasewood-Basin Big Sagebrush	GW-U:SI	Severe Drought	0.0071	0.1000	3			Yes		
Greasewood-Basin Big Sagebrush	GW-U:SI	Greasewood-Basin Big Sagebrush	GW-U:SI	Severe Drought	0.0071	0.9000	3		-1	No		
Greasewood-Basin Big Sagebrush	GW-U:SI	Greasewood-Basin Big Sagebrush	GW-U:SI	Wild-Horse-Grazing	0.0030		3		2	No		
Greasewood-Basin Big Sagebrush	GW-U:SI	Greasewood-Basin Big Sagebrush	GW-B:Closed	Natural-Recovery	0.0000	1.0000	5			No	10	
Greasewood-Basin Big Sagebrush	GW-U:SI	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	AG-Invasion	0.0010	1.0000		4		No		
Greasewood-Basin Big Sagebrush	GW-U:SI	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	AG-Invasion	0.0010	1.0000	5			No		
Greasewood-Basin Big Sagebrush	GW-U:SI	Pickleweed	PW-A:All	Range Shift	0.0010	0.8000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-U:SI	Playa	PL-A:Barren	Range Shift	0.0010	0.2000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Wild-Horse-Grazing	0.0030			2		Yes		
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Wild-Horse-Grazing	0.0030	0.0010	3			Yes		
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Cattle+Sheep-Grazing	0.0030		3		1	No		
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Severe Drought	0.0071	0.1000	3			Yes		
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Wild-Horse-Grazing	0.0030	0.9990	3		2	No		
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI	Competition	0.2000	1.0000	5			No	3	
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI	Competition	0.3300	1.0000		4		No	3	
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	ReplacementFire	0.0020	1.0000				Yes		
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Wet-Year	0.1000	1.0000				No		
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Pickleweed	PW-A:All	Range Shift	0.0010	0.8000		1	1	No	60	
Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Playa	PL-A:Barren	ReplacementFire	0.0010	0.2000		1		No		
Juniper Savanna	JUN-A:All	Juniper Savanna	JUN-A:All	Cattle+Sheep-Grazing	0.0090	0.9990	3		1	No		
Juniper Savanna	JUN-A:All	Juniper Savanna	JUN-A:All	Wild-Horse-Grazing	0.0090	0.9990			2	No		
Juniper Savanna	JUN-A:All	Juniper Savanna	JUN-U:Bare Ground	Cattle+Sheep-Grazing	0.0090	0.0010	3			Yes		
Juniper Savanna	JUN-A:All	Juniper Savanna	JUN-U:Bare Ground	Wild-Horse-Grazing	0.0090	0.0010				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Juniper Savanna	JUN-A:All	Juniper Savanna	JUN-A:All	ReplacementFire	0.0050	1.0000				Yes		
Juniper Savanna	JUN-A:All	Juniper Savanna	JUN-U:Annual Spp	AG-Invasion	0.0025	1.0000				No		
Juniper Savanna	JUN-A:All	Semi-Desert Grassland	SDG-A:Open	Range Shift	0.0776			1	1	No	60	
Juniper Savanna	JUN-B:Open	Juniper Savanna	JUN-B:Open	Cattle+Sheep-Grazing	0.0090	0.9990			1	No		
Juniper Savanna	JUN-B:Open	Juniper Savanna	JUN-B:Open	Wild-Horse-Grazing	0.0090	0.9990			2	No		
Juniper Savanna	JUN-B:Open	Juniper Savanna	JUN-U:Bare Ground	Cattle+Sheep-Grazing	0.0090	0.0010				No		
Juniper Savanna	JUN-B:Open	Juniper Savanna	JUN-U:Bare Ground	Wild-Horse-Grazing	0.0090	0.0010				Yes		
Juniper Savanna	JUN-B:Open	Juniper Savanna	JUN-A:All	ReplacementFire	0.0050	1.0000				Yes		
Juniper Savanna	JUN-B:Open	Juniper Savanna	JUN-U:SAP	AG-Invasion	0.0010	1.0000				No		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-C:Open	Cattle+Sheep-Grazing	0.0090	0.9990				No		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-U:TEA	Cattle+Sheep-Grazing	0.0090	0.0010				No		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-A:All	ReplacementFire	0.0050					Yes		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-B:Open	Severe Drought	0.0070	0.1000				Yes		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-C:Open	Severe Drought	0.0070	0.9000				Yes		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-U:TEA	AG-Invasion	0.0010					No		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-A:All	Senescence	0.0100		2000			Yes		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-D:Open	Cattle+Sheep-Grazing	0.0090	0.9990				No		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-U:TEA	Cattle+Sheep-Grazing	0.0090	0.0010				No		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-A:All	ReplacementFire	0.0020					Yes		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-C:Open	Insect/Disease	0.0167	0.1000				Yes		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-D:Open	Insect/Disease	0.0167	0.9000				Yes		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-D:Open	SurfaceFire	0.0010					No		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-U:TEA	AG-Invasion	0.0010					No		
Juniper Savanna	JUN-U:Annual Spp	Juniper Savanna	JUN-A:All	Herbicide-Plateau+Native-Seed	1.0000	0.8000		5		Yes		
Juniper Savanna	JUN-U:Annual Spp	Juniper Savanna	JUN-U:Annual Spp	Cattle+Sheep-Grazing	0.0090				1	No		
Juniper Savanna	JUN-U:Annual Spp	Juniper Savanna	JUN-U:Annual Spp	Herbicide-Plateau+Native-Seed	1.0000	0.2000		5		Yes		
Juniper Savanna	JUN-U:Annual Spp	Juniper Savanna	JUN-U:Annual Spp	Wild-Horse-Grazing	0.0090				2	No		
Juniper Savanna	JUN-U:Annual Spp	Juniper Savanna	JUN-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Juniper Savanna	JUN-U:Annual Spp	Semi-Desert Grassland	SDG-U:SAP	Range Shift	0.0776			1	1	Yes	60	
Juniper Savanna	JUN-U:Bare Ground	Juniper Savanna	JUN-U:Annual Spp	AG-Invasion	0.0050							
Juniper Savanna	JUN-U:Bare Ground	Semi-Desert Grassland	SDG-U:Bare Ground	Range Shift	0.0076		1	1			60	
Juniper Savanna	JUN-U:SAP	Juniper Savanna	JUN-U:Annual Spp	Cattle+Sheep-Grazing	0.0090	0.0010				Yes		
Juniper Savanna	JUN-U:SAP	Juniper Savanna	JUN-U:Annual Spp	Wild-Horse-Grazing	0.0090	0.0010				Yes		
Juniper Savanna	JUN-U:SAP	Juniper Savanna	JUN-U:SAP	Cattle+Sheep-Grazing	0.0090	0.9990			1	No		
Juniper Savanna	JUN-U:SAP	Juniper Savanna	JUN-U:SAP	Wild-Horse-Grazing	0.0090	0.9990			2	No		
Juniper Savanna	JUN-U:SAP	Juniper Savanna	JUN-U:Annual Spp	ReplacementFire	0.0100	1.0000				Yes		
Juniper Savanna	JUN-U:TEA	Juniper Savanna	JUN-U:TEA	Cattle+Sheep-Grazing	0.0090					No		
Juniper Savanna	JUN-U:TEA	Juniper Savanna	JUN-U:Annual Spp	ReplacementFire	0.0050	1.0000				Yes		
Juniper Savanna	JUN-U:TEA	Juniper Savanna	JUN-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Juniper Savanna	JUN-U:TEA	Juniper Savanna	JUN-U:TEA	Severe Drought	0.0070	0.9000				Yes		
Limber-Bristlecone Pine	LB-A:All	Curl-leaf Mountain Mahogany	CMM-A:All	Range Shift	0.0166	0.4000		1	1	No	60	
Limber-Bristlecone Pine	LB-A:All	Limber-Bristlecone Pine	LB-A:All	ReplacementFire	0.0010					Yes		
Limber-Bristlecone Pine	LB-A:All	Limber-Bristlecone Pine	LB-A:All	Severe Drought	0.0070				-2	No		
Limber-Bristlecone Pine	LB-A:All	Limber-Bristlecone Pine	LB-A:All	SurfaceFire	0.0010					No		
Limber-Bristlecone Pine	LB-A:All	Mixed Conifer	MC-A:All	Range Shift	0.0166	0.6000		1	1	No	60	
Limber-Bristlecone Pine	LB-B:Open	Limber-Bristlecone Pine	LB-A:All	ReplacementFire	0.0010	1.0000	100	249		Yes		
Limber-Bristlecone Pine	LB-B:Open	Limber-Bristlecone Pine	LB-B:Open	SurfaceFire	0.0020	1.0000	100	249		No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Limber-Bristlecone Pine	LB-C:Open	Limber-Bristlecone Pine	LB-A:All	Insect/Disease	0.0001		250			Yes		
Limber-Bristlecone Pine	LB-C:Open	Limber-Bristlecone Pine	LB-A:All	ReplacementFire	0.0010	1.0000	250			Yes		
Limber-Bristlecone Pine	LB-C:Open	Limber-Bristlecone Pine	LB-C:Open	SurfaceFire	0.0020	1.0000	250			No		
Little-leaf Mountain Mahogany	LLMM-A:All	Little-leaf Mountain Mahogany	LLMM-A:All	NativeGrazing	1.0000	0.0200				Yes		
Little-leaf Mountain Mahogany	LLMM-A:All	Black Sagebrush	BS-A:All	Range Shift	0.0451	0.2000		1	1	No	60	
Little-leaf Mountain Mahogany	LLMM-A:All	Stansbury Cliffrose	SC-A:All	Range Shift	0.0451	0.8000		1	1	No	60	
Little-leaf Mountain Mahogany	LLMM-B:Open	Little-leaf Mountain Mahogany	LLMM-A:All	ReplacementFire	0.0070					Yes		
Little-leaf Mountain Mahogany	LLMM-B:Open	Little-leaf Mountain Mahogany	LLMM-B:Open	NativeGrazing	0.0100				-1	No		
Little-leaf Mountain Mahogany	LLMM-B:Open	Little-leaf Mountain Mahogany	LLMM-C:Closed	Tree-Invasion	0.0050		79					
Little-leaf Mountain Mahogany	LLMM-B:Open	Little-leaf Mountain Mahogany	LLMM-U:SAP	AG-Invasion	0.0010					No		
Little-leaf Mountain Mahogany	LLMM-C:Closed	Little-leaf Mountain Mahogany	LLMM-A:All	ReplacementFire	0.0070					Yes		
Little-leaf Mountain Mahogany	LLMM-C:Closed	Little-leaf Mountain Mahogany	LLMM-B:Open	Severe Drought	0.0071	0.1000				Yes		
Little-leaf Mountain Mahogany	LLMM-C:Closed	Little-leaf Mountain Mahogany	LLMM-C:Closed	Severe Drought	0.0071	0.9000				Yes		
Little-leaf Mountain Mahogany	LLMM-C:Closed	Little-leaf Mountain Mahogany	LLMM-U:TEA	AG-Invasion	0.0010					No		
Little-leaf Mountain Mahogany	LLMM-U:Annual Spp	Little-leaf Mountain Mahogany	LLMM-U:Annual Spp	ReplacementFire	0.0500	1.0000				Yes		
Little-leaf Mountain Mahogany	LLMM-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Range Shift	0.0451	0.2000		1	1	No	60	
Little-leaf Mountain Mahogany	LLMM-U:Annual Spp	Stansbury Cliffrose	SC-U:Annual Spp	Range Shift	0.0451	0.8000		1	1	No	60	
Little-leaf Mountain Mahogany	LLMM-U:SAP	Little-leaf Mountain Mahogany	LLMM-U:Annual Spp	ReplacementFire	0.0078					Yes		
Little-leaf Mountain Mahogany	LLMM-U:SAP	Little-leaf Mountain Mahogany	LLMM-U:TEA	Tree-Invasion	0.0050		79			Yes		
Little-leaf Mountain Mahogany	LLMM-U:TEA	Little-leaf Mountain Mahogany	LLMM-U:Annual Spp	ReplacementFire	0.0078							
Little-leaf Mountain Mahogany	LLMM-U:TEA	Little-leaf Mountain Mahogany	LLMM-U:SAP	Severe Drought	0.0071	0.1000				Yes		
Little-leaf Mountain Mahogany	LLMM-U:TEA	Little-leaf Mountain Mahogany	LLMM-U:TEA	Severe Drought	0.0071	0.9000				Yes		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-A:All	Cattle+Sheep-Grazing	0.0170	0.9990	3		1	No		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-A:All	ReplacementFire	0.0040					Yes		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-A:All	Severe Drought	0.0070				-1	No		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-A:All	Wild-Horse-Grazing	0.0170	0.9990			2	No		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-U:Bare Ground	Cattle+Sheep-Grazing	0.0170	0.0005	3			Yes		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-U:Bare Ground	Wild-Horse-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0170	0.0005	3			Yes		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-U:Early-Shrub	Wild-Horse-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-A:All	Mixed Salt Desert	MSD-A:All	Range Shift	0.0409			1	1	No	60	
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-A:All	ReplacementFire	0.0040					Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-A:All	Severe Drought	0.0070	0.1000				Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-B:Open	Cattle+Sheep-Grazing	0.0170	0.9990			1	No		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-B:Open	Severe Drought	0.0070	0.9000				Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-B:Open	Wild-Horse-Grazing	0.0170	0.9990			2	No		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-U:Bare Ground	Cattle+Sheep-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-U:Bare Ground	Wild-Horse-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-U:Early-Shrub	Wild-Horse-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-U:SAP	AG-Invasion	0.0010					No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-A:All	ReplacementFire	0.0040					Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-A:All	RxFire	1.0000	0.6000				Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-A:All	Thin	1.0000			200		Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-B:Open	Severe Drought	0.0070	0.1000				Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-C:Closed	Cattle+Sheep-Grazing	0.0170	0.9990			1	No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-C:Closed	RxFire	1.0000	0.4000				No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-C:Closed	Severe Drought	0.0070	0.9000				Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-C:Closed	Small-Tree-Lopping	1.0000		150			Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-C:Closed	Wild-Horse-Grazing	0.0170	0.9990			2	No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:Bare Ground	Cattle+Sheep-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:Bare Ground	Wild-Horse-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:Depleted	Cattle+Sheep-Grazing	0.0170	0.0005			1	No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:Depleted	Wild-Horse-Grazing	0.0170	0.0005			2	No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:SAP	AG-Invasion	0.0010			249		No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:TEA	AG-Invasion	0.0010		250			No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:TEA	Tree-Encroachment	0.0071		250			No		
Low Sagebrush	LS-U:Annual Spp	Low Sagebrush	LS-U:Annual Spp	Cattle+Sheep-Grazing	0.0170				1	No		
Low Sagebrush	LS-U:Annual Spp	Low Sagebrush	LS-U:Annual Spp	Chaining+Native-Seed	1.0000	0.4000		5		Yes		
Low Sagebrush	LS-U:Annual Spp	Low Sagebrush	LS-U:Annual Spp	ReplacementFire	0.0500					Yes		
Low Sagebrush	LS-U:Annual Spp	Low Sagebrush	LS-U:Annual Spp	Wild-Horse-Grazing	0.0170				2	No		
Low Sagebrush	LS-U:Annual Spp	Low Sagebrush	LS-U:Seeded Native	Chaining+Native-Seed	1.0000	0.6000		5		Yes		
Low Sagebrush	LS-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	Range Shift	0.0409			1	1	No	60	
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:Depleted	Severe Drought	0.0070	0.9000				Yes		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:Depleted	Small-Tree-Lopping	1.0000		150			Yes		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:Early-Shrub	ReplacementFire	0.0040					Yes		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:Early-Shrub	Severe Drought	0.0070	0.1000				Yes		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:SA	AG-Invasion	0.0050					No		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:TEA	Tree-Invasion	0.0050		200			Yes		
Low Sagebrush	LS-U:Early-Shrub	Low Sagebrush	LS-B:Open	Natural-Recovery	0.0000	1.0000	25	119		No		
Low Sagebrush	LS-U:Early-Shrub	Low Sagebrush	LS-C:Closed	Natural-Recovery	0.0000	1.0000	120			No		
Low Sagebrush	LS-U:Early-Shrub	Low Sagebrush	LS-U:Early-Shrub	ReplacementFire	0.0040	1.0000				Yes		
Low Sagebrush	LS-U:Early-Shrub	Mixed Salt Desert	MSD-U:Early-Shrub	Range Shift	0.0409			1	1	No	60	
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:Annual Spp	Cattle+Sheep-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:Annual Spp	ReplacementFire	0.0059					Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:Annual Spp	Wild-Horse-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:SA	Cattle+Sheep-Grazing	0.0170	0.9995			1	No		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:SA	Severe Drought	0.0070	0.9000				Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:SA	Small-Tree-Lopping	1.0000		150			Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:SA	Wild-Horse-Grazing	0.0170	0.9995			2	No		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:SA+	Wet-Year	0.1000					No		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:TEA	Tree-Invasion	0.0050		200			Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:Annual Spp	ReplacementFire	0.0090					Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:Annual Spp	Wild-Horse-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:SA	FineFuelDecomp	0.3300					No	2	
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:SA+	Herbicide-Plateau+Native-Seed	1.0000	0.2000				No		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:SA+	Severe Drought	0.0070	0.9000				Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:SA+	Small-Tree-Lopping	1.0000		150			Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:SA+	Wet-Year	0.1000					No		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:SA+	Wild-Horse-Grazing	0.0170	0.9995			2	No		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:SAP	Herbicide-Plateau+Native-Seed	1.0000	0.2000				No		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:Seeded Native	Herbicide-Plateau+Native-Seed	1.0000	0.6000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:TEA	Tree-Invasion	0.0050		200			Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-A:All	Severe Drought	0.0070	0.0100				Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-B:Open	Natural-Recovery	0.0010	1.0000		149		No	10	
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-C:Closed	Natural-Recovery	0.0010	1.0000	150			No	10	
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:Annual Spp	Cattle+Sheep-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:Annual Spp	ReplacementFire	0.0059	0.9500				Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:Annual Spp	Wild-Horse-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SA	Cattle+Sheep-Grazing	0.0170	0.0005			1	No		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SA	Wild-Horse-Grazing	0.0170	0.0005			2	No		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP	Cattle+Sheep-Grazing	0.0170	0.9990			1	No		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP	Severe Drought	0.0070	0.9000				Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP	Small-Tree-Lopping	1.0000		150			Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP	Wild-Horse-Grazing	0.0170	0.9990			2	No		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP+	Wet-Year	0.1000	1.0000				No		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP-A	ReplacementFire	0.0059	0.0500				Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP-A	Severe Drought	0.0070	0.0900				Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:TEA	Tree-Invasion	0.0050	1.0000	200			Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-B:Open	Spot-Herbicide+Native-Seed	1.0000	0.7000				Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:Annual Spp	Cattle+Sheep-Grazing	0.0170	0.0005				Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:Annual Spp	ReplacementFire	0.0089	1.0000				Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:Annual Spp	Wild-Horse-Grazing	0.0170	0.0050				Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SA+	Cattle+Sheep-Grazing	0.0170	0.0005			1	No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SA+	Wild-Horse-Grazing	0.0170	0.0050			2	No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP	FineFuelDecomp	0.3300	1.0000				No	2	
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Cattle+Sheep-Grazing	0.0170	0.9990			1	No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Severe Drought	0.0070	0.9000				Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Small-Tree-Lopping	1.0000		150			Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Spot-Herbicide+Native-Seed	1.0000	0.3000				No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Wet-Year	0.1000	1.0000				No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Wild-Horse-Grazing	0.0170	0.9990			2	No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:TEA	Tree-Invasion	0.0050	1.0000	200			Yes		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-A:All	Severe Drought	0.0070	0.0900				No		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:Annual Spp	Cattle+Sheep-Grazing	0.0170	0.0010				Yes		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:Annual Spp	ReplacementFire	0.0059	0.9500				Yes		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:Annual Spp	Severe Drought	0.0070	0.0100				Yes		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:Annual Spp	Wild-Horse-Grazing	0.0170	0.0005	6			Yes		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:Bare Ground	Wild-Horse-Grazing	0.0170			5		Yes		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:Bare Ground	Wild-Horse-Grazing	0.0170	0.0005	6		2	No		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:SAP-A	Cattle+Sheep-Grazing	0.0170	0.9990			1	No		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:SAP-A	ReplacementFire	0.0059	0.0500				Yes		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:SAP-A	Severe Drought	0.0070	0.9000			-1	No		
Low Sagebrush	LS-U:SAP-A	Low Sagebrush	LS-U:SAP-A	Wild-Horse-Grazing	0.0170	0.9990	6		2	No		
Low Sagebrush	LS-U:SAP-A	Mixed Salt Desert	MSD-U:Annual Spp	Range Shift	0.0409			1	1	No	60	
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-A:All	Natural-Recovery	0.3300	1.0000	3	24		No	5	
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-B:Open	Natural-Recovery	0.3300	1.0000	25	149		No	5	
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-C:Closed	Natural-Recovery	0.3300	1.0000	150			No	5	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Bare Ground	Cattle+Sheep-Grazing	0.0170	0.0005	6			No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Bare Ground	Wild-Horse-Grazing	0.0170	0.0005	6	25		Yes		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Depleted	Cattle+Sheep-Grazing	0.0170	0.0010	26		1	No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Depleted	Wild-Horse-Grazing	0.0170	0.0005	26		2	No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0170		3	5		Yes		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0170	0.0005	6	25		No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Early-Shrub	Severe Drought	0.0070	0.1000	4			Yes		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Early-Shrub	Wild-Horse-Grazing	0.0170			5		Yes		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Early-Shrub	Wild-Horse-Grazing	0.0170	0.0005	6	25		Yes		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:SAP	AG-Invasion	0.0010	1.0000				No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Seeded Native	Cattle+Sheep-Grazing	0.0170	0.9990	6		1	No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Seeded Native	ReplacementFire	0.0040	1.0000				Yes		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Seeded Native	Severe Drought	0.0070	0.9000	4		-1	No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Seeded Native	Wild-Horse-Grazing	0.0170	0.9990	6		2	No		
Low Sagebrush	LS-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Range Shift	0.0409			1	1	No	60	
Low Sagebrush	LS-U:SI-A	Low Sagebrush	LS-A:All	Natural-Recovery	0.0000		5			No	10	
Low Sagebrush	LS-U:SI-A	Low Sagebrush	LS-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Low Sagebrush	LS-U:SI-A	Low Sagebrush	LS-U:Early-Shrub	Wild-Horse-Grazing	0.0170			2		Yes		
Low Sagebrush	LS-U:SI-A	Low Sagebrush	LS-U:SI-A	Cattle+Sheep-Grazing	0.0170		3		1	No		
Low Sagebrush	LS-U:SI-A	Low Sagebrush	LS-U:SI-A	ReplacementFire	0.0010					Yes		
Low Sagebrush	LS-U:SI-A	Low Sagebrush	LS-U:SI-A	Severe Drought	0.0070	0.9000	3		-1	No		
Low Sagebrush	LS-U:SI-A	Low Sagebrush	LS-U:SI-A	Severe Drought	0.0071	0.1000	3			Yes		
Low Sagebrush	LS-U:SI-A	Low Sagebrush	LS-U:SI-A	Wild-Horse-Grazing	0.0170		3		2	No		
Low Sagebrush	LS-U:SI-A	Low Sagebrush	LS-U:SI-A+AG	AG-Invasion	0.0010					No		
Low Sagebrush	LS-U:SI-A	Mixed Salt Desert	MSD-U:SI	Range Shift	0.0409			1	1	No	60	
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:Annual Spp	Wild-Horse-Grazing	0.0170			2		Yes		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A	Competition	1.0000					No	3	
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	Cattle+Sheep-Grazing	0.0170		3		1	No		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	ReplacementFire	0.0020					Yes		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	Severe Drought	0.0070	0.9000	3		-1	No		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	Severe Drought	0.0071	0.1000	3			Yes		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	Wet-Year	0.1000					No		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	Wild-Horse-Grazing	0.0170		3		2	No		
Low Sagebrush	LS-U:SI-A+AG	Mixed Salt Desert	MSD-U:SI+AG	Range Shift	0.0409			1	1	No	60	
Low Sagebrush	LS-U:SI-B	Low Sagebrush	LS-A:All	ReplacementFire	0.0010					Yes		
Low Sagebrush	LS-U:SI-B	Low Sagebrush	LS-B:Open	Natural-Recovery	0.0000					No	10	
Low Sagebrush	LS-U:SI-B	Low Sagebrush	LS-U:SI-B	Cattle+Sheep-Grazing	0.0170				1	No		
Low Sagebrush	LS-U:SI-B	Low Sagebrush	LS-U:SI-B	Severe Drought	0.0070				-1	No		
Low Sagebrush	LS-U:SI-B	Low Sagebrush	LS-U:SI-B	Wild-Horse-Grazing	0.0170				2	No		
Low Sagebrush	LS-U:SI-B	Low Sagebrush	LS-U:SI-B+AG	AG-Invasion	0.0010					No		
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-A+AG	ReplacementFire	0.0020					Yes		
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-B	Competition	1.0000					No	3	
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-B+AG	Cattle+Sheep-Grazing	0.0170				1	No		
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-B+AG	Severe Drought	0.0070				-1	No		
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-B+AG	Wet-Year	0.1000					No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-B+AG	Wild-Horse-Grazing	0.0170				2	No		
Low Sagebrush	LS-U:SI-C	Low Sagebrush	LS-A:All	ReplacementFire	0.0010					Yes		
Low Sagebrush	LS-U:SI-C	Low Sagebrush	LS-C:Closed	Natural-Recovery	0.0000					No	10	
Low Sagebrush	LS-U:SI-C	Low Sagebrush	LS-U:SI-C	Cattle+Sheep-Grazing	0.0170				1	No		
Low Sagebrush	LS-U:SI-C	Low Sagebrush	LS-U:SI-C	Severe Drought	0.0070				-1	No		
Low Sagebrush	LS-U:SI-C	Low Sagebrush	LS-U:SI-C	Wild-Horse-Grazing	0.0170				2	No		
Low Sagebrush	LS-U:SI-C	Low Sagebrush	LS-U:SI-C+AG	AG-Invasion	0.0010					No		
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SI-A+AG	ReplacementFire	0.0020					Yes		
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SI-C	Competition	1.0000					No	3	
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SI-C+AG	Cattle+Sheep-Grazing	0.0170				1	No		
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SI-C+AG	Severe Drought	0.0070				-1	No		
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SI-C+AG	Wet-Year	0.1000					No		
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SI-C+AG	Wild-Horse-Grazing	0.0170				2	No		
Low Sagebrush	LS-U:TEA	Low Sagebrush	LS-B:Open	Small-Tree-Lopping	1.0000	0.0500						
Low Sagebrush	LS-U:TEA	Low Sagebrush	LS-U:Annual Spp	ReplacementFire	0.0050	1.0000	200			Yes		
Low Sagebrush	LS-U:TEA	Low Sagebrush	LS-U:Annual Spp	Severe Drought	0.0070	0.0500	200			Yes		
Low Sagebrush	LS-U:TEA	Low Sagebrush	LS-U:Early-Shrub	Severe Drought	0.0070	0.0500	200			Yes		
Low Sagebrush	LS-U:TEA	Low Sagebrush	LS-U:SA	Small-Tree-Lopping	1.0000	0.5000	200		25	Yes		
Low Sagebrush	LS-U:TEA	Low Sagebrush	LS-U:SAP	Severe Drought	0.0070	0.0500	200			Yes		
Low Sagebrush	LS-U:TEA	Low Sagebrush	LS-U:SAP	Small-Tree-Lopping	1.0000	0.4500	200		25	Yes		
Low Sagebrush	LS-U:TEA	Low Sagebrush	LS-U:TEA	Severe Drought	0.0070	0.8500	200			Yes		
Mixed Conifer	MC-A:All	Mixed Conifer	MC-A:All	ReplacementFire	0.0080					Yes		
Mixed Conifer	MC-A:All	Mixed Conifer	MC-A:All	Severe Drought	0.0070					Yes		
Mixed Conifer	MC-A:All	Pinyon-Juniper	PJ-A:All	Range Shift	0.0264	0.5000		1	1	No	60	
Mixed Conifer	MC-A:All	Ponderosa Pine	PP-A:All	Range Shift	0.0264	0.5000		1	1	No	60	
Mixed Conifer	MC-B:Closed	Mixed Conifer	MC-A:All	ReplacementFire	0.0100					Yes		
Mixed Conifer	MC-B:Closed	Mixed Conifer	MC-B:Open	Insect/Disease	0.0100					No		
Mixed Conifer	MC-B:Closed	Mixed Conifer	MC-B:Open	MixedFire	0.0160					No		
Mixed Conifer	MC-B:Closed	Mixed Conifer	MC-U:TEA	AG-Invasion	0.0010					No		
Mixed Conifer	MC-B:Open	Mixed Conifer	MC-A:All	ReplacementFire	0.0003			69		Yes		
Mixed Conifer	MC-B:Open	Mixed Conifer	MC-A:All	ReplacementFire	0.0050		70			Yes		
Mixed Conifer	MC-B:Open	Mixed Conifer	MC-B:Closed	Fuel-Build-Up	1.0000					No	35	
Mixed Conifer	MC-B:Open	Mixed Conifer	MC-B:Open	Insect/Disease	0.0100					Yes		
Mixed Conifer	MC-B:Open	Mixed Conifer	MC-B:Open	SurfaceFire	0.0003			69		Yes		
Mixed Conifer	MC-B:Open	Mixed Conifer	MC-B:Open	SurfaceFire	0.0017		70			No		
Mixed Conifer	MC-B:Open	Mixed Conifer	MC-U:TEA	AG-Invasion	0.0010					No		
Mixed Conifer	MC-C:Closed	Mixed Conifer	MC-C:Open	Chainsaw-Thinning	1.0000	1.0000		129		No		
Mixed Conifer	MC-C:Closed	Mixed Conifer	MC-C:Open	Chainsaw-Thinning	1.0000	1.0000	130			Yes		
Mixed Conifer	MC-C:Closed	Mixed Conifer	MC-A:All	ReplacementFire	0.0100	1.0000				Yes		
Mixed Conifer	MC-C:Closed	Mixed Conifer	MC-C:Open	Insect/Disease	0.0056	1.0000				Yes		
Mixed Conifer	MC-C:Closed	Mixed Conifer	MC-C:Open	MixedFire	0.0017	1.0000				Yes		
Mixed Conifer	MC-C:Closed	Mixed Conifer	MC-U:TEA	AG-Invasion	0.0010	1.0000				No		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-B:Open	Chainsaw-Thinning	1.0000			149		Yes		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-C:Open	Chainsaw-Thinning	1.0000		150			Yes		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-A:All	ReplacementFire	0.0007			149		Yes		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-A:All	ReplacementFire	0.0050		150			Yes		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-B:Open	Insect/Disease	0.0010			149		Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-B:Open	Insect/Disease	0.0050		150			Yes		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-C:Closed	Fuel-Build-Up	1.0000					No	70	
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-C:Open	SurfaceFire	0.0017			149		No		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-C:Open	SurfaceFire	0.0063		150			No		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-U:TEA	AG-Invasion	0.0010					No		
Mixed Conifer	MC-U:Annual Spp	Mixed Conifer	MC-U:Annual Spp	ReplacementFire	0.1000	1.0000		29		Yes		
Mixed Conifer	MC-U:Annual Spp	Pinyon-Juniper	PJ-U:Annual Spp	Range Shift	0.0264	0.5000		1	1	No	60	
Mixed Conifer	MC-U:Annual Spp	Ponderosa Pine	PP-U:Annual Spp	Range Shift	0.0264	0.5000		1	1	No	60	
Mixed Conifer	MC-U:TEA	Mixed Conifer	MC-U:TEA	Chainsaw-Thinning	1.0000	1.0000	100	149		No		
Mixed Conifer	MC-U:TEA	Mixed Conifer	MC-U:TEA	Chainsaw-Thinning	1.0000	1.0000	150			Yes		
Mixed Conifer	MC-U:TEA	Mixed Conifer	MC-B:Closed	Alternate-Succession2	0.0100	1.0000	30	99		Yes	10	
Mixed Conifer	MC-U:TEA	Mixed Conifer	MC-C:Closed	Alternate-Succession2	0.0100	1.0000	100			No	10	
Mixed Conifer	MC-U:TEA	Mixed Conifer	MC-U:Annual Spp	MixedFire	0.0151	0.7500	30			Yes		
Mixed Conifer	MC-U:TEA	Mixed Conifer	MC-U:Annual Spp	ReplacementFire	0.0056	1.0000	30			Yes		
Mixed Conifer	MC-U:TEA	Mixed Conifer	MC-U:TEA	Insect/Disease	0.0056	1.0000	30			Yes		
Mixed Conifer	MC-U:TEA	Mixed Conifer	MC-U:TEA	MixedFire	0.0152	0.2500	30			Yes		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-A:All	Cattle+Sheep-Grazing	0.0040	0.9995	3		1	No		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-A:All	Very-Wet-Year	0.0181					Yes		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-A:All	Wild-Horse-Grazing	0.0040	0.9990			2	No		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-U:Annual Spp	AG-Invasion	0.0025					No		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-U:Bare Ground	Cattle+Sheep-Grazing	0.0040	0.0005	3			Yes		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-U:Bare Ground	Wild-Horse-Grazing	0.0040	0.0010				Yes		
Mixed Salt Desert	MSD-A:All	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0027			1	1	No	60	
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-A:All	Thin	1.0000					Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-A:All	Very-Wet-Year	0.0181					Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-B:Open	Cattle+Sheep-Grazing	0.0040	0.9995			1	No		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-B:Open	Severe Drought	0.0070	0.9000				Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-B:Open	Wild-Horse-Grazing	0.0040	0.9990			2	No		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-C:Open	Severe Drought	0.0070	0.1000			1	Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-U:Bare Ground	Wild-Horse-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-U:Early-Shrub	Cattle+Sheep-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-U:Early-Shrub	Wild-Horse-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-U:SAP	AG-Invasion	0.0010					No		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-A:All	Severe Drought	0.0070	0.1000			1	Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-A:All	Thin	1.0000					Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-A:All	Very-Wet-Year	0.0181					Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-C:Open	Cattle+Sheep-Grazing	0.0040	0.9995			1	No		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-C:Open	Severe Drought	0.0070	0.9000				Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-C:Open	Wild-Horse-Grazing	0.0040	0.9990			2	No		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-U:Bare Ground	Cattle+Sheep-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-U:Bare Ground	Wild-Horse-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-U:Early-Shrub	Wild-Horse-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-U:SAP	AG-Invasion	0.0010					No		
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	Cattle+Sheep-Grazing	0.0040					Yes		
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.2500		5		Yes		
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	Herbicide-Plateau+Seed	1.0000	0.2500		5		Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	Wild-Horse-Grazing	0.0040					Yes		
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:SI	Chaining+Plateau+Seed	1.0000	0.5000		5		Yes		
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:SI	Herbicide-Plateau+Seed	1.0000	0.5000		5		Yes		
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:SI+AG	Chaining+Plateau+Seed	1.0000	0.2500		5		Yes		
Mixed Salt Desert	MSD-U:Annual Spp	Mixed Salt Desert	MSD-U:SI+AG	Herbicide-Plateau+Seed	1.0000	0.2500		5		Yes		
Mixed Salt Desert	MSD-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Range Shift	0.0027			1	1	No	60	
Mixed Salt Desert	MSD-U:Bare Ground	Mixed Salt Desert	MSD-U:Annual Spp	AG-Invasion	0.0050							
Mixed Salt Desert	MSD-U:Bare Ground	Mixed Salt Desert	MSD-U:Exotic Forb	Exotic-Invasion	0.0005					Yes		
Mixed Salt Desert	MSD-U:Bare Ground	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0027		1	1			60	
Mixed Salt Desert	MSD-U:Early-Shrub	Mixed Salt Desert	MSD-U:Early-Shrub	ReplacementFire	0.0010					Yes		
Mixed Salt Desert	MSD-U:Early-Shrub	Mixed Salt Desert	MSD-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Mixed Salt Desert	MSD-U:Early-Shrub	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0027			1	1	No	60	
Mixed Salt Desert	MSD-U:Exotic Forb	Mixed Salt Desert	MSD-U:Exotic Forb	Cattle+Sheep-Grazing	0.0040					1	No	
Mixed Salt Desert	MSD-U:Exotic Forb	Mixed Salt Desert	MSD-U:Exotic Forb	ReplacementFire	0.0100							
Mixed Salt Desert	MSD-U:Exotic Forb	Mixed Salt Desert	MSD-U:Exotic Forb	Wild-Horse-Grazing	0.0040					2	No	
Mixed Salt Desert	MSD-U:Exotic Forb	Greasewood-Basin Big Sagebrush	GW-U:Exotic Forb	Range Shift	0.0027			1	1	No	60	
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:Annual Spp	Cattle+Sheep-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:Annual Spp	ReplacementFire	0.0100					Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:Annual Spp	Very-Wet-Year	0.0181					Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:Annual Spp	Wild-Horse-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:SAP	Cattle+Sheep-Grazing	0.0040	0.9995				1	No	
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:SAP	Wild-Horse-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:SAP	Wild-Horse-Grazing	0.0040	0.9990				2	No	
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:SAP+	Wet-Year	0.1000					No		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:Annual Spp	Cattle+Sheep-Grazing	0.0040	0.0005				Yes		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:Annual Spp	ReplacementFire	0.0150					Yes		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:Annual Spp	Very-Wet-Year	0.0181					Yes		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:Annual Spp	Wild-Horse-Grazing	0.0040	0.0010				Yes		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:SAP	FineFuelDecomp	0.3300					No	2	
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:SAP+	Cattle+Sheep-Grazing	0.0040	0.9995				1	No	
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:SAP+	Wet-Year	0.1000					No		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:SAP+	Wild-Horse-Grazing	0.0040	0.9990				2	No	
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-B:Open	Natural-Recovery	0.3300	1.0000	3	5		No	5	
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-B:Open	Natural-Recovery	0.3300	1.0000	6			No	5	
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Early-Shrub	Cattle+Sheep-Grazing	0.0040		3	3		Yes		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Early-Shrub	Cattle+Sheep-Grazing	0.0040	0.0010	4			Yes		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Early-Shrub	Severe Drought	0.0071	0.1000	4			Yes		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Early-Shrub	Wild-Horse-Grazing	0.0040			5		Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Early-Shrub	Wild-Horse-Grazing	0.0040	0.0010	6			Yes		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Exotic Forb	Exotic-Invasion	0.0005			5		No		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:SAP	AG-Invasion	0.0010	1.0000				No		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Cattle+Sheep-Grazing	0.0040	0.9990	4		1	No		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Severe Drought	0.0071	0.9000	4		-1	No		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Very-Wet-Year	0.0181	1.0000				Yes		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Wild-Horse-Grazing	0.0040	0.9990	6		2	No		
Mixed Salt Desert	MSD-U:Seeded Native	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0027			1	1	No	60	
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-A:All	Natural-Recovery	0.0001	1.0000		5		No	10	
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-B:Open	Natural-Recovery	0.0010	1.0000	6			No	10	
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-U:Early-Shrub	Wild-Horse-Grazing	0.0040			2		Yes		
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-U:Early-Shrub	Wild-Horse-Grazing	0.0040	0.0010	3			Yes		
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-U:SI	Cattle+Sheep-Grazing	0.0040		3		1	No		
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-U:SI	Severe Drought	0.0071	0.1000	3			Yes		
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-U:SI	Severe Drought	0.0071	0.9000	3		-1	No		
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-U:SI	Thin	1.0000					Yes		
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-U:SI	Wild-Horse-Grazing	0.0040	0.9990	3		2	No		
Mixed Salt Desert	MSD-U:SI	Mixed Salt Desert	MSD-U:SI+AG	AG-Invasion	0.0010	1.0000				No		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:Annual Spp	Wild-Horse-Grazing	0.0040	0.0010		2		Yes		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:Annual Spp	Wild-Horse-Grazing	0.0040	0.0010	3			Yes		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI	Competition	0.2000	1.0000		5		No	3	
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI	Competition	0.3300	1.0000	6			No	3	
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI	Herbicide-Plateau	1.0000	0.8000				No		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	Cattle+Sheep-Grazing	0.0040		3		1	No		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	Herbicide-Plateau	1.0000	0.2000				No		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	ReplacementFire	0.0020	1.0000				Yes		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	Severe Drought	0.0071	0.1000	3			Yes		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	Thin	1.0000					Yes		
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	Very-Wet-Year	0.0181	1.0000				Yes		
Mixed Salt Desert	MSD-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Range Shift	0.0027			1	1	No	60	
Mixed Salt Desert	MSD-U:SI+AG	Mixed Salt Desert	MSD-U:SI+AG	Wild-Horse-Grazing	0.0040	0.9990	3		2	No		
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Cattle+Sheep-Grazing	0.0760	0.9995				No	20	
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Fence	1.0000					No	50	
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Wild-Horse-Grazing	0.0760	0.9990				Yes	20	
Montane Riparian	MR-A:All	Montane Riparian	MR-U:EFT	Exotic-Invasion	0.0001					No	5	
Montane Riparian	MR-A:All	Montane Riparian	MR-U:Hummocked	Cattle+Sheep-Grazing	0.0760	0.0005				Yes	20	
Montane Riparian	MR-A:All	Montane Riparian	MR-U:Hummocked	Wild-Horse-Grazing	0.0760	0.0010				Yes	20	
Montane Riparian	MR-A:All	Basin Wildrye	BW-A:All	Range Shift	0.1640	0.2000		1	1	No	60	
Montane Riparian	MR-A:All	Desert Wash	DWA-A:All	Range Shift	0.1640	0.8000		1	1	No	60	
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Flooding-7yr	0.1400				-1	No		
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Weed-Inventory+Treat	1.0000					No	3	
Montane Riparian	MR-B:Open	Montane Riparian	MR-B:Open	Alternate-Succession2	1.0000	0.9900				No	20	60

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Montane Riparian	MR-B:Open	Montane Riparian	MR-B:Open	Cattle+Sheep-Grazing	0.0760	0.9995			1	No	20	
Montane Riparian	MR-B:Open	Montane Riparian	MR-B:Open	Fence	1.0000					No	50	
Montane Riparian	MR-B:Open	Montane Riparian	MR-B:Open	Wild-Horse-Grazing	0.0760	0.9990			2	No	20	
Montane Riparian	MR-B:Open	Montane Riparian	MR-C:Closed	Alternate-Succession2	1.0000	0.0100	20			Yes	20	60
Montane Riparian	MR-B:Open	Montane Riparian	MR-U:SFE	Cattle+Sheep-Grazing	0.0760	0.0005				No	20	
Montane Riparian	MR-B:Open	Montane Riparian	MR-U:SFE	Wild-Horse-Grazing	0.0760	0.0010			2	No	20	
Montane Riparian	MR-B:Open	Montane Riparian	MR-A:All	Flooding-20yr	0.0500				4	Yes		
Montane Riparian	MR-B:Open	Montane Riparian	MR-A:All	ReplacementFire	0.0067					Yes		
Montane Riparian	MR-B:Open	Montane Riparian	MR-B:Open	Weed-Inventory+Treat	1.0000					No	3	
Montane Riparian	MR-B:Open	Montane Riparian	MR-U:EFT	Exotic-Invasion	0.0001					No	5	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-B:Open	Chainsaw-Thinning	1.0000		50			Yes		
Montane Riparian	MR-C:Closed	Montane Riparian	MR-C:Closed	Cattle+Sheep-Grazing	0.0760	0.9995			1	No	20	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-C:Closed	Fence	1.0000					No	50	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-C:Closed	Wild-Horse-Grazing	0.0760	0.9990			2	No	20	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-U:SFE	Cattle+Sheep-Grazing	0.0760	0.0005			1	No	20	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-U:SFE	Wild-Horse-Grazing	0.0760	0.0010			2	No	20	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-A:All	Flooding-100yr	0.0100					Yes		
Montane Riparian	MR-C:Closed	Montane Riparian	MR-A:All	ReplacementFire	0.0067					Yes		
Montane Riparian	MR-C:Closed	Montane Riparian	MR-C:Closed	Weed-Inventory+Treat	1.0000					No	3	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-U:EFT	Exotic-Invasion	0.0001					Yes	5	
Montane Riparian	MR-U:Annual Spp	Montane Riparian	MR-U:Annual Spp	Cattle+Sheep-Grazing	0.0760		3		1	No	20	
Montane Riparian	MR-U:Annual Spp	Montane Riparian	MR-U:Annual Spp	Fence	1.0000	1.0000				Yes	50	
Montane Riparian	MR-U:Annual Spp	Montane Riparian	MR-U:Annual Spp	Wild-Horse-Grazing	0.0760				2	No	20	
Montane Riparian	MR-U:Annual Spp	Basin Wildrye	BW-U:Annual Spp	Range Shift	0.1640	0.2000		1	1	No	60	
Montane Riparian	MR-U:Annual Spp	Desert Wash	DWA-U:SA	Range Shift	0.1640	0.8000		1	1	No	60	
Montane Riparian	MR-U:Annual Spp	Montane Riparian	MR-A:All	Flooding-100yr	0.0100	0.0100				Yes		
Montane Riparian	MR-U:Annual Spp	Montane Riparian	MR-A:All	Floodplain-Restoration	1.0000	0.9000				Yes		
Montane Riparian	MR-U:Annual Spp	Montane Riparian	MR-A:All	Water-Table-Uplift	1.0000	1.0000				Yes		
Montane Riparian	MR-U:Annual Spp	Montane Riparian	MR-U:Annual Spp	Flooding-100yr	0.0100	0.9900				Yes		
Montane Riparian	MR-U:Annual Spp	Montane Riparian	MR-U:Annual Spp	Floodplain-Restoration	1.0000	0.1000				Yes		
Montane Riparian	MR-U:Annual Spp	Montane Riparian	MR-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Montane Riparian	MR-U:Bare Ground	Montane Riparian	MR-U:Annual Spp	AG-Invasion	0.0050					Yes		
Montane Riparian	MR-U:Bare Ground	Montane Riparian	MR-U:EFT	Exotic-Invasion	0.0005					Yes	5	
Montane Riparian	MR-U:Bare Ground	Four-Wing Saltbush	FWS-U:Bare Ground	Range Shift	0.1640	0.4000	1	1		No	60	
Montane Riparian	MR-U:Bare Ground	Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Range Shift	0.1640	0.4000	1	1		No	60	
Montane Riparian	MR-U:Bare Ground	Wyoming Big Sagebrush upland	WSUp-U:Bare Ground	Range Shift	0.1640	0.2000	1	1		No	60	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Bare Ground	Cattle+Sheep-Grazing	0.0760	0.0005				Yes	20	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Bare Ground	Wild-Horse-Grazing	0.0760	0.0005				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	Cattle+Sheep-Grazing	0.0760	0.9995			1	No	20	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	Fence	1.0000	1.0000				No	50	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	Wild-Horse-Grazing	0.0760	0.0005				Yes	20	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	Wild-Horse-Grazing	0.0760	0.9990			2	No	20	
Montane Riparian	MR-U:Desertified	Basin Wildrye	BW-U:Depleted-C	Range Shift	0.1640	0.2000		1	1	No	60	
Montane Riparian	MR-U:Desertified	Desert Wash	DWA-A:All	Range Shift	0.1640	0.8000		1	1	No	60	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-A:All	Flooding-100yr	0.0100	0.0100				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-A:All	Floodplain-Recovery	0.0010	1.0000				Yes	10	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-A:All	Floodplain-Restoration	1.0000	0.9000				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	Flooding-100yr	0.0100	0.9900				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	Floodplain-Restoration	1.0000	0.1000				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	OHV	0.0067	1.0000				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:SAP	AG-Invasion	0.0050					No		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:SFE	Water-Table-Uplift	1.0000	1.0000				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:TEA	Tree-Invasion	0.0080	1.0000	50			Yes		
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Cattle+Sheep-Grazing	0.0760		3		1	No	20	
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Fence	1.0000	1.0000				No	50	
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Flooding-100yr	0.0100		20			Yes		
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Flooding-20yr	0.0500		5	19	4	Yes		
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Wild-Horse-Grazing	0.0760				2	No	20	
Montane Riparian	MR-U:EFT	Basin Wildrye	BW-U:Exotic Forb	Range Shift	0.1640	0.2000		1	1	No	60	
Montane Riparian	MR-U:EFT	Desert Wash	DWA-U:EFT	Range Shift	0.1640	0.8000		1	1	No	60	
Montane Riparian	MR-U:EFT	Montane Riparian	MR-A:All	Exotic-Control	1.0000	0.7000		4		No		20
Montane Riparian	MR-U:EFT	Montane Riparian	MR-B:Open	Exotic-Control	1.0000	0.7000	5	19		No		20
Montane Riparian	MR-U:EFT	Montane Riparian	MR-C:Closed	Exotic-Control	1.0000	0.7000	20			No		20
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Exotic-Control	1.0000	0.3000				Yes		20
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	ReplacementFire	0.0067	1.0000				Yes		
Montane Riparian	MR-U:Hummocked	Montane Riparian	MR-U:EFT	Exotic-Invasion	0.0001					No	5	
Montane Riparian	MR-U:Hummocked	Basin Wildrye	BW-A:All	Range Shift	0.1642	0.2000	1	1			60	
Montane Riparian	MR-U:Hummocked	Desert Wash	DWA-U:Bare Ground	Range Shift	0.1642	0.8000	1	1			60	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:Annual Spp	Cattle+Sheep-Grazing	0.0760	0.0005				Yes	20	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:Annual Spp	Wild-Horse-Grazing	0.0760	0.0010				Yes	20	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SAP	Cattle+Sheep-Grazing	0.0760	0.9995			1	No	20	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SAP	Fence	1.0000	1.0000				No	50	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SAP	Wild-Horse-Grazing	0.0760	0.9990			2	No	20	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:TEA	Tree-Invasion	0.0010	0.0080	50			Yes		
Montane Riparian	MR-U:SAP	Basin Wildrye	BW-U:SAP	Range Shift	0.1640	0.2000		1	1	No	60	
Montane Riparian	MR-U:SAP	Desert Wash	DWA-U:SAP	Range Shift	0.1640	0.8000		1	1	No	60	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-A:All	Flooding-100yr	0.0100	0.0100				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-A:All	Floodplain-Restoration	1.0000	0.9000				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:Annual Spp	Flooding-100yr	0.0100	0.4950				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:Annual Spp	ReplacementFire	0.0225	0.9000				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SAP	Flooding-100yr	0.0100	0.4950				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SAP	Floodplain-Restoration	1.0000	0.1000				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SAP	ReplacementFire	0.0225	0.1000				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SFE	Water-Table-Uplift	1.0000	1.0000				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Bare Ground	Cattle+Sheep-Grazing	0.0760	0.0005	3			Yes	20	
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Bare Ground	Wild-Horse-Grazing	0.0760	0.0010				Yes	20	
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Cattle+Sheep-Grazing	0.0760	0.9995	3		1	No	20	
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Fence	1.0000					No	50	
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Wild-Horse-Grazing	0.0760	0.9990			2	No	20	
Montane Riparian	MR-U:Seeded Native	Basin Wildrye	BW-U:Seeded Native	Range Shift	0.1640	0.2000		1	1	No	60	
Montane Riparian	MR-U:Seeded Native	Desert Wash	DWA-A:All	Range Shift	0.1640	0.8000		1	1	No	60	
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-A:All	Flooding-100yr	0.0100	0.0100				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-A:All	Floodplain-Recovery	0.0010					Yes	10	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-A:All	Floodplain-Restoration	1.0000	0.9000				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-A:All	Water-Table-Uplift	1.0000					Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:SAP	AG-Invasion	0.0010					No		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Flooding-100yr	0.0100	0.9900				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Floodplain-Restoration	1.0000	0.1000				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	ReplacementFire	0.0050					Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:TEA	Tree-Invasion	0.0080		50			Yes		
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:Desertified	Cattle+Sheep-Grazing	0.0760	0.0005	3			Yes	20	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:Desertified	Wild-Horse-Grazing	0.0760	0.0010				Yes	20	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Cattle+Sheep-Grazing	0.0760	0.9995	3		1	No	20	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Chainsaw-Thinning	1.0000		50		5	Yes		
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Fence	1.0000	1.0000				No	50	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Wild-Horse-Grazing	0.0760	0.9990			2	No	20	
Montane Riparian	MR-U:SFE	Basin Wildrye	BW-A:All	Range Shift	0.1640	0.2000		1	1	No	60	
Montane Riparian	MR-U:SFE	Desert Wash	DWA-U:Early-Shrub	Range Shift	0.1640	0.8000		1	1	No	60	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:EFT	Exotic-Invasion	0.0001	1.0000				Yes	5	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Flooding-100yr	0.0100	1.0000	20			Yes		
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Flooding-20yr	0.0500	1.0000	5	19		Yes		
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	ReplacementFire	0.0067	1.0000				Yes		
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-U:Annual Spp	Wild-Horse-Grazing	0.0760					Yes	20	
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-U:SI+AG	Cattle+Sheep-Grazing	0.0760		3		1	No	20	
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-U:SI+AG	Fence	1.0000					No	50	
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-U:SI+AG	Wild-Horse-Grazing	0.0760				2	No	20	
Montane Riparian	MR-U:SI+AG	Basin Wildrye	BW-U:SI+AG	Range Shift	0.1640	0.2000		1	1	No	60	
Montane Riparian	MR-U:SI+AG	Desert Wash	DWA-U:SA	Range Shift	0.1640	0.8000		1	1	No	60	
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-A:All	Flooding-100yr	0.0100	0.0100				Yes		
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-A:All	Floodplain-Restoration	1.0000	0.9000				Yes		
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-A:All	Water-Table-Uplift	1.0000					Yes		
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-U:Annual Spp	Flooding-100yr	0.0100	0.1000				Yes		
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-U:Annual Spp	ReplacementFire	0.0020	0.2000				Yes		
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-U:SI+AG	Flooding-100yr	0.0100	0.8900				Yes		
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-U:SI+AG	Floodplain-Restoration	1.0000	0.1000				Yes		
Montane Riparian	MR-U:SI+AG	Montane Riparian	MR-U:SI+AG	ReplacementFire	0.0020	0.8000				Yes		
Montane Riparian	MR-U:TEA	Montane Riparian	MR-U:Desertified	Chainsaw-Thinning	1.0000	1.0000	50		1	Yes		
Montane Riparian	MR-U:TEA	Montane Riparian	MR-U:TEA	Fence	1.0000	1.0000	50			No	50	
Montane Riparian	MR-U:TEA	Montane Riparian	MR-A:All	Floodplain-Restoration	1.0000	0.9000	50			Yes		
Montane Riparian	MR-U:TEA	Montane Riparian	MR-U:Annual Spp	ReplacementFire	0.0075	0.5000	50			Yes		
Montane Riparian	MR-U:TEA	Montane Riparian	MR-U:Desertified	Floodplain-Restoration	1.0000	0.1000	50			Yes		
Montane Riparian	MR-U:TEA	Montane Riparian	MR-U:Desertified	ReplacementFire	0.0075	0.5000	50			Yes		
Montane Riparian	MR-U:TEA	Montane Riparian	MR-U:SAP	Water-Table-Uplift	1.0000	1.0000	50			Yes		
Montane Sagebrush Steppe	MSS-A:All	Montane Sagebrush Steppe	MSS-A:All	Cattle+Sheep-Grazing	0.0210	0.9995	3			No		
Montane Sagebrush Steppe	MSS-A:All	Montane Sagebrush Steppe	MSS-A:All	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Montane Sagebrush Steppe	MSS-A:All	Montane Sagebrush Steppe	MSS-U:Bare Ground	Cattle+Sheep-Grazing	0.0210	0.0005	3			Yes		
Montane Sagebrush Steppe	MSS-A:All	Montane Sagebrush Steppe	MSS-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-A:All	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-A:All	Black Sagebrush	BS-A:All	Range Shift	0.0302	0.5000		1	1	No	60	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Montane Sagebrush Steppe	MSS-A:All	Montane Sagebrush Steppe	MSS-A:All	ReplacementFire	0.0125	1.0000		11		Yes		
Montane Sagebrush Steppe	MSS-A:All	Montane Sagebrush Steppe	MSS-U:SAP-A	AG-Invasion	0.0025			11		No		
Montane Sagebrush Steppe	MSS-A:All	Wyoming Big Sagebrush upland	WSup-A:All	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-A:All	Thin	1.0000					Yes		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-B:Open	Cattle+Sheep-Grazing	0.0210	0.9995				No		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-B:Open	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-U:Bare Ground	Cattle+Sheep-Grazing	0.0210	0.0005				No		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-A:All	ReplacementFire	0.0250					Yes		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-U:SAP	AG-Invasion	0.0010					No		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-A:All	Thin	1.0000					Yes		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-C:Closed	Cattle+Sheep-Grazing	0.0210	0.9995				No		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-C:Closed	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-U:Bare Ground	Cattle+Sheep-Grazing	0.0210	0.0005				No		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-U:Depleted	Wild-Horse-Grazing	0.0210	0.0005			2	No		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-A:All	ReplacementFire	0.0200					Yes		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-B:Open	Severe Drought	0.0070	0.1000				Yes		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-C:Closed	Severe Drought	0.0070	0.9000				Yes		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-D:Open	Tree-Invasion	0.0080		80			Yes		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-U:SAP	AG-Invasion	0.0010					No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-D:Open	Cattle+Sheep-Grazing	0.0210	0.9995				No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-D:Open	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-U:Bare Ground	Cattle+Sheep-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-U:Depleted	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-A:All	ReplacementFire	0.0200					Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-A:All	RxFire	1.0000	0.7000				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-B:Open	Severe Drought	0.0070	0.0300				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-C:Closed	Mastication	1.0000		100			Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-C:Closed	Severe Drought	0.0070	0.0700				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-C:Closed	Small-Tree-Lopping	1.0000		100			Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-D:Open	RxFire	1.0000	0.3000				No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-D:Open	Severe Drought	0.0070	0.9000				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-U:SAP	AG-Invasion	0.0010			99		No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-U:TEA	AG-Invasion	0.0010		100		8	Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-B:Open	Chaining+Native-Seed	0.0000	0.8000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Chaining+Native-Seed	0.0000	0.2000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Masticate+Native-Seed	0.0000	0.1000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-U:TEA	Tree-Encroachment	0.0071		200			No		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-A:All	ReplacementFire	0.0130	1.0000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-A:All	RxFire	1.0000	0.7000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-B:Open	Masticate+Native-Seed	0.0000	0.9000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-B:Open	Severe Drought	0.0070	0.1000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-E:Closed	RxFire	1.0000	0.3000				No		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-E:Closed	Severe Drought	0.0070	0.9000			5	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-U:TEA	AG-Invasion	0.0010	1.0000				No		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:Annual Spp	Cattle+Sheep-Grazing	0.0210		3			No		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:Annual Spp	Chaining+Native-Seed	1.0000	0.2000		5		Yes		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.0500		5		Yes		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:Annual Spp	Wild-Horse-Grazing	0.0210				2	No		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:Seeded Native	Chaining+Native-Seed	1.0000	0.8000		5		Yes		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:SI-A	Chaining+Plateau+Seed	1.0000	0.9000		5		Yes		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Chaining+Plateau+Seed	1.0000	0.0500		5		Yes		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:Annual Spp	Herbicide-Plateau+Seed	1.0000	0.1000		5		Yes		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:SI-A	Herbicide-Plateau+Seed	1.0000	0.8000		5		Yes		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Herbicide-Plateau+Seed	1.0000	0.1000		5		Yes		
Montane Sagebrush Steppe	MSS-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:Bare Ground	Montane Sagebrush Steppe	MSS-U:Annual Spp	AG-Invasion	0.0050							
Montane Sagebrush Steppe	MSS-U:Bare Ground	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005					Yes		
Montane Sagebrush Steppe	MSS-U:Bare Ground	Black Sagebrush	BS-U:Bare Ground	Range Shift	0.0302	0.5000	1	1		No	60	
Montane Sagebrush Steppe	MSS-U:Bare Ground	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Range Shift	0.0302	0.5000	1	1		No	60	
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Depleted	Chaining+Native-Seed	1.0000	0.2000				No		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Seeded Native	2xChaining+Native-Seed	1.0000					Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Seeded Native	Chaining+Native-Seed	1.0000	0.8000				Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Seeded Native	Spyke+Native-Seed	1.0000					Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Seeded Native	Thin+Native-Seed	1.0000					Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Depleted	Severe Drought	0.0070	0.9000				Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Depleted	Small-Tree-Lopping	1.0000		100			Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Early-Shrub	ReplacementFire	0.0200					Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Severe Drought	0.0070	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:SA	AG-Invasion	0.0050					No		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:TEA	Tree-Invasion	0.0080		80			Yes		
Montane Sagebrush Steppe	MSS-U:Early-Shrub	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0001					No		
Montane Sagebrush Steppe	MSS-U:Early-Shrub	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Montane Sagebrush Steppe	MSS-U:Early-Shrub	Black Sagebrush	BS-U:Early-Shrub	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:Early-Shrub	Montane Sagebrush Steppe	MSS-U:Early-Shrub	ReplacementFire	0.0200					Yes		
Montane Sagebrush Steppe	MSS-U:Early-Shrub	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:Exotic Forb	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Cattle+Sheep-Grazing	0.0210				1	No		
Montane Sagebrush Steppe	MSS-U:Exotic Forb	Montane Sagebrush Steppe	MSS-U:Exotic Forb	ReplacementFire	0.0300							
Montane Sagebrush Steppe	MSS-U:Exotic Forb	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Wild-Horse-Grazing	0.0210				2	No		
Montane Sagebrush Steppe	MSS-U:Exotic Forb	Black Sagebrush	BS-U:Exotic Forb	Range Shift	0.0302			1	1	No	60	
Montane Sagebrush Steppe	MSS-U:Exotic Forb	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Range Shift	0.0302			1	1	No	60	
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:Annual Spp	Wild-Horse-Grazing	0.0210					Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:SA	Small-Tree-Lopping	1.0000		100			Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:SA	Wild-Horse-Grazing	0.0210			2		No		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:Annual Spp	ReplacementFire	0.0300					Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:SA	Severe Drought	0.0070	0.9000				Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:SA+	Wet-Year	0.1000					No		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:TEA	Tree-Invasion	0.0080		80			Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:Annual Spp	Wild-Horse-Grazing	0.0210	0.0010				Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:SA	FineFuelDecomp	0.3300					No	2	
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:SA+	Mastication	1.0000		100		38	Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:SA+	Small-Tree-Lopping	1.0000		100			Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:SA+	Wet-Year	0.1000					No		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:SA+	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:Annual Spp	ReplacementFire	0.0450					Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:SA+	Severe Drought	0.0070	0.9000			-1	No		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:TEA	Tree-Invasion	0.0080		80			Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:Annual Spp	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SA	Cattle+Sheep-Grazing	0.0210	0.0005				No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SA	Wild-Horse-Grazing	0.0210	0.0005			2	No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Cattle+Sheep-Grazing	0.0210	0.9995				No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Hypo-Hatchet-Spyke	1.0000	0.1000	100			No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Hypo-Hatchet-Spyke	1.0000	0.9000	100		39	Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:Annual Spp	ReplacementFire	0.0300					Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Masticate+Native-Seed	1.0000		150		39	Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Severe Drought	0.0070	0.9000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Small-Tree-Lopping	1.0000		100			Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP+	Wet-Year	0.1000					No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:TEA	Tree-Invasion	0.0080		80			Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:Annual Spp	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SA	Wild-Horse-Grazing	0.0210	0.0005			2	No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SA+	Cattle+Sheep-Grazing	0.0210	0.0005				No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP	FineFuelDecomp	0.3300					No	2	
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Cattle+Sheep-Grazing	0.0210	0.9995				No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Masticate+Herbicide+Seed	1.0000	0.1000	150		38	No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Wet-Year	0.1000					No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Masticate+Herbicide+Seed	1.0000	0.2000	150			Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:Annual Spp	ReplacementFire	0.0450					Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Hypo-Hatchet-Spyke	1.0000	0.1000	100			No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Hypo-Hatchet-Spyke	1.0000	0.9000	100		38	Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Severe Drought	0.0070	0.9000			-1	No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Small-Tree-Lopping	1.0000		100		38	Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SI-C	Masticate+Herbicide+Seed	1.0000	0.7000	150			Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:TEA	Tree-Invasion	0.0080		80			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-A:All	Severe Drought	0.0070	0.0900						
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:Annual Spp	ReplacementFire	0.0188	0.9500						
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:Annual Spp	Severe Drought	0.0070	0.0100						
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:Annual Spp	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:SA	Cattle+Sheep-Grazing	0.0210	0.0005			1	No		
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:SAP-A	Cattle+Sheep-Grazing	0.0210	0.9995			1	No		
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:SAP-A	ReplacementFire	0.0188	0.0500						
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:SAP-A	Severe Drought	0.0070	0.9000						
Montane Sagebrush Steppe	MSS-U:SAP-A	Montane Sagebrush Steppe	MSS-U:SAP-A	Wild-Horse-Grazing	0.0210	0.9990			1	No		
Montane Sagebrush Steppe	MSS-U:SAP-A	Black Sagebrush	BS-U:SAP-A	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:SAP-A	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Bare Ground	Cattle+Sheep-Grazing	0.0210	0.0005	3			Yes		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Bare Ground	Wild-Horse-Grazing	0.0210			5		Yes		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0010	6	38		No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Depleted	Wild-Horse-Grazing	0.0210	0.0010	39		2	No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Severe Drought	0.0071	0.1000	4			Yes		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Exotic Forb	Exotic-Invasion	0.0005			12		No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Seeded Native	Cattle+Sheep-Grazing	0.0210	0.9995	3			No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Seeded Native	Severe Drought	0.0071	0.9000	4		-1	No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Seeded Native	Wild-Horse-Grazing	0.0210	0.9990	6		2	No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Black Sagebrush	BS-U:Seeded Native	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-A:All	Natural-Recovery	0.3300	1.0000	3	11		No	5	
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-B:Open	Natural-Recovery	0.3300	1.0000	12	49		No	5	
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-C:Closed	Natural-Recovery	0.3300	1.0000	50			No	5	
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:SAP	AG-Invasion	0.0010	1.0000	12			No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:SAP-A	AG-Invasion	0.0010	1.0000		11		No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Seeded Native	ReplacementFire	0.0050	1.0000				Yes		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Forb+Grass-Native-Seeding+Chaining	1.0000	0.0500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-U:SI-A	Cattle+Sheep-Grazing	0.0210		3			No		
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-U:SI-A	Forb+Grass-Native-Seeding+Chaining	1.0000	0.9500				No	5	
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-U:SI-A	Severe Drought	0.0071	0.1000	3			Yes		
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-U:SI-A	Severe Drought	0.0071	0.9000	3		-1	No		
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-U:SI-A	Wild-Horse-Grazing	0.0210				2	No		
Montane Sagebrush Steppe	MSS-U:SI-A	Black Sagebrush	BS-U:SI-A	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-A:All	Natural-Recovery	0.0001	1.0000	5			No	10	
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-U:SI-A	ReplacementFire	0.0050	1.0000				Yes		
Montane Sagebrush Steppe	MSS-U:SI-A	Montane Sagebrush Steppe	MSS-U:SI-A+AG	AG-Invasion	0.0010	1.0000				No		
Montane Sagebrush Steppe	MSS-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:SI-A	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:Annual Spp	Forb+Grass-Native-Seeding+Chaining	1.0000	0.0500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:Annual Spp	Wild-Horse-Grazing	0.0210	0.0010				Yes		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Cattle+Sheep-Grazing	0.0210		3			No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Forb+Grass-Native-Seeding+Chaining	1.0000	0.9500				No	5	
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Severe Drought	0.0071	0.1000	3			Yes		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A	Competition	0.3300	1.0000		11		No	3	
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	ReplacementFire	0.0100	1.0000		11		Yes		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Wet-Year	0.1000	1.0000		11		No		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Range Shift	0.0302	0.5000		1	1	No	60	
Montane Sagebrush Steppe	MSS-U:SI-B	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Forb+Grass-Native-Seeding+Chaining	1.0000	0.0500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-B	Montane Sagebrush Steppe	MSS-U:SI-A	Forb+Grass-Native-Seeding+Chaining	1.0000	0.9500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-B	Montane Sagebrush Steppe	MSS-U:SI-A	Thin	1.0000					Yes		
Montane Sagebrush Steppe	MSS-U:SI-B	Montane Sagebrush Steppe	MSS-U:SI-B	Cattle+Sheep-Grazing	0.0210					No		
Montane Sagebrush Steppe	MSS-U:SI-B	Montane Sagebrush Steppe	MSS-U:SI-B	Wild-Horse-Grazing	0.0210				2	No		
Montane Sagebrush Steppe	MSS-U:SI-B	Montane Sagebrush Steppe	MSS-B:Open	Natural-Recovery	0.0010					No	10	
Montane Sagebrush Steppe	MSS-U:SI-B	Montane Sagebrush Steppe	MSS-U:SI-A	ReplacementFire	0.0050					Yes		
Montane Sagebrush Steppe	MSS-U:SI-B	Montane Sagebrush Steppe	MSS-U:SI-B+AG	AG-Invasion	0.0010					No		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:Annual Spp	Forb+Grass-Native-Seeding+Chaining	1.0000	0.0500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Forb+Grass-Native-Seeding+Chaining	1.0000	0.9500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Thin	1.0000					Yes		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-B+AG	Cattle+Sheep-Grazing	0.0210					No		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-B+AG	Wild-Horse-Grazing	0.0210				2	No		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	ReplacementFire	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-B	Competition	0.3300					No	3	
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-B	Herbicide-Plateau+Seed	1.0000	0.7000				No		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-B+AG	Herbicide-Plateau+Seed	1.0000	0.3000				No		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-B+AG	Wet-Year	0.1000					No		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-D+AG	Tree-Invasion	0.0080		40			Yes		
Montane Sagebrush Steppe	MSS-U:SI-C	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Forb+Grass-Native-Seeding+Chaining	1.0000	0.0500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-C	Montane Sagebrush Steppe	MSS-U:SI-A	Thin	1.0000					Yes		
Montane Sagebrush Steppe	MSS-U:SI-C	Montane Sagebrush Steppe	MSS-U:SI-B	Forb+Grass-Native-Seeding+Chaining	1.0000	0.9500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-C	Montane Sagebrush Steppe	MSS-U:SI-C	Cattle+Sheep-Grazing	0.0210					No		
Montane Sagebrush Steppe	MSS-U:SI-C	Montane Sagebrush Steppe	MSS-U:SI-C	Wild-Horse-Grazing	0.0210				2	No		
Montane Sagebrush Steppe	MSS-U:SI-C	Montane Sagebrush Steppe	MSS-C:Closed	Natural-Recovery	0.0100					No	10	
Montane Sagebrush Steppe	MSS-U:SI-C	Montane Sagebrush Steppe	MSS-U:SI-A	ReplacementFire	0.0050					Yes		
Montane Sagebrush Steppe	MSS-U:SI-C	Montane Sagebrush Steppe	MSS-U:SI-C+AG	AG-Invasion	0.0010					No		
Montane Sagebrush Steppe	MSS-U:SI-C	Montane Sagebrush Steppe	MSS-U:SI-D	Tree-Invasion	0.0080		80			Yes		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Thin	1.0000					Yes		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-B+AG	Forb+Grass-Native-Seeding+Chaining	1.0000	0.0500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Cattle+Sheep-Grazing	0.0210					No		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Forb+Grass-Native-Seeding+Chaining	1.0000	0.9500				Yes	5	
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Wild-Horse-Grazing	0.0210				2	No		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	ReplacementFire	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C	Competition	0.2000					No	3	
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C	Herbicide-Plateau+Seed	1.0000	0.7000				No		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Herbicide-Plateau+Seed	1.0000	0.3000				No		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Wet-Year	0.1000					No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-D+AG	Tree-Invasion	0.0080		80			Yes		
Montane Sagebrush Steppe	MSS-U:SI-D	Montane Sagebrush Steppe	MSS-U:SI-B	Chaining+Seed	1.0000					Yes		
Montane Sagebrush Steppe	MSS-U:SI-D	Montane Sagebrush Steppe	MSS-U:SI-C	Small-Tree-Lopping	1.0000		100			Yes		
Montane Sagebrush Steppe	MSS-U:SI-D	Montane Sagebrush Steppe	MSS-U:SI-D	Cattle+Sheep-Grazing	0.0210					No		
Montane Sagebrush Steppe	MSS-U:SI-D	Montane Sagebrush Steppe	MSS-U:SI-D	Wild-Horse-Grazing	0.0210				2	No		
Montane Sagebrush Steppe	MSS-U:SI-D	Montane Sagebrush Steppe	MSS-D:Open	Natural-Recovery	0.1000					No	10	
Montane Sagebrush Steppe	MSS-U:SI-D	Montane Sagebrush Steppe	MSS-U:SI-A	ReplacementFire	0.0050					Yes		
Montane Sagebrush Steppe	MSS-U:SI-D	Montane Sagebrush Steppe	MSS-U:SI-D+AG	AG-Invasion	0.0010					No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-C	Masticate+Herbicide+Seed	1.0000	0.8000	100			Yes		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Hypo-Hatchet-Spyke	1.0000	0.0500				No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Hypo-Hatchet-Spyke	1.0000	0.9500				Yes		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-D+AG	Cattle+Sheep-Grazing	0.0210					No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-D+AG	Masticate+Herbicide+Seed	1.0000	0.2000	100			No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-D+AG	Wild-Horse-Grazing	0.0210				2	No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	ReplacementFire	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Masticate+Seed	1.0000		100			No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Small-Tree-Lopping	1.0000		100			Yes		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-D	Competition	0.1000					No	3	
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-D+AG	Wet-Year	0.1000					No		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:Annual Spp	Masticate+Seed	1.0000	0.1500				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:Annual Spp	RxFire+Seed+Chain	1.0000	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SI-A	Masticate+Seed	1.0000	0.7000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SI-A	RxFire+Seed+Chain	1.0000	0.5000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Masticate+Seed	1.0000	0.1500				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SI-A+AG	RxFire+Seed+Chain	1.0000	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:TEA	RxFire+Seed+Chain	1.0000	0.3000				No		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:Annual Spp	Masticate+Herbicide+Seed	1.0000	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:Annual Spp	ReplacementFire	0.0075	0.5000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SI-A	Masticate+Herbicide+Seed	1.0000	0.8000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Masticate+Herbicide+Seed	1.0000	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:TEA	Severe Drought	0.0070	0.9000				Yes		
Pickleweed	PW-A:All	Playa	PL-A:Barren	Range Shift	0.0001			1	1	No	60	
Pinyon-Juniper	PJ-A:All	Pinyon-Juniper	PJ-A:All	Cattle+Sheep-Grazing	0.0090	0.9995		3		No		
Pinyon-Juniper	PJ-A:All	Pinyon-Juniper	PJ-A:All	Wild-Horse-Grazing	0.0090	0.9990				No		
Pinyon-Juniper	PJ-A:All	Pinyon-Juniper	PJ-U:Bare Ground	Cattle+Sheep-Grazing	0.0090	0.0005		3		Yes		
Pinyon-Juniper	PJ-A:All	Pinyon-Juniper	PJ-U:Bare Ground	Wild-Horse-Grazing	0.0090	0.0010				Yes		
Pinyon-Juniper	PJ-A:All	Pinyon-Juniper	PJ-U:Exotic Forb	Exotic-Invasion	0.0001	1.0000		9		No		
Pinyon-Juniper	PJ-A:All	Black Sagebrush	BS-A:All	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-A:All	Pinyon-Juniper	PJ-A:All	ReplacementFire	0.0050	1.0000		9		Yes		
Pinyon-Juniper	PJ-A:All	Pinyon-Juniper	PJ-U:Annual Spp	AG-Invasion	0.0025			9		No		
Pinyon-Juniper	PJ-A:All	Wyoming Big Sagebrush upland	WSup-A:All	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-B:Open	Pinyon-Juniper	PJ-B:Open	Cattle+Sheep-Grazing	0.0090	0.9995				No		
Pinyon-Juniper	PJ-B:Open	Pinyon-Juniper	PJ-B:Open	Wild-Horse-Grazing	0.0090	0.9990			2	No		
Pinyon-Juniper	PJ-B:Open	Pinyon-Juniper	PJ-U:Bare Ground	Cattle+Sheep-Grazing	0.0090	0.0005				Yes		
Pinyon-Juniper	PJ-B:Open	Pinyon-Juniper	PJ-U:Bare Ground	Wild-Horse-Grazing	0.0090	0.0010				Yes		
Pinyon-Juniper	PJ-B:Open	Pinyon-Juniper	PJ-A:All	ReplacementFire	0.0050					Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Pinyon-Juniper	PJ-B:Open	Pinyon-Juniper	PJ-U:SAP	AG-Invasion	0.0010					No		
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-C:Open	Chainsaw-Thinning	1.0000					No	100	
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-C:Open	Masticate+Seed	1.0000					No	100	
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-A:All	ReplacementFire	0.0050					Yes	30	
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-B:Open	Severe Drought	0.0070	0.1000				Yes	30	
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-C:Open	Severe Drought	0.0070	0.9000				Yes	30	
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-U:TEA	AG-Invasion	0.0010					No		
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-A:All	Masticate+Native-Seed	1.0000					No	100	
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-A:All	Senescence	0.0100		2000			Yes		
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-D:Open	Chainsaw-Thinning	1.0000					No	100	
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-A:All	Insect/Disease	0.0167	0.0100	200		5	Yes	30	
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-A:All	ReplacementFire	0.0020					Yes	30	
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-B:Open	Insect/Disease	0.0167	0.0900	200			Yes	30	
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-D:Open	Insect/Disease	0.0167	0.9000	200			Yes	30	
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-D:Open	SurfaceFire	0.0010					No		
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-U:TEA	AG-Invasion	0.0010					No		
Pinyon-Juniper	PJ-U:Annual Spp	Pinyon-Juniper	PJ-U:Annual Spp	Cattle+Sheep-Grazing	0.0090					No		
Pinyon-Juniper	PJ-U:Annual Spp	Pinyon-Juniper	PJ-U:Annual Spp	Wild-Horse-Grazing	0.0090				2	No		
Pinyon-Juniper	PJ-U:Annual Spp	Pinyon-Juniper	PJ-U:Exotic Forb	Exotic-Invasion	0.0001	1.0000				No		
Pinyon-Juniper	PJ-U:Annual Spp	Pinyon-Juniper	PJ-U:SI+AG	Chaining+Seed	1.0000	0.1500		5				
Pinyon-Juniper	PJ-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:Annual Spp	Pinyon-Juniper	PJ-U:Annual Spp	Chaining+Seed	1.0000	0.1500		5		Yes		
Pinyon-Juniper	PJ-U:Annual Spp	Pinyon-Juniper	PJ-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Pinyon-Juniper	PJ-U:Annual Spp	Pinyon-Juniper	PJ-U:SI	Chaining+Seed	1.0000	0.7000		5		Yes		
Pinyon-Juniper	PJ-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:Bare Ground	Pinyon-Juniper	PJ-U:Exotic Forb	Exotic-Invasion	0.0005							
Pinyon-Juniper	PJ-U:Bare Ground	Black Sagebrush	BS-U:Bare Ground	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:Bare Ground	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:Exotic Forb	Pinyon-Juniper	PJ-A:All	Exotic-Control	1.0000	0.6000				Yes		
Pinyon-Juniper	PJ-U:Exotic Forb	Pinyon-Juniper	PJ-U:Exotic Forb	Exotic-Control	1.0000	0.4000				No		
Pinyon-Juniper	PJ-U:Exotic Forb	Pinyon-Juniper	PJ-U:Exotic Forb	ReplacementFire	0.0050	1.0000				Yes		
Pinyon-Juniper	PJ-U:Exotic Forb	Black Sagebrush	BS-U:Annual Spp	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:Exotic Forb	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:SAP	Pinyon-Juniper	PJ-U:Annual Spp	Cattle+Sheep-Grazing	0.0090	0.0005				Yes		
Pinyon-Juniper	PJ-U:SAP	Pinyon-Juniper	PJ-U:Annual Spp	Wild-Horse-Grazing	0.0090	0.0010				Yes		
Pinyon-Juniper	PJ-U:SAP	Pinyon-Juniper	PJ-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Pinyon-Juniper	PJ-U:SAP	Pinyon-Juniper	PJ-U:SAP	Cattle+Sheep-Grazing	0.0090	0.9995				No		
Pinyon-Juniper	PJ-U:SAP	Pinyon-Juniper	PJ-U:SAP	Wild-Horse-Grazing	0.0090	0.9990			2	No		
Pinyon-Juniper	PJ-U:SAP	Pinyon-Juniper	PJ-U:Annual Spp	ReplacementFire	0.0100	1.0000				Yes		
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-U:Bare Ground	Cattle+Sheep-Grazing	0.0090	0.0005	3			Yes		
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-U:Bare Ground	Wild-Horse-Grazing	0.0090			2		Yes		
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-U:SI	Cattle+Sheep-Grazing	0.0090	0.9995	3			No		
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-U:SI	Wild-Horse-Grazing	0.0090		3		2	No		
Pinyon-Juniper	PJ-U:SI	Black Sagebrush	BS-U:SI-A	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-B:Open	Natural-Recovery	0.0000	1.0000	5	29		No	10	
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-C:Open	Natural-Recovery	0.0000	1.0000	30	99		No	10	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-D:Open	Natural-Recovery	0.0000	1.0000	100			No	10	
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-U:SI	ReplacementFire	0.0010	1.0000				Yes		
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-U:SI	Severe Drought	0.0070	0.1000	3			Yes		
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-U:SI	Severe Drought	0.0070	0.9000	3		-1	No		
Pinyon-Juniper	PJ-U:SI	Pinyon-Juniper	PJ-U:SI+AG	AG-Invasion	0.0010	1.0000				No		
Pinyon-Juniper	PJ-U:SI	Wyoming Big Sagebrush upland	WSup-U:SI-A	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:SI+AG	Pinyon-Juniper	PJ-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Pinyon-Juniper	PJ-U:SI+AG	Pinyon-Juniper	PJ-U:Annual Spp	Wild-Horse-Grazing	0.0090			2		Yes		
Pinyon-Juniper	PJ-U:SI+AG	Pinyon-Juniper	PJ-U:SI+AG	Cattle+Sheep-Grazing	0.0090		3			No		
Pinyon-Juniper	PJ-U:SI+AG	Pinyon-Juniper	PJ-U:SI+AG	Wild-Horse-Grazing	0.0090	0.9990	3		2	No		
Pinyon-Juniper	PJ-U:SI+AG	Black Sagebrush	BS-U:SI-A+AG	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:SI+AG	Pinyon-Juniper	PJ-U:SI	Competition	0.3300	1.0000				No	3	
Pinyon-Juniper	PJ-U:SI+AG	Pinyon-Juniper	PJ-U:SI+AG	ReplacementFire	0.0020	1.0000				Yes		
Pinyon-Juniper	PJ-U:SI+AG	Pinyon-Juniper	PJ-U:SI+AG	Severe Drought	0.0070	0.1000	3			Yes		
Pinyon-Juniper	PJ-U:SI+AG	Pinyon-Juniper	PJ-U:SI+AG	Severe Drought	0.0070	0.9000	3		-1	No		
Pinyon-Juniper	PJ-U:SI+AG	Pinyon-Juniper	PJ-U:SI+AG	Wet-Year	0.1000	1.0000				No		
Pinyon-Juniper	PJ-U:SI+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Range Shift	0.0776	0.5000		1	1	No	60	
Pinyon-Juniper	PJ-U:TEA	Pinyon-Juniper	PJ-U:TEA	Chainsaw-Thinning	1.0000					No	100	
Pinyon-Juniper	PJ-U:TEA	Pinyon-Juniper	PJ-U:Annual Spp	ReplacementFire	0.0030	1.0000				Yes	30	
Pinyon-Juniper	PJ-U:TEA	Pinyon-Juniper	PJ-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes	30	
Pinyon-Juniper	PJ-U:TEA	Pinyon-Juniper	PJ-U:TEA	Severe Drought	0.0070	0.9000				Yes	30	
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-A:All	Cattle+Sheep-Grazing	0.0210	0.9995	3			No		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-A:All	Severe Drought	0.0071	0.1000				Yes		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-A:All	Severe Drought	0.0071	0.9000			-1	No		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-A:All	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-U:Bare Ground	Cattle+Sheep-Grazing	0.0210	0.0005	3			Yes		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0010				Yes		
Ponderosa Pine	PP-A:All	Curl-leaf Mountain Mahogany	CMM-A:All	Range Shift	0.2048	0.3300		1	1	No	60	
Ponderosa Pine	PP-A:All	Pinyon-Juniper	PJ-A:All	Range Shift	0.2048	0.6700		1	1	No	60	
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-A:All	ReplacementFire	0.0100					Yes		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-B:Closed	Fuel-Build-Up	1.0000		38			Yes	38	
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-A:All	ReplacementFire	0.0067					Yes		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-B:Closed	RxFire	1.0000	0.3000				No		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-B:Open	Chainsaw-Thinning	1.0000					No		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-B:Open	Insect/Disease	0.0050					Yes		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-B:Open	MixedFire	0.0400					No		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-B:Open	RxFire	1.0000	0.7000				No		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-U:TEA	AG-Invasion	0.0010					No		
Ponderosa Pine	PP-B:Open	Ponderosa Pine	PP-B:Open	Cattle+Sheep-Grazing	0.0210					No		
Ponderosa Pine	PP-B:Open	Ponderosa Pine	PP-B:Open	Wild-Horse-Grazing	0.0210					No		
Ponderosa Pine	PP-B:Open	Ponderosa Pine	PP-A:All	ReplacementFire	0.0003					Yes		
Ponderosa Pine	PP-B:Open	Ponderosa Pine	PP-B:Closed	Fuel-Build-Up	1.0000					No	30	
Ponderosa Pine	PP-B:Open	Ponderosa Pine	PP-B:Open	SurfaceFire	0.0550					No		
Ponderosa Pine	PP-B:Open	Ponderosa Pine	PP-U:TEA	AG-Invasion	0.0010					No		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-B:Open	Senescence	0.0100		400			Yes		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-C:Open	Chainsaw-Thinning	1.0000			199		No		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-A:All	ReplacementFire	0.0050		210			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-A:All	ReplacementFire	0.0067			209		Yes		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-C:Closed	RxFire	1.0000	0.3000				No		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-C:Open	Chainsaw-Thinning	1.0000		200			Yes		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-C:Open	Insect/Disease	0.0050			209		Yes		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-C:Open	Insect/Disease	0.0100		210			Yes		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-C:Open	MixedFire	0.0500					No		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-C:Open	RxFire	1.0000	0.7000				No		
Ponderosa Pine	PP-C:Closed	Ponderosa Pine	PP-U:TEA	AG-Invasion	0.0010					No		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-B:Open	Senescence	0.0100		400			Yes		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-C:Open	Cattle+Sheep-Grazing	0.0210				1	No		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-C:Open	Wild-Horse-Grazing	0.0210					No		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-A:All	ReplacementFire	0.0025					Yes		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-C:Closed	Fuel-Build-Up	1.0000					No	50	
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-C:Open	SurfaceFire	0.0550					No		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-U:TEA	AG-Invasion	0.0010					No		
Ponderosa Pine	PP-U:Annual Spp	Ponderosa Pine	PP-U:Annual Spp	Cattle+Sheep-Grazing	0.0210					No		
Ponderosa Pine	PP-U:Annual Spp	Ponderosa Pine	PP-U:Annual Spp	Wild-Horse-Grazing	0.0210				2	No		
Ponderosa Pine	PP-U:Annual Spp	Curl-leaf Mountain Mahogany	CMM-A:All	Range Shift	0.2048	0.3300		1	1	No	60	
Ponderosa Pine	PP-U:Annual Spp	Pinyon-Juniper	PJ-U:Annual Spp	Range Shift	0.2048	0.6700		1	1	No	60	
Ponderosa Pine	PP-U:Annual Spp	Ponderosa Pine	PP-U:Annual Spp	ReplacementFire	0.1000	1.0000			39	Yes		
Ponderosa Pine	PP-U:Bare Ground	Ponderosa Pine	PP-U:Bare Ground	AG-Invasion	0.0050					Yes		
Ponderosa Pine	PP-U:Bare Ground	Curl-leaf Mountain Mahogany	CMM-A:All	Range Shift	0.0248	0.3300	1	1		No	60	
Ponderosa Pine	PP-U:Bare Ground	Pinyon-Juniper	PJ-U:Bare Ground	Range Shift	0.0248	0.6700	1	1		No	60	
Ponderosa Pine	PP-U:FIC-B-Closed	Ponderosa Pine	PP-A:All	Masticate+PIPO-Planting	1.0000	0.5000			5	Yes		
Ponderosa Pine	PP-U:FIC-B-Closed	Ponderosa Pine	PP-A:All	ReplacementFire	0.0130					Yes		
Ponderosa Pine	PP-U:FIC-B-Closed	Ponderosa Pine	PP-A:All	Severe Drought	0.0070	0.0100			5	Yes		
Ponderosa Pine	PP-U:FIC-B-Closed	Ponderosa Pine	PP-U:FIC-B-Closed	Severe Drought	0.0070	0.9000				Yes		
Ponderosa Pine	PP-U:FIC-B-Closed	Ponderosa Pine	PP-U:FIC-B-Open	Severe Drought	0.0070	0.0900				Yes		
Ponderosa Pine	PP-U:FIC-B-Open	Ponderosa Pine	PP-A:All	Masticate+PIPO-Planting	1.0000				5	Yes		
Ponderosa Pine	PP-U:FIC-B-Open	Ponderosa Pine	PP-A:All	ReplacementFire	0.0130							
Ponderosa Pine	PP-U:FIC-B-Open	Ponderosa Pine	PP-A:All	Severe Drought	0.0070	0.1000			5	Yes		
Ponderosa Pine	PP-U:FIC-B-Open	Ponderosa Pine	PP-U:FIC-B-Open	Cattle+Sheep-Grazing	0.0210					No		
Ponderosa Pine	PP-U:FIC-B-Open	Ponderosa Pine	PP-U:FIC-B-Open	Severe Drought	0.0070	0.9000				Yes		
Ponderosa Pine	PP-U:FIC-C-Closed	Ponderosa Pine	PP-A:All	Masticate+PIPO-Planting	1.0000	0.5000			5	Yes		
Ponderosa Pine	PP-U:FIC-C-Closed	Ponderosa Pine	PP-A:All	ReplacementFire	0.0130					Yes		
Ponderosa Pine	PP-U:FIC-C-Closed	Ponderosa Pine	PP-A:All	Severe Drought	0.0070	0.0100			5	Yes		
Ponderosa Pine	PP-U:FIC-C-Closed	Ponderosa Pine	PP-U:FIC-B-Closed	Severe Drought	0.0070	0.0900				Yes		
Ponderosa Pine	PP-U:FIC-C-Closed	Ponderosa Pine	PP-U:FIC-C-Closed	Severe Drought	0.0070	0.9000				Yes		
Ponderosa Pine	PP-U:FIC-C-Open	Ponderosa Pine	PP-A:All	Masticate+PIPO-Planting	1.0000				5	Yes		
Ponderosa Pine	PP-U:FIC-C-Open	Ponderosa Pine	PP-A:All	ReplacementFire	0.0130							
Ponderosa Pine	PP-U:FIC-C-Open	Ponderosa Pine	PP-A:All	Severe Drought	0.0070	0.0100			5	Yes		
Ponderosa Pine	PP-U:FIC-C-Open	Ponderosa Pine	PP-U:FIC-B-Open	Severe Drought	0.0130	0.0900						
Ponderosa Pine	PP-U:FIC-C-Open	Ponderosa Pine	PP-U:FIC-C-Open	Cattle+Sheep-Grazing	0.0210					No		
Ponderosa Pine	PP-U:FIC-C-Open	Ponderosa Pine	PP-U:FIC-C-Open	Severe Drought	0.0130	0.9000				Yes		
Ponderosa Pine	PP-U:SI	Ponderosa Pine	PP-U:SI	Cattle+Sheep-Grazing	0.0210		3		1	No		
Ponderosa Pine	PP-U:SI	Ponderosa Pine	PP-U:SI	Severe Drought	0.0070	0.1000				Yes		
Ponderosa Pine	PP-U:SI	Ponderosa Pine	PP-U:SI	Severe Drought	0.0070	0.9000			-1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Ponderosa Pine	PP-U:SI	Ponderosa Pine	PP-U:SI	Wild-Horse-Grazing	0.0210				2	No		
Ponderosa Pine	PP-U:SI	Ponderosa Pine	PP-U:SI+AG	AG-Invasion	0.0010					No		
Ponderosa Pine	PP-U:SI	Curl-leaf Mountain Mahogany	CMM-U:SI	Range Shift	0.2048	0.3300	1	1		No	60	
Ponderosa Pine	PP-U:SI	Pinyon-Juniper	PJ-U:SI	Range Shift	0.2048	0.6700	1	1		No	60	
Ponderosa Pine	PP-U:SI+AG	Ponderosa Pine	PP-U:Annual Spp	Wild-Horse-Grazing	0.0210	0.0010				Yes		
Ponderosa Pine	PP-U:SI+AG	Ponderosa Pine	PP-U:SI+AG	Cattle+Sheep-Grazing	0.0210		3		1	No		
Ponderosa Pine	PP-U:SI+AG	Ponderosa Pine	PP-U:SI+AG	ReplacementFire	0.0025					Yes		
Ponderosa Pine	PP-U:SI+AG	Ponderosa Pine	PP-U:SI+AG	Severe Drought	0.0070	0.1000				Yes		
Ponderosa Pine	PP-U:SI+AG	Ponderosa Pine	PP-U:SI+AG	Severe Drought	0.0070	0.9000			-1	No		
Ponderosa Pine	PP-U:SI+AG	Ponderosa Pine	PP-U:SI+AG	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Ponderosa Pine	PP-U:SI+AG	Curl-leaf Mountain Mahogany	CMM-U:SI+AG	Range Shift	0.2048	0.3300	1	1		No	60	
Ponderosa Pine	PP-U:SI+AG	Pinyon-Juniper	PJ-U:SI+AG	Range Shift	0.2048	0.6700	1	1		No	60	
Ponderosa Pine	PP-U:TEA	Ponderosa Pine	PP-U:TEA	Cattle+Sheep-Grazing	0.0210					No		
Ponderosa Pine	PP-U:TEA	Ponderosa Pine	PP-U:TEA	Wild-Horse-Grazing	0.0210					No		
Ponderosa Pine	PP-U:TEA	Ponderosa Pine	PP-B:Closed	Natural-Recovery	0.0100			159		No	3	
Ponderosa Pine	PP-U:TEA	Ponderosa Pine	PP-C:Closed	Natural-Recovery	0.0100		160			No	30	
Ponderosa Pine	PP-U:TEA	Ponderosa Pine	PP-U:Annual Spp	Insect/Disease	0.0050	0.1000				Yes		
Ponderosa Pine	PP-U:TEA	Ponderosa Pine	PP-U:Annual Spp	MixedFire	0.0400	0.2500				Yes		
Ponderosa Pine	PP-U:TEA	Ponderosa Pine	PP-U:Annual Spp	ReplacementFire	0.0067					Yes		
Ponderosa Pine	PP-U:TEA	Ponderosa Pine	PP-U:TEA	Insect/Disease	0.0050	0.9000				Yes		
Ponderosa Pine	PP-U:TEA	Ponderosa Pine	PP-U:TEA	MixedFire	0.0400	0.7500				No		
Road	Road:Bare Ground	Road	Road:Bare Ground	ReplacementFire	0.0050							
Saline Meadow	WMas-A:Open	Saline Meadow	WMas-A:Open	Cattle+Sheep-Grazing	0.0240	0.9995				No		
Saline Meadow	WMas-A:Open	Saline Meadow	WMas-A:Open	Weed-Inventory+Treat	1.0000	1.0000		2		No	3	
Saline Meadow	WMas-A:Open	Saline Meadow	WMas-A:Open	Wet-Year	0.1000	1.0000		2	1	Yes		
Saline Meadow	WMas-A:Open	Saline Meadow	WMas-A:Open	Wild-Horse-Grazing	0.0240	0.9990			2	No		
Saline Meadow	WMas-A:Open	Saline Meadow	WMas-U:AGPG	AG-Invasion	0.0010	1.0000		2		No		
Saline Meadow	WMas-A:Open	Saline Meadow	WMas-U:Bare Ground	Cattle+Sheep-Grazing	0.0240	0.0005				Yes		
Saline Meadow	WMas-A:Open	Saline Meadow	WMas-U:Bare Ground	Wild-Horse-Grazing	0.0240	0.0010				No		
Saline Meadow	WMas-A:Open	Saline Meadow	WMas-U:Exotic Forb	Exotic-Invasion	0.0010	1.0000		2		Yes	5	
Saline Meadow	WMas-A:Open	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0188			1	1	No	60	
Saline Meadow	WMas-B:Closed	Saline Meadow	WMas-B:Closed	Cattle+Sheep-Grazing	0.0240	0.9995			1	No		
Saline Meadow	WMas-B:Closed	Saline Meadow	WMas-B:Closed	Severe Drought	0.0070				2	No		
Saline Meadow	WMas-B:Closed	Saline Meadow	WMas-B:Closed	Weed-Inventory+Treat	1.0000					No	3	
Saline Meadow	WMas-B:Closed	Saline Meadow	WMas-B:Closed	Wet-Year	0.1000					Yes		
Saline Meadow	WMas-B:Closed	Saline Meadow	WMas-B:Closed	Wild-Horse-Grazing	0.0240	0.9990			2	No		
Saline Meadow	WMas-B:Closed	Saline Meadow	WMas-U:AGPG	AG-Invasion	0.0010	0.0010				No		
Saline Meadow	WMas-B:Closed	Saline Meadow	WMas-U:Depleted	Cattle+Sheep-Grazing	0.0240	0.0005				No		
Saline Meadow	WMas-B:Closed	Saline Meadow	WMas-U:Depleted	Wild-Horse-Grazing	0.0240	0.0010			2	No		
Saline Meadow	WMas-B:Closed	Saline Meadow	WMas-U:Exotic Forb	Exotic-Invasion	0.0010					Yes	5	
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-A:Open	Wet-Year	0.1000	0.1000				Yes		
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-B:Closed	Thin	1.0000					Yes		
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-B:Closed	Wet-Year	0.1000	0.9000				Yes		
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-C:Open	Cattle+Sheep-Grazing	0.0240	0.9995				No		
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-C:Open	Severe Drought	0.0070				1	No		
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-C:Open	Weed-Inventory+Treat	1.0000					No	3	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-C:Open	Wild-Horse-Grazing	0.0240	0.9990			2	No		
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-U:Depleted	Cattle+Sheep-Grazing	0.0240	0.0005				No		
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-U:Depleted	Wild-Horse-Grazing	0.0240	0.0010			2	No		
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-U:Exotic Forb	Exotic-Invasion	0.0010					Yes	5	
Saline Meadow	WMas-C:Open	Saline Meadow	WMas-U:SAP	AG-Invasion	0.0010					No		
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:AGPG	Cattle+Sheep-Grazing	0.0240	0.9995	3			No		
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:AGPG	ReplacementFire	0.0100	0.5000	3			Yes	2	
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:AGPG	Weed-Inventory+Treat	1.0000					No	3	
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:AGPG	Wet-Year	0.1000					Yes		
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:AGPG	Wild-Horse-Grazing	0.0240	0.0005				Yes		
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:AGPG	Wild-Horse-Grazing	0.0240	0.9990			2	No		
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:Annual Spp	Cattle+Sheep-Grazing	0.0240	0.0005	3			Yes		
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:Annual Spp	ReplacementFire	0.0100	5.0000				Yes	2	
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:Annual Spp	Wild-Horse-Grazing	0.0240	0.0005				Yes		
Saline Meadow	WMas-U:AGPG	Saline Meadow	WMas-U:Exotic Forb	Exotic-Invasion	0.0010					Yes	5	
Saline Meadow	WMas-U:AGPG	Greasewood-Basin Big Sagebrush	GW-U:SAP	Range Shift	0.0188			1	1	No	60	
Saline Meadow	WMas-U:Annual Spp	Saline Meadow	WMas-A:Open	Herbicide-Plateau+Native-Seed	1.0000	0.8000				Yes		
Saline Meadow	WMas-U:Annual Spp	Saline Meadow	WMas-U:Annual Spp	Cattle+Sheep-Grazing	0.0240		3			No		
Saline Meadow	WMas-U:Annual Spp	Saline Meadow	WMas-U:Annual Spp	Herbicide-Plateau+Native-Seed	1.0000	0.2000			5	Yes		
Saline Meadow	WMas-U:Annual Spp	Saline Meadow	WMas-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes	2	
Saline Meadow	WMas-U:Annual Spp	Saline Meadow	WMas-U:Annual Spp	Weed-Inventory+Treat	1.0000	1.0000				No	3	
Saline Meadow	WMas-U:Annual Spp	Saline Meadow	WMas-U:Annual Spp	Wild-Horse-Grazing	0.0240				2	No		
Saline Meadow	WMas-U:Annual Spp	Saline Meadow	WMas-U:Exotic Forb	Exotic-Invasion	0.0010	1.0000				Yes	5	
Saline Meadow	WMas-U:Annual Spp	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Range Shift	0.0188			1	1	No	60	
Saline Meadow	WMas-U:Bare Ground	Saline Meadow	WMas-U:Annual Spp	AG-Invasion	0.0050					Yes		
Saline Meadow	WMas-U:Bare Ground	Saline Meadow	WMas-U:Exotic Forb	Exotic-Invasion	0.0005					Yes		
Saline Meadow	WMas-U:Bare Ground	Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Range Shift	0.0188		1	1		No	60	
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-A:Open	Thin	1.0000					Yes		
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-A:Open	Thin+Native-Seed	1.0000	0.7000				Yes		
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-C:Open	Thin+Native-Seed	1.0000	0.3000				Yes		
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-U:Annual Spp	AG-Invasion	0.0050					No		
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-U:Bare Ground	Cattle+Sheep-Grazing	0.0240	0.0005	3			Yes		
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-U:Bare Ground	Wild-Horse-Grazing	0.0240	0.0010				Yes		
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-U:Depleted	Cattle+Sheep-Grazing	0.0240	0.9995	3			No		
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-U:Depleted	Weed-Inventory+Treat	1.0000					No	3	
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-U:Depleted	Wet-Year	0.1000					Yes		
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-U:Depleted	Wild-Horse-Grazing	0.0240	0.9990			2	No		
Saline Meadow	WMas-U:Depleted	Saline Meadow	WMas-U:Exotic Forb	Exotic-Invasion	0.0010					Yes	5	
Saline Meadow	WMas-U:Depleted	Greasewood-Basin Big Sagebrush	GW-B:Closed	Range Shift	0.0188			1	1	No	60	
Saline Meadow	WMas-U:Exotic Forb	Saline Meadow	WMas-A:Open	Exotic-Control	1.0000	0.6000		2		No		20
Saline Meadow	WMas-U:Exotic Forb	Saline Meadow	WMas-B:Closed	Exotic-Control	1.0000	0.6000	3	22		No		20
Saline Meadow	WMas-U:Exotic Forb	Saline Meadow	WMas-C:Open	Exotic-Control	1.0000	0.6000	23			No		20
Saline Meadow	WMas-U:Exotic Forb	Saline Meadow	WMas-U:Exotic Forb	Cattle+Sheep-Grazing	0.0240		3		1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Saline Meadow	WMas-U:Exotic Forb	Saline Meadow	WMas-U:Exotic Forb	Exotic-Control	1.0000	0.4000				Yes		20
Saline Meadow	WMas-U:Exotic Forb	Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	Range Shift	0.0188			1	1	No	60	
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-A:Open	Thin+Herbicide+Native-Seed	1.0000	0.9000				Yes		
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:AGPG	Cattle+Sheep-Grazing	0.0240	0.0005				Yes		
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:AGPG	ReplacementFire	0.0100	0.5000				Yes	2	
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:AGPG	Thin+Herbicide+Native-Seed	1.0000	0.1000				Yes		
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:AGPG	Utilities	0.1000					Yes		
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:AGPG	Wild-Horse-Grazing	0.0240	0.0005				Yes		
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:Annual Spp	ReplacementFire	0.0100	0.5000				Yes	2	
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:Exotic Forb	Exotic-Invasion	0.0010					Yes	5	
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:SAP	Cattle+Sheep-Grazing	0.0240	0.9995				No		
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:SAP	Weed-Inventory+Treat	1.0000					No	3	
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:SAP	Wet-Year	0.1000					Yes		
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:SAP	Wild-Horse-Grazing	0.0240	0.0005				Yes		
Saline Meadow	WMas-U:SAP	Saline Meadow	WMas-U:SAP	Wild-Horse-Grazing	0.0240	0.9990			2	No		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-A:Open	Cattle+Sheep-Grazing	0.0160	0.9990	3		1	No		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-A:Open	NativeGrazing	0.0100	1.0000			-1	No		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-A:Open	ReplacementFire	0.0083	1.0000				Yes		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-A:Open	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005	3			Yes		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160	0.0005	3			Yes		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-U:Early-Shrub	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-U:SAP	AG-Invasion	0.0025					No		
Semi-Desert Grassland	SDG-A:Open	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0040			1	1	No	60	
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-A:Open	ReplacementFire	0.0100					Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-A:Open	Severe Drought	0.0070	0.1000				Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-A:Open	Thin	1.0000					Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-B:Closed	Cattle+Sheep-Grazing	0.0160	0.9990			1	No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-B:Closed	NativeGrazing	0.0100					Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-B:Closed	Severe Drought	0.0070	0.9000				Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-B:Closed	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005				No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:Depleted	Cattle+Sheep-Grazing	0.0160	0.0005				No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:Depleted	Wild-Horse-Grazing	0.0160	0.0005			2	No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:SAP	AG-Invasion	0.0010					No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:TEA	Tree-Encroachment	0.0001		200			Yes		
Semi-Desert Grassland	SDG-U:Bare Ground	Semi-Desert Grassland	SDG-U:SAP	AG-Invasion	0.0050							
Semi-Desert Grassland	SDG-U:Bare Ground	Greasewood-Basin Big Sagebrush	GW-U:Bare Ground	Range Shift	0.0040		1	1			60	
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005	3			Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Depleted	Cattle+Sheep-Grazing	0.0160	0.9990	3		1	No		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Depleted	ReplacementFire	0.0100					Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Depleted	Severe Drought	0.0070	0.9000				Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Depleted	Thin+Herbicide+Seed	1.0000	0.3000			5	Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Depleted	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160	0.0005	3			No		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Early-Shrub	Severe Drought	0.0070	0.1000				Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Early-Shrub	Wild-Horse-Grazing	0.0160	0.0005				Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:SAP	AG-Invasion	0.0050					No		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:SI	Thin+Herbicide+Seed	1.0000	0.7000			5	Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:TEA	Tree-Encroachment	0.0001		200			No		
Semi-Desert Grassland	SDG-U:Early-Shrub	Semi-Desert Grassland	SDG-U:Early-Shrub	ReplacementFire	0.0100					Yes		
Semi-Desert Grassland	SDG-U:Early-Shrub	Semi-Desert Grassland	SDG-U:Early-Shrub	Thin+Herbicide+Seed	1.0000	0.3000				Yes		
Semi-Desert Grassland	SDG-U:Early-Shrub	Semi-Desert Grassland	SDG-U:SAP	Thin+Herbicide+Seed	1.0000	0.1000				Yes		
Semi-Desert Grassland	SDG-U:Early-Shrub	Semi-Desert Grassland	SDG-U:SI	Thin+Herbicide+Seed	1.0000	0.6000				Yes		
Semi-Desert Grassland	SDG-U:Early-Shrub	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0040			1	1	No	60	
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Cattle+Sheep-Grazing	0.0160	0.0010	3			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Cattle+Sheep-Grazing	0.0160	0.9990	3		1	No		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Chaining+Native-Seed	1.0000	0.5000		5		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Chaining+Plateau+Seed	1.0000	0.2000		5		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	NativeGrazing	0.0100				2	Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	ReplacementFire	0.0150		20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Severe Drought	0.0070	0.1000				Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Severe Drought	0.0070	0.9000			2	Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Thin+Herbicide+Native-Seed	1.0000	0.5000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Wild-Horse-Grazing	0.0160	0.0010				Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP+	ReplacementFire	0.1000			19		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP+	Wet-Year	0.1000					No		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:Seeded Native	Chaining+Native-Seed	1.0000	0.5000		5		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:Seeded Native	Thin+Herbicide+Native-Seed	1.0000	0.5000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SI	Chaining+Plateau+Seed	1.0000	0.6000		5		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SI+AG	Chaining+Plateau+Seed	1.0000	0.2000		5		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:TEA	Tree-Encroachment	0.0001		200			Yes		
Semi-Desert Grassland	SDG-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:SAP	Range Shift	0.0040			1	1	No	60	
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP	FineFuelDecomp	0.3300	1.0000				No	2	
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP	Thin+Herbicide+Seed	1.0000	0.2500				Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Cattle+Sheep-Grazing	0.0160	0.0010	3			Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Cattle+Sheep-Grazing	0.0160	0.9990	3		1	No		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	ReplacementFire	0.1400	1.0000		19		Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	ReplacementFire	0.1400	1.0000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Severe Drought	0.0070	0.1000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Severe Drought	0.0070	0.9000	20		2	Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Wet-Year	0.1000	1.0000				No		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Wild-Horse-Grazing	0.0160	0.0010				Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Wild-Horse-Grazing	0.0160	0.9990			2	No		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SI	Thin+Herbicide+Seed	1.0000	0.5000				No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SI+AG	Thin+Herbicide+Seed	1.0000	0.2500				Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:TEA	Tree-Encroachment	0.0001		200			No		
Semi-Desert Grassland	SDG-U:SAP+	Greasewood-Basin Big Sagebrush	GW-U:SAP+	Range Shift	0.0040			1	1	No	60	
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-A:Open	Natural-Recovery	0.3330	1.0000		19		No	5	
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-B:Closed	Natural-Recovery	0.3330	1.0000	20			No	5	
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Bare Ground	Cattle+Sheep-Grazing	0.0160		3	5		No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Bare Ground	Cattle+Sheep-Grazing	0.0160	0.0005	6			Yes		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Bare Ground	Wild-Horse-Grazing	0.0160	0.0005	6			Yes		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0160	0.0005	6			Yes		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Early-Shrub	Severe Drought	0.0071	0.1000	4			Yes		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Early-Shrub	Wild-Horse-Grazing	0.0160			5		Yes		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Early-Shrub	Wild-Horse-Grazing	0.0160	0.0005	6			Yes		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:SAP	AG-Invasion	0.0010	1.0000				No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Seeded Native	Cattle+Sheep-Grazing	0.0160	0.9990	6		1	No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Seeded Native	ReplacementFire	0.0083	1.0000		19		Yes		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Seeded Native	ReplacementFire	0.0100	1.0000	20					
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Seeded Native	Severe Drought	0.0071	0.9000	4		-1	No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Seeded Native	Wild-Horse-Grazing	0.0160	0.9990	6		2	No		
Semi-Desert Grassland	SDG-U:Seeded Native	Greasewood-Basin Big Sagebrush	GW-A:All	Range Shift	0.0040			1	1	No	60	
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-A:Open	Natural-Recovery	0.0000		5	19		No	10	
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-B:Closed	Natural-Recovery	0.0000		20			No	10	
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:Bare Ground	Wild-Horse-Grazing	0.0160			2		Yes		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI	Cattle+Sheep-Grazing	0.0160		3		1	No		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI	ReplacementFire	0.0010			19		Yes		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI	ReplacementFire	0.0050		20			Yes		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI	Severe Drought	0.0071	0.1000	3	19		Yes		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI	Severe Drought	0.0071	0.1000	20			Yes		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI	Severe Drought	0.0071	0.9000	3	19	-1	No		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI	Severe Drought	0.0071	0.9000	20		2	Yes		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI	Wild-Horse-Grazing	0.0160		3		2	No		
Semi-Desert Grassland	SDG-U:SI	Semi-Desert Grassland	SDG-U:SI+AG	AG-Invasion	0.0010	1.0000				No		
Semi-Desert Grassland	SDG-U:SI	Greasewood-Basin Big Sagebrush	GW-U:SI	Range Shift	0.0040			1	1	No	60	
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SAP	Drought_36mo(t+2)	0.0071			2		Yes		
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SAP	Wild-Horse-Grazing	0.0160			2		Yes		
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SI	Competition	0.3330	1.0000				No	3	
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SI+AG	Cattle+Sheep-Grazing	0.0160		3		1	No		
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SI+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No		
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SI+AG	ReplacementFire	0.0020	1.0000				Yes		
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SI+AG	Severe Drought	0.0071	0.1000	3			Yes		
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SI+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SI+AG	Wet-Year	0.1000	1.0000				No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Semi-Desert Grassland	SDG-U:SI+AG	Semi-Desert Grassland	SDG-U:SI+AG	Wild-Horse-Grazing	0.0160		3		2	No		
Semi-Desert Grassland	SDG-U:SI+AG	Greasewood-Basin Big Sagebrush	GW-U:SI+AG	Range Shift	0.0040			1	1	No	60	
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:Early-Shrub	ReplacementFire	0.0075	0.5000	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:Early-Shrub	Severe Drought	0.0070	0.0500	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:SAP+	Masticate+Herbicide+Seed	1.0000	0.2000	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:SAP+	ReplacementFire	0.0075	0.5000	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:SAP+	Severe Drought	0.0070	0.0500	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:SI	Masticate+Herbicide+Seed	1.0000	0.6000	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:SI+AG	Masticate+Herbicide+Seed	1.0000	0.2000	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:TEA	Severe Drought	0.0070	0.9000	150			Yes		
Sparsely Vegetated	Sparse-A:Sparse	Sparsely Vegetated	Sparse-A:Sparse	ReplacementFire	0.0010					Yes		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	Severe Drought	0.0070					No		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	Wet-Year	0.1000			2		Yes		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	Wild-Horse-Grazing	0.0100	0.9990			2	No		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-B:Closed	Alternate-Succession1	1.0000		12			Yes	11	
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-U:Bare Ground	Cattle+Sheep-Grazing	0.0100	0.0005	3			Yes		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-U:Bare Ground	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-A:All	Black Sagebrush	BS-A:All	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-A:All	Juniper Savanna	JUN-A:All	Range Shift	0.0302	0.5000		1	1	No	60	
Stansbury Cliffrose	SC-A:All	Mixed Salt Desert	MSD-A:All	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	Cattle+Sheep-Grazing	0.0100	0.9990	3			1	No	
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	NativeGrazing	0.0010			4		Yes		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	NativeGrazing	0.0010		5		-1	No		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	ReplacementFire	0.0020					Yes		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-U:Annual Spp	AG-Invasion	0.0025					No		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0005	3			No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-B:Closed	Wild-Horse-Grazing	0.0100	0.9990			2	No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-U:Bare Ground	Cattle+Sheep-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-U:Bare Ground	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-U:Depleted	Wild-Horse-Grazing	0.0100	0.0005			2	No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-A:All	ReplacementFire	0.0100					Yes		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-A:All	Severe Drought	0.0070	0.0100				Yes		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-B:Closed	Cattle+Sheep-Grazing	0.0100	0.9990			1	No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-B:Closed	NativeGrazing	0.0010				-1	No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-B:Closed	Severe Drought	0.0070	0.9900				No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-U:Depleted	Cattle+Sheep-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-U:SAP	AG-Invasion	0.0010					No		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-A:All	Masticate+Herbicide+Native-Seed	1.0000	0.7000	5			Yes		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-B:Closed	Chainsaw-Thinning	1.0000	0.7000				Yes		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-C:Open	Wild-Horse-Grazing	0.0100	0.9990				No		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-U:Annual Spp	Masticate+Herbicide+Native-Seed	1.0000	0.1000				Yes		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-U:Bare Ground	Masticate+Herbicide+Native-Seed	1.0000	0.2000				Yes		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-U:SAP	Chainsaw-Thinning	1.0000	0.3000	13			Yes		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-U:TEA	Wild-Horse-Grazing	0.0100	0.0010				No		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-A:All	ReplacementFire	0.0067					Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-B:Closed	Severe Drought	0.0070	0.1000				Yes		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-C:Open	Cattle+Sheep-Grazing	0.0100	0.9990				No		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-C:Open	Severe Drought	0.0070	0.9000				Yes		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-U:TEA	AG-Invasion	0.0010					No		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-U:TEA	Cattle+Sheep-Grazing	0.0100	0.0010				No		
Stansbury Cliffrose	SC-C:Open	Stansbury Cliffrose	SC-U:TEA	Tree-Encroachment	0.0071		250			No		
Stansbury Cliffrose	SC-U:Annual Spp	Stansbury Cliffrose	SC-U:Annual Spp	Cattle+Sheep-Grazing	0.0100				1	No		
Stansbury Cliffrose	SC-U:Annual Spp	Stansbury Cliffrose	SC-U:Annual Spp	Chaining+Native-Seed	1.0000	0.2000		5		Yes		
Stansbury Cliffrose	SC-U:Annual Spp	Stansbury Cliffrose	SC-U:Annual Spp	Wet-Year	0.1000	1.0000		2		Yes		
Stansbury Cliffrose	SC-U:Annual Spp	Stansbury Cliffrose	SC-U:Annual Spp	Wild-Horse-Grazing	0.0100				2	No		
Stansbury Cliffrose	SC-U:Annual Spp	Stansbury Cliffrose	SC-U:Seeded Native	Chaining+Native-Seed	1.0000	0.8000		5		Yes		
Stansbury Cliffrose	SC-U:Annual Spp	Black Sagebrush	BS-U:Annual Spp	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-U:Annual Spp	Juniper Savanna	JUN-U:Annual Spp	Range Shift	0.0302	0.5000		1	1	No	60	
Stansbury Cliffrose	SC-U:Annual Spp	Mixed Salt Desert	MSD-U:Annual Spp	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-U:Annual Spp	Stansbury Cliffrose	SC-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Stansbury Cliffrose	SC-U:Annual Spp	Stansbury Cliffrose	SC-U:Annual Spp	Spot-Herbicide+Native-Seed	1.0000	0.3000		5		Yes		
Stansbury Cliffrose	SC-U:Annual Spp	Stansbury Cliffrose	SC-U:SAP	Alternate-Succession2	1.0000	1.0000	12			Yes	3	
Stansbury Cliffrose	SC-U:Annual Spp	Stansbury Cliffrose	SC-U:Seeded Native	Spot-Herbicide+Native-Seed	1.0000	0.7000		5		Yes		
Stansbury Cliffrose	SC-U:Bare Ground	Stansbury Cliffrose	SC-U:Annual Spp	AG-Invasion	0.0050							
Stansbury Cliffrose	SC-U:Bare Ground	Black Sagebrush	BS-U:Bare Ground	Range Shift	0.0302	0.2500	1	1		No	60	
Stansbury Cliffrose	SC-U:Bare Ground	Juniper Savanna	JUN-U:Bare Ground	Range Shift	0.0320	0.5000	1	1		No	60	
Stansbury Cliffrose	SC-U:Bare Ground	Mixed Salt Desert	MSD-U:Bare Ground	Range Shift	0.0302	0.2500	1	1		No	60	
Stansbury Cliffrose	SC-U:Depleted	Stansbury Cliffrose	SC-U:Depleted	Small-Tree-Lopping	1.0000		80	99		Yes		
Stansbury Cliffrose	SC-U:Depleted	Stansbury Cliffrose	SC-U:TEA	Tree-Invasion	1.0000	0.1000	80			Yes		
Stansbury Cliffrose	SC-U:Depleted	Stansbury Cliffrose	SC-A:All	ReplacementFire	0.0083	0.1000				Yes		
Stansbury Cliffrose	SC-U:Depleted	Stansbury Cliffrose	SC-U:Depleted	Severe Drought	0.0070	0.9900				No		
Stansbury Cliffrose	SC-U:Depleted	Stansbury Cliffrose	SC-U:Early-Shrub	ReplacementFire	0.0100	0.9000				Yes		
Stansbury Cliffrose	SC-U:Depleted	Stansbury Cliffrose	SC-U:Early-Shrub	Severe Drought	0.0070	0.0100				No		
Stansbury Cliffrose	SC-U:Depleted	Stansbury Cliffrose	SC-U:SAP	AG-Invasion	0.0050					No		
Stansbury Cliffrose	SC-U:Early-Shrub	Black Sagebrush	BS-U:Early-Shrub	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-U:Early-Shrub	Mixed Salt Desert	MSD-U:Early-Shrub	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-U:Early-Shrub	Stansbury Cliffrose	SC-U:Early-Shrub	ReplacementFire	0.0100	1.0000				Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:Annual Spp	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Cattle+Sheep-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Wild-Horse-Grazing	0.0100	0.9990			2	No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:Annual Spp	Cattle+Sheep-Grazing	0.0100	0.0005			1	No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:Annual Spp	ReplacementFire	0.0150					Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:Annual Spp	Severe Drought	0.0070	0.0100				Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Cattle+Sheep-Grazing	0.0100	0.9990				No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Masticate+Herbicide+Native-Seed	1.0000	0.3000	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	NativeGrazing	0.0010				-1	No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Severe Drought	0.0070	0.9900				No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Small-Tree-Lopping	1.0000		80	99		Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Spyke+Plateau+Native-Seed	1.0000	0.3000	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP+	Wet-Year	0.1000					No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:Seeded Native	Masticate+Herbicide+Native-Seed	1.0000	0.7000	100		13	Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:Seeded Native	Spyke+Plateau+Native-Seed	1.0000	0.7000	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:TEA	Tree-Invasion	0.0050		80			Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:Annual Spp	Cattle+Sheep-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP	FineFuelDecomp	0.3300	1.0000	13			No	2	
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Wet-Year	0.1000	1.0000	13			No		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Wild-Horse-Grazing	0.0100	0.0005				Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Wild-Horse-Grazing	0.0100	0.9990			2	No		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:Annual Spp	ReplacementFire	0.0025	1.0000	13			Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:Annual Spp	Severe Drought	0.0070	0.0100	13			Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP	Masticate+Herbicide+Native-Seed	1.0000	0.1500	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP	Spyke+Plateau+Native-Seed	1.0000	0.1500	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Cattle+Sheep-Grazing	0.0100	0.0005	13			Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Cattle+Sheep-Grazing	0.0100	0.9990	13		1	No		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Masticate+Herbicide+Native-Seed	1.0000	0.1500	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Severe Drought	0.0070	0.9900	13			No		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Small-Tree-Lopping	1.0000	1.0000	80	99	13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Spyke+Plateau+Native-Seed	1.0000	0.1500	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:Seeded Native	Masticate+Herbicide+Native-Seed	1.0000	0.7000	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:Seeded Native	Spyke+Plateau+Native-Seed	1.0000	0.7000	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:TEA	Tree-Invasion	0.0050	1.0000	80			Yes		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-A:All	Natural-Recovery	0.3330	1.0000		12		No	5	
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-B:Closed	Natural-Recovery	0.3330	1.0000	13	79		No	5	
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-C:Open	Natural-Recovery	0.3330	1.0000	80			No	5	
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Annual Spp	AG-Invasion	0.0010	1.0000		12		No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Bare Ground	Cattle+Sheep-Grazing	0.0100	0.0010	4			No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Bare Ground	Wild-Horse-Grazing	0.0100	0.0010	6			No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100		3	3		No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Early-Shrub	Wild-Horse-Grazing	0.0100			5		No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:SAP	AG-Invasion	0.0010	1.0000	13			No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	Cattle+Sheep-Grazing	0.0100	0.9990	4		1	No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	ReplacementFire	0.0020	1.0000		12		Yes		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	ReplacementFire	0.0067	1.0000	80			Yes		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	ReplacementFire	0.0100	1.0000	13	79		Yes		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	Severe Drought	0.0070	0.0100	13			Yes		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	Severe Drought	0.0070	0.9900	13			No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	Wet-Year	0.1000			2		Yes		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	Wild-Horse-Grazing	0.0100	0.9990	6		2	No		
Stansbury Cliffrose	SC-U:Seeded Native	Black Sagebrush	BS-U:Seeded Native	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-U:Seeded Native	Juniper Savanna	JUN-A:All	Range Shift	0.0302	0.5000		1	1	No	60	
Stansbury Cliffrose	SC-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:Bare Ground	Wild-Horse-Grazing	0.0100			2		Yes		
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:SI-A	Severe Drought	0.0071	0.1000	3			Yes		
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:SI-A	Severe Drought	0.0071	0.9000	3		-1	No		
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:SI-A	Wild-Horse-Grazing	0.0100		3		2	No		
Stansbury Cliffrose	SC-U:SI-A	Black Sagebrush	BS-U:SI-A	Range Shift	0.0302	0.2500		1	1	No	60	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Stansbury Cliffrose	SC-U:SI-A	Juniper Savanna	JUN-A:All	Range Shift	0.0302	0.5000		1	1	No	60	
Stansbury Cliffrose	SC-U:SI-A	Mixed Salt Desert	MSD-U:SI	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-A:All	Natural-Recovery	0.0000	1.0000	5			No	10	
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:SI-A	Cattle+Sheep-Grazing	0.0100		3		1	No		
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:SI-A	NativeGrazing	0.0010	1.0000		4		Yes		
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:SI-A	NativeGrazing	0.0010	1.0000	5		-1	No		
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:SI-A	ReplacementFire	0.0010	1.0000				Yes		
Stansbury Cliffrose	SC-U:SI-A	Stansbury Cliffrose	SC-U:SI-A+AG	AG-Invasion	0.0010	1.0000				No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:Annual Spp	Wild-Horse-Grazing	0.0100			2		No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Severe Drought	0.0071	0.1000	3			Yes		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Wild-Horse-Grazing	0.0100		3		2	No		
Stansbury Cliffrose	SC-U:SI-A+AG	Black Sagebrush	BS-U:SI-A	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-U:SI-A+AG	Juniper Savanna	JUN-U:Annual Spp	Range Shift	0.0302	0.5000		1	1	No	60	
Stansbury Cliffrose	SC-U:SI-A+AG	Mixed Salt Desert	MSD-U:SI+AG	Range Shift	0.0302	0.2500		1	1	No	60	
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A	Competition	0.3300	1.0000		12		No	3	
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A	Herbicide-Plateau	1.0000	0.7000		12		No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Cattle+Sheep-Grazing	0.0100		3		1	No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Herbicide-Plateau	1.0000	0.3000		12		No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	NativeGrazing	0.0010	1.0000		4		Yes		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	NativeGrazing	0.0010	1.0000	5	12	-1	No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	ReplacementFire	0.0020	1.0000		12		Yes		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Wet-Year	0.1000	1.0000		12		No		
Stansbury Cliffrose	SC-U:SI-B	Stansbury Cliffrose	SC-U:SI-B	Wild-Horse-Grazing	0.0100		13	79	2	No		
Stansbury Cliffrose	SC-U:SI-B	Stansbury Cliffrose	SC-B:Closed	Natural-Recovery	0.0000	1.0000	13	79		No	10	
Stansbury Cliffrose	SC-U:SI-B	Stansbury Cliffrose	SC-U:SI-A	ReplacementFire	0.0010	1.0000	13	79		Yes		
Stansbury Cliffrose	SC-U:SI-B	Stansbury Cliffrose	SC-U:SI-A	Severe Drought	0.0070	0.0100	13	79		Yes		
Stansbury Cliffrose	SC-U:SI-B	Stansbury Cliffrose	SC-U:SI-B	Cattle+Sheep-Grazing	0.0100		13	79	1	No		
Stansbury Cliffrose	SC-U:SI-B	Stansbury Cliffrose	SC-U:SI-B	NativeGrazing	0.0010	1.0000	13	79	-1	No		
Stansbury Cliffrose	SC-U:SI-B	Stansbury Cliffrose	SC-U:SI-B	Severe Drought	0.0070	0.9900	13	79		No		
Stansbury Cliffrose	SC-U:SI-B	Stansbury Cliffrose	SC-U:SI-B+AG	AG-Invasion	0.0010	1.0000	13	79		No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Wild-Horse-Grazing	0.0100				2	No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-A+AG	ReplacementFire	0.0020	1.0000				Yes		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Severe Drought	0.0070	0.0100				Yes		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B	Competition	0.3300	1.0000				No	3	
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B	Herbicide-Plateau	1.0000	0.7000				No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Cattle+Sheep-Grazing	0.0100				1	No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Herbicide-Plateau	1.0000	0.3000				No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	NativeGrazing	0.0010	1.0000			-1	No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Severe Drought	0.0070	0.9900				Yes		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Wet-Year	0.1000	1.0000				No		
Stansbury Cliffrose	SC-U:SI-C	Stansbury Cliffrose	SC-U:SI-C	Cattle+Sheep-Grazing	0.0100					No		
Stansbury Cliffrose	SC-U:SI-C	Stansbury Cliffrose	SC-U:SI-C	Wild-Horse-Grazing	0.0100					No		
Stansbury Cliffrose	SC-U:SI-C	Stansbury Cliffrose	SC-C:Open	Natural-Recovery	0.0000	1.0000	80			No	10	
Stansbury Cliffrose	SC-U:SI-C	Stansbury Cliffrose	SC-U:SI-A	Severe Drought	0.0070	0.0100	80			Yes		
Stansbury Cliffrose	SC-U:SI-C	Stansbury Cliffrose	SC-U:SI-B	Severe Drought	0.0070	0.0900	80			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Stansbury Cliffrose	SC-U:SI-C	Stansbury Cliffrose	SC-U:SI-C	ReplacementFire	0.0010	1.0000	80			Yes		
Stansbury Cliffrose	SC-U:SI-C	Stansbury Cliffrose	SC-U:SI-C	Severe Drought	0.0070	0.9000	80			No		
Stansbury Cliffrose	SC-U:SI-C	Stansbury Cliffrose	SC-U:SI-C+AG	AG-Invasion	0.0010	1.0000	80			No		
Stansbury Cliffrose	SC-U:SI-C	Stansbury Cliffrose	SC-U:TEA	Tree-Encroachment	0.0071		250			No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C+AG	Wild-Horse-Grazing	0.0100					No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-A+AG	ReplacementFire	0.0020	1.0000	80			Yes		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Severe Drought	0.0070	0.0100	80			Yes		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-B	Spyke+Plateau+Native-Seed	1.0000	0.7000	100			Yes		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Severe Drought	0.0070	0.0900	80			Yes		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Spyke+Plateau+Native-Seed	1.0000	0.3000	100			Yes		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C	Competition	0.2000	1.0000	80			No	3	
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C	Herbicide-Plateau	1.0000	0.7000	80	99		No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C+AG	Cattle+Sheep-Grazing	0.0100					No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C+AG	Herbicide-Plateau	1.0000	0.3000	80	99		No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C+AG	Severe Drought	0.0070	0.9000	80			No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C+AG	Wet-Year	0.1000	1.0000	80			No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:TEA	Tree-Encroachment	0.0071		250			No		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Annual Spp	Masticate+Herbicide+Native-Seed	1.0000	0.2000	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Annual Spp	ReplacementFire	0.0075	1.0000	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Annual Spp	Severe Drought	0.0070	0.0100	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Annual Spp	Spyke+Plateau+Native-Seed	1.0000	0.2000	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Early-Shrub	Severe Drought	0.0070	0.0450	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:SAP	Masticate+Herbicide+Native-Seed	1.0000	0.2000	80		13	Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:SAP	Severe Drought	0.0070	0.0450	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:SAP	Spyke+Plateau+Native-Seed	1.0000	0.2000	80		13	Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Seeded Native	Masticate+Herbicide+Native-Seed	1.0000	0.6000	80		13	Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Seeded Native	Spyke+Plateau+Native-Seed	1.0000	0.6000	80		13	Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:TEA	Severe Drought	0.0070	0.9000	80			Yes		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-A:All	Cattle+Sheep-Grazing	0.0210	0.0005	3			Yes		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-A:All	Cattle+Sheep-Grazing	0.0210	0.9995	3			No		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-A:All	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-A:All	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-A:All	ReplacementFire	0.0125					Yes		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-U:Annual Spp	AG-Invasion	0.0025					No		
Utah Serviceberry	US-A:All	Wyoming Big Sagebrush upland	WSup-A:All	Range Shift	0.0403			1	1	No	60	
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-A:All	Cattle+Sheep-Grazing	0.0210	0.0005				Yes		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-B:Closed	Cattle+Sheep-Grazing	0.0210	0.9995				No		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-B:Closed	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-U:Depleted	Wild-Horse-Grazing	0.0210	0.0005			2	No		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-A:All	ReplacementFire	0.0200					Yes		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-U:SAP	AG-Invasion	0.0010					No		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-A:All	Cattle+Sheep-Grazing	0.0210	0.0005				No		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-A:All	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-C:Closed	Cattle+Sheep-Grazing	0.0210	0.9995				No		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-C:Closed	Wild-Horse-Grazing	0.0210	0.9990	2			No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-D:Open	Tree-Invasion	0.0080		80			Yes		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-U:Depleted	Wild-Horse-Grazing	0.0210	0.0005	2			No		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-A:All	ReplacementFire	0.0250					Yes		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-B:Closed	Severe Drought	0.0070	0.1000				Yes		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-C:Closed	Severe Drought	0.0070	0.9000				Yes		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-U:SAP	AG-Invasion	0.0010					No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-A:All	RxFire	1.0000	0.7000				Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-B:Closed	Chainsaw-Thinning	1.0000	0.6000				Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-C:Closed	Chainsaw-Thinning	1.0000	0.4000				Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-C:Closed	Small-Tree-Lopping	1.0000					Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-D:Open	Cattle+Sheep-Grazing	0.0210	0.9995				No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-D:Open	RxFire	1.0000	0.3000				No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-U:TEA	AG-Invasion	0.0010					No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-U:TEA	Cattle+Sheep-Grazing	0.0210	0.0005				No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-U:TEA	Tree-Encroachment	0.0071		350			No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-U:TEA	Tree-Encroachment	0.0071	0.1000	200	299		No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-U:TEA	Tree-Encroachment	0.0071	0.9000	300	349		No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-A:All	ReplacementFire	0.0130					Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-C:Closed	Severe Drought	0.0070	0.1000				Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-D:Open	Severe Drought	0.0070	0.9000				No		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-A:All	Herbicide-Plateau+Native-Seed	1.0000	0.6000		5		Yes		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:Annual Spp	Cattle+Sheep-Grazing	0.0210					No		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.1000		5		Yes		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:Annual Spp	Herbicide-Plateau+Native-Seed	1.0000	0.4000		5		Yes		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:Annual Spp	Wild-Horse-Grazing	0.0210				2	No		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:SI-A	Chaining+Plateau+Seed	1.0000	0.8000		5		Yes		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:SI-A+AG	Chaining+Plateau+Seed	1.0000	0.1000		5		Yes		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:Annual Spp	Herbicide-Plateau+Seed	1.0000	0.2500		5		Yes		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:SAP	Alternate-Succession2	0.1000	1.0000	5			No	6	
Utah Serviceberry	US-U:Annual Spp	Utah Serviceberry	US-U:SI-A	Herbicide-Plateau+Seed	1.0000	0.7500		5		Yes		
Utah Serviceberry	US-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Range Shift	0.0403			1	1	No	60	
Utah Serviceberry	US-U:Bare Ground	Utah Serviceberry	US-U:Annual Spp	AG-Invasion	0.0050					Yes		
Utah Serviceberry	US-U:Bare Ground	Wyoming Big Sagebrush upland	WSup-A:All	Range Shift	0.0403		1	1		No	60	
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:Depleted	Chaining+Seed	1.0000	0.2000			4	Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:Depleted	Small-Tree-Lopping	1.0000		80			Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:SI-A	Chaining+Seed	1.0000	0.8000				Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:TEA	AG-Invasion	0.0050		80					
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:TEA	Tree-Invasion	0.0080		80			Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:Depleted	Severe Drought	0.0070	0.9000				Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:Early-Shrub	ReplacementFire	0.0200					Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:Early-Shrub	Severe Drought	0.0070	0.1000				Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:SAP	AG-Invasion	0.0050			79		No		
Utah Serviceberry	US-U:Early-Shrub	Utah Serviceberry	US-U:Early-Shrub	ReplacementFire	0.0200	1.0000				Yes		
Utah Serviceberry	US-U:Early-Shrub	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Range Shift	0.0403			1	1	No	60	
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-B:Closed	Chaining+Plateau+Native-Seed	1.0000	0.4000	80			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-C:Closed	Chaining+Plateau+Native-Seed	1.0000	0.4000	80			No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:Annual Spp	Cattle+Sheep-Grazing	0.0210	0.0005	5			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Cattle+Sheep-Grazing	0.0210	0.9995	5			No		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Chaining+Plateau+Native-Seed	1.0000	0.1000	80			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Chaining+Plateau+Native-Seed	1.0000	0.1000	80		15	Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:TEA	Tree-Invasion	0.0080	1.0000	80			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-A:All	Thin+Herbicide+Native-Seed	1.0000	0.7000	5	19		Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-B:Closed	Thin+Herbicide+Native-Seed	1.0000	0.7000	20	79		Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:Annual Spp	ReplacementFire	0.0250	1.0000	5			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:Annual Spp	Severe Drought	0.0070	0.1000	5			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Severe Drought	0.0070	0.9000	5			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Small-Tree-Lopping	1.0000	1.0000	80	149	14	Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Thin+Herbicide+Native-Seed	1.0000	0.3000	5	79		No		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP+	Wet-Year	0.1000	1.0000	5			No		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:Annual Spp	Cattle+Sheep-Grazing	0.0210	0.0005	5			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:Annual Spp	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP	FineFuelDecomp	0.3300	1.0000	5			No	2	
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP+	Cattle+Sheep-Grazing	0.0210	0.9995	5			No		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP+	Chaining+Plateau+Seed	1.0000	0.1000	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP+	Wet-Year	0.1000	1.0000	5			No		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP+	Wild-Horse-Grazing	0.0210	0.0005				Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP+	Wild-Horse-Grazing	0.0210	0.9990			2	No		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-B	Chaining+Plateau+Seed	1.0000	0.3500	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-B+AG	Chaining+Plateau+Seed	1.0000	0.1000	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-B+AG	Thin+Herbicide+Seed	1.0000	0.3000	20	79				
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-C	Chaining+Plateau+Seed	1.0000	0.3500	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-C+AG	Chaining+Plateau+Seed	1.0000	0.1000	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:TEA	Tree-Invasion	0.0080	1.0000	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:Annual Spp	ReplacementFire	0.0500	1.0000	5			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:Annual Spp	Severe Drought	0.0070	0.1000	5			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP	Severe Drought	0.0070	0.9000	5			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP+	Small-Tree-Lopping	1.0000	1.0000	80	149	14	Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-A	Thin+Herbicide+Seed	1.0000	0.7000	5	19		Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-A+AG	Thin+Herbicide+Seed	1.0000	0.3000	5	19		Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-B	Thin+Herbicide+Seed	1.0000	0.7000	20	79		Yes		
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:Bare Ground	Wild-Horse-Grazing	0.0210	0.0010	3			Yes		
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:Early-Shrub	Wild-Horse-Grazing	0.0210			2		Yes		
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:SI-A	Cattle+Sheep-Grazing	0.0210		3			No		
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:SI-A	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:SI-A	Severe Drought	0.0071	0.1000	3			Yes		
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:SI-A	Severe Drought	0.0071	0.9000	3		-1	No		
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:SI-A	Wild-Horse-Grazing	0.0210	0.9990	3		2	No		
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:SI-A	ReplacementFire	0.0010	1.0000		4		Yes		
Utah Serviceberry	US-U:SI-A	Utah Serviceberry	US-U:SI-A+AG	AG-Invasion	0.0010	1.0000		4		No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Utah Serviceberry	US-U:SI-A	Wyoming Big Sagebrush upland	WSup-A:All	Range Shift	0.0403			1	1	No	60	
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:Annual Spp	Severe Drought	0.0071	0.1000	3			Yes		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:Annual Spp	Wild-Horse-Grazing	0.0210			2		Yes		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Cattle+Sheep-Grazing	0.0210					No		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Wild-Horse-Grazing	0.0210		3		2	No		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A	Competition	0.3300	1.0000		4		No	3	
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A	Herbicide-Plateau+Seed	1.0000	0.8000		4		Yes		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Herbicide-Plateau+Seed	1.0000	0.2000		4		Yes		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	ReplacementFire	0.0020	1.0000		4		Yes		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Wet-Year	0.1000	1.0000		4		No		
Utah Serviceberry	US-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Range Shift	0.0403			1	1	No	60	
Utah Serviceberry	US-U:SI-B	Utah Serviceberry	US-U:SI-B	Cattle+Sheep-Grazing	0.0210					No		
Utah Serviceberry	US-U:SI-B	Utah Serviceberry	US-U:SI-B	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Utah Serviceberry	US-U:SI-B	Utah Serviceberry	US-U:SI-B	Wild-Horse-Grazing	0.0210				2	No		
Utah Serviceberry	US-U:SI-B	Utah Serviceberry	US-B:Closed	Natural-Recovery	0.0010	1.0000	5	19		No	10	
Utah Serviceberry	US-U:SI-B	Utah Serviceberry	US-U:SI-A	ReplacementFire	0.0010	1.0000	5	19		Yes		
Utah Serviceberry	US-U:SI-B	Utah Serviceberry	US-U:SI-B+AG	AG-Invasion	0.0010	1.0000	5	19		No		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B+AG	Cattle+Sheep-Grazing	0.0210					No		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B+AG	Wild-Horse-Grazing	0.0210				2	No		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-A+AG	ReplacementFire	0.0020	1.0000	5	19		Yes		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B	Competition	0.3300	1.0000	5	19		No	3	
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B	Herbicide-Plateau+Seed	1.0000	0.8000	5	19		No		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B+AG	Herbicide-Plateau+Seed	1.0000	0.2000	5	19		No		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B+AG	Wet-Year	0.1000	1.0000	5	19		No		
Utah Serviceberry	US-U:SI-C	Utah Serviceberry	US-U:SI-C	Cattle+Sheep-Grazing	0.0210					No		
Utah Serviceberry	US-U:SI-C	Utah Serviceberry	US-U:SI-C	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Utah Serviceberry	US-U:SI-C	Utah Serviceberry	US-U:SI-C	Wild-Horse-Grazing	0.0210				2	No		
Utah Serviceberry	US-U:SI-C	Utah Serviceberry	US-U:SI-D	Tree-Invasion	0.0080		80			Yes		
Utah Serviceberry	US-U:SI-C	Utah Serviceberry	US-C:Closed	Natural-Recovery	0.0100					No	10	
Utah Serviceberry	US-U:SI-C	Utah Serviceberry	US-U:SI-A	ReplacementFire	0.0010					Yes		
Utah Serviceberry	US-U:SI-C	Utah Serviceberry	US-U:SI-C+AG	AG-Invasion	0.0010					No		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C+AG	Cattle+Sheep-Grazing	0.0210					No		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C+AG	Wild-Horse-Grazing	0.0210				2	No		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-D+AG	Tree-Invasion	0.0080		80			Yes		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-A+AG	ReplacementFire	0.0020					Yes		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C	Competition	0.2000					No	3	
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C	Herbicide-Plateau+Seed	1.0000	0.8000				No		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C+AG	Herbicide-Plateau+Seed	1.0000	0.2000				No		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C+AG	Wet-Year	0.1000					No		
Utah Serviceberry	US-U:SI-D	Utah Serviceberry	US-U:SI-D	Cattle+Sheep-Grazing	0.0210					No		
Utah Serviceberry	US-U:SI-D	Utah Serviceberry	US-D:Open	Natural-Recovery	0.1000	1.0000	80			No	10	
Utah Serviceberry	US-U:SI-D	Utah Serviceberry	US-U:SI-A	ReplacementFire	0.0010	1.0000	80			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Utah Serviceberry	US-U:SI-D	Utah Serviceberry	US-U:SI-C	Chainsaw-Thinning	1.0000	1.0000	80			Yes		
Utah Serviceberry	US-U:SI-D	Utah Serviceberry	US-U:SI-D+AG	AG-Invasion	0.0010	1.0000	80			No		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-D+AG	Cattle+Sheep-Grazing	0.0210					No		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-A+AG	ReplacementFire	0.0020	1.0000	80			Yes		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-C	Masticate+Herbicide+Seed	1.0000	0.8000	100			Yes		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-D	Competition	0.1000	1.0000	80			No	3	
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-D+AG	Masticate+Herbicide+Seed	1.0000	0.2000	100			Yes		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-D+AG	Wet-Year	0.1000	1.0000	80			No		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:TEA	Severe Drought	0.0070	0.9000				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-A:All	Masticate+Native-Seed	1.0000	0.7000				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:Annual Spp	Chainsaw-Thinning	1.0000	0.2500				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:Annual Spp	Masticate+Native-Seed	1.0000	0.3000				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:Annual Spp	Masticate+Seed	1.0000	0.1000				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:Annual Spp	ReplacementFire	0.0075	1.0000				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:Annual Spp	Severe Drought	0.0070	0.0500				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:Early-Shrub	Severe Drought	0.0070	0.0500				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:SAP	Chainsaw-Thinning	1.0000	0.7500				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:SAP	Masticate+Seed	1.0000	0.1000			2	Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:SAP	Masticate+Seed	1.0000	0.1000			5	Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:SI-B	Masticate+Seed	1.0000	0.3500				Yes		
Utah Serviceberry	US-U:TEA	Utah Serviceberry	US-U:SI-C	Masticate+Seed	1.0000	0.3500				Yes		
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Cattle+Sheep-Grazing	0.0540	0.9990			1	No	20	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Fence	1.0000					No	20	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Wild-Horse-Grazing	0.0540	0.9990			2	No	20	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-U:Hummocked	Cattle+Sheep-Grazing	0.0540	0.0010				Yes	20	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-U:Hummocked	Wild-Horse-Grazing	0.0540	0.0010				Yes	20	
Wet Meadow-Montane	WM-A:Open	Basin Wildrye	BW-A:All	Range Shift	0.0930	0.7000		1	1	No	60	
Wet Meadow-Montane	WM-A:Open	Saline Meadow	WMas-A:Open	Range Shift	0.0930	0.2000		1	1	No	60	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Severe Drought	0.0070					Yes		
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Very-Wet-Year	0.0181				1	Yes		
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Weed-Inventory+Treat	1.0000					No	3	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0001					No	5	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-A:Open	Very-Wet-Year	0.0181				1	Yes		
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Cattle+Sheep-Grazing	0.0540	0.9990			1	No	20	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Fence	1.0000					No	20	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Wild-Horse-Grazing	0.0540	0.9990			2	No	20	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-C:Open	Alternate-Succession2	1.0000					Yes		1
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-U:Hummocked	Cattle+Sheep-Grazing	0.0540	0.0010				No	20	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-U:Hummocked	Wild-Horse-Grazing	0.0540	0.0010				Yes	20	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-A:Open	ReplacementFire	0.0250					Yes	5	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Severe Drought	0.0070				1	No		
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Weed-Inventory+Treat	1.0000					No	3	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Wet-Year	0.1000					Yes		
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0001					No	5	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-A:Open	Thin	1.0000					Yes		
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-A:Open	Very-Wet-Year	0.0181				1	Yes		
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-C:Open	Cattle+Sheep-Grazing	0.0540	0.9990			1	No	20	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-C:Open	Fence	1.0000					No	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-C:Open	Wild-Horse-Grazing	0.0540	0.9990			2	No	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-U:Hummocked	Cattle+Sheep-Grazing	0.0540	0.0005				Yes	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-U:Hummocked	Wild-Horse-Grazing	0.0540	0.0005				Yes	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-U:SFE	Cattle+Sheep-Grazing	0.0540	0.0005			1	No	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-U:SFE	Wild-Horse-Grazing	0.0540	0.0005			2	No	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-A:Open	ReplacementFire	0.0250					Yes	5	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-B:Closed	Wet-Year	0.1000					Yes		
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-C:Open	Severe Drought	0.0070				1	No		
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-C:Open	Weed-Inventory+Treat	1.0000					No	3	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0001					Yes	5	
Wet Meadow-Montane	WM-U:Annual Spp	Wet Meadow-Montane	WM-U:Annual Spp	Cattle+Sheep-Grazing	0.0540				1	No	20	
Wet Meadow-Montane	WM-U:Annual Spp	Wet Meadow-Montane	WM-U:Annual Spp	Fence	1.0000	1.0000				No	20	
Wet Meadow-Montane	WM-U:Annual Spp	Wet Meadow-Montane	WM-U:Annual Spp	Wild-Horse-Grazing	0.0540				2	No	20	
Wet Meadow-Montane	WM-U:Annual Spp	Basin Wildrye	BW-U:Annual Spp	Range Shift	0.0930	0.7000		1	1	No	60	
Wet Meadow-Montane	WM-U:Annual Spp	Saline Meadow	WMas-U:Annual Spp	Range Shift	0.0930	0.3000		1	1	No	60	
Wet Meadow-Montane	WM-U:Annual Spp	Wet Meadow-Montane	WM-A:Open	Floodplain-Restoration	1.0000	0.9000				Yes		
Wet Meadow-Montane	WM-U:Annual Spp	Wet Meadow-Montane	WM-A:Open	Water-Table-Uplift	1.0000	0.7000				Yes	15	
Wet Meadow-Montane	WM-U:Annual Spp	Wet Meadow-Montane	WM-U:Annual Spp	Floodplain-Restoration	1.0000	0.1000				Yes		
Wet Meadow-Montane	WM-U:Annual Spp	Wet Meadow-Montane	WM-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Wet Meadow-Montane	WM-U:Annual Spp	Wet Meadow-Montane	WM-U:Annual Spp	Water-Table-Uplift	1.0000	0.3000				No	15	
Wet Meadow-Montane	WM-U:Bare Ground	Wet Meadow-Montane	WM-U:Annual Spp	AG-Invasion	0.0050					Yes		
Wet Meadow-Montane	WM-U:Bare Ground	Wet Meadow-Montane	WM-U:Bare Ground	Water-Table-Uplift	1.0000	0.3000				No	15	
Wet Meadow-Montane	WM-U:Bare Ground	Wet Meadow-Montane	WM-U:Hummocked	Water-Table-Uplift	1.0000	0.7000				Yes	15	
Wet Meadow-Montane	WM-U:Bare Ground	Basin Wildrye	BW-U:Bare Ground	Range Shift	0.0930	0.7000	1	1		No	60	
Wet Meadow-Montane	WM-U:Bare Ground	Saline Meadow	WMas-U:Bare Ground	Range Shift	0.0923	0.3000	1	1		No	60	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Cattle+Sheep-Grazing	0.0540	0.9990			1	No	20	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Fence	1.0000					No	20	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Severe Drought	0.0070	0.1000	10	74		Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Severe Drought	0.0070	0.1000	75		10	Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Severe Drought	0.0070	0.9000	10	74	10	Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Severe Drought	0.0070	0.9000	75		75	Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Thin	1.0000					Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Wild-Horse-Grazing	0.0540	0.9990			2	No	20	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Early-Shrub	Cattle+Sheep-Grazing	0.0540	0.0005				Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Early-Shrub	Wild-Horse-Grazing	0.0540	0.0005				Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Control	1.0000					No	5	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Inset	Very-Wet-Year	0.0181					Yes		
Wet Meadow-Montane	WM-U:Desertified	Basin Wildrye	BW-A:All	Range Shift	0.0930	0.7000		1	1	No	60	
Wet Meadow-Montane	WM-U:Desertified	Saline Meadow	WMas-U:Depleted	Range Shift	0.0930	0.2000		1	1	No	60	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-A:Open	Floodplain-Restoration	1.0000	0.9000				Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-A:Open	Water-Table-Uplift	1.0000	0.7000				Yes	15	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Annual Spp	AG-Invasion	0.0050			22		No		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Floodplain-Restoration	1.0000	0.1000				Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	ReplacementFire	0.0200					Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Severe Drought	0.0070			9		Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Water-Table-Uplift	1.0000	0.3000				No	15	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:SA	AG-Invasion	0.0050		23			No		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:TEA	Tree-Invasion	0.0080		75			Yes		
Wet Meadow-Montane	WM-U:Early-Shrub	Wet Meadow-Montane	WM-U:Early-Shrub	ReplacementFire	0.0200					Yes		
Wet Meadow-Montane	WM-U:Early-Shrub	Wet Meadow-Montane	WM-U:Early-Shrub	Water-Table-Uplift	1.0000	0.3000				No	15	
Wet Meadow-Montane	WM-U:Early-Shrub	Wet Meadow-Montane	WM-U:SFE	Water-Table-Uplift	1.0000	0.7000				Yes	15	
Wet Meadow-Montane	WM-U:Early-Shrub	Basin Wildrye	BW-U:Early-Shrub	Range Shift	0.0930	0.7000	1	1		No	60	
Wet Meadow-Montane	WM-U:Early-Shrub	Saline Meadow	WMas-U:SAP	Range Shift	0.0930	0.3000	1	1		No	60	
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Cattle+Sheep-Grazing	0.0540				1	No	20	
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Fence	1.0000					No	20	
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Wild-Horse-Grazing	0.0540				2	No	20	
Wet Meadow-Montane	WM-U:Exotic Forb	Basin Wildrye	BW-U:Exotic Forb	Range Shift	0.0930	0.7000		1	1	No	60	
Wet Meadow-Montane	WM-U:Exotic Forb	Saline Meadow	WMas-U:Exotic Forb	Range Shift	0.0930	0.2000		1	1	No	60	
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-A:Open	Exotic-Control	1.0000	0.9000		2		No		20
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-B:Closed	Exotic-Control	1.0000	0.9000	3	22		No		20
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-C:Open	Exotic-Control	1.0000	0.9000	23			No		20
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Control	1.0000	0.1000				No		20
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	ReplacementFire	0.0250					Yes	5	
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Very-Wet-Year	0.0181				1	Yes		
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-A:Open	Natural-Recovery	1.0000					Yes	5	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Desertified	Cattle+Sheep-Grazing	0.0540	0.0010				Yes		
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Desertified	Wild-Horse-Grazing	0.0540	0.0010				Yes		
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0005					No	5	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Cattle+Sheep-Grazing	0.0540	0.9990				Yes	20	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Fence	1.0000					No	20	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	ReplacementFire	0.0250		2			Yes	5	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Weed-Inventory+Treat	1.0000					No	3	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Wet-Year	0.1000				3	Yes		
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Wild-Horse-Grazing	0.0540	0.9990				Yes	20	
Wet Meadow-Montane	WM-U:Hummocked	Basin Wildrye	BW-U:Depleted-C	Range Shift	0.0930	0.7000		1	1	No	60	
Wet Meadow-Montane	WM-U:Hummocked	Saline Meadow	WMas-U:Depleted	Range Shift	0.0930	0.2000		1	1	No	60	
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-A:Open	Water-Table-Uplift	1.0000	0.7000				Yes		
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Desertified	Water-Table-Uplift	1.0000	0.3000				No		
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset	Cattle+Sheep-Grazing	0.0540	0.9990			1	No		
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset	ReplacementFire	0.0250					Yes	5	
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset	Severe Drought	0.0070			2				
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset	Severe Drought	0.0070		3		1	No		
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset	Very-Wet-Year	0.0181				1	Yes		
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset	Wet-Year	0.1000		3	22	4	Yes		
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset	Wet-Year	0.1000		23		24	Yes		
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset	Wild-Horse-Grazing	0.0540	0.9990			2	No		
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset-EF	Exotic-Invasion	0.0001					No	5	
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset-Hummocked	Cattle+Sheep-Grazing	0.0540	0.0010						
Wet Meadow-Montane	WM-U:Inset	Wet Meadow-Montane	WM-U:Inset-Hummocked	Wild-Horse-Grazing	0.0540	0.0010						
Wet Meadow-Montane	WM-U:Inset	Basin Wildrye	BW-A:All	Range Shift	0.0930	0.7000		1	1	No	60	
Wet Meadow-Montane	WM-U:Inset	Saline Meadow	WMas-A:Open	Range Shift	0.0930	0.3000		1	1	No	60	
Wet Meadow-Montane	WM-U:Inset-EF	Wet Meadow-Montane	WM-A:Open	Water-Table-Uplift	1.0000	0.7000				Yes		
Wet Meadow-Montane	WM-U:Inset-EF	Wet Meadow-Montane	WM-U:Exotic Forb	Water-Table-Uplift	1.0000	0.3000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wet Meadow-Montane	WM-U:Inset-EF	Wet Meadow-Montane	WM-U:Inset-EF	Cattle+Sheep-Grazing	0.0540				1	No		
Wet Meadow-Montane	WM-U:Inset-EF	Wet Meadow-Montane	WM-U:Inset-EF	Wild-Horse-Grazing	0.0540				2	No		
Wet Meadow-Montane	WM-U:Inset-EF	Basin Wildrye	BW-U:Exotic Forb	Range Shift	0.0930	0.7000		1		No	60	
Wet Meadow-Montane	WM-U:Inset-EF	Saline Meadow	WMas-U:Exotic Forb	Range Shift	0.9300	0.3000		1		No	60	
Wet Meadow-Montane	WM-U:Inset-Hummocked	Wet Meadow-Montane	WM-U:Bare Ground	Water-Table-Uplift	1.0000	0.3000				Yes		
Wet Meadow-Montane	WM-U:Inset-Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Water-Table-Uplift	1.0000	0.7000				Yes		
Wet Meadow-Montane	WM-U:Inset-Hummocked	Wet Meadow-Montane	WM-U:Inset-EF	Exotic-Invasion	0.0005					No	5	
Wet Meadow-Montane	WM-U:Inset-Hummocked	Wet Meadow-Montane	WM-U:Inset-Hummocked	Cattle+Sheep-Grazing	0.0540							
Wet Meadow-Montane	WM-U:Inset-Hummocked	Wet Meadow-Montane	WM-U:Inset-Hummocked	Wet-Year	0.1200				3	Yes		
Wet Meadow-Montane	WM-U:Inset-Hummocked	Wet Meadow-Montane	WM-U:Inset-Hummocked	Wild-Horse-Grazing	0.0540							
Wet Meadow-Montane	WM-U:Inset-Hummocked	Basin Wildrye	BW-U:Bare Ground	Range Shift	0.0930	0.7000		1	1	No	60	
Wet Meadow-Montane	WM-U:Inset-Hummocked	Saline Meadow	WMas-U:Bare Ground	Range Shift	0.0930	0.3000		1	1	No	60	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Annual Spp	Cattle+Sheep-Grazing	0.0540	0.0010				Yes	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Annual Spp	Thin	1.0000					Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Annual Spp	Wild-Horse-Grazing	0.0540	0.0010				Yes	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Control	1.0000					No	5	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Cattle+Sheep-Grazing	0.0540	0.9990			1	No	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Fence	1.0000					No	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Wild-Horse-Grazing	0.0540	0.9990			2	No	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-A:Open	Floodplain-Restoration	1.0000	0.9000				Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-A:Open	Water-Table-Uplift	1.0000	0.7000				Yes	15	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Annual Spp	ReplacementFire	0.0375					Yes	5	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Floodplain-Restoration	1.0000	0.1000				Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Severe Drought	0.0070	0.9000				Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Water-Table-Uplift	1.0000	0.3000				No	15	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:TEA	Tree-Invasion	0.0080		75			Yes		
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-A:Open	Natural-Recovery	1.0000					Yes	10	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-A:Open	Thin+Herbicide+Native-Seed	1.0000					Yes		
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:Annual Spp	Wild-Horse-Grazing	0.0540	0.0010				Yes	20	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:Desertified	Cattle+Sheep-Grazing	0.0540	0.0010	3			No	20	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Cattle+Sheep-Grazing	0.0540	0.9990	3		1	No	20	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Fence	1.0000					No	20	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Wet-Year	0.1000		3	22	3	Yes		
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Wet-Year	0.1000		23		13	Yes		
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Wild-Horse-Grazing	0.0540	0.9990			2	No	20	
Wet Meadow-Montane	WM-U:SFE	Basin Wildrye	BW-U:Early-Shrub	Range Shift	0.0930	0.7000		1	1	No	60	
Wet Meadow-Montane	WM-U:SFE	Saline Meadow	WMas-U:Depleted	Range Shift	0.0930	0.2000		1	1	No	60	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0001					No	5	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	ReplacementFire	0.0250					Yes	5	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Very-Wet-Year	0.0181				1	Yes		
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Weed-Inventory+Treat	1.0000					No	3	
Wet Meadow-Montane	WM-U:SI	Wet Meadow-Montane	WM-A:Open	Water-Table-Uplift	1.0000	0.7000				Yes	15	
Wet Meadow-Montane	WM-U:SI	Wet Meadow-Montane	WM-U:SI	Water-Table-Uplift	1.0000	0.3000				No	15	
Wet Meadow-Montane	WM-U:SI	Basin Wildrye	BW-U:SI	Range Shift	0.0930	0.7000	1	1		No	60	
Wet Meadow-Montane	WM-U:SI	Saline Meadow	WMas-A:Open	Range Shift	0.0930	0.3000	1	1		Yes	60	
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-A:Open	Water-Table-Uplift	1.0000	0.7000				Yes	15	
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Annual Spp	Water-Table-Uplift	1.0000	0.3000				No	15	
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Desertified	Small-Tree-Lopping	1.0000	1.0000			1	Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-A:Open	Floodplain-Restoration	1.0000	0.9000				Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Annual Spp	Floodplain-Restoration	1.0000	0.1000				Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Annual Spp	ReplacementFire	0.0074	0.5000				Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Annual Spp	Severe Drought	0.0070	0.0500				Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Desertified	ReplacementFire	0.0074	0.5000				Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Early-Shrub	Severe Drought	0.0070	0.0500				Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:TEA	Severe Drought	0.0070	0.9000				Yes		
Winterfat	WF-A:All	Winterfat	WF-A:All	Cattle+Sheep-Grazing	0.0110	0.9995	3			No		
Winterfat	WF-A:All	Winterfat	WF-A:All	Wild-Horse-Grazing	0.0110	0.9990			2	No		
Winterfat	WF-A:All	Winterfat	WF-U:Annual Spp	AG-Invasion	0.0025					No		
Winterfat	WF-A:All	Winterfat	WF-U:Bare Ground	Cattle+Sheep-Grazing	0.0110	0.0005	3			Yes		
Winterfat	WF-A:All	Winterfat	WF-U:Bare Ground	Wild-Horse-Grazing	0.0110	0.0010				Yes		
Winterfat	WF-B:Open	Winterfat	WF-A:All	ReplacementFire	0.0010					Yes		
Winterfat	WF-B:Open	Winterfat	WF-A:All	Very-Wet-Year	0.0180	0.2000				Yes		
Winterfat	WF-B:Open	Winterfat	WF-B:Open	Cattle+Sheep-Grazing	0.0110	0.9995				No		
Winterfat	WF-B:Open	Winterfat	WF-B:Open	Very-Wet-Year	0.0180	0.8000				Yes		
Winterfat	WF-B:Open	Winterfat	WF-B:Open	Wild-Horse-Grazing	0.0110	0.9990			-2	No		
Winterfat	WF-B:Open	Winterfat	WF-U:Bare Ground	Cattle+Sheep-Grazing	0.0110	0.0005				Yes		
Winterfat	WF-B:Open	Winterfat	WF-U:Bare Ground	Wild-Horse-Grazing	0.0110	0.0010				Yes		
Winterfat	WF-B:Open	Winterfat	WF-U:SAP	AG-Invasion	0.0010					Yes		
Winterfat	WF-C:Closed	Winterfat	WF-A:All	ReplacementFire	0.0010					Yes		
Winterfat	WF-C:Closed	Winterfat	WF-A:All	Very-Wet-Year	0.0180	0.0500				Yes		
Winterfat	WF-C:Closed	Winterfat	WF-B:Open	Very-Wet-Year	0.0180	0.1500				Yes		
Winterfat	WF-C:Closed	Winterfat	WF-C:Closed	Cattle+Sheep-Grazing	0.0110	0.9995				No		
Winterfat	WF-C:Closed	Winterfat	WF-C:Closed	Very-Wet-Year	0.0180	0.8000				Yes		
Winterfat	WF-C:Closed	Winterfat	WF-C:Closed	Wild-Horse-Grazing	0.0110	0.9990			2	No		
Winterfat	WF-C:Closed	Winterfat	WF-U:Depleted	Cattle+Sheep-Grazing	0.0110	0.0005				No		
Winterfat	WF-C:Closed	Winterfat	WF-U:Depleted	Wild-Horse-Grazing	0.0110	0.0010			50	Yes		
Winterfat	WF-C:Closed	Winterfat	WF-U:SAP	AG-Invasion	0.0010					No		
Winterfat	WF-U:Annual Spp	Winterfat	WF-U:Annual Spp	Cattle+Sheep-Grazing	0.0110					No		
Winterfat	WF-U:Annual Spp	Winterfat	WF-U:Annual Spp	Herbicide-Plateau+Native-Seed	1.0000	0.5000				Yes		
Winterfat	WF-U:Annual Spp	Winterfat	WF-U:Annual Spp	Herbicide-Plateau+Planting	1.0000	0.4000				No		
Winterfat	WF-U:Annual Spp	Winterfat	WF-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Winterfat	WF-U:Annual Spp	Winterfat	WF-U:Annual Spp	Wild-Horse-Grazing	0.0110				2	No		
Winterfat	WF-U:Annual Spp	Winterfat	WF-U:Seeded Native	Herbicide-Plateau+Native-Seed	1.0000	0.5000				Yes		
Winterfat	WF-U:Annual Spp	Winterfat	WF-U:Seeded Native	Herbicide-Plateau+Planting	1.0000	0.6000				Yes		
Winterfat	WF-U:Bare Ground	Winterfat	WF-U:Annual Spp	AG-Invasion	0.0050							
Winterfat	WF-U:Depleted	Winterfat	WF-A:All	Shrub+Grass-Seeding	1.0000	0.6000		49		No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Winterfat	WF-U:Depleted	Winterfat	WF-B:Open	Grass-Seeding	1.0000	0.7000	50	149		No		
Winterfat	WF-U:Depleted	Winterfat	WF-C:Closed	Grass-Seeding	1.0000	0.7000	150			No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Bare Ground	Cattle+Sheep-Grazing	0.0110	0.0005				Yes		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Bare Ground	Very-Wet-Year	0.0180					Yes		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Bare Ground	Wild-Horse-Grazing	0.0110	0.0010				Yes		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Depleted	Cattle+Sheep-Grazing	0.0110	0.9995				No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Depleted	Grass-Seeding	1.0000	0.3000				No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Depleted	Shrub+Grass-Seeding	1.0000	0.4000		49		No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Depleted	Wild-Horse-Grazing	0.0110	0.9990			-2	No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Exotic Forb	Exotic-Invasion	0.0010					No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:SA	AG-Invasion	0.0050					No		
Winterfat	WF-U:SA	Winterfat	WF-B:Open	Herbicide-Plateau+Native-Seed	1.0000	0.6000		149		No		
Winterfat	WF-U:SA	Winterfat	WF-C:Closed	Herbicide-Plateau+Native-Seed	1.0000	0.6000	150			No		
Winterfat	WF-U:SA	Winterfat	WF-U:Annual Spp	Cattle+Sheep-Grazing	0.0110	0.0005				Yes		
Winterfat	WF-U:SA	Winterfat	WF-U:Annual Spp	ReplacementFire	0.0100	1.0000				Yes		
Winterfat	WF-U:SA	Winterfat	WF-U:Annual Spp	Very-Wet-Year	0.0180	0.1000				Yes		
Winterfat	WF-U:SA	Winterfat	WF-U:Annual Spp	Wild-Horse-Grazing	0.0110	0.0010				Yes		
Winterfat	WF-U:SA	Winterfat	WF-U:Exotic Forb	Exotic-Invasion	0.0010	1.0000				Yes		
Winterfat	WF-U:SA	Winterfat	WF-U:SA	Cattle+Sheep-Grazing	0.0110	0.9995				No		
Winterfat	WF-U:SA	Winterfat	WF-U:SA	Herbicide-Plateau+Native-Seed	1.0000	0.4000						
Winterfat	WF-U:SA	Winterfat	WF-U:SA	Wild-Horse-Grazing	0.0110	0.9990			-2	No		
Winterfat	WF-U:SA	Winterfat	WF-U:SA+	Very-Wet-Year	0.0180	0.9000				No		
Winterfat	WF-U:SA+	Winterfat	WF-B:Open	Herbicide-Plateau+Native-Seed	1.0000	0.5000		149		No		
Winterfat	WF-U:SA+	Winterfat	WF-C:Closed	Herbicide-Plateau+Native-Seed	1.0000	0.5000	150			No		
Winterfat	WF-U:SA+	Winterfat	WF-U:Annual Spp	Cattle+Sheep-Grazing	0.0110	0.0005				Yes		
Winterfat	WF-U:SA+	Winterfat	WF-U:Annual Spp	ReplacementFire	0.0150	1.0000				Yes		
Winterfat	WF-U:SA+	Winterfat	WF-U:Annual Spp	Very-Wet-Year	0.0181	1.0000				Yes		
Winterfat	WF-U:SA+	Winterfat	WF-U:Annual Spp	Wild-Horse-Grazing	0.0110	0.0010				Yes		
Winterfat	WF-U:SA+	Winterfat	WF-U:SA	FineFuelDecomp	0.3300	1.0000				No	2	
Winterfat	WF-U:SA+	Winterfat	WF-U:SA	Herbicide-Plateau+Native-Seed	1.0000	0.5000				No		
Winterfat	WF-U:SA+	Winterfat	WF-U:SA+	Cattle+Sheep-Grazing	0.0110	0.9995			-1	No		
Winterfat	WF-U:SA+	Winterfat	WF-U:SA+	Exotic-Invasion	0.0010	1.0000				No		
Winterfat	WF-U:SA+	Winterfat	WF-U:SA+	Wet-Year	0.1000	1.0000				No		
Winterfat	WF-U:SA+	Winterfat	WF-U:SA+	Wild-Horse-Grazing	0.0110	0.9990			-2	No		
Winterfat	WF-U:SAP	Winterfat	WF-B:Open	Herbicide-Plateau+Native-Seed	1.0000	0.7000		149		No		
Winterfat	WF-U:SAP	Winterfat	WF-C:Closed	Herbicide-Plateau+Native-Seed	1.0000	0.7000	150			No		
Winterfat	WF-U:SAP	Winterfat	WF-U:Annual Spp	Cattle+Sheep-Grazing	0.0110	0.0005				Yes		
Winterfat	WF-U:SAP	Winterfat	WF-U:Annual Spp	ReplacementFire	0.0100					Yes		
Winterfat	WF-U:SAP	Winterfat	WF-U:Annual Spp	Very-Wet-Year	0.0180	0.1000				Yes		
Winterfat	WF-U:SAP	Winterfat	WF-U:Annual Spp	Wild-Horse-Grazing	0.0110	0.0005				Yes		
Winterfat	WF-U:SAP	Winterfat	WF-U:Exotic Forb	Exotic-Invasion	0.0010					No		
Winterfat	WF-U:SAP	Winterfat	WF-U:SA	Wild-Horse-Grazing	0.0110	0.0005			-2	No		
Winterfat	WF-U:SAP	Winterfat	WF-U:SAP	Cattle+Sheep-Grazing	0.0110	0.9995				No		
Winterfat	WF-U:SAP	Winterfat	WF-U:SAP	Herbicide-Plateau+Native-Seed	1.0000	0.3000				No		
Winterfat	WF-U:SAP	Winterfat	WF-U:SAP	Wild-Horse-Grazing	0.0110	0.9990			-2	No		
Winterfat	WF-U:SAP	Winterfat	WF-U:SAP+	Very-Wet-Year	0.0180	0.9000				No		
Winterfat	WF-U:SAP+	Winterfat	WF-B:Open	Herbicide-Plateau+Native-Seed	1.0000	0.6000		149		No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Winterfat	WF-U:SAP+	Winterfat	WF-C:Closed	Herbicide-Plateau+Native-Seed	1.0000	0.6000	150			No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:Annual Spp	Cattle+Sheep-Grazing	0.0110	0.0005				Yes		
Winterfat	WF-U:SAP+	Winterfat	WF-U:Annual Spp	ReplacementFire	0.0150	1.0000				Yes		
Winterfat	WF-U:SAP+	Winterfat	WF-U:Annual Spp	Wild-Horse-Grazing	0.0110	0.0005				Yes		
Winterfat	WF-U:SAP+	Winterfat	WF-U:Exotic Forb	Exotic-Invasion	0.0010	1.0000				No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:SA+	Wild-Horse-Grazing	0.0110	0.0005			-2	No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:SAP	FineFuelDecomp	0.3300	1.0000				No	2	
Winterfat	WF-U:SAP+	Winterfat	WF-U:SAP	Herbicide-Plateau+Native-Seed	1.0000	0.4000				No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:SAP+	Cattle+Sheep-Grazing	0.0110	0.9995				No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:SAP+	Very-Wet-Year	0.0180	1.0000				No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:SAP+	Wet-Year	0.1000	1.0000				No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:SAP+	Wild-Horse-Grazing	0.0110	0.9990			-2	No		
Winterfat	WF-U:SAP-A	Winterfat	WF-A:All	Herbicide-Plateau+Native-Seed	1.0000	0.7000				No		
Winterfat	WF-U:SAP-A	Winterfat	WF-U:Annual Spp	Cattle+Sheep-Grazing	0.0110	0.0005	3			Yes		
Winterfat	WF-U:SAP-A	Winterfat	WF-U:Annual Spp	ReplacementFire	0.0100					Yes		
Winterfat	WF-U:SAP-A	Winterfat	WF-U:Annual Spp	Very-Wet-Year	0.0180	0.1000				Yes		
Winterfat	WF-U:SAP-A	Winterfat	WF-U:Annual Spp	Wild-Horse-Grazing	0.0110	0.0010				Yes		
Winterfat	WF-U:SAP-A	Winterfat	WF-U:Exotic Forb	Exotic-Invasion	0.0010					No		
Winterfat	WF-U:SAP-A	Winterfat	WF-U:SAP-A	Cattle+Sheep-Grazing	0.0110	0.9995	3		1	No		
Winterfat	WF-U:SAP-A	Winterfat	WF-U:SAP-A	Herbicide-Plateau+Native-Seed	1.0000	0.3000				No		
Winterfat	WF-U:SAP-A	Winterfat	WF-U:SAP-A	Very-Wet-Year	0.0180	0.9000				Yes		
Winterfat	WF-U:SAP-A	Winterfat	WF-U:SAP-A	Wild-Horse-Grazing	0.0110	0.9990			-2	No		
Winterfat	WF-U:Seeded Native	Winterfat	WF-A:All	Natural-Recovery	0.3300	1.0000	3	49		No	5	
Winterfat	WF-U:Seeded Native	Winterfat	WF-B:Open	Natural-Recovery	0.3300	1.0000	50	149		No	5	
Winterfat	WF-U:Seeded Native	Winterfat	WF-C:Closed	Natural-Recovery	0.3300	1.0000	150			No	5	
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Bare Ground	Cattle+Sheep-Grazing	0.0110		3	5		Yes		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Bare Ground	Cattle+Sheep-Grazing	0.0110	0.0005	6	49		Yes		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Bare Ground	Wild-Horse-Grazing	0.0110			5		Yes		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Bare Ground	Wild-Horse-Grazing	0.0110	0.0010	6			Yes		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Depleted	Cattle+Sheep-Grazing	0.0110	0.0005	50		1	No		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Depleted	Drought 24mo(t+1)	0.0382			3		Yes		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Depleted	Severe Drought	0.0071	0.1000	4			Yes		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Exotic Forb	Exotic-Invasion	0.0005	1.0000				Yes		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:SAP	AG-Invasion	0.0010	1.0000				No		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Seeded Native	Cattle+Sheep-Grazing	0.0110	0.9995	6			No		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Seeded Native	Severe Drought	0.0071	0.9000	4		-1	No		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Seeded Native	Very-Wet-Year	0.0180	1.0000				Yes		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Seeded Native	Wild-Horse-Grazing	0.0110	0.9990	6		2	No		
Winterfat	WF-U:SI	Winterfat	WF-A:All	Natural-Recovery	0.0000			5		No	10	
Winterfat	WF-U:SI	Winterfat	WF-B:Open	Natural-Recovery	0.0000		6					
Winterfat	WF-U:SI	Winterfat	WF-U:Bare Ground	Wild-Horse-Grazing	0.0110			2		Yes		
Winterfat	WF-U:SI	Winterfat	WF-U:Depleted	Drought_36mo(t+2)	0.0071			2		Yes		
Winterfat	WF-U:SI	Winterfat	WF-U:SI	Cattle+Sheep-Grazing	0.0110		3		1	No		
Winterfat	WF-U:SI	Winterfat	WF-U:SI	Severe Drought	0.0071	0.1000	3			Yes		
Winterfat	WF-U:SI	Winterfat	WF-U:SI	Severe Drought	0.0071	0.9000	3		-1	No		
Winterfat	WF-U:SI	Winterfat	WF-U:SI	Very-Wet-Year	0.0181		50			Yes		
Winterfat	WF-U:SI	Winterfat	WF-U:SI	Wild-Horse-Grazing	0.0110		3		2	No		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Winterfat	WF-U:SI	Winterfat	WF-U:SI+AG	AG-Invasion	0.0010					No		
Winterfat	WF-U:SI+AG	Winterfat	WF-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Winterfat	WF-U:SI+AG	Winterfat	WF-U:Annual Spp	Wild-Horse-Grazing	0.0110			2		No		
Winterfat	WF-U:SI+AG	Winterfat	WF-U:SI	Competition	1.0000					No	3	
Winterfat	WF-U:SI+AG	Winterfat	WF-U:SI+AG	Cattle+Sheep-Grazing	0.0110		3		1	No		
Winterfat	WF-U:SI+AG	Winterfat	WF-U:SI+AG	ReplacementFire	0.0020					Yes		
Winterfat	WF-U:SI+AG	Winterfat	WF-U:SI+AG	Severe Drought	0.0071	0.1000	3			Yes		
Winterfat	WF-U:SI+AG	Winterfat	WF-U:SI+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Winterfat	WF-U:SI+AG	Winterfat	WF-U:SI+AG	Very-Wet-Year	0.0018		50			Yes		
Winterfat	WF-U:SI+AG	Winterfat	WF-U:SI+AG	Wet-Year	0.1000					No		
Winterfat	WF-U:SI+AG	Winterfat	WF-U:SI+AG	Wild-Horse-Grazing	0.0110		3		2	No		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-A:All	Cattle+Sheep-Grazing	0.0190	0.0005	3			Yes		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-A:All	Wild-Horse-Grazing	0.0190	0.9990			2	No		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Wild-Horse-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wild-Horse-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-A:All	Big Sagebrush semi-desert	BSsd-A:All	Range Shift	0.0080	0.7500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-A:All	Semi-Desert Grassland	SDG-A:Open	Range Shift	0.0080	0.2500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-A:All	Cattle+Sheep-Grazing	0.0190	0.9990	3		1	No		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0040					Yes		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Cattle+Sheep-Grazing	0.0190	0.0005	3			Yes		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-U:SAP-A	AG-Invasion	0.0025					No		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-A:All	Thin	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-B:Open	Wild-Horse-Grazing	0.0190	0.9990			2	No		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Cattle+Sheep-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Wild-Horse-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wild-Horse-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-B:Open	Cattle+Sheep-Grazing	0.0190	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Cattle+Sheep-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-U:SAP	AG-Invasion	0.0010					No		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	Spyke	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	Thin	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	Thin+Herbicide+Native-Seed	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	Thin+Native-Seed	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-C:Closed	Wild-Horse-Grazing	0.0190	0.9990			2	No		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Cattle+Sheep-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Wild-Horse-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-U:Depleted	Wild-Horse-Grazing	0.0190	0.0005			2	No		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-B:Open	Severe Drought	0.0070	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-C:Closed	Cattle+Sheep-Grazing	0.0190	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-C:Closed	Severe Drought	0.0070	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-D:Open	Tree-Invasion	0.0080		100			Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-U:Depleted	Cattle+Sheep-Grazing	0.0190	0.0005			1	No		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-U:SAP	AG-Invasion	0.0010					No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-C:Closed	Mastication	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-C:Closed	Small-Tree-Lopping	1.0000					Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-D:Open	Wild-Horse-Grazing	0.0190	0.9990			2	No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Cattle+Sheep-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Wild-Horse-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-U:Depleted	Wild-Horse-Grazing	0.0190	0.0005			2	No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-C:Closed	Severe Drought	0.0070	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-D:Open	Cattle+Sheep-Grazing	0.0190	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-D:Open	Severe Drought	0.0070	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-U:Depleted	Cattle+Sheep-Grazing	0.0190	0.0005			1	No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-U:SAP	AG-Invasion	0.0010			124		No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-U:TEA	AG-Invasion	0.0010		125			No		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-B:Open	Chaining+Native-Seed	1.0000	0.7000				Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-B:Open	Masticate+Native-Seed	1.0000	0.7500				Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Chaining+Native-Seed	1.0000	0.3000				Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Masticate+Native-Seed	1.0000	0.2500				Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-U:TEA	Tree-Encroachment	0.0071		200			No		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0080					Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-B:Open	Severe Drought	0.0070	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-E:Closed	Severe Drought	0.0070	0.9000			5	No		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-U:TEA	AG-Invasion	0.0010					No		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Chaining+Native-Seed	1.0000	0.5000		5		Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Chaining+Plateau+Seed	1.0000	0.1000		5		Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wild-Horse-Grazing	0.0190					No		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Chaining+Native-Seed	1.0000	0.5000		5		Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:SI-A	Chaining+Plateau+Seed	1.0000	0.8000		5		Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Chaining+Plateau+Seed	1.0000	0.1000		5		Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Herbicide-Plateau+Seed	1.0000	0.1500		5		Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Range Shift	0.0080	0.7500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Semi-Desert Grassland	SDG-U:SAP	Range Shift	0.0080	0.2500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Cattle+Sheep-Grazing	0.0190		3			No		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Herbicide-Plateau+Seed	1.0000	0.1500		5		Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	ReplacementFire	0.1000	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wyoming Big Sagebrush upland	WSup-U:SI-A	Herbicide-Plateau+Seed	1.0000	0.7000		5		Yes		
Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	AG-Invasion	0.0050							
Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Exotic-Invasion	0.0005					Yes		
Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Big Sagebrush semi-desert	BSsd-U:Bare Ground	Range Shift	0.0080	0.7500	1	1		No	60	
Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Semi-Desert Grassland	SDG-U:Bare Ground	Range Shift	0.0080	0.2500	1	1		No	60	
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Depleted	Chaining+Native-Seed	1.0000	0.3000				No		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Depleted	Small-Tree-Lopping	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Depleted	Small-Tree-Lopping	1.0000		100			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	2xChaining+Native-Seed	1.0000		60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Chaining+Native-Seed	1.0000	0.7000				No		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Spyke+Native-Seed	1.0000		60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Thin+Native-Seed	1.0000		60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Depleted	Severe Drought	0.0070	0.9000	60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	ReplacementFire	0.0100		60			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Severe Drought	0.0070	0.1000	60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:SA	AG-Invasion	0.0050		60			No		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:TEA	Tree-Invasion	0.0080		100			Yes		
Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Range Shift	0.0080	0.7500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Semi-Desert Grassland	SDG-U:Early-Shrub	Range Shift	0.0080	0.2500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	ReplacementFire	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Cattle+Sheep-Grazing	0.0190				1	No		
Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	ReplacementFire	0.0150							
Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Wild-Horse-Grazing	0.0190				2	No		
Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Range Shift	0.0080	0.7500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Semi-Desert Grassland	SDG-U:Early-Shrub	Range Shift	0.0080	0.2500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Cattle+Sheep-Grazing	0.0190	0.0010				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wild-Horse-Grazing	0.0190	0.0010				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA	Chaining+Seed	1.0000	0.1500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA	Small-Tree-Lopping	1.0000		100	150		Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA	Wild-Horse-Grazing	0.0190	0.9990			2	No		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SI-B	Chaining+Seed	1.0000	0.7000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Chaining+Seed	1.0000	0.1500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	ReplacementFire	0.0150					Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA	Cattle+Sheep-Grazing	0.0190	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA	Severe Drought	0.0070	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA+	Wet-Year	0.1000					No		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:TEA	Tree-Invasion	0.0080		100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Cattle+Sheep-Grazing	0.0190	0.0010				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wild-Horse-Grazing	0.0190	0.0010				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA	FineFuelDecomp	0.3300					No	2	
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Mastication	1.0000		100		39	Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Small-Tree-Lopping	1.0000		100	150		Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Wet-Year	0.1000					No		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Wild-Horse-Grazing	0.0190	0.9990			2	No		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	ReplacementFire	0.0225					Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Cattle+Sheep-Grazing	0.0190	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Severe Drought	0.0070	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:TEA	Tree-Invasion	0.0080		100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wild-Horse-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SA	Wild-Horse-Grazing	0.0190	0.0005			2	No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Severe Drought	0.0070	0.0900				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Wild-Horse-Grazing	0.0190	0.9990			2	No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP-A	ReplacementFire	0.0150	0.9500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Cattle+Sheep-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	ReplacementFire	0.0150	0.0500				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Severe Drought	0.0070	0.0100				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SA	Alternate-Succession2	0.0100		50			No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SA	Cattle+Sheep-Grazing	0.0190	0.0005			1	No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Cattle+Sheep-Grazing	0.0190	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Hypo-Hatchet-Spyke	1.0000	0.1000	100			No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Hypo-Hatchet-Spyke	1.0000	0.9000	100		39	Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Masticate+Native-Seed	1.0000		100		39	Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Severe Drought	0.0070	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Small-Tree-Lopping	1.0000		100	150	39	Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP+	Wet-Year	0.1000					No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:TEA	Tree-Invasion	0.0080		100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wild-Horse-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Exotic-Invasion	0.0005					No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SA+	Wild-Horse-Grazing	0.0190	0.0005			2	No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP	FineFuelDecomp	0.3300					No	2	
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Masticate+Herbicide+Seed	1.0000	0.1000	150		38	Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Wet-Year	0.1000					No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Wild-Horse-Grazing	0.0190	0.9990			2	No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Cattle+Sheep-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	ReplacementFire	0.0225					Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SA+	Cattle+Sheep-Grazing	0.0190	0.0005			1	No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Cattle+Sheep-Grazing	0.0190	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Hypo-Hatchet-Spyke	1.0000	0.1000	100			No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Hypo-Hatchet-Spyke	1.0000	0.9000	100		37	Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Severe Drought	0.0070	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Small-Tree-Lopping	1.0000		100	149	37	Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SI-C	Masticate+Herbicide+Seed	1.0000	0.7000	150			Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Masticate+Herbicide+Seed	1.0000	0.2000	150			Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:TEA	Tree-Invasion	0.0080		100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-A:All	Severe Drought	0.0070	0.0900				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Cattle+Sheep-Grazing	0.0190	0.0005						
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	ReplacementFire	0.0060	0.9500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Severe Drought	0.0070	0.0100				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wild-Horse-Grazing	0.0150	0.0050				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Wild-Horse-Grazing	0.0150	0.0050				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Exotic-Invasion	0.0006					No		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:SA	Cattle+Sheep-Grazing	0.0190	0.0005			1	No		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:SAP-A	Cattle+Sheep-Grazing	0.0190	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:SAP-A	ReplacementFire	0.0060	0.0500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:SAP-A	Severe Drought	0.0070	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wyoming Big Sagebrush upland	WSup-U:SAP-A	Wild-Horse-Grazing	0.0150	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Big Sagebrush semi-desert	BSsd-U:Annual Spp	Range Shift	0.0080	0.7500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:SAP-A	Semi-Desert Grassland	SDG-U:SAP	Range Shift	0.0080	0.2500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-A:All	Natural-Recovery	0.3300	1.0000	3	19		No	5	
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-B:Open	Natural-Recovery	0.3300	1.0000	20	59		No	5	
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-C:Closed	Natural-Recovery	0.3300	1.0000	60			No	5	

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	AG-Invasion	0.0010	1.0000		19		No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Cattle+Sheep-Grazing	0.0190	0.0005	3			Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Bare Ground	Wild-Horse-Grazing	0.0190	0.0005				Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Cattle+Sheep-Grazing	0.0190		3	5	1	Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Cattle+Sheep-Grazing	0.0190	0.0005	6			Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Drought 24mo(t+1)	0.0382			3		Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Severe Drought	0.0071	0.1000	4			Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wild-Horse-Grazing	0.0190			5		Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wild-Horse-Grazing	0.0190	0.0005	6			Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Exotic Forb	Exotic-Invasion	0.0005			19		No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:SAP	AG-Invasion	0.0010	1.0000	20			No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Cattle+Sheep-Grazing	0.0190	0.9990	6		1	No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	ReplacementFire	0.0020			19		Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	ReplacementFire	0.0100	1.0000	20			Yes		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Severe Drought	0.0071	0.9000	4		-1	No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wild-Horse-Grazing	0.0190	0.9990	6		2	No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Range Shift	0.0080	0.7500	1	1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Semi-Desert Grassland	SDG-U:Seeded Native	Range Shift	0.0080	0.2500	1	1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Drought_36mo(t+2)	0.0071			2		Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wild-Horse-Grazing	0.0190			2		Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:SI-A	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:SI-A	Severe Drought	0.0071	0.1000	3			Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:SI-A	Severe Drought	0.0071	0.9000	3		-1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:SI-A	Wild-Horse-Grazing	0.0190		3		2	No		
Wyoming Big Sagebrush upland	WSup-U:SI-A	Big Sagebrush semi-desert	BSsd-U:SI-A	Range Shift	0.0080	0.7500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:SI-A	Semi-Desert Grassland	SDG-U:SI	Range Shift	0.0080	0.2500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-A:All	Natural-Recovery	0.0000	1.0000	5	19		No	10	
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:SI-A	Cattle+Sheep-Grazing	0.0190		3		1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:SI-A	ReplacementFire	0.0010	1.0000		19		Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	AG-Invasion	0.0010	1.0000		19		No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Drought_36mo(t+2)	0.0071			2		Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wild-Horse-Grazing	0.0190			2		Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Wild-Horse-Grazing	0.0190	0.0010	3			Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Severe Drought	0.0071	0.1000	3			Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Severe Drought	0.0071	0.9000	3		-1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wild-Horse-Grazing	0.0190	0.9990	3		1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Range Shift	0.0080	0.7500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Semi-Desert Grassland	SDG-U:SI+AG	Range Shift	0.0080	0.2500		1	1	No	60	
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A	Competition	0.3300	1.0000				No	3	
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A	Herbicide-Plateau+Seed	1.0000	0.8000				No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Cattle+Sheep-Grazing	0.0190		3		1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Herbicide-Plateau+Seed	1.0000	0.2000				No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	ReplacementFire	0.0020	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wet-Year	0.1000	1.0000				No		
Wyoming Big Sagebrush upland	WSup-U:SI-B	Wyoming Big Sagebrush upland	WSup-U:SI-B	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Wyoming Big Sagebrush upland	WSup-U:SI-B	Wyoming Big Sagebrush upland	WSup-U:SI-B	Thin	1.0000					Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wyoming Big Sagebrush upland	WSup-U:SI-B	Wyoming Big Sagebrush upland	WSup-U:SI-B	Wild-Horse-Grazing	0.0190				2	No		
Wyoming Big Sagebrush upland	WSup-U:SI-B	Wyoming Big Sagebrush upland	WSup-B:Open	Natural-Recovery	0.0000					No	10	
Wyoming Big Sagebrush upland	WSup-U:SI-B	Wyoming Big Sagebrush upland	WSup-U:SI-A	ReplacementFire	0.0010					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-B	Wyoming Big Sagebrush upland	WSup-U:SI-B	Cattle+Sheep-Grazing	0.0190				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-B	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	AG-Invasion	0.0010					No		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wild-Horse-Grazing	0.0190				2	No		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	ReplacementFire	0.0020					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B	Competition	0.3300					No	3	
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B	Herbicide-Plateau+Seed	1.0000	0.8000				No		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Cattle+Sheep-Grazing	0.0190				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Herbicide-Plateau+Seed	1.0000	0.2000				No		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wet-Year	0.1000					No		
Wyoming Big Sagebrush upland	WSup-U:SI-C	Wyoming Big Sagebrush upland	WSup-U:SI-A	Thin	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C	Wyoming Big Sagebrush upland	WSup-U:SI-C	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Wyoming Big Sagebrush upland	WSup-U:SI-C	Wyoming Big Sagebrush upland	WSup-U:SI-C	Wild-Horse-Grazing	0.0190				2	No		
Wyoming Big Sagebrush upland	WSup-U:SI-C	Wyoming Big Sagebrush upland	WSup-U:SI-A	ReplacementFire	0.0010	1.0000	60			Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C	Wyoming Big Sagebrush upland	WSup-U:SI-C	Cattle+Sheep-Grazing	0.0190				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-C	Wyoming Big Sagebrush upland	WSup-U:SI-C	Natural-Recovery	0.0000	1.0000	60			No	10	
Wyoming Big Sagebrush upland	WSup-U:SI-C	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	AG-Invasion	0.0010	1.0000	60			No		
Wyoming Big Sagebrush upland	WSup-U:SI-C	Wyoming Big Sagebrush upland	WSup-U:SI-D	Tree-Invasion	0.0080	1.0000	100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Forb+Grass-Native-Seeding+Chaining	1.0000					No	5	
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wild-Horse-Grazing	0.0190				2	No		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	ReplacementFire	0.0020					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B	Thin+Herbicide+Native-Seed	1.0000	0.8000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Thin+Herbicide+Native-Seed	1.0000	0.2000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C	Competition	0.2000					No	3	
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Cattle+Sheep-Grazing	0.0190				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wet-Year	0.1000					No		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Tree-Invasion	0.0080		100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D	Wyoming Big Sagebrush upland	WSup-U:SI-B	Chaining+Seed	1.0000	1.0000	100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D	Wyoming Big Sagebrush upland	WSup-U:SI-D	Wild-Horse-Grazing	0.0190				2	No		
Wyoming Big Sagebrush upland	WSup-U:SI-D	Wyoming Big Sagebrush upland	WSup-D:Open	Natural-Recovery	0.0000	1.0000	100			No	10	
Wyoming Big Sagebrush upland	WSup-U:SI-D	Wyoming Big Sagebrush upland	WSup-U:SI-A	ReplacementFire	0.0010	1.0000	100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D	Wyoming Big Sagebrush upland	WSup-U:SI-C	Small-Tree-Lopping	1.0000	1.0000	100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D	Wyoming Big Sagebrush upland	WSup-U:SI-D	Cattle+Sheep-Grazing	0.0190				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-D	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	AG-Invasion	0.0010	1.0000	100			No		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wild-Horse-Grazing	0.0190				2	No		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	ReplacementFire	0.0020					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C	Masticate+Herbicide+Seed	1.0000	0.8000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Hypo-Hatchet-Spyke	1.0000	0.9500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Masticate+Herbicide+Seed	1.0000	0.2000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Mastication	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Small-Tree-Lopping	1.0000					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D	Competition	0.1000					No	3	
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Cattle+Sheep-Grazing	0.0190				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Hypo-Hatchet-Spyke	1.0000	0.0500				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems.

From Vegetation Type	From Class	To Vegetation Type	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wet-Year	0.1000					No		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Chaining+Seed	1.0000	0.1500				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	RxFire+Seed+Chain	1.0000	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SI-A	Chaining+Seed	1.0000	0.7000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SI-A	RxFire+Seed+Chain	1.0000	0.5000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Chaining+Seed	1.0000	0.1500				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	RxFire+Seed+Chain	1.0000	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:TEA	RxFire+Seed+Chain	1.0000	0.3000				No		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Masticate+Herbicide+Seed	1.0000	0.2500	150			Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	ReplacementFire	0.0075	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Spp	Severe Drought	0.0070	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SI-A	Masticate+Herbicide+Seed	1.0000	0.7000	150			Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Masticate+Herbicide+Seed	1.0000	0.0500	150			Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:TEA	Severe Drought	0.0070	0.9000				Yes		

Appendix 3 Unified Ecological Departure

Ecological Systems – Natural Range of Variability

For ecological systems, the primary metric used to report ecological condition is known as Unified Ecological Departure (UED). UED is a single, integrated measure that combines concepts of: (1) ecological departure in the traditional sense, (2) uncharacteristic vegetation classes that are particularly undesirable, and (3) allowable amounts of certain uncharacteristic vegetation classes that are benign or not harmful. Each of these three concepts will be described in turn below, followed by how they are merged into the metric of unified ecological departure.

Traditional Ecological Departure

In its traditional sense, ecological departure is a broad-scale measure of the condition or “health” of each ecological system. It was originally developed under the national LANDFIRE program as the concept of Fire Regime Condition (Rollins 2009) and has been used as the main measure of condition for ecological systems in many previous LCF projects in California, Nevada, and Utah. Ecological departure integrates species composition, vegetation structure, and disturbance regimes to estimate an ecological system’s *departure* from its natural range of variability. Technically, an ecological departure value calculates the dissimilarity between:

- (1) The percentages of a system’s vegetation classes expected under reference conditions (NRV, Table A3-1); and
- (2) The percentages of that system’s vegetation classes actually present on the landscape.

Traditional ecological departure thus summarizes, in a single number, how out-of-balance each ecological system is in terms of dissimilarity between the actual amounts of vegetation classes present in an area, and the amounts of those classes that would be expected to occur under a reference baseline of natural disturbance regimes and current climate (NRV).

Traditional ecological departure is scored on a scale of 0% to 100% departure from NRV: Zero percent represents NRV itself (no departure), while 100% represents total departure. In other words, higher numbers indicate increasing departure. These scores are further classified into “Ecological Departure Class” where: Class 1 represents low departure ($\leq 33\%$); Class 2 represents moderate departure (34 - 66%); and Class 3 represents high departure ($\geq 67\%$) (Hann et al. 2004; Rollins 2009). An example of the calculation of traditional ecological departure, and assignment to the corresponding ecological departure class, is shown in Table A3-2.

Table A3-1. Natural Range of Variability (%) for ecological systems of the Pine Valley-Mountain Home project area. Letters A to E indicate the succession position of a reference class. The terms All, Closed, and Open, respectively, refer to canopy closure of upper-layer life form relative to canopy closure potential of ecological system: variable, closed, and open canopy closure.

Ecological System	Vegetation Class	NRV (%)
Aspen Woodland	ASP-A:All	8
	ASP-B:Closed	25
	ASP-C:Closed	39
	ASP-D:Open	28
Aspen-Mixed Conifer	ASM-A:All	9
	ASM-B:Closed	32
	ASM-C:Closed	37
	ASM-D:Open	10
	ASM-E:Closed	12
Basin Wildrye	BW-A:All	20
	BW-B:Closed	62
	BW-C:Open	18
Big Sagebrush semi-desert	BSsd-A:All	7
	BSsd-B:Open	23
	BSsd-C:Closed	69
Black Sagebrush	BS-A:All	17
	BS-B:Open	51
	BS-C:Closed	19
	BS-D:Open	12
Calcareous Grassland	CG-A:Open	18
	CG-B:Closed	82
Curl-leaf Mountain Mahogany	CMM-A:All	8
	CMM-B:Open	13
	CMM-C:Closed	13
	CMM-D:Closed	33
	CMM-D:Open	33
Desert Wash	DWA-A:All	3
	DWA-B:Closed	10
	DWA-C:Closed	87
Four-Wing Saltbush	FWS-A:All	10
	FWS-B:Open	28
	FWS-C:Closed	62
Greasewood-Basin Big Sagebrush	GW-A:All	7
	GW-B:Closed	93
Juniper Savanna	JUN-A:All	3
	JUN-B:Open	6
	JUN-C:Open	26
	JUN-D:Open	65

Table A3-1. Natural Range of Variability (%) for ecological systems of the Pine Valley-Mountain Home project area. Letters A to E indicate the succession position of a reference class. The terms All, Closed, and Open, respectively, refer to canopy closure of upper-layer life form relative to canopy closure potential of ecological system: variable, closed, and open canopy closure.

Ecological System	Vegetation Class	NRV (%)
Limber-Bristlecone Pine	LB-A:All	10
	LB-B:Open	14
	LB-C:Open	76
Little-leaf Mountain Mahogany	LLMM-A:All	14
	LLMM-B:Open	64
	LLMM-C:Closed	22
Low Sagebrush	LS-A:All	10
	LS-B:Open	39
	LS-C:Closed	51
Mixed Conifer	MC-A:All	18
	MC-B:Closed	18
	MC-B:Open	18
	MC-C:Closed	25
	MC-C:Open	21
Mixed Salt Desert	MSD-A:All	8
	MSD-B:Open	89
	MSD-C:Open	2
Montane Riparian	MR-A:All	3
	MR-B:Open	92
	MR-C:Closed	5
Montane Sagebrush Steppe	MSS-A:All	21
	MSS-B:Open	34
	MSS-C:Closed	39
	MSS-D:Open	3
	MSS-E:Closed	2
Pickleweed	PW-A:All	100
Pinyon-Juniper	PJ-A:All	3
	PJ-B:Open	8
	PJ-C:Open	25
	PJ-D:Open	64
Playa	PL-A:Barren	100
Ponderosa Pine	PP-A:All	10
	PP-B:Closed	11
	PP-B:Open	32
	PP-C:Closed	3
	PP-C:Open	44
Saline Meadow	WMas-A:Open	1
	WMas-B:Closed	86
	WMas-C:Open	13

Table A3-1. Natural Range of Variability (%) for ecological systems of the Pine Valley-Mountain Home project area. Letters A to E indicate the succession position of a reference class. The terms All, Closed, and Open, respectively, refer to canopy closure of upper-layer life form relative to canopy closure potential of ecological system: variable, closed, and open canopy closure.

Ecological System	Vegetation Class	NRV (%)
Semi-Desert Grassland	SDG-A:Open	18
	SDG-B:Closed	82
Stansbury Cliffrose	SC-A:All	10
	SC-B:Closed	37
	SC-C:Open	53
Utah Serviceberry	US-A:All	9
	US-B:Closed	29
	US-C:Closed	60
	US-D:Open	3
Wet Meadow-Montane	WM-A:Open	5
	WM-B:Closed	90
	WM-C:Open	5
Winterfat	WF-A:All	15
	WF-B:Open	50
	WF-C:Closed	35
Wyoming Big Sagebrush upland	WSup-A:All	16
	WSup-B:Open	28
	WSup-C:Closed	42
	WSup-D:Open	6
	WSup-E:Closed	8

Table A3-2. Example of calculation of traditional Ecological Departure and assignment to Ecological Departure Class.

	Vegetation Class ¹						Sum
	A	B	C	D	E	U	
Natural range of variability (%)	20	50	15	10	5	0	100%
Current acres by class in project area	182	7,950	58,718	6,659	264	46,123	119,896 ac
Current % by class in project area	0.1	6.6	49.0	5.6	0.2	38.5	100%
Minimum of NRV % or Current %	0.1	6.6	15.0	5.6	0.2	0	27.5%
Ecological Departure (%) ²							72.5%
Ecological Departure Class ³							3

1. Standard LANDFIRE coding: A = early-development; B = mid-development, closed; C = mid-development, open; D = late-development, open; E = late-development, closed; and U = uncharacteristic.

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

3. Ecological Departure Class: 1 for $0\% \leq ED \leq 33\%$; 2 for $34\% \leq ED \leq 66\%$; 3 for $67\% \leq ED \leq 100\%$.

Undesirability of Certain Uncharacteristic Classes

Not all uncharacteristic (non-reference) vegetation classes are equal: Some uncharacteristic classes create heightened challenges because their presence represents significant ecological degradation or unacceptably high levels of hazard to public safety, and their restoration is either very difficult (ecologically) or very expensive, or both. Such classes are particularly undesirable and meet at least one of the three following criteria:

- (1) $\geq 5\%$ cover of invasive non-native species,
- (2) very expensive to restore, or
- (3) a direct pathway to one of the aforementioned classes (invaded or very expensive to restore).

In past LCF projects, TNC and partners used percent-area of these undesirable classes as a second measure of condition for ecological systems, alongside traditional ecological departure. This project does not report amounts of undesirable classes separately, though these classes do figure prominently into the measure of unified ecological departure, explained below. In ST-Sim’s Ecological Departure menu, the value of undesirable classes is termed “Undesirability” and ranges from 0 (neutral uncharacteristic class, such as dominated by rabbitbrush) to 2 (very bad such as invaded by Russian knapweed). The levels of Undesirability of uncharacteristic classes in the PV-MH project area are shown in Table A3-3.

Table A3-3. Level of undesirability (0 to 2) of uncharacteristic classes. If an uncharacteristic class is not listed, its undesirability level is assumed to be zero. Full description of classes appears in Appendix 1.

Ecological System	Class	Undesirability Level
Aspen Woodland	ASP-U:Depleted-B	1
	ASP-U:Depleted-C	1
	ASP-U:Depleted-D	1
	ASP-U->MSS:All	1
Aspen-Mixed Conifer	ASM-U->MC:All	1
Basin Wildrye	BW-U:Annual Spp	1
	BW-U:Bare Ground	1
	BW-U:Depleted	1
	BW-U:Early-Shrub	1
	BW-U:Exotic Forb	2
	BW-U:SAP	0
	BW-U:SAP+	1
	BW-U:Seeded Native	0
	BW-U:SI	0
	BW-U:SI+AG	0
	BW-U:TEA	1

Table A3-3. Level of undesirability (0 to 2) of uncharacteristic classes. If an uncharacteristic class is not listed, its undesirability level is assumed to be zero. Full description of classes appears in Appendix 1.

Ecological System	Class	Undesirability Level
Big Sagebrush semi-desert	BSsd-U:Annual Spp	1
	BSsd-U:Bare Ground	1
	BSsd-U:Depleted	1
	BSsd-U:Early-Shrub	0
	BSsd-U:SA	1
	BSsd-U:SA+	1
	BSsd-U:SAP	0
	BSsd-U:SAP+	1
	BSsd-U:Seeded Native	0
	BSsd-U:SI-A	0
	BSsd-U:SI-A+AG	0
	BSsd-U:SI-B	0
	BSsd-U:SI-B+AG	0
	BSsd-U:SI-C	0
	BSsd-U:SI-C+AG	0
	BSsd-U:TEA	1
Black Sagebrush	BS-U:Annual Spp	1
	BS-U:Bare Ground	1
	BS-U:Depleted	1
	BS-U:Early-Shrub	0
	BS-U:SA	1
	BS-U:SA+	1
	BS-U:SAP	0
	BS-U:SAP+	1
	BS-U:Seeded Native	0
	BS-U:SI-A	0
	BS-U:SI-A+AG	0
	BS-U:SI-B	0
	BS-U:SI-B+AG	0
	BS-U:SI-C	0
	BS-U:SI-C+AG	0
	BS-U:TEA	1
Calcareous Grassland	CG-U:Bare Ground	1
	CG-U:Depleted	0
	CG-U:Early-Shrub	0
	CG-U:SAP	1
	CG-U:SAP+	1
	CG-U:SAP-A	0
	CG-U:Seeded Native	0

Table A3-3. Level of undesirability (0 to 2) of uncharacteristic classes. If an uncharacteristic class is not listed, its undesirability level is assumed to be zero. Full description of classes appears in Appendix 1.

Ecological System	Class	Undesirability Level
Calcareous Grassland (Cont'd)	CG-U:SI	0
	CG-U:SI+AG	0
Curl-leaf Mountain Mahogany	CMM-U:Annual Spp	1
	CMM-U:SI	0
	CMM-U:SI+AG	0
	CMM-U:TEA	0
Desert Wash	DWA-U:Bare Ground	0
	DWA-U:Early-Shrub	1
	DWA-U:EFT	2
	DWA-U:SA	1
	DWA-U:SA+	0
	DWA-U:SAP	0
	DWA-U:SAP+	1
Four-Wing Saltbush	FWS-U:Annual Spp	1
	FWS-U:Bare Ground	1
	FWS-U:Depleted	0
	FWS-U:Early-Shrub	0
	FWS-U:SAP	0
	FWS-U:SAP+	1
	FWS-U:Seeded Native	0
	FWS-U:SI	0
FWS-U:SI+AG	0	
Greasewood-Basin Big Sagebrush	GW-U:Annual Spp	1
	GW-U:Bare Ground	1
	GW-U:Exotic Forb	2
	GW-U:SAP	1
	GW-U:SAP+	1
	GW-U:SI	0
Juniper Savanna	JUN-U:Annual Spp	1
	JUN-U:Bare Ground	1
	JUN-U:Early-Shrub	0
	JUN-U:SAP	0
	JUN-U:TEA	0
Little-leaf Mountain Mahogany	LLMM-U:Annual Spp	1
	LLMM-U:SAP	0
	LLMM-U:TEA	1
Low Sagebrush	LS-U:Annual Spp	1
	LS-U:Bare Ground	1
	LS-U:Depleted	1

Table A3-3. Level of undesirability (0 to 2) of uncharacteristic classes. If an uncharacteristic class is not listed, its undesirability level is assumed to be zero. Full description of classes appears in Appendix 1.

Ecological System	Class	Undesirability Level
Low Sagebrush (Cont'd)	LS-U:Early-Shrub	0
	LS-U:SA	1
	LS-U:SA+	1
	LS-U:SAP	0
	LS-U:SAP+	1
	LS-U:SAP-A	0
	LS-U:Seeded Native	0
	LS-U:SI-A	0
	LS-U:SI-A+AG	0
	LS-U:SI-B	0
	LS-U:SI-B+AG	0
	LS-U:SI-C	0
	LS-U:SI-C+AG	0
	LS-U:TEA	1
Mixed Conifer	MC-U:Annual Spp	0
	MC-U:TEA	0
Mixed Salt Desert	MSD-U:Annual Spp	1
	MSD-U:Bare Ground	1
	MSD-U:Early-Shrub	0
	MSD-U:Exotic Forb	2
	MSD-U:SAP	0
	MSD-U:SAP+	1
	MSD-U:Seeded Native	0
	MSD-U:SI	0
MSD-U:SI+AG	0	
Montane Riparian	MR-U:Annual Spp	1
	MR-U:Bare Ground	1
	MR-U:Desertified	1
	MR-U:EFT	2
	MR-U:Hummocked	1
	MR-U:SAP	1
	MR-U:Seeded Native	0
	MR-U:SFE	0
	MR-U:SI+AG	1
MR-U:TEA	1	
Montane Sagebrush Steppe	MSS-U:Annual Spp	1
	MSS-U:Bare Ground	1
	MSS-U:Depleted	1
	MSS-U:Early-Shrub	0

Table A3-3. Level of undesirability (0 to 2) of uncharacteristic classes. If an uncharacteristic class is not listed, its undesirability level is assumed to be zero. Full description of classes appears in Appendix 1.

Ecological System	Class	Undesirability Level
Montane Sagebrush Steppe (Cont'd)	MSS-U:SA	1
	MSS-U:SA+	1
	MSS-U:SAP	0
	MSS-U:SAP	0
	MSS-U:SAP+	1
	MSS-U:Seeded Native	0
	MSS-U:SI-A	0
	MSS-U:SI-A+AG	0
	MSS-U:SI-B	0
	MSS-U:SI-B+AG	0
	MSS-U:SI-C	0
	MSS-U:SI-C+AG	0
	MSS-U:SI-D	0
	MSS-U:SI-D+AG	0
	MSS-U:TEA	1
Pinyon-Juniper Woodland	PJ-U:Annual Spp	1
	PJ-U:Bare Ground	1
	PJ-U:Exotic Forb	1
	PJ-U:SAP	0
	PJ-U:SI	0
	PJ-U:SI+AG	0
	PJ-U:TEA	0
Ponderosa Pine	PP-U:Annual Spp	1
	PP-U:Bare Ground	1
	PP-U:FIC-B-Closed	1
	PP-U:FIC-B-Open	0
	PP-U:FIC-C-Closed	1
	PP-U:FIC-C-Open	0
	PP-U:SI	0
	PP-U:SI+AG	0
	PP-U:TEA	0
Saline Meadow	WMas-U:AGPG	0
	WMas-U:Annual Spp	1
	WMas-U:Bare Ground	1
	WMas-U:Depleted	1
	WMas-U:Exotic Forb	2
	WMas-U:SAP	0
Semi-desert Grassland	SDG-U:Bare Ground	1
	SDG-U:Depleted	1

Table A3-3. Level of undesirability (0 to 2) of uncharacteristic classes. If an uncharacteristic class is not listed, its undesirability level is assumed to be zero. Full description of classes appears in Appendix 1.

Ecological System	Class	Undesirability Level
Semi-desert Grassland (Cont'd)	SDG-U:Early-Shrub	0
	SDG-U:SAP	0
	SDG-U:SAP+	1
	SDG-U:Seeded Native	0
	SDG-U:SI	0
	SDG-U:SI+AG	0
	SDG-U:TEA	1
	Stansbury Cliffrose	SC-U:Annual Spp
	SC-U:Bare Ground	1
	SC-U:Depleted	1
	SC-U:Early-Shrub	0
	SC-U:SAP	0
	SC-U:SAP+	1
	SC-U:Seeded Native	0
	SC-U:SI-A	0
	SC-U:SI-A+AG	0
	SC-U:SI-B	0
	SC-U:SI-B+AG	0
	SC-U:SI-C	0
	SC-U:SI-C+AG	0
	SC-U:TEA	1
Utah Serviceberry	US-U:Annual Spp	1
	US-U:Bare Ground	1
	US-U:Depleted	1
	US-U:Early-Shrub	0
	US-U:SAP	0
	US-U:SAP+	1
	US-U:SI-A	0
	US-U:SI-A+AG	0
	US-U:SI-B	0
	US-U:SI-B+AG	0
	US-U:SI-C	0
	US-U:SI-C+AG	0
	US-U:SI-D	0
	US-U:SI-D+AG	0
	US-U:TEA	1
Wet Meadow-Montane	WM-U:Annual Spp	1
	WM-U:Bare Ground	1
	WM-U:Desertified	1

Table A3-3. Level of undesirability (0 to 2) of uncharacteristic classes. If an uncharacteristic class is not listed, its undesirability level is assumed to be zero. Full description of classes appears in Appendix 1.

Ecological System	Class	Undesirability Level
Wet Meadow-Montane (Cont'd)	WM-U:Early-Shrub	1
	WM-U:Exotic Forb	2
	WM-U:Hummocked	1
	WM-U:SA	1
	WM-U:SFE	0
	WM-U:TEA	1
	Winterfat	WF-U:Annual Spp
WF-U:Bare Ground		1
WF-U:Depleted		1
WF-U:Exotic Forb		2
WF-U:SA		1
WF-U:SA+		1
WF-U:SAP		0
WF-U:SAP+		1
WF-U:SAP-A		0
WF-U:Seeded Native		0
WF-U:SI		0
WF-U:SI+AG	0	
Wyoming Big Sagebrush-Upland	WSup-U:Annual Spp	1
	WSup-U:Bare Ground	1
	WSup-U:Depleted	1
	WSup-U:Early-Shrub	0
	WSup-U:Exotic Forb	2
	WSup-U:SA	1
	WSup-U:SA+	1
	WSup-U:SAP	0
	WSup-U:SAP+	1
	WSup-U:SAP-A	0
	WSup-U:Seeded Native	0
	WSup-U:SI-A	0
	WSup-U:SI-A+AG	0
	WSup-U:SI-B	0
	WSup-U:SI-B+AG	0
	WSup-U:SI-C	0
	WSup-U:SI-C+AG	0
	WSup-U:SI-D	0
WSup-U:SI-D+AG	0	
WSup-U:TEA	1	

Allowable Thresholds of Certain Uncharacteristic Classes

Some uncharacteristic classes have been expressly created by managers to meet management objectives. Classes of this type do not represent significant ecological degradation (e.g. severe soil loss) or high levels of public-safety hazard (e.g. copious fuel buildups). Moreover, they often benefit wildlife. Classic examples of such classes are seedings with non-native introduced species such as crested wheatgrass, where a complement of native shrubs, forbs and grasses is still present. These classes are acceptable or “allowable” in moderation – i.e., in amounts up to an agreed-upon threshold for each one. Allowable classes included irrigated pastures in wetter systems, native species seedings, and seeding containing in whole or part introduced species (e.g., crested wheatgrass and forage kochia). BLM managers and experts defined the threshold of allowable uncharacteristic classes at 60% for non-native seeded classes within each ecological system because of an extensive legacy of old seedings that have undergone woody succession. Devotion of scarce management/restoration funds to “fixing” sub-threshold amounts of these allowable (but still uncharacteristic) classes had minimal priority – far lower than projects that focus on treating highly undesirable vegetation classes.

These harmless or benign uncharacteristic classes were formally labeled as “Threshold Percent” in the ST-Sim Ecological Departure menu, and are labeled as Allowable Threshold Percent in Table A3-4. Their presence contributes to the integrated measure of unified ecological departure, described in the following section.

Table A3-4. Percent threshold of class area per ecological system below which no ecological departure accumulates and above which ecological departure accrues normally. Among seeded classes, the total threshold of 60% is distributed following the same distribution as in the NRV of reference classes.

Ecological System	Vegetation Class	Allowable Threshold Percent
Basin Wildrye- Montane		
	BW-U:Seeded Native	20
	BW-U:SI	60
Big Sagebrush-semidesert		
	BSsd-U:Seeded Native	7
	BSsd-U:SI-A	4.2
	BSsd-U:SI-B	15.6
	BSsd-U:SI-C	40.2
Black Sagebrush		
	BS-U:Seeded Native	9
	BS-U:SI-A	9.6
	BS-U:SI-B	30
	BS-U:SI-C	11.4
Calcareous Grassland		
	CG-U:Seeded Native	18
	CG-U:SI	60

Table A3-4. Percent threshold of class area per ecological system below which no ecological departure accumulates and above which ecological departure accrues normally. Among seeded classes, the total threshold of 60% is distributed following the same distribution as in the NRV of reference classes.

Ecological System	Vegetation Class	Allowable Threshold Percent
Four-Wing Saltbush		
	FWS-U:Seeded Native	10
	FWS-U:SI	60
Greasewood		
	GW-U:SI	60
Low Sagebrush		
	LS-U:Seeded Native	10
	LS-U:SI-A	10
	LS-U:SI-B	6
	LS-U:SI-C	25.8
Mixed Salt Desert		
	MSD-U:Seeded Native	8
	MSD-U:SI	60
Montane Sagebrush Steppe		
	MSS-U:Seeded Native	22
	MSS-U:SI-A	13.2
	MSS-U:SI-B	20.4
	MSS-U:SI-C	24
	MSS-U:SI-D	1.8
Pinyon-Juniper Woodland		
	PJ-U:SI	60
Semi-desert Grassland		
	SDG-U:Seeded Native	18
	SDG-U:SI	60
Stansbury Cliffrose		
	SC-U:Seeded Native	9
	SC-U:SI-A	6
	SC-U:SI-B	26.4
	SC-U:SI-C	28.2
Utah Serviceberry		
	US-U:SI-A	5.4
	US-U:SI-B	16.8
	US-U:SI-C	36
	US-U:SI-D	1.2
Winterfat		
	WF-U:Seeded Native	15
	WF-U:SI	60

Table A3-4. Percent threshold of class area per ecological system below which no ecological departure accumulates and above which ecological departure accrues normally. Among seeded classes, the total threshold of 60% is distributed following the same distribution as in the NRV of reference classes.

Ecological System	
Vegetation Class	Allowable Threshold Percent
Wyoming Big Sagebrush-Upland	
WSup-U:Seeded Native	16
WSup-U:SI-A	9.6
WSup-U:SI-B	16.8
WSup-U:SI-C	27
WSup-U:SI-D	5.4

Unified Ecological Departure

Unified ecological departure gives a more realistic accounting of condition or health of ecological systems, as it incorporates traditional ecological departure, levels of undesirability for uncharacteristic vegetation classes, and threshold percentage of allowable classes. Importantly, the concept of UED also solves a double-counting problem in which the same class had been counted twice in prior LCF projects that used both traditional departure and the concept of “High Risk Vegetation Classes” in certain calculations. Finally, as with traditional departure, the UED measure may not reliably measure condition of ecological systems with very small areas of occurrence, such as wetlands or meadows.

Appendix 4. Management Actions/Treatments and Costs in Ecological Systems

Ecological System →	Aspen Woodland	Aspen Mixed Conifer	Basin Wildrye	Big Sagebrush semi-desert	Black Sagebrush
Management Action/Treatment ↓					
2xChaining+Native-Seed				\$242.50	\$242.50
2xChaining+Plateau+Seed				\$185.00	\$230.00
2xChaining+Seed			\$202.50		\$202.50
Aerial-Seed					
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow			\$306.50	\$306.50	\$306.50
Aerial-Spyke+Aerial-Seed+Chain-Harrow			\$266.50	\$266.50	\$266.50
Chaining+Native-Seed				\$245.00	\$205.00
Chaining+Plateau+Native-Seed				\$275.00	\$232.50
Chaining+Plateau+Seed				\$160.00	\$160.00
Chaining+Seed					\$165.00
Chainsaw-Thinning	\$112.50	\$150.00			\$112.50
Exotic-Control			\$320.00		
Exotic-Control+Native-Seed			\$360.00		
Fence	\$10,000.00	\$10,000.00			
Floodplain-Restoration					
Forb+Grass-Native-Seeding+Chaining			\$160.00	\$160.00	\$160.00
Grass-Seeding					
Herbicide-Plateau					
Herbicide-Plateau+Native-Seed					
Herbicide-Plateau+Planting					
Herbicide-Plateau+Seed			\$117.50	\$130.00	\$117.50
Hypo-Hatchet-Spyke					\$37.50
Masticate+Herbicide+Native-Seed			\$645.00		
Masticate+Herbicide+Seed			\$700.00		\$605.00
Masticate+Native-Seed			\$720.00		\$617.50
Masticate+PIPO-Planting					
Masticate+Seed					\$577.50
Mastication					\$475.00
RxFire	\$300.00	\$300.00	\$200.00		
RxFire+Seed+Chain					\$365.00
Shrub+Grass-Seeding					
Small-Rock-Dam					
Small-Tree-Lopping	\$60.00		\$112.50		\$150.00
Spot-Herbicide+Native-Seed					
Spyke				\$30.00	
Spyke+Native-Seed			\$172.50	\$172.50	\$205.00
Spyke+Plateau+Native-Seed					
Thin			\$35.00	\$35.00	\$35.00
Thin+Herbicide+Native-Seed			\$130.00	\$180.00	
Thin+Herbicide+Seed					
Thin+Native-Seed			\$115.00	\$165.00	\$160.00
Water-Table-Uplift					
Weed-Inventory+Treat			\$253.00		

Appendix 4. Management Actions/Treatments and Costs in Ecological Systems

Ecological System →	Calcareous Grassland	Desert Wash	Four- Wing Saltbush	Greasewood Basin Big Sagebrush	Low Sagebrush	Mixed Conifer
Management Action/Treatment ↓						
2xChaining+Native-Seed						
2xChaining+Plateau+Seed						
2xChaining+Seed						
Aerial-Seed						
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow					\$306.50	
Aerial-Spyke+Aerial-Seed+Chain-Harrow					\$266.50	
Chaining+Native-Seed	\$205.00				\$205.00	
Chaining+Plateau+Native-Seed						
Chaining+Plateau+Seed	\$192.50		\$192.50	\$192.50		
Chaining+Seed						
Chainsaw-Thinning						\$150.00
Exotic-Control		\$320.00				
Exotic-Control+Native-Seed						
Fence						
Floodplain-Restoration						
Forb+Grass-Native-Seeding+Chaining	\$160.00					
Grass-Seeding						
Herbicide-Plateau						
Herbicide-Plateau+Native-Seed					\$140.00	
Herbicide-Plateau+Planting						
Herbicide-Plateau+Seed			\$130.00	\$117.50		
Hypo-Hatchet-Spyke						
Masticate+Herbicide+Native-Seed						
Masticate+Herbicide+Seed						
Masticate+Native-Seed						
Masticate+PIPO-Planting						
Masticate+Seed						
Mastication						
RxFire					\$200.00	
RxFire+Seed+Chain						
Shrub+Grass-Seeding						
Small-Rock-Dam						
Small-Tree-Lopping					\$150.00	
Spot-Herbicide+Native-Seed					\$140.00	
Spyke						
Spyke+Native-Seed						
Spyke+Plateau+Native-Seed						
Thin	\$35.00				\$35.00	
Thin+Herbicide+Native-Seed	\$180.00					
Thin+Herbicide+Seed	\$115.00		\$115.00			
Thin+Native-Seed			\$135.00			
Water-Table-Uplift						
Weed-Inventory+Treat		\$253.00				

Appendix 4. Management Actions/Treatments and Costs in Ecological Systems

Ecological System →	Mixed Salt Desert	Montane Riparian	Montane Sagebrush Steppe	Pinyon Juniper	Ponderosa Pine	Saline Meadow
Management Action/Treatment ↓						
2xChaining+Native-Seed			\$242.50			
2xChaining+Plateau+Seed						
2xChaining+Seed						
Aerial-Seed				\$20.00		
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow			\$306.50			
Aerial-Spyke+Aerial-Seed+Chain-Harrow	\$266.50		\$266.50			
Chaining+Native-Seed			\$205.00			
Chaining+Plateau+Native-Seed						
Chaining+Plateau+Seed	\$192.50		\$192.50			
Chaining+Seed			\$165.00	\$165.00		
Chainsaw-Thinning		\$150.00		\$150.00	\$112.50	
Exotic-Control		\$360.00		\$430.00		\$360.00
Exotic-Control+Native-Seed						
Fence		\$8,000.00				
Floodplain-Restoration		\$2,000.00				
Forb+Grass-Native-Seeding+Chaining			\$160.00			
Grass-Seeding						
Herbicide-Plateau	\$15.00					
Herbicide-Plateau+Native-Seed						\$140.00
Herbicide-Plateau+Planting						
Herbicide-Plateau+Seed	\$117.50		\$117.50			
Hypo-Hatchet-Spyke			\$37.50			
Masticate+Herbicide+Native-Seed						
Masticate+Herbicide+Seed			\$605.00			
Masticate+Native-Seed			\$617.50	\$617.50		
Masticate+PIPO-Planting					\$1,120.00	
Masticate+Seed			\$577.50	\$670.00		
Mastication			\$475.00			
RxFire			\$100.00		\$200.00	
RxFire+Seed+Chain			\$365.00			
Shrub+Grass-Seeding						
Small-Rock-Dam		\$500.00				
Small-Tree-Lopping		\$150.00	\$150.00			
Spot-Herbicide+Native-Seed						
Spyke						
Spyke+Native-Seed			\$205.00			
Spyke+Plateau+Native-Seed						
Thin	\$35.00		\$35.00			\$150.00
Thin+Herbicide+Native-Seed						\$180.00
Thin+Herbicide+Seed						
Thin+Native-Seed			\$160.00			\$165.00
Water-Table-Uplift		\$500.00				
Weed-Inventory+Treat		\$253.00				\$253.00

Appendix 4. Management Actions/Treatments and Costs in Ecological Systems

Ecological System →						
Management Action/Treatment ↓	Semi-Desert Grassland	Stansbury Cliffrose	Utah Serviceberry	Wet Meadow-Montane	Winterfat	Wyoming Big Sagebrush-upland
2xChaining+Native-Seed						\$242.50
2xChaining+Plateau+Seed						
2xChaining+Seed						
Aerial-Seed						
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	\$306.50			\$306.50		\$306.50
Aerial-Spyke+Aerial-Seed+Chain-Harrow	\$266.50			\$266.50		\$266.50
Chaining+Native-Seed	\$205.00	\$245.00	\$245.00			\$205.00
Chaining+Plateau+Native-Seed			\$275.00			
Chaining+Plateau+Seed	\$192.50		\$192.50			\$192.50
Chaining+Seed			\$165.00			\$165.00
Chainsaw-Thinning		\$112.50	\$112.50			
Exotic-Control				\$360.00		
Exotic-Control+Native-Seed						
Fence				\$8,000.00		
Floodplain-Restoration				\$2,000.00		
Forb+Grass-Native-Seeding+Chaining	\$160.00		\$160.00			\$160.00
Grass-Seeding					\$125.00	
Herbicide-Plateau		\$15.00				
Herbicide-Plateau+Native-Seed					\$140.00	
Herbicide-Plateau+Planting					\$140.00	
Herbicide-Plateau+Seed			\$130.00			\$117.50
Hypo-Hatchet-Spyke						\$37.50
Masticate+Herbicide+Native-Seed		\$645.00				
Masticate+Herbicide+Seed	\$700.00		\$700.00			\$605.00
Masticate+Native-Seed			\$617.50			\$617.50
Masticate+PIPO-Planting						
Masticate+Seed			\$577.50			
Mastication						\$475.00
RxFire			\$100.00			
RxFire+Seed+Chain			\$365.00			\$365.00
Shrub+Grass-Seeding					\$175.00	
Small-Rock-Dam				\$500.00		
Small-Tree-Lopping		\$112.50	\$112.50	\$112.50		\$75.00
Spot-Herbicide+Native-Seed		\$140.00				
Spyke						\$30.00
Spyke+Native-Seed						\$205.00
Spyke+Plateau+Native-Seed		\$220.00				
Thin	\$35.00			\$150.00		\$35.00
Thin+Herbicide+Native-Seed	\$180.00		\$180.00	\$180.00		\$155.00
Thin+Herbicide+Seed	\$115.00		\$115.00			
Thin+Native-Seed	\$165.00					\$140.00
Water-Table-Uplift				\$500.00		
Weed-Inventory+Treat				\$253.00		