

Landscape Conservation Forecasting™ Hamlin Valley and Black Mountains

Report to Bureau of Land Management, Cedar City Field Office
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Executive Summary

Introduction

The Cedar City Field Office (CCFO) of the Bureau of Land Management (BLM) is located in southwestern Utah in the Great Basin ecoregion, and encompasses approximately 2.1 million acres of public land in Beaver, Iron, and a small portion of Washington Counties, Utah. The BLM and The Nature Conservancy (TNC) are jointly investigating issues of vegetation, fire, and sensitive species in the CCFO that the BLM can utilize in future decision making.

Accordingly, in September 2012 the BLM entered into a Cooperative Agreement with TNC to apply the *Landscape Conservation Forecasting*[™] (LCF[™]) process – including satellite imagery, remote sensing, predictive ecological management models, and cost-benefit assessments – to two large landscapes within the CCFO known as Hamlin Valley and Black Mountains. As written in the Agreement itself:

“The primary objective is to develop a realistic and cost-effective management plan for ecological systems of Hamlin Valley and Black Mountains that forecasts ecological condition of all ecological systems using 3-4 alternative management scenarios chosen by stakeholders. An important secondary objective is to work cooperatively with BLM staff and selected stakeholders to develop a common set of land management goals and assumptions about the ecology of the project area, and reach agreement on the credibility of forecasted results that could eventually be incorporated in BLM plans and actions.”

These two large landscapes within the CCFO are also important for two high-profile wildlife species. Hamlin Valley and Black Mountains both support populations of Greater sage-grouse (*Centrocercus urophasianus*). The Black Mountains also contain populations of the Utah prairie dog (*Cynomys parvidens*), which is federally listed as Threatened. The traditional nature of this LCF[™] project was thus expanded beyond the scope of the Cooperative Agreement to address conditions of habitat suitability – both current and predicted into the future – for sage-grouse and Utah prairie dog.

The Hamlin Valley and Black Mountains project areas together encompass about 630,000 acres (255,000 ha) of largely undeveloped lands. The Hamlin Valley project area is bordered to the west by the Nevada state line. The Black Mountains area lies just west of the Interstate 15 highway corridor and the western margin of the Utah High Plateaus.

Hamlin Valley is a classic basin and range valley bordered on either side by mountain ranges, and draining north along a north-south long axis orientation. The geology is made of carbonate sedimentary and volcanic rocks. The Black Mountains are a more circular low range surrounded by extensive subxeric flat desert lands to the south and west, and by the rapid rise of the High Plateaus to the east. Their geology is primarily volcanic.

The populations of Greater sage-grouse in both landscapes are small and some of the most southern in the species' entire range. The Black Mountains population of the Utah prairie dog

is one of the healthiest populations of that species, and this is the most important area that will promote species recovery within the Southwest Desert.

A series of interrelated ecological changes and management concerns have developed over a period of time in and around these two large landscapes. One of these has been the invasion, spread and proliferation of non-native annual grasses, particularly cheatgrass (*Bromus tectorum*), through much of the lower and middle elevations of the project areas. This has greatly increased the volume of fine fuels, and has contributed to significant increases in fire frequency and intensity in the past few decades, especially in the Black Mountains.

Not only has this degraded the ecological integrity of affected vegetation communities, it has also led to large ignition risks and wildfire hazards to human populations and infrastructure, especially in the Black Mountains on account of their proximity to Cedar City and to major transportation corridors. Where significant fires have occurred, restoration of the burned areas becomes an important goal.

Elsewhere in the two large landscapes, increases in coverage of coniferous trees – Utah juniper and pinyon pine at middle elevations, montane conifers at upper elevations – have degraded the ecological integrity of shrublands and forests. These out-of-balance buildups of conifers have also led to alteration of fire regimes and development of greater fire hazards.

The elevated conservation status of Greater sage-grouse and Utah prairie dog heightens the concern for prevention of or restoration from degraded habitat conditions that have been caused by the factors noted above.

This LCF™ project aims to provide BLM managers with a systematic process to identify future site-specific, cost-effective vegetation and fire-management projects to protect, enhance and restore ecological and species-habitat conditions in these large landscapes of the CCFO.

Process and Methods

The Landscape Conservation Forecasting™ process for the BLM Cedar City Field Office consists of six 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 Great Basin and Mojave Desert "library" of models, 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 and Utah prairie dog using the metric of Functional Acres.

4. Use the computerized ecological models to forecast anticipated future condition of ecological systems, and of habitat suitability for the two species, under minimum management (analogous to the “no-action” alternative of NEPA).
5. Use the computerized ecological models to forecast anticipated future condition of ecological systems, and of habitat suitability for the two species, under alternative “active” management scenarios (suites of specific actions or treatments).
6. Use Return On Investment (ROI) analyses to assess which actions for which ecological systems yield the most advantageous (“bang for the buck”) results for the systems and the two species’ habitats.

TNC contracted with Spatial Solutions Inc. to produce maps of ecological systems and their current vegetation classes via remote sensing of satellite imagery, verified by observations from extensive on-the-ground field trips that occurred in October 2012 and June-July 2013. Twenty-six ecological systems and a large number of reference (basically pre-settlement status) and anthropogenically altered (termed “uncharacteristic”) vegetation classes were mapped on the two Project Areas.

To develop the predictive ecological models used in this project, existing state-and-transition models in the TNC library were revised by local experts to reflect decisions regarding the project’s ecological systems, vegetation classes, and disturbances.

The models also contain transitions among classes that represent several types of pathways including vegetation *succession* (the passage of time); *ecological processes* such as fire or flooding; *disturbances* such as annual grass invasion or arroyo downcutting; and *active management treatments* such as mechanical thinning, herbicide, or prescribed fire. Models were constructed and run using the modeling software ST-Sim, a product of ApexRMS, Ltd.

In past LCF™ projects, non-spatial modeling was conducted because there were no explicit spatial questions that justified the increased complexity of spatial modeling. However, because this CCFO project incorporates habitat suitability for two species, where the species’ fitness depends on the proximity of landscape features, spatial modeling was required. 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 species habitat suitability, and future simulated vegetation rasters allow estimation of future species habitat suitability.

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 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 unharmed or benign, such as introduced species seedings.

Ecological departure in its traditional sense is a value generated by calculating the *dissimilarity* between: (1) the amounts of vegetation classes expected under reference (pre-settlement)

conditions; and (2) the amounts of vegetation classes that are currently present on the landscape. In other words, traditional ecological departure summarizes, in a single number, how out-of-balance each ecological system is in terms of dissimilarity between the current amounts of its vegetation classes that are present in an area, and the amounts of those classes that would be expected to occur under a reference baseline of natural disturbance regimes.

UED thus gives a more realistic accounting of condition or health, and is the official metric of condition for ecological systems in this report. However, identities of highly undesirable vegetation classes are also reported, as added information for managers because these classes are usually the targets at which treatment actions are aimed. In other words, the specific identities of highly undesirable classes in an ecological system can be masked within the UED measure, so these classes are also shown as the “problems” that largely drive the selection of treatment actions.

The condition of habitat for the two species of concern – Greater sage-grouse and Utah prairie dog – was reported at the landscape-scale using the metric 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.

For Greater sage-grouse, heuristic RSFs were developed because only very limited movement data and no demographic data exist from collared sage-grouse from the distinct Hamlin Valley and Black Mountains populations. Without sufficient data, especially demographic data, it was not possible to build statistical logistic regression equations representing different RSFs. Using sage-grouse demographic and movement data from the entire State of Utah, experts assisted with defining the shape of RSFs that had the strongest effect on sage-grouse habitat suitability. Each RSF was bound between 0 (not suitable) and 1 (very suitable). The independent variables for the different RSFs were either the distance to the closest critical attribute (e.g., type of vegetation, busy road), the proportion of a feature in the surrounding habitat, or the contribution of a pixel’s vegetation type to the seasonal habitat.

Proceeding from a March 2014 expert workshop in Salt Lake City, sage-grouse RSFs were divided into three seasonal sets:

- nesting (nest site selection and nest success, also called breeding): five RSFs.
- summer (brood-rearing): five RSFs.
- winter: three RSFs.

The summary habitat suitability of each seasonal set was the average of its component RSFs (5, 5, and 3 respectively), which thus assumes that all functions had the same importance within each season.

The overall habitat suitability across all three seasons was the average of the individual seasonal RSFs multiplied by their evenness (per Simpson’s evenness index). The resulting overall value per pixel was between 0 (not suitable) and 1 (very suitable). Statistical habitat

suitability models are not constructed as such, especially not using an evenness index. However, in the absence of a more formal approach, the above calculations accounted for both the contribution of seasonal habitat suitability (poor to excellent), and whether some seasonal habitats were deficient and, as a result, lowered the overall habitat suitability as done in more formal per-capita population growth model estimation for sage-grouse in Eureka County, Nevada..

For Utah prairie dog, found only in the Black Mountains project area, calculation of habitat suitability is not seasonal and far simpler. Proceeding from the March 2014 expert workshop in Salt Lake City, two RSFs were calculated based on vegetation classes and distance to prairie dog towns. These two RSFs were considered equally important, thus overall habitat suitability for Utah prairie dog was simply the average of the two functions, bounded between 0 and 1.

In addition to habitat suitability, the more intuitive *functional area* metric was calculated. Functional area is a single landscape-wide metric, unlike UED that is measured separately for each ecological system. Expressed in acres or hectares, functional area is the sum over all pixels in a landscape of the product of the area of each pixel by the overall habitat suitability (scaled 0 to 1) of that pixel. It can also be calculated as the area of a pixel (all the same in a grid) multiplied by the sum of the overall habitat suitability (scaled 0 to 1) of each pixel in the landscape. By definition, functional area is always equal or smaller than the size of the landscape.

Using the computer-based models, TNC simulated the likely future condition of each ecological system (measured by unified ecological departure), and of greater sage-grouse and Utah prairie dog (measured by habitat suitability), after 25 years under a scenario of *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. Potential sources of future ecosystem alteration were explicitly included in the *MINIMUM MANAGEMENT* model simulations. These sources include increased invasion rates of non-native species (annual grasses and exotic forbs), increased tree encroachment rates in shrublands, modified mean fire return intervals in shrublands, livestock grazing, and periodic “natural” events such as floods and drought.

Eleven ecological systems were selected for analyses of future management in Hamlin Valley and Black Mountains, though not all eleven occur in both areas. These ecological 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.

Future simulations of active management are **the heart of the LCF process**, per the project’s Cooperative Agreement that states the following with regard to its objectives:

The primary objective is to develop a realistic and cost-effective management plan for ecological systems of Hamlin Valley and Black Mountains that forecasts ecological

condition of all ecological systems using 3-4 alternative management scenarios chosen by stakeholders.

Accordingly, TNC and BLM-CCFO staff worked jointly on three interrelated tasks toward achieving this objective: (1) develop a set of more-specific guiding *management objectives*; (2) define a comprehensive set of *management actions*, also known as treatments or strategies, that the CCFO and other partners can implement; and (3) analyze the results of various alternative *management scenarios*, i.e., combinations of management actions that have a similar theme.

Participants at the project's second workshop in April 2014 developed a set of guiding management objectives, consistent with BLM multiple-use management, for this LCF™ Project:

- Maintain or improve unified ecological departure of the major vegetation types (ecological systems) in the project areas.
- Prevent expansion, and reduce the extent if possible, of “high-risk” vegetation classes in the project areas – vegetation that is difficult or expensive to treat successfully, such as 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 areas.
- Maintain or enhance the quality of wildlife habitat, with special attention to Greater sage-grouse and Utah prairie dog, in the project areas.
- Maintain or enhance the integrity of riparian corridors and wet meadows in the project areas.
- Help develop and prioritize active management treatments through Return On Investment analyses, and make treatment projects competitive for potential funding sources.

Project participants identified various management actions (also termed treatments or strategies) toward achieving the management objectives listed above for the two project areas and their ecological systems. All management actions were fundamentally designed to improve the condition of ecological systems that are currently in an undesirable condition, and/or abate the most serious current and future problems that face the ecological systems or human infrastructure. Each management action had a cost-per-acre figure determined for it, using various published sources as well as the local experience of agency staff and stakeholders.

Management scenarios represent common “themes” for grouping individual management actions, so that the effectiveness of sets-of-actions can be better compared within and across ecological systems. Scenarios are comparable to alternatives proposed in agency planning documents or project-specific National Environmental Policy Act (NEPA) analyses. Based on past experience in the region, TNC recommended the use of three management scenarios that have become more-or-less standardized in the LCF™ process:

1. **MINIMUM MANAGEMENT** – a “control” scenario of custodial management with no proactive projects other than maintaining practices that include fire suppression and current livestock

grazing where it is permitted. This scenario can be considered as a no-treatment control, which is required for ROI estimation, but it does not always represent current management.

2. **MAXIMUM MANAGEMENT** – a scenario in which virtually unlimited funds are allocated to actions with the goal of improving ecological condition (reducing unified ecological departure and/or highly undesirable classes) to the greatest extent possible. This scenario assumes no financial or other resource constraints on action implementation (i.e., annual agency budgets were typically exceeded).
3. **PREFERRED MANAGEMENT** – a scenario of management actions identified interactively by managers and stakeholders at the workshops, aimed at reducing unified ecological departure and/or highly undesirable classes as much as possible within the constraints of anticipated (realistic) agency budgets, management funding availability, and regulatory requirements. Basically, the **PREFERRED MANAGEMENT** scenario seeks a set of actions that produces the highest ROI, or ratio of benefit (improvement in condition) to affordable cost.

Each scenario 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.

The **MAXIMUM MANAGEMENT** and **PREFERRED MANAGEMENT** scenarios are often referred to collectively as Active Management scenarios, because they are comprised of specific management actions, in contrast to the **MINIMUM MANAGEMENT** scenario which contains no proactive management actions.

The three scenarios listed above were simulated for each ecological system for 25 years using ST-Sim state-and-transition modeling software. Five model replicates were run for each scenario to capture extremes in processes such as fire activity, drought, and flash-flooding. For ecological systems, the main reporting variable (output) for each simulation was the future-condition measure of unified ecological departure. For the two species, reporting variables were habitat suitability and functional area of sage-grouse (Hamlin Valley and Black Mountains) and of Utah prairie dog (Black Mountains only) for the entire landscape. Other measures were reported including acres actually treated and the 25-year total cost of treatments.

The final step in the LCFTM process was to calculate for each active-management scenario the ratio of: (1) the predicted *benefit* of the scenario, as measured by magnitude of ecological improvement, to (2) the total *cost* of the scenario's management actions. TNC developed this ratio as an ecological ROI metric to identify scenarios that produced the greatest ecological benefit per dollar invested across multiple scenarios, and across the multiple selected ecological systems.

The predicted *benefit* is the amount of improvement in unified ecological departure that a scenario provides after 25 years, relative to the unified ecological departure that is predicted to

occur after 25 years of MINIMUM MANAGEMENT. Said another way, the benefit is the difference between the future UED score of an active management scenario and the future UED score of “no action” management. The baseline used to calculate improvement in condition is the UED score of the MINIMUM MANAGEMENT scenario after 25 years, NOT the UED score as it is at the current time.

Return On Investment values are a useful tool for land managers to decide where to allocate scarce management resources among many possible choices on lands that they administer, or among scenarios in a given landscape for the benefit of a species of special concern. Of course, managers may also select final scenarios, actions or treatment areas based upon a variety of additional factors, such as availability of financial resources, regulatory constraints, and other multiple-use or societal objectives.

Key Conclusions

Key conclusions of the Landscape Conservation Forecasting™ assessment in the BLM Cedar City Field Office are summarized below:

1. The Hamlin Valley and Black Mountains Project Areas, encompassing about 630,000 acres (255,000 ha) combined, are largely undeveloped landscapes that support a diversity of ecological systems in the southeastern part of the Great Basin ecoregion.
2. Twenty-six ecological systems were identified in the two Project Areas, and they and their component vegetation classes were mapped to a high degree of accuracy and precision via interpretation of satellite imagery.
3. Eleven of the ecological systems were selected for detailed modeling analyses based on their size, current and likely future condition (degree of ecological departure), and/or other features of importance to the CCFO.
4. Analyses of habitat suitability were done for two species, Greater sage-grouse and Utah prairie dog, at the present time and as modeled in the future under several different types of management scenarios.
5. At present, many ecological systems in the two Project Areas are in fair to poor condition, as indicated by high values of the metric of unified ecological departure, although this metric allows for a limited area of introduced-species seedings to be considered beneficial. This is especially true of systems that cover extensive areas, are readily accessible, and/or support various multiple land uses.
6. For the most part, conditions after 25 years of “MINIMUM MANAGEMENT” (no active treatments or management) are forecasted to remain moderately to highly departed – especially in large, accessible systems with multiple land uses.

7. Most of the poor ecological conditions (high departure values) in ecological systems can be attributed to six types of problems that are substantial or widespread across the two Project Areas: (1) encroachment by juniper and pinyon pine trees; (2) annual grasses, primarily cheatgrass; (3) degraded or depleted shrubland understories; (4) exotic forbs; (5) loss of aspen clone; and (6) excessive shrub cover in association with habitat occupied by Utah prairie dogs.
8. Return On Investment values are high or moderately high for most shrubland ecological systems in the two Project Areas (e.g., Utah serviceberry, several types of sagebrush). In general, such systems face moderate to severe problems that can be costly to address, but treatments do achieve some predicted improvement (i.e., the problems are not intractable), and the large total costs are spread over very large acreages.
9. Return On Investment values are generally near zero in systems that are small and also face substantial problems that are costly to address (e.g., Montane Riparian, Wet Meadow, Aspen Woodland). Treatments may still be desirable in such cases so as to keep problems in check and forestall wholesale degradation.
10. Some ecological systems with low ROI (e.g., Ponderosa Pine, Pinyon-Juniper) may realize treatment-induced benefits that are not “seen” by the UED metric, so that desirable ecological or public-safety outcomes may still be achieved via treatments.
11. The ROI value (of the PREFERRED MANAGEMENT scenario) for Greater sage-grouse in Hamlin Valley is greater than the ROI for that species in the Black Mountains, and this difference is significant at the 95% confidence level. The ROI value for Utah prairie dog in the Black Mountains is substantially negative, because predicted results of the active PREFERRED scenario are worse (in terms of prairie dog habitat suitability) than results of the “no action” MINIMUM MANAGEMENT scenario. Adjustment of management actions to achieve better predicted results for Utah prairie dog may come at the expense of somewhat diminished future conditions for ecological systems and Greater sage-grouse across the whole Black Mountains project area.
12. Managers may select management actions and treatment areas based upon additional factors beyond ROI values. Such additional factors could include availability of financial resources, public-safety concerns, regulatory constraints, and other multiple-use or societal objectives.
13. Spatial simulation maps of the future identify areas of most probable implementation of the more commonly used management actions.

Introduction

Project Background and Agreement

The Cedar City Field Office (CCFO) of the Bureau of Land Management (BLM) is located in southwestern Utah in the Great Basin ecoregion, and encompasses approximately 2.1 million acres of public land in Beaver, Iron, and a small portion of Washington Counties, Utah. The CCFO supports a variety of resources and resource uses including habitat for wildlife and wild horses as well as rangeland for livestock grazing. These public lands also provide opportunities for recreation and energy/mineral development. The BLM and The Nature Conservancy (TNC) are jointly investigating issues of vegetation, fire, and sensitive species in the CCFO that the BLM can utilize in future decision making.

The current ecological condition of the area's major vegetation types, also known as ecological systems, can be mapped with great accuracy. The future ecological condition of such systems under alternative management scenarios can be predicted with computer state-and-transition models. Knowledge of these current and predicted-future ecological conditions can be used to develop management and restoration actions toward achieving BLM management objectives within the constraints of realistic budgets. Managers can do this using a process developed by TNC known as *Landscape Conservation Forecasting*[™] (LCF[™]). The LCF[™] process guides the formulation of future site-specific, cost-effective vegetation and fire management projects to protect, enhance and restore the ecological condition of landscapes (Low et al. 2010). LCF[™] is well suited for the development of management or restoration treatment projects over large areas, and in fact it should be applied in large areas for optimal results.

Accordingly, in September 2012 the BLM entered into a Cooperative Agreement with TNC to apply the LCF[™] process – including satellite imagery, remote sensing, predictive ecological models, and cost-benefit assessments (Provencher et al. 2008, 2009; Low et al. 2010) – to two large landscapes within the CCFO known as Hamlin Valley and Black Mountains. As written in the Agreement itself:

“The primary objective is to develop a realistic and cost-effective management plan for ecological systems of Hamlin Valley and Black Mountains that forecasts ecological condition of all ecological systems using 3-4 alternative management scenarios chosen by stakeholders. An important secondary objective is to work cooperatively with BLM staff and selected stakeholders to develop a common set of land management goals and assumptions about the ecology of the project area, and reach agreement on the credibility of forecasted results that could eventually be incorporated in BLM plans and actions.”

This work with the CCFO builds upon, and extends northward, results of TNC-led LCF[™] projects with the BLM St. George Field Office (Provencher et al. 2012) and the Pine Valley Ranger District of the Dixie National Forest (Tuhy et al. 2014). This current CCFO project is not formally linked to either of those prior two, but it does add significantly to the body of such knowledge in southwestern Utah, and incorporates recent enhancements of the LCF[™] process itself.

As noted above, ecological systems are the main subject or “currency” of the LCF™ process. However, the two large landscapes within the CCFO are also important for two high-profile wildlife species. Hamlin Valley and Black Mountains both support populations of Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse). The Black Mountains also contain populations of the Utah prairie dog (*Cynomys parvidens*), which is federally listed as Threatened.

Accordingly, the traditional nature of this LCF™ project was expanded beyond the scope of the Cooperative Agreement to address conditions of habitat suitability – both current and predicted into the future – for sage-grouse and Utah prairie dog. This was challenging for the sage-grouse because no demographic data exist for it in either of these two large landscapes. Therefore an innovative approach to sage-grouse habitat suitability was developed, based on expert knowledge and subsequent modeling of “resource selection” attributes, built upon the foundational ecological-system structure of the LCF™ process.

This report is submitted to the BLM Cedar City Field Office as one of the primary products to be delivered under terms of this Cooperative Agreement.

Project Area

Location and Features

The Hamlin Valley and Black Mountains project areas are located in portions of Beaver and Iron Counties in southwestern Utah (Figure 1). Together these two landscapes encompass about 630,000 acres (255,000 ha) of largely undeveloped lands in the southeastern part of the Great Basin ecoregion. The Hamlin Valley project area is bordered to the west by the Nevada state line. The Black Mountains area lies just west of the Interstate 15 highway corridor and the western margin of the Utah High Plateaus.

Hamlin Valley is a classic basin and range valley bordered on either side by mountain ranges, and draining north along a north-south long axis orientation. The geology is made of carbonate sedimentary and volcanic rocks. The Black Mountains are a more circular low range surrounded by extensive subxeric flat desert lands to the south and west, and by the rapid rise of the High Plateaus to the east. Their geology is primarily volcanic. Due to proximity of both landscapes to the Mojave Desert ecoregion and the Pine Valley Mountains to the south, and the High Plateaus to the east, summer monsoonal storms are more frequent in these landscapes than in the majority of the Great Basin dominated by winter precipitation.

Vegetation is zonal with subxeric shrublands at the lower elevations, and a mosaic of woodlands and sagebrush shrublands at middle and upper elevations. The sagebrush-dominated valley floor of Hamlin Valley at around 6,200 feet (1,890 m) elevation is substantially higher than the low desert country surrounding the Black Mountains that is dominated by mixed salt desert scrub.

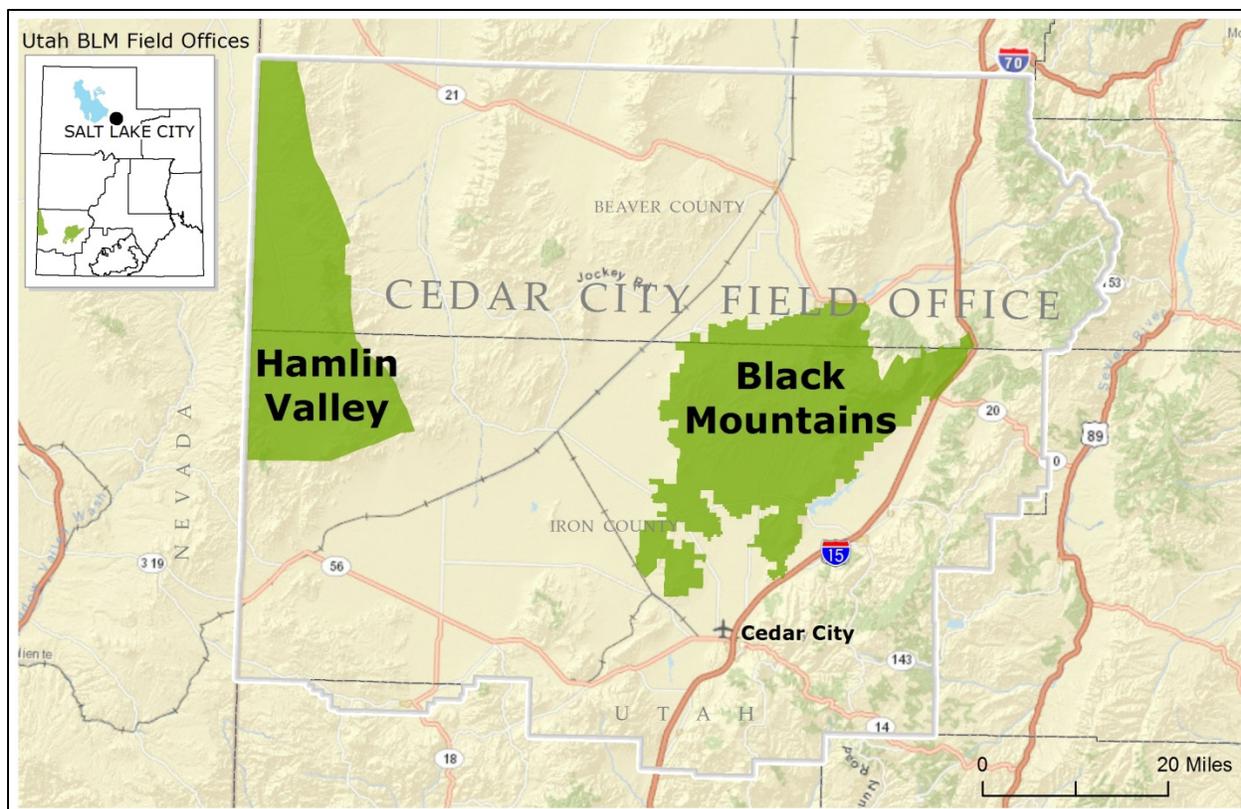


Figure 1. The Hamlin Valley and Black Mountains Project Areas in Beaver and Iron Counties, Utah.

The populations of sage-grouse in both landscapes are small and some of the most southern in the species' entire range. The Black Mountains population of the Utah prairie dog is one of the healthiest populations of that species, and this is the most important area that will promote species recovery within the Southwest Desert.

Ecological and Management Setting

A series of interrelated ecological changes and management concerns have developed over a period of time in and around these two large landscapes of the CCFO, and served as the impetus for this LCFTM project. One of these concerns has been the invasion, spread and proliferation of non-native annual grasses, particularly cheatgrass (*Bromus tectorum*), through much of the lower and middle elevations of the two project areas. This has greatly increased the volume of fine fuels, and has contributed to significant increases in fire frequency and intensity in the past few decades, especially in the Black Mountains.

The combination of invasive non-native plants and altered fire regimes has degraded the ecological integrity of affected habitats and vegetation communities. This combination has also led to large ignition risks and wildfire hazards to human populations and infrastructure, especially in the Black Mountains on account of their proximity to Cedar City and to major

transportation corridors. Where significant fires have occurred, restoration of the burned areas becomes an important goal.

Elsewhere in the two large landscapes, increases in coverage of coniferous trees – Utah juniper and pinyon pine at middle elevations, montane conifers at upper elevations – have degraded the ecological integrity of shrublands and forests. These out-of-balance buildups of conifers have also led to alteration of fire regimes and development of greater fire hazards.

The elevated conservation status of sage-grouse and Utah prairie dog heightens the concern for prevention of or restoration from degraded habitat conditions that have been caused by the factors noted above.

In response to these concerns, managers and staff of the CCFO needed accurate maps of locations where degraded ecological conditions exist, and a systematic process to identify future site-specific, cost-effective vegetation and fire-management projects to protect, enhance and restore ecological and species-habitat conditions in these large landscapes.

Process and Methods

The Landscape Conservation Forecasting™ process for the BLM Cedar City Field Office consists of six 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 Great Basin and Mojave Desert “library” of models, 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 and Utah prairie dog using the metric of Functional Acres.
4. Use the computerized ecological models (2nd step) to forecast anticipated future condition of ecological systems, and of habitat suitability for the two species, under minimum management (analogous to the “no-action” alternative of NEPA).
5. Use the computerized ecological models (2nd step) to forecast anticipated future condition of ecological systems, and of habitat suitability for the two species, under alternative “active” management scenarios (suites of specific actions or treatments).
6. Use Return On Investment (ROI) analyses to assess which actions for which ecological systems yield the most advantageous (“bang for the buck”) results for the systems and the two species’ habitats.

A diagram that displays the relationship of these six components to each other is presented below, and the timeline of the project appears in Table 1 on the following page.

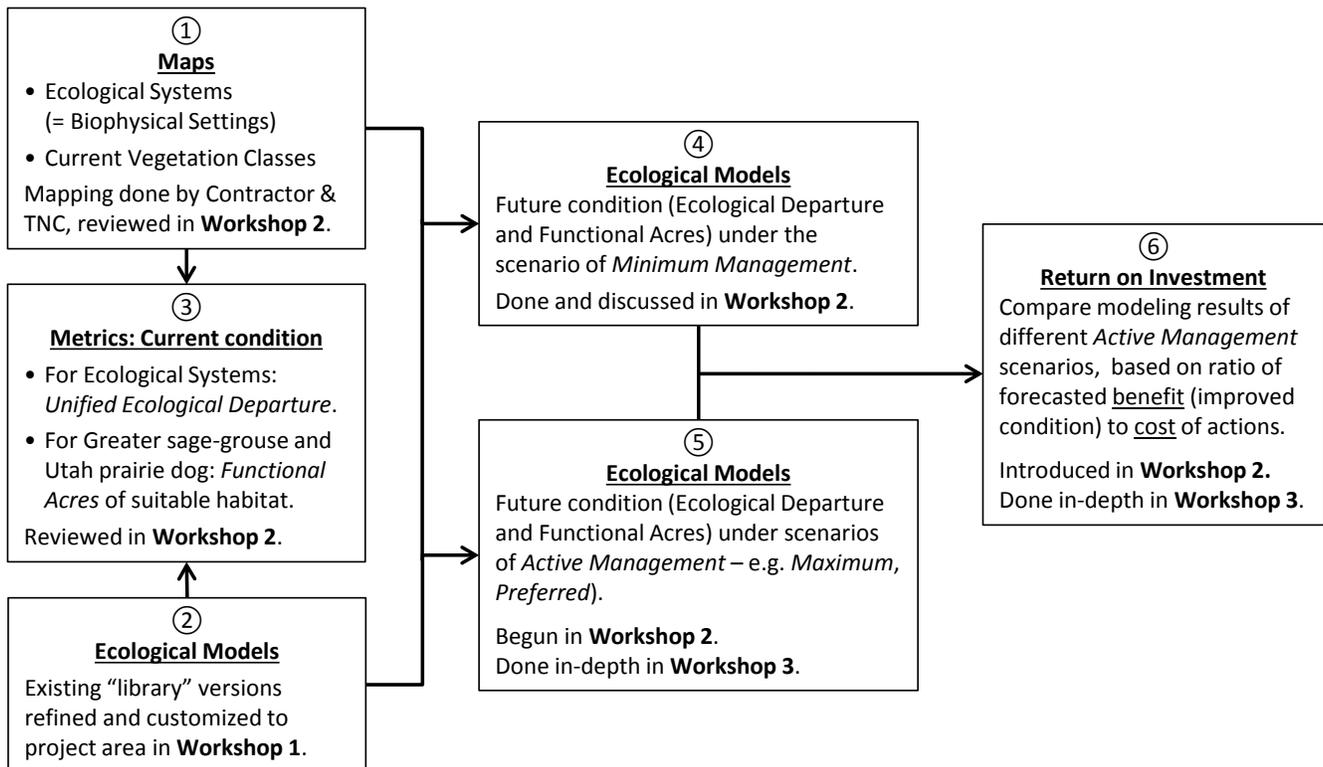


Table 1. Timeline of BLM Cedar City Field Office LCF™ project.

	2012	2013			2014			2015			
	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jul
Biophysical setting & vegetation class descriptions											
Remote sensing: Mapping											
Remote sensing: Field work											
Ecological model building											
Workshop 1: Ecological model review											
Current condition of ecological systems											
Modeling of future condition under Minimum Management scenario											
Workshop 2: Review maps, treatments, current & future conditions, ROI.											
Modeling of future condition under alternative Active Mgmt scenarios											
Return-on-Investment analyses											
Workshop 3: Review results of Active Management modeling.											
Report preparation											
Accuracy Assessment											

Descriptions of methods used in each of the project’s six component steps are presented in the subsections that follow.

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, 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, and is named by its dominant vegetation.

Within each ecological system, component vegetation classes are based on factors such as:

- Successional stages – early to mid to late.
- Vegetation canopy – open versus 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 systems of the Hamlin Valley and Black Mountains areas were not mapped using this approach, because NRCS soil surveys are not complete for the entirety of both areas.

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

Definition and Description of Vegetation Prior to Mapping

Draft descriptions were compiled of ecological systems and their component vegetation classes that were believed to occur in Hamlin Valley and the Black Mountains, based on an inventory of ecological sites from the different NRCS soil surveys, and vegetation descriptions from the nearby Pine Valley Ranger District. These brief descriptions were used in the field for remote sensing interpretation, were vetted and approved pending further revisions by the BLM project manager (Dan Fletcher) on April 1, 2013, and were distributed to participants of the project's first workshop held November 13-15, 2013. This was the master list of ecological systems and their vegetation classes that was used for vegetation mapping preliminary analysis and field work (see below).

In a normal LCF™ process, review of vegetation descriptions is the object of a winter workshop prior to remote sensing. However, signing of the BLM-TNC Cooperative Agreement in late summer 2012, and the first of two remote sensing field surveys conducted during October 2012, prevented us from having a timely workshop. Remote sensing, therefore, proceeded with draft vegetation descriptions. During the November 2013 workshop, participants reviewed and agreed upon the specific ecological systems and their classes that occur on the CCFO. These participants also suggested minor revisions that were completed by the project's second workshop, held April 9-11, 2014.

Remote Sensing Analysis and Ground-Truthing

Spatial Solutions, Inc. was contracted by TNC to conduct vegetation mapping via interpretation of satellite imagery of the project area, which started on September 10, 2012. Discussions were held between Spatial Solutions, TNC, and the Field Office's Project Manager to agree upon specific sets of RapidEye satellite imagery (5×5-m pixels of multispectral imagery) that would be acquired for mapping. Remote sensing was conducted from archival RapidEye 5-m resolution multi-spectral satellite imagery from July 21, 2011 for Hamlin Valley and from June 3, 2011 for the Black Mountains. We discovered that June 3rd was too early for the Black Mountains (most vegetation types could not be separated in the infrared) and did not show many recent fires; therefore, new RapidEye imagery from June 19, 2013 was acquired for the Black Mountains. Moreover, freely available 1-m resolution NAIP imagery was used to assist interpretation of the 5-m multi-spectral imagery. The imagery was clipped to the boundary defined by the Field Office, and then buffered outward by 100 m. Private inholdings were part of the imagery.

TNC sent descriptions of ecological systems and vegetation classes (see above) to Spatial Solutions. Spatial Solutions used these data to develop an unsupervised¹ vegetation classification of the selected satellite imagery, which was to be ground-truthed via fieldwork in September-October 2012 and June-July 2013.

Spatial Solutions used the software Imagine® from Leica Geosystems to conduct an iterative unsupervised classification of 5×5-m RapidEye imagery for the two landscapes. The unsupervised classification of the satellite imagery was used to interpret rasters and is described in Provencher et al. (2008, 2009) 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 September 30 to October 5, 2012. Both landscapes were explored mostly on roads in a 4WD vehicle, but also by hiking for less-accessible locations.

The goal of this field work was to visit all unique spectral class signatures (i.e., representing all of the systems and classes present) and document their vegetation and site features via rapid ("cruising") observations. However, because the remote sensing timeline did not follow the traditional timeline of LCF™ projects starting in the winter, this first field trip was designed as a more cursory acquisition of observations and was focused more on ecological systems than on vegetation classes. During this September to October 2012 trip, a large number (3,000+ per landscape) of rapid observations were documented.

1. In 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 is in contrast to 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.

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., 10,000) 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 the air) in more difficult terrain.

A draft geo-layer of ecological systems and vegetation classes was spot-verified, and more observations were collected from data-poor areas, during a second field trip from June 24 to July 2, 2013. The primary activity of the second field trip was to provide the vast majority of “road and hiking observations” from areas that were unable to be accessed during the September-October 2012 field trip, as well from areas already visited. About 10 days were spent in each landscape. Also at each pre-selected field location with a prior expectation of results, TNC verified the expected ecological system and its current vegetation class.

This final field trip allowed Spatial Solutions to complete final maps of ecological systems and their current vegetation classes, which were delivered to TNC in January 2014 for Hamlin Valley and March 2014 for the Black Mountains. The last iteration in the final draft map of current vegetation classes was used to calculate draft ecological departure scores (defined farther below). The final vegetation maps and ecological departure scores were reviewed at the project’s first “management” workshop held April 9-11, 2014.

The ecological systems that were finally mapped for the Hamlin Valley and Black Mountains project areas are shown in Table 2. They reflect the influence of geology, landforms, soils, elevation, and ecological processes such as fire, flooding, and insect outbreaks. These ecological systems and their component vegetation classes are described in Appendix 1.

A number of difficulties were encountered during remote sensing. The following challenges and solutions were dealt with:

1. The most difficult mapping was at lower elevation in the flatter part of the salt desert scrub communities. Mapping was difficult because soil reflectance overpowered light reflected by vegetation. Moreover, a few feet of difference in elevation and slight soil changes often completely changed vegetation types. Considerable field observations were required to distinguish among alkali sacaton meadows, greasewood, mixed salt desert, and winterfat, especially when the systems were inter-mingled in a complex manner. Four-wing saltbush was only mapped where observed. The easiest of these four difficult systems was alkali

Table 2. Ecological systems of Hamlin Valley and Black Mountains based on 2011 archival and 2013 new 5-m RapidEye satellite imagery interpreted in 2012 and 2013.

Ecological System	Hamlin Valley (Acres)	Black Mountains (Acres)
Aspen Woodland	118.6	4.8
Aspen-Mixed Conifer	391.8	—
Basin Wildrye	1,402.3	1,413.0
Big Sagebrush semi-desert	—	12.1
Black Sagebrush	54,115.4	62,371.4
Curl-leaf Mountain Mahogany	5,262.1	1,178.1
Desert Wash	32.4	6.1
Four-Wing Saltbush	—	125.9
Gambel Oak-Mountain Shrub	1.5	360.8
Greasewood-Basin Big Sagebrush	68.3	6,123.0
Juniper Savanna	—	2,764.2
Limber-Bristlecone Pine	36.9	—
Low Sagebrush	2,227.9	799.1
Mixed Conifer	305.3	10.9
Mixed Salt Desert	—	541.2
Montane Riparian	178.7	124.7
Montane Sagebrush Steppe	98,208.7	38,280.3
Pinyon-Juniper	46,891.4	36,488.4
Ponderosa Pine	1,086.3	—
Semi-Desert Grassland	—	319.6
Stansbury Cliffrose	—	2,070.5
Utah Serviceberry	8,947.6	1,018.3
Wet Meadow-Alkali Sacaton	—	320.9
Wet Meadow-Montane	143.8	50.9
Winterfat	1,005.7	3,979.9
Wyoming Big Sagebrush upland	65,340.5	197,690.5
TOTALS	285,765.2	356,054.7

sacaton because the abundant grass reflected more infrared. Greasewood flats were distinct, except where they blended into alkali sacaton meadows.

2. It was difficult to separate the widespread Wyoming big sagebrush from the less common mountain big sagebrush, which is the indicator species for montane sagebrush steppe, at their ecotone. If mountain big sagebrush could not be positively identified, an arbitrary GIS cutoff at 6,500 feet of elevation was used.
3. In the Black Mountains, black sagebrush (*Artemisia nova*) and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) apparently hybridize. The “hybrid” was observed in the southern part of the Black Mountains as having all the traits of black sagebrush but the height of Wyoming big sagebrush. This hybrid was difficult to map because it spectrally appeared as Wyoming big sagebrush, but had the aspect of black sagebrush looking at it

from the ground. We spent considerable time verifying the identity of vegetation patches in this area. Hybrid areas were labeled black sagebrush.

4. We found three primary types of mountain shrub communities: Gambel oak (*Quercus gambelii*), Stansbury cliffrose (*Purshia mexicana*; Black Mountains only), and Utah serviceberry (*Amelanchier utahensis*). Gambel oak was easily identified in the infrared. Similarly, Utah serviceberry was straightforward to identify in the infrared (although not as deep red as Gambel oak), including similar types it was lumped with such as bitterbrush (*Purshia tridentata*) and squaw apple (*Peraphyllum ramosissimum*). The greatest difficulties were found interpreting unburned cliffrose (see above for burned cliffrose), because it commonly intermingled with pinyon (*Pinus monophylla* and *P. edulis*) and juniper (*Juniperus osteosperma*), thus looking like pinyon-juniper woodlands, and could be dominated by desert bitterbrush (*Purshia glandulosa*), which is a hybrid between Stansbury cliffrose and bitterbrush. Separation of tree-encroached cliffrose from true pinyon-juniper woodlands required more field visits, although cliffrose shrubs reflect more in the infrared than pure pinyon-juniper. We lumped desert bitterbrush into the cliffrose community because desert bitterbrush's flat and spiraling stems, smaller than those of mature cliffrose, remained standing years after fire.
5. Separation of ecological systems in burned areas proved challenging, especially in the Black Mountains. Burned areas usually contained no to little remaining evidence of sagebrush (*Artemisia* spp.) and mountain shrub communities. Separation of these communities in burned areas required a substantial amount of field observations and locating burned and live specimens. Identification of Stansbury cliffrose (including desert bitterbrush) sites was easier because the burned, flat, and slowly spiraling stems of cliffrose remained standing even years after burning. Separation of low sagebrush (*Artemisia arbuscula*), black sagebrush, and the three big sagebrush subspecies was the most difficult because woody material did not remain standing. Generally, low and black sagebrush did not burn, or not as much as big sagebrush. Therefore, low and black sagebrush could be easily found, or burned cases could be distinguished by the greater brightness of the reflecting soils. An elevation threshold of 6,500 ft was used to separate Wyoming and mountain big sagebrush zones. The basin wildrye (*Elymus cinereus*) – basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) system was found in shallow bottoms where soil appeared deeper and loamy. Basin wildrye was not always present due to past management, but skeletons of large basin big sagebrush was a good indicator combined with geomorphic position and soil depth. Generally this type was redder in the infrared than adjacent big sagebrush types.
6. We initially mapped montane riparian systems if riparian vegetation was present. Many small ephemeral riparian corridors do not contain willows, cottonwoods, and other mesic and wet shrubs; instead, the vegetation surrounding the corridor is the same in the corridor (often pinyon-juniper). We named those areas by the vegetation we could see, but not as riparian vegetation. In addition, we identified desert washes with true gravel and sand beds, obvious flooding channels, and that were dry but not dewatered by diversions.
7. It was generally straightforward to distinguish between big sagebrush steppe and pinyon-juniper woodland ecological systems. It was more difficult to separate wooded vegetation

classes of big sagebrush shrublands from true pinyon-juniper woodlands. As we have done elsewhere (Low et al. 2010), shrublands encroached by trees usually contain dead sagebrush shrubs, little perennial grass cover, and trees are usually conical indicating ages of <125 years. 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). In areas we did not visit, we used slopes >30% or distinctive soils to positively identify true woodlands. Several occurrences of true woodlands in the Black Mountains contained ancient trees of large diameter where the open canopy had a distinct texture on the imagery, but the understory was sparse perhaps due to very low productivity of the soils.

Ecological Systems – Natural Range of Variability

In order to calculate current or future condition (“health”) of each ecological system, using a process described farther below, it is first necessary to define the Natural Range of Variability (NRV) for each system. NRV 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 was calculated with the state-and-transition modeling software ST-Sim within the Syncrosim platform (www.apexrms.com, www.syncrosim.org; Daniel and Frid 2012). To determine the NRV for each ecological system in the project area, we modified models from TNC projects completed with the Dixie National Forest (Tuhy et al. 2014), Great Basin National Park (Provencher et al. 2013), and BLM St. George Field Office (Provencher et al. 2012). The NRV (reference) percentages of vegetation classes for each ecological system in the Hamlin Valley and Black Mountains project areas are listed below in Table 3.

Predictive Ecological Models

The LCFTM process includes the simulation of management scenarios using state-and-transition predictive models for each ecological system. A state-and-transition model is a discrete, box-and-arrow representation of the continuous variation in vegetation composition and structure of an ecological system (Bestelmeyer et al. 2004). An example of an older state-and-transition model for mountain big sagebrush from eastern Nevada is shown in Forbis et al. (2006). 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.

Predictive models for ecological systems include several different types of vegetation classes: reference, uncharacteristic, and management vegetation classes.

Table 3. Natural Range of Variability for ecological systems of Hamlin Valley and Black Mountains.

Ecological System ↓	Class →	NRV (Reference) Percentages ¹					
		A	B	C	D	E	U
Aspen Woodland		7%	23%	43%	27%	0%	0%
Aspen-Mixed Conifer		7%	24%	39%	11%	19%	0%
Basin Wildrye		18%	63%	19%	0%	0%	0%
Big Sagebrush semi-desert		7%	23%	70%	0%	0%	0%
Black Sagebrush		15%	48%	25%	12%	0%	0%
Curl-leaf Mountain Mahogany		8%	12%	14%	23%	43%	0%
Desert Wash		3%	11%	86%	0%	0%	0%
Four-Wing Saltbush		8%	21%	71%	0%	0%	0%
Gambel Oak-Mountain Shrub		8%	25%	67%	0%	0%	0%
Greasewood-Basin Big Sagebrush		7%	93%	0%	0%	0%	0%
Juniper Savanna		2%	7%	25%	66%	0%	0%
Limber-Bristlecone Pine		10%	14%	76%	0%	0%	0%
Low Sagebrush		10%	37%	53%	0%	0%	0%
Mixed Conifer		22%	25%	13%	10%	30%	0%
Mixed Salt Desert		6%	62%	32%	0%	0%	0%
Montane Riparian		14%	25%	61%	0%	0%	0%
Montane Sagebrush Steppe		22%	34%	39%	3%	2%	0%
Pinyon-Juniper		3%	6%	25%	66%	0%	0%
Ponderosa Pine		10%	9%	25%	52%	4%	0%
Semi-Desert Grassland		18%	82%	0%	0%	0%	0%
Stansbury Cliffrose		9%	37%	54%	0%	0%	0%
Utah Serviceberry		9%	28%	49%	14%	0%	0%
Wet Meadow-Alkali Sacaton		1%	86%	13%	0%	0%	0%
Wet Meadow-Montane		3%	89%	8%	0%	0%	0%
Winterfat		10%	52%	38%	0%	0%	0%
Wyoming Big Sagebrush upland		14%	29%	42%	6%	9%	0%

1. Standard LANDFIRE codes for the 5-box vegetation model: A = early-development; B = mid-development, closed; C = mid-development, open; D = late-development, open; E = late-development, closed; and U = uncharacteristic. This terminology was often modified (Appendix 1).

The classes of pre-settlement vegetation defined by the NRV are considered to be each ecological system's core *reference* condition. At their core, therefore, all models have the LANDFIRE reference condition represented by some variation around the A-B-C-D-E reference classes (see Table 3). The A-E classes typically represent succession, 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*.

The current landscape contains vegetation classes (in many ecological systems) that would not be expected under natural disturbance regimes, and thus would not have been present in reference conditions. These non-reference classes are termed uncharacteristic (“U”) classes. The two main categories of uncharacteristic classes comprise vegetation or site conditions that result from:

- (1) disturbances beyond what would be considered “natural,” whether caused by human actions or not; 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 species to provide forage for livestock and wildlife.

In addition to modeling reference conditions, therefore, predictive models also include the full range of uncharacteristic classes in the project area.

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

- (1) vegetation succession (the passage of time);
- (2) ecological processes, such as fire or flooding;
- (3) disturbances, such as annual grass invasion or arroyo downcutting; and
- (4) active management treatments, such as mechanical thinning, herbicide, or prescribed fire.

To develop the predictive ecological models used in this project, existing state-and-transition models in the TNC library were revised to reflect decisions regarding the project’s ecological systems and vegetation classes that were made in the first workshop (see Table 1). Models were constructed and run using the modeling software ST-Sim, a product of ApexRMS, Ltd. A complete list of model parameter values (probabilistic transitions) appears in Appendix 2.

In past LCFTM projects, non-spatial modeling was generally conducted because there were no explicit spatial questions that justified the increased difficulty of spatial modeling. Because we report here on species habitat suitability, where a species’ fitness depends on the proximity of landscape features, spatial modeling was required. 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 species habitat suitability, and future simulated vegetation rasters allow estimation of future species habitat suitability. To create alternative future rasters of vegetation, ST-Sim’s spatial modeling necessitates input of additional data and rules to run simulations. There are six types of data/rules needed: size distribution, spread distribution, patch prioritization, spatial multipliers, direction multipliers, and adjacency multipliers.

The first set of additional spatial data consists of all the spatial frequency distributions for all natural and management disturbances (Appendix 3). These distributions define the number of times out of 100 events that a disturbance of a certain size (area) occurs. For example, based on federal fire occurrence data from 1980 to 2012 for each 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.

The spread distribution applied only to the spread of non-native annual grasses (i.e., cheatgrass), exotic forb species, and native trees into shrublands from an infested source pixel into nearby or distant pixels. For annual grasses, 99.9% of dispersal was within 5 m of a pixel (which was 70 m), and the remaining 0.1% was within 30 m. For exotic forbs, the frequencies and distances were, respectively, 99.9% and 0.1% for 1 m and 30 m. For pinyon or juniper encroachment into shrublands, the frequencies and distances were, respectively, 99.99% and 0.01% for 10 m and 30 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.

Spatial multipliers are used either to enhance or to constrain natural or managed disturbances. We used two types of multipliers. The first type prevented actions that remove or thin sagebrush cover from being implemented (in the simulations) within 500 m of any lek. Actions that remove trees and rabbitbrush, or restore wet meadows, for example, were allowed. The second type of spatial multiplier was based on sage-grouse habitat suitability and prevented actions that removed or thinned sagebrush in areas of higher sage-grouse habitat suitability for the first 15 years of simulations. After 15 years of simulated management, spatial constraints based on sage-grouse habitat suitability were lifted (but see Adjacency Multipliers).

Direction multipliers governed the non-uniform direction of fire spread primarily following southwest to northeast prevailing winds. Table 4 shows the degree of fire spread and the multiplicative factor of fire spread. For example, for every one pixel of fire spreading in the 270° (west) direction, fire spreads 7 pixels in the 45° (northeast) direction.

Table 4. Direction multipliers for fire spread of all types.

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

Adjacency Multipliers allow simulations to modify the rate of implementation of disturbances based on the average condition of pixels around a focal pixel, which experts chose to be a 200-m radius – the longer the radius, the longer the duration of each 25-year simulation.

After the 15th year of the simulations when spatial multipliers for sage-grouse habitat suitability ceased, adjacency multipliers started “protecting” pixels whose average brood-rearing value was ≥ 0.5 . We focused on brood-rearing because it is considered the most limiting seasonal habitat of sage-grouse. Brood-rearing points for each ecological system and its vegetation classes were obtained from Appendix 5. Actions that were prevented were those that either removed or thinned sagebrush cover. If the area surrounding the focal pixel had an average value < 0.5 , all actions were allowable.

Assessment of Current Condition

Ecological Systems

For ecological systems, the primary metric used to report current ecological condition is known as Unified Ecological Departure (UED). This 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 uncharacteristic or benign. 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, and has been used as the main measure of condition for ecological systems in many previous LCFTM projects in 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 is generated by a formula that calculates the dissimilarity between:

- (1) the amounts (percentage) of vegetation classes expected under reference conditions (NRV, Table 3); and
- (2) the amounts (percentage) of vegetation classes that are currently 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 current 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, the higher the number, the greater the departure. Further, a coarser metric known as Ecological Departure Class is used to group ecological departure scores into three categories: 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). An example of the calculation of traditional ecological departure, and assignment to the corresponding ecological departure class, is shown in Table 5.

Table 5. 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 in this LCFTM project they are identified with the label “high risk vegetation classes” (HRVC). HRVCs are defined as uncharacteristic vegetation classes that 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 these classes (invaded or very expensive to restore).

In past LCFTM projects, TNC and partners used percent-area of HRVCs as a second measure of current condition for ecological systems, alongside traditional ecological departure. This project no longer reports amounts of HRVCs separately, though these undesirable classes do figure prominently into the measure of unified ecological departure, explained below.

Allowable Thresholds of Certain Uncharacteristic Classes

Not all uncharacteristic (non-reference) vegetation classes are equal, for a second reason: Some uncharacteristic classes have been expressly created by managers toward the meeting of 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). Classic examples of such classes are seedings with non-native 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. The devoting of scarce management/restoration funds to “fixing” sub-threshold amounts of these allowable (but still uncharacteristic) classes has minimal priority – far lower than projects that focus on treating highly undesirable vegetation classes.

The identification of these unharmed or benign uncharacteristic classes is relatively new to the LCF™ process. They do not (yet) have a formal name, and they are not used as a third discrete measure of current condition for ecological systems. Rather, their presence contributes to the new integrated measure of condition known as unified ecological departure, described in the following section.

Unified Ecological Departure

Advancements in the LCF™ process, as multiple projects were completed, began to expose flaws in the system used to measure ecological condition. A concise list of the most fundamental past flaws is as follows:

- Later projects began to use two measures side-by-side: traditional ecological departure and high risk vegetation classes; it would be best to use only one metric.
- The two measures that came to be used (traditional departure and high risk classes) are not independent of each other; high risk classes are by definition uncharacteristic classes which contribute to departure, so statistical dependencies were created.
- High-risk classes are **Bad Actors**, but their “badness” (heightened undesirability) is not adequately reflected in the traditional measure of ecological departure.
- Conversely, some uncharacteristic classes are acceptable (in moderation), but the degree to which they are allowable is not adequately reflected in the traditional measure of ecological departure.

The latter two points above can be summed up in the general statement that calculation of ecological departure in its traditional sense does not differentiate among uncharacteristic vegetation classes. All uncharacteristic classes contribute equally to increasing traditional ecological departure, because all uncharacteristic classes have an “expected” NRV/reference value of 0% (see Tables 3 and 5).

Therefore a new measure of ecological condition known as unified ecological departure was recently created to remedy the flaws pointed out above. In a nutshell, unified ecological departure begins with ecological departure calculated the traditional way, and then:

- scores the departure higher (makes condition worse) according to amounts of high risk vegetation classes present; and
- scores the departure slightly lower (makes condition slightly better) according to agreed-upon threshold levels of allowable uncharacteristic classes present.

Unified ecological departure thus gives a more realistic accounting of ecological condition or health. It also solves a double-counting problem that had existed in calculating the Return On Investment measure for ecological systems (defined later), by which different future active-management scenarios are compared against each other. The technical description of unified ecological departure appears in Appendix 4.

Unified ecological departure is the official metric of current condition for ecological systems in this report. However, in describing condition (current and future) of ecological systems in the **Findings** section farther below, amounts of high risk classes are highlighted as the “problems” that largely drive the selection of treatment actions. The modeled results of applying those treatments are then shown as predicted reductions (in most cases) of those problem classes. This highlighting of high risk classes may be useful to managers, because the single UED measure can mask specific identities of high risk classes in an ecological system.

Habitat Suitability for Species

In addition to unified ecological departure, management success was measured at the landscape-scale using the metric of habitat suitability for the two species of concern – sage-grouse and Utah prairie dog – based on the current and 25-year simulated vegetation maps. Habitat suitability is calculated from resource selection functions.

Resource Selection Functions for Greater Sage-Grouse

For sage-grouse, resource selection functions were divided into three seasonal sets: nesting (nest site selection and nest success, also called breeding), summer (brood-rearing), and winter. The resource selection functions described below were the result of a sage-grouse expert workshop held on March 13, 2014 at TNC’s office in Salt Lake City.

We developed heuristic resource selection functions because there is only very limited movement data from collared sage-grouse from the distinct Hamlin Valley and Black Mountains populations. Without sufficient data, it was not possible to build statistical logistic regression equations representing different resource selection functions. Using sage-grouse demographic and movement data from the entire State of Utah, experts assisted with defining the shape of resource selection functions that had the strongest effect on sage-grouse habitat suitability. Each resource selection function was bound between 0 (not suitable) and 1 (very suitable). The

independent variables for the different resource selection functions were either the distance to the closest critical attribute (e.g., type of vegetation, busy road), the proportion of a feature in the surrounding habitat, or the contribution of a pixel's vegetation type to the seasonal habitat.

Five resource selection functions characterized the nesting (i.e., breeding) season ($RSF_{N,i}$; see Appendix 5 for detailed equations):

1. $RSF_{N,1}$: Distance of each pixel (nest site) to the closest lek – habitat suitability was high up to 5 km from the closest lek and then rapidly decreased with distance.
2. $RSF_{N,2}$: Distance of each pixel (nest site) to the closest trees – habitat suitability increased up to a distance of 2 km from trees, and after 2 km habitat was fully suitable.
3. $RSF_{N,3}$: Proportion of pixels with adequate shrub cover between each pixel (nest site) and the closest lek – habitat suitability increased with the proportion of adequate pixels.
4. **Black Mountains only** – $RSF_{N,4}$: Distance of each pixel (nest site) to the closest busy road – habitat suitability increased with distance with most severe reduction of suitability at less than 150m from busy roads followed by a rapid increase, and no effect after 2.8 - 6.1 km (1.8 to 3.8 miles).
5. $RSF_{N,5}$: Resource selection function was equal to the expert-defined value of the vegetation class (Appendix 5) to breeding habitat for each pixel (nest site).

The summary habitat suitability of the nesting season was the average of the five resource selection functions (RSF_N), which thus assumes that all functions had the same importance.

Five resource selection functions characterized the summer (i.e., brood-rearing) season ($RSF_{S,i}$):

1. $RSF_{S,1}$: Distance of each pixel to the closest 2,134 m (7,000 ft) elevation contour (i.e., mountain big sagebrush) – habitat suitability was high up to 10 km from each pixel to the closest contour line and then rapidly decreased with distance.
2. $RSF_{S,2}$: Distance of each pixel to closest moist vegetation (i.e., Wet Meadow during late-brood rearing, Montane Riparian during late-brood rearing, Montane Sagebrush Steppe during early-brood rearing, and Mountain Shrub during early-brood rearing) – habitat suitability decreased with increasing distance between each pixel and the moist vegetation.
3. $RSF_{S,4}$: Distance of each pixel to the closest lek – habitat suitability remained high up to 5 km from each pixel and then decreased rapidly until it was nearly null at about 10 km.
4. $RSF_{S,4}$: Distance of each pixel to the closest trees – habitat suitability increased up to a distance of 2 km from trees and after 2 km habitat was fully suitable (same function as for nesting).
5. $RSF_{S,5}$: Resource selection function was equal to the expert-defined value of the vegetation class (Appendix 5) to breeding habitat for each pixel.

The summary habitat suitability of the summer season was the average of the five resource selection functions (RSF_S), which thus assumes that all functions had the same importance.

Three resource selection functions characterized the winter season ($RSF_{w,i}$):

1. $RSF_{w,1}$: Distance of each pixel to an area where >75% of pixels have an acceptable cover of sagebrush – habitat suitability was high up to 5 km from the closest lek and then rapidly decreased with distance.
2. $RSF_{w,2}$: Distance of each pixel to the closest low or black sagebrush pixel – habitat suitability linearly decreased up to a distance of 25 km and then became null.
3. $RSF_{w,3}$: Resource selection function was equal to the expert-defined value of the vegetation class (Appendix 5) to breeding habitat for each pixel.

The summary habitat suitability of the winter season was the average of the three resource selection functions (RSF_w), which thus assumes that all functions had the same importance.

The overall habitat suitability across all seasons was the average of RSF_N , RSF_S , and RSF_w multiplied by the evenness (Simpson's evenness index) among RSF_N , RSF_S , and RSF_w . The resulting overall value per pixel was between 0 (not suitable) and 1 (very suitable). Statistical habitat suitability models are not constructed as such, especially not using an evenness index. However, in the absence of a more formal approach, the above calculations allowed us to account for both the contribution of seasonal habitat suitability (poor to excellent), and whether some seasonal habitats were deficient and, as a result, lowered the overall habitat suitability.

Resource Selection Functions for Utah Prairie Dog

Among the two landscapes of this project, the Utah prairie dog is found only in the Black Mountains project area, which is considered a source population. Unlike for the sage-grouse, calculation of habitat suitability of Utah prairie dog is not seasonal and far simpler. The resource selection functions described below also were the result of a Utah prairie dog expert workshop held on March 13, 2014 at TNC's office in Salt Lake City.

Two resource selection functions were calculated based on vegetation classes and distance to prairie dog towns:

1. A step function with values of 0 or 1 where each pixel only receives a score of 1 if all pixels within a 200-acre window around the pixel have a shrub cover of $\leq 15\%$, which were primarily the reference and uncharacteristic early-succession vegetation classes (Appendix 1). Utah prairie dog does not tolerate shrub cover greater than 15%.
2. Distance of a pixel to the closest prairie dog town – habitat suitability was high and constant up to 3 km of a pixel to closest prairie dog town and then decreased from 3 to 5 km to a value of zero.

Because both resource selection functions were considered equally important, overall habitat suitability was simply the average of the two functions and was bounded between 0 and 1.

Synthesis – Habitat Suitability and Functional Area

Two metrics per species – habitat suitability and functional area – are involved in the synthesis of results and decision making. As seen later, habitat suitability is the more appropriate metric to calculate ecological Return On Investment because it is a non-dimensional value between zero and one, which is required, whereas functional area is a dimensional metric (i.e., as units). For reporting change in habitat suitability that managers can relate to, we opted to calculate the more intuitive *functional area* as a metric, expressed in acres or hectares, to follow the approach recently adopted by the DOI and Barrick Gold of North America for mitigation of sage-grouse habitat in Nevada (Barrick Nevada Sage-Grouse Bank Enabling Agreement, 2015, US Fish and Wildlife Service, Bureau of Land Management, and Barrick Gold of North America: http://www.blm.gov/style/medialib/blm/nv/wildlife_fishes/sage_grouse/barrick_nv_sage_grouse.Par.65037.File.dat/DOI-Barrick%20Sage%20Grouse%20Agreement%20March2015.pdf).

Functional area was also adopted for the State of Nevada Sagebrush Ecosystem Council’s mitigation program. Functional area is the sum over all pixels in a landscape of the product of the area of each pixel by the overall habitat suitability (scaled 0 to 1) of that pixel. It can also be calculated as the area of a pixel (all the same in a grid) multiplied by the sum of the overall habitat suitability (scaled 0 to 1) of each pixel in the landscape. By definition, functional area is always equal or smaller than the size of the landscape.

Accounting for Variability in Disturbances and Climate

The basic ST-Sim state-and-transition models incorporate by default stochastic disturbance rates that vary around a mean value for a particular disturbance associated with each vegetation class of each ecological system. For example, fire is a major disturbance factor for most ecological systems, including replacement fire, mixed severity fire, and surface fire. These fire regimes have different rates (i.e., mean fire return interval) that are incorporated into the models for each ecological system where they are relevant. ST-Sim automatically supplies minor variability around these rates. However, in real-world conditions the disturbance rates are likely to vary appreciably over time, and more than that provided by ST-Sim’s default variability. To simulate strong yearly variability for fire activity, climate-induced mortality and non-native species fertilization, insect and disease outbreaks, non-native species invasion rates, tree encroachment rate, loss of herbaceous understory, and flooding, TNC incorporated *temporal multipliers* in the model-run replicates. Due to the extremely episodic nature of weather, fire, and flooding in the Great Basin and Mojave Desert, temporal multipliers have profound effects on model-run results (reporting variables).

A temporal multiplier is a number in a yearly time series that multiplies a base disturbance rate in the state-and-transition models. For example, in a given year, a temporal multiplier of one implies no change in a disturbance rate, whereas a multiplier of zero is a complete suppression of the disturbance rate, and a multiplier of three triples the disturbance rate. Temporal multipliers can be obtained from data, statistical projections, mechanistic equations, and

heuristic equations. A more detailed explanation of temporal multipliers is presented in Appendix 6.

Assessment of Future Condition – MINIMUM MANAGEMENT

Using the computer-based models, TNC simulated the likely future condition of each ecological system (measured by unified ecological departure), and of greater sage-grouse and Utah prairie dog (measured by habitat suitability), after 25 years under a scenario of *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 inventory or treatment of exotic forbs, no prescribed fire, no vegetation treatments, etc. The *MINIMUM MANAGEMENT* scenario is also required to calculate ecological Return On Investment (ROI, defined later). Potential sources of future ecosystem alteration were explicitly included in the *MINIMUM MANAGEMENT* model simulations. These sources include increased invasion rates of non-native species (annual grasses and exotic forbs), increased tree encroachment rates in shrublands, modified mean fire return intervals in shrublands, livestock grazing, and periodic “natural” events such as floods and drought.

Unified ecological departure is the primary measure used for assessing future condition in each ecological system after 25 years of *MINIMUM MANAGEMENT*. Future UED values are also grouped into three Classes: Class 1 represents low departure of $\leq 33\%$; Class 2 represents moderate departure of 34-66%; and Class 3 represents high departure of $\geq 67\%$.

The functional areas of sage-grouse and Utah prairie dog calculated from different management scenarios after 25 years of simulation can be compared. Functional area is a single landscape-wide metric, unlike UED that is measured separately for each ecological system. Although scenarios were designed to reduce unified ecological departure (improve condition) in a cost-effective manner, increased functional area was considered highly desirable – actually necessary to managers’ endorsement of proposed actions – as a *post facto* measure of success.

Assessment of Future Condition – Alternative Active Management Strategies

Eleven ecological systems were selected for analyses of future management in Hamlin Valley and Black Mountains, though not all eleven occur in both areas (Table 6). The ecological systems in Table 6 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.

Table 6. Ecological systems of Hamlin Valley and Black Mountains selected for management analyses.

Ecological System	Hamlin Valley (Acres)	Black Mountains (Acres)
Aspen Woodland	118.6	4.8
Black Sagebrush	54,115.4	62,371.4
Low Sagebrush	2,227.9	799.1
Montane Riparian	178.7	124.7
Montane Sagebrush Steppe	98,208.7	38,280.3
Pinyon-Juniper	46,891.4	36,488.4
Ponderosa Pine	1,086.3	—
Stansbury Cliffrose	—	2,070.5
Utah Serviceberry	8,947.6	1,018.3
Wet Meadow-Montane	143.8	50.9
Wyoming Big Sagebrush upland	65,340.5	197,690.5
TOTALS	277,258.9	338,898.9

Future simulations of active management are **the heart of the LCF process**, per the project’s Cooperative Agreement that states the following with regard to its objectives:

The primary objective is to develop a realistic and cost-effective management plan for ecological systems of Hamlin Valley and Black Mountains that forecasts ecological condition of all ecological systems using 3-4 alternative management scenarios chosen by stakeholders. An important secondary objective is to work cooperatively with BLM staff and selected stakeholders to develop a common set of land management goals and assumptions about the ecology of the project area, and reach agreement on the credibility of forecasted results that could eventually be incorporated in BLM plans and actions.

Accordingly, TNC and BLM Field Office staff worked jointly on three interrelated tasks toward achieving these purposes:

1. We developed a set of more-specific guiding *management objectives*;
2. We defined a comprehensive set of *management actions*, also known as treatments or strategies, that the CCFO and other partners can implement; and
3. We analyzed the results of various alternative *management scenarios*, i.e., combinations of management actions that have a similar theme.

Management Objectives

Participants at the project’s second workshop in April 2014 developed a set of guiding management objectives, consistent with BLM multiple-use management, for this LCF™ Project.

These objectives will influence the types or “themes” of active management treatments that are modeled and reported as the central products of this Cooperative Agreement between the BLM and The Nature Conservancy. These management objectives are listed in the box below.

Management Objectives for the LCF™ project for Hamlin Valley and Black Mountains

- Maintain or improve unified ecological departure of the major vegetation types (ecological systems) in the project areas.
- Prevent expansion, and reduce the extent if possible, of “high-risk” vegetation classes in the project areas – vegetation that is difficult or expensive to treat successfully, such as 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 areas.
- Maintain or enhance the quality of wildlife habitat, with special attention to Greater sage-grouse and Utah prairie dog, in the project areas.
- Maintain or enhance the integrity of riparian corridors and wet meadows in the project areas.
- Help develop and prioritize active management treatments through Return On Investment analyses, and make treatment projects competitive for potential funding sources.

Management Actions

Project participants identified various management actions (also termed treatments or strategies) toward achieving the management objectives for the two project areas and their ecological systems. The effectiveness of actions was tested using the predictive ecological models. All management actions were fundamentally designed to: (1) improve the condition of ecological systems that are currently in an undesirable condition, and/or (2) abate the most serious current and future problems that face the ecological systems or human infrastructure.

Initial sets of management actions were developed by participants in the project’s second workshop. Each management action had a cost-per-acre figure determined for it, using various published sources as well as the local experience of agency staff and stakeholders. The management actions identified for ecological systems in the two project areas appear in Appendix 7.

TNC then conducted computer runs of the state-and-transition models to test and refine suites of actions for each of the selected ecological systems (Table 6) over a 25-year time horizon. These models included a “failure rate” for many management actions to reflect that some actions only partially succeed at restoring a vegetation class, although full cost is incurred for failure. Several alternative management actions and levels of treatment were tested to develop successful scenarios (see below). This process of “successive approximation” created a robust set of actions that in many cases reduced unified ecological departure, specifically by reducing amounts of high risk vegetation classes, while seeking to minimize cost.

Management Scenarios

Management scenarios represent common “themes” for grouping individual management actions, so that the effectiveness of sets-of-actions can be better compared within and across ecological systems. Scenarios are comparable to alternatives proposed in agency planning documents or project-specific National Environmental Policy Act (NEPA) analyses. Based on past experience in eastern California, Nevada, and western Utah, TNC recommended the use of three management scenarios that have become more-or-less standardized in the LCF™ process. These three standard scenarios are described in Table 7.

Table 7. Descriptions of standard management scenarios for Hamlin Valley and Black Mountains.

STANDARD MANAGEMENT SCENARIOS
MINIMUM MANAGEMENT
This is a control scenario that includes only natural disturbances, unmanaged non-native species invasion, fire suppression management, and current livestock grazing where it is permitted. Fire suppression by agencies was simulated by reducing natural, reference fire return intervals using time series that reflect current fire events from the immediate and nearby areas (temporal multiplier). Fire event data were obtained from the Federal Fire Occurrence Website. In essence, this scenario can be considered as a no-treatment control, but it does not always represent current management.
MAXIMUM MANAGEMENT
This scenario allocates virtually unlimited management funds to actions with the goal of improving ecological condition (reducing unified ecological departure and/or high risk classes) to the greatest extent possible. This scenario assumes no financial or other resource constraints on action implementation (i.e., annual agency budgets were typically exceeded).
PREFERRED MANAGEMENT
This scenario was identified interactively by managers and stakeholders at the workshops. It aims to reduce unified ecological departure and/or specific “problem” high risk classes as much as possible within the constraints of anticipated (realistic) agency budgets, management funding availability, and regulatory requirements. Basically, the PREFERRED MANAGEMENT scenario seeks a set of actions that produces the highest return on investment, or ratio of benefit (improvement in condition) to affordable cost.

Each scenario 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. Cost information for each management action for each ecological system, under all scenarios, is listed in Appendix 7.

The MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios are often referred to collectively as Active Management scenarios, because they are comprised of specific management actions, in contrast to the MINIMUM MANAGEMENT scenario which contains no proactive management actions.

The application of specific actions within management scenarios will be presented individually for ecological systems farther down in this report, in **Findings** under the section **Predicted Future Condition – Management Scenarios and Actions**.

Computer Simulations and Reporting Variables

The scenarios from Table 7 were simulated for each ecological system for 25 years using ST-Sim state-and-transition modeling software. Five model replicates were run for each scenario to capture extremes in processes such as fire activity, drought, and flash-flooding. For ecological systems, the main reporting variable (output) for each simulation was the future-condition measure of unified ecological departure. For the two species, reporting variables were habitat suitability and functional area of sage-grouse (Hamlin Valley and Black Mountains) and of Utah prairie dog (Black Mountains only) for the entire landscape. Other measures were reported including acres actually treated and the 25-year total cost of treatments.

Return On Investment Analysis

The final step in the LCFTM process was to calculate for each active-management scenario the ratio of: (1) the predicted *benefit* of the scenario, as measured by magnitude of ecological improvement, to (2) the total *cost* of the scenario's management actions. TNC developed this ratio as an ecological Return On Investment (ROI) metric to identify scenarios that produced the greatest ecological benefit per dollar invested across multiple scenarios, and across the multiple selected ecological systems.

The predicted *benefit* is the amount of improvement in unified ecological departure that a scenario provides after 25 years, relative to the unified ecological departure that is predicted to occur after 25 years of MINIMUM MANAGEMENT. Said another way, the benefit is the difference between the future UED score of an active management scenario and the future UED score of "no action" management. The baseline used to calculate improvement in condition is the UED score of the MINIMUM MANAGEMENT scenario after 25 years, NOT the UED score as it is at the current time.

To calculate the ROI for an active management scenario, its predicted benefit is divided by the total 25-year cost of its management actions (treatments), and that result is multiplied by the area (acreage) of the ecological system being modeled. The formula for ROI of an active management scenario in the i_{th} ecological system thus appears as follows:

$$ROI_i = \frac{(UED_{MINIMUM,i} - UED_{ACTIVE,i}) \times Acres_{ACTIVE,i}}{TotalCost_{ACTIVE,i}}$$

where $0\% \leq UED \leq 100\%$ and TotalCost is the cumulative 25-year cost of implementing an active scenario in the i_{th} ecological system.

For species habitat suitability (HS, where $0 \leq HS \leq 1$) multiplied by 100 for conversion to a percentage, ecological ROI is calculated for the two species as shown below.

For sage-grouse:

$$ROI_{GRSG} = \frac{100 \times (HS_{ACTIVE,GRSG} - HS_{MINIMUM,GRSG})}{TotalCost_{ACTIVE,GRSG}}$$

For Utah prairie dog:

$$ROI_{UPD} = \frac{100 \times (HS_{ACTIVE,UPD} - HS_{MINIMUM,UPD})}{TotalCost_{ACTIVE,UPD}}$$

Return On Investment values are a useful tool for land managers to decide where to allocate scarce management resources among many possible choices on lands that they administer, or among scenarios in a given landscape for the benefit of a species of special concern. Of course, managers may also select final scenarios, actions or treatment areas based upon a variety of additional factors, such as availability of financial resources, regulatory constraints, and other multiple-use or societal objectives.

Findings

Ecological Systems

Twenty-six ecological systems were mapped in the Hamlin Valley and Black Mountains Project Areas (Table 2 and Figures 2 and 3), of which eleven were selected for more detailed management analyses (Table 6). The largest systems, all with over 35,000 acres, are mostly intermediate-elevation shrublands and woodlands including Black Sagebrush, Montane Sagebrush Steppe, Wyoming Big Sagebrush upland, and Pinyon-Juniper. Mingled with these at similar elevations are moderate-sized systems such as Basin Wildrye, Curl-leaf Mountain Mahogany, Greasewood-Basin Big Sagebrush, Juniper Savanna, Low Sagebrush, Stansbury Cliffrose, Utah Serviceberry, Winterfat, and Ponderosa Pine. Among the smallest systems are those influenced by water (Montane Riparian, Wet Meadow-Montane, Wet Meadow-Alkali Sacaton, Desert Wash); and those more widespread on lower lands adjacent to the Project Areas (Big Sagebrush semidesert, Mixed Salt Desert, Semi-Desert Grassland). Well-represented but not especially abundant are montane and subalpine forests primarily in the mountains above Hamlin Valley, including Aspen Woodland, Aspen-Mixed Conifer, Mixed Conifer, and Limber-Bristlecone Pine. Specific acreage figures for each ecological system in the two Project Areas appear in Table 2.

Current Condition

Ecological Systems: Unified Ecological Departure

Current values of unified ecological departure for ecological systems in the Hamlin Valley and Black Mountains Project Areas appear in Table 8. The presence of highly-departed systems, particularly in the Black Mountains, largely reflects a preponderance of uncharacteristic vegetation classes, at the expense of reference classes. In some systems the high unified departure is exacerbated by significant amounts of high risk vegetation classes. In general the most common and widespread forms of uncharacteristic (and high risk) classes include those with:

- presence/abundance of invasive non-native species, especially cheatgrass in terrestrial shrubland/woodland systems, and exotic forbs in riparian systems;
- proliferation of conifers in shrubland systems (pinyon and juniper encroachment) and in aspen systems (montane conifer dominance);
- depleted species composition, especially loss of understory species in shrubland systems and loss of aspen clones in aspen systems.

A full list of all vegetation classes in all ecological systems in the two Project Areas at the current time, including their acreages, appears in Appendix 8. High risk vegetation classes are yellow-highlighted in this Appendix 8 list.

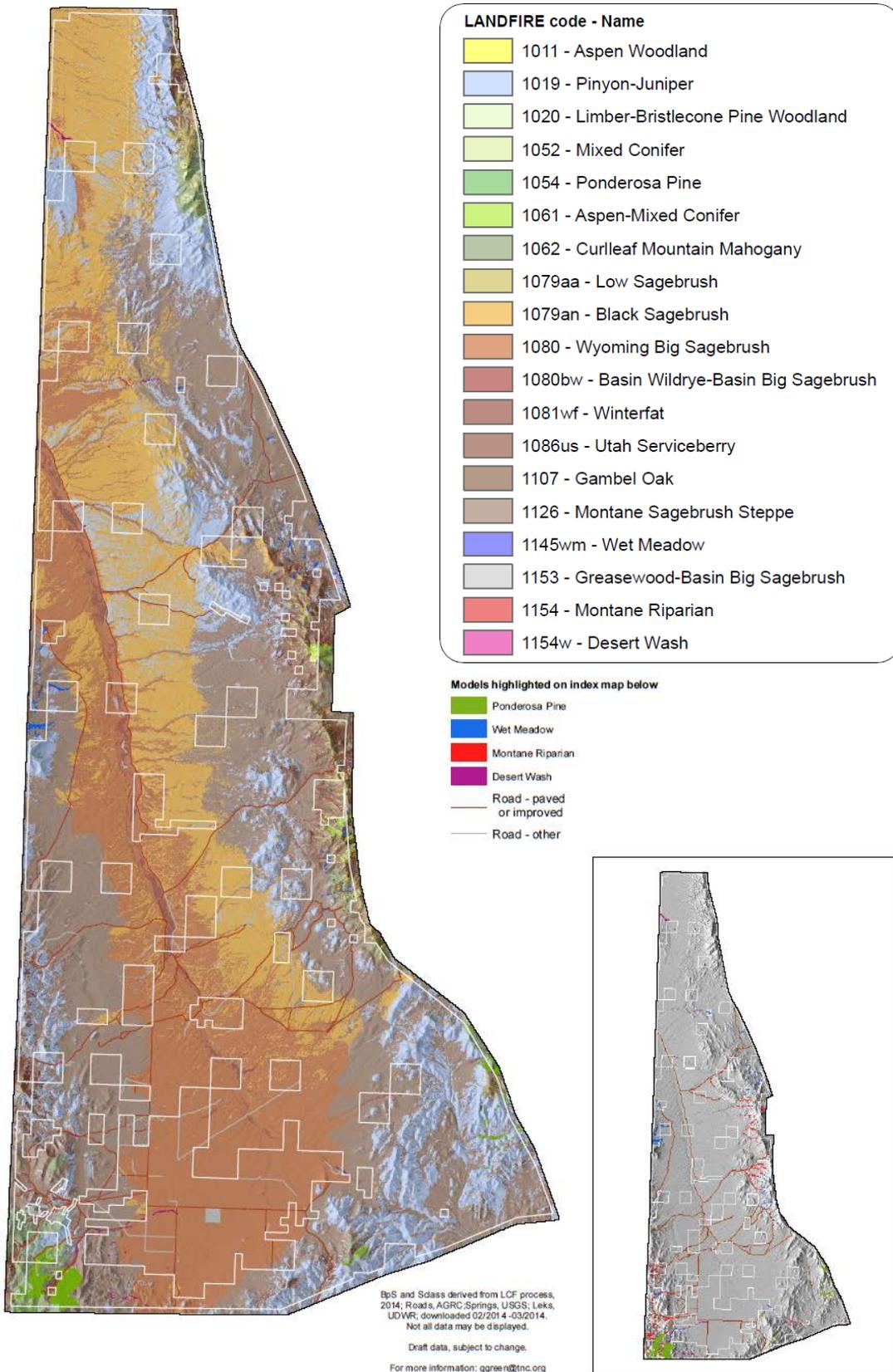


Figure 2. Ecological systems of the Hamlin Valley Project Area.

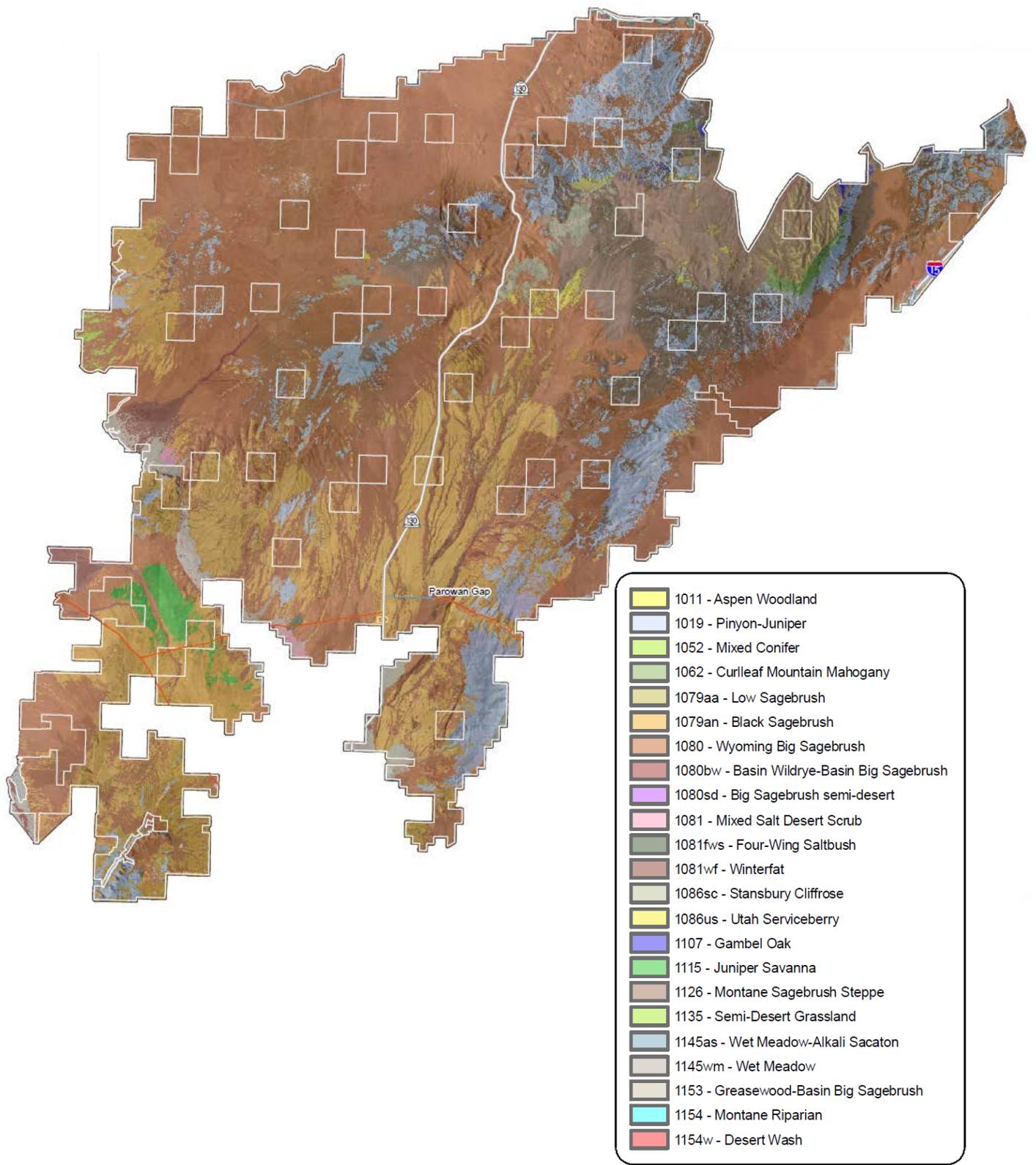


Figure 3. Ecological systems of the Black Mountains Project Area.

Table 8. Current unified ecological departure in all ecological systems in the Hamlin Valley and Black Mountains Project Areas. Systems shaded turquoise are those selected for management analyses.

Ecological System	Hamlin Valley		Black Mountains	
	Acres	UED	Acres	UED
Aspen Woodland	118.6	56	4.8	100
Aspen-Mixed Conifer	391.8	58	—	—
Basin Wildrye	1,402.3	100	1,413.0	100
Big Sagebrush semi-desert	—	—	12.1	100
Black Sagebrush	54,115.4	97	62,371.4	84
Curl-leaf Mountain Mahogany	5,262.1	32	1,178.1	56
Desert Wash	32.4	86	6.1	89
Four-Wing Saltbush	—	—	125.9	92
Gambel Oak-Mountain Shrub	1.5	8	360.8	66
Greasewood-Basin Big Sagebrush	68.3	100	6,123.0	91
Juniper Savanna	—	—	2,764.2	48
Limber-Bristlecone Pine	36.9	10	—	—
Low Sagebrush	2,227.9	20	799.1	42
Mixed Conifer	305.3	72	10.9	57
Mixed Salt Desert	—	—	541.2	97
Montane Riparian	178.7	74	124.7	100
Montane Sagebrush Steppe	98,208.7	100	38,280.3	99
Pinyon-Juniper	46,891.4	34	36,488.4	34
Ponderosa Pine	1,086.3	43	—	—
Semi-Desert Grassland	—	—	319.6	100
Stansbury Cliffrose	—	—	2,070.5	71
Utah Serviceberry	8,947.6	46	1,018.3	35
Wet Meadow-Alkali Sacaton	—	—	320.9	67
Wet Meadow-Montane	143.8	19	50.9	65
Winterfat	1,005.7	56	3,979.9	94
Wyoming Big Sagebrush upland	65,340.5	58	197,690.5	100

Code to cell colors: 0-33 34-66 67-100

Greater Sage-Grouse: Habitat Suitability

The spatial distribution of habitat suitability values for Greater sage-grouse at the current time is shown in Figure 4 for Hamlin Valley, and in Figure 5 for the Black Mountains. Lighter values represent better suitability and darker values represent poorer suitability.

In Hamlin Valley, areas of higher Greater sage-grouse suitability are found along the axial valley bottom because: (1) leks are distributed there like a string of pearls in more open sagebrush shrublands; and (2) the slopes farthest away from the valley axis on either side are shrublands encroached with trees and, therefore, unsuitable for sage-grouse (Figure 4).

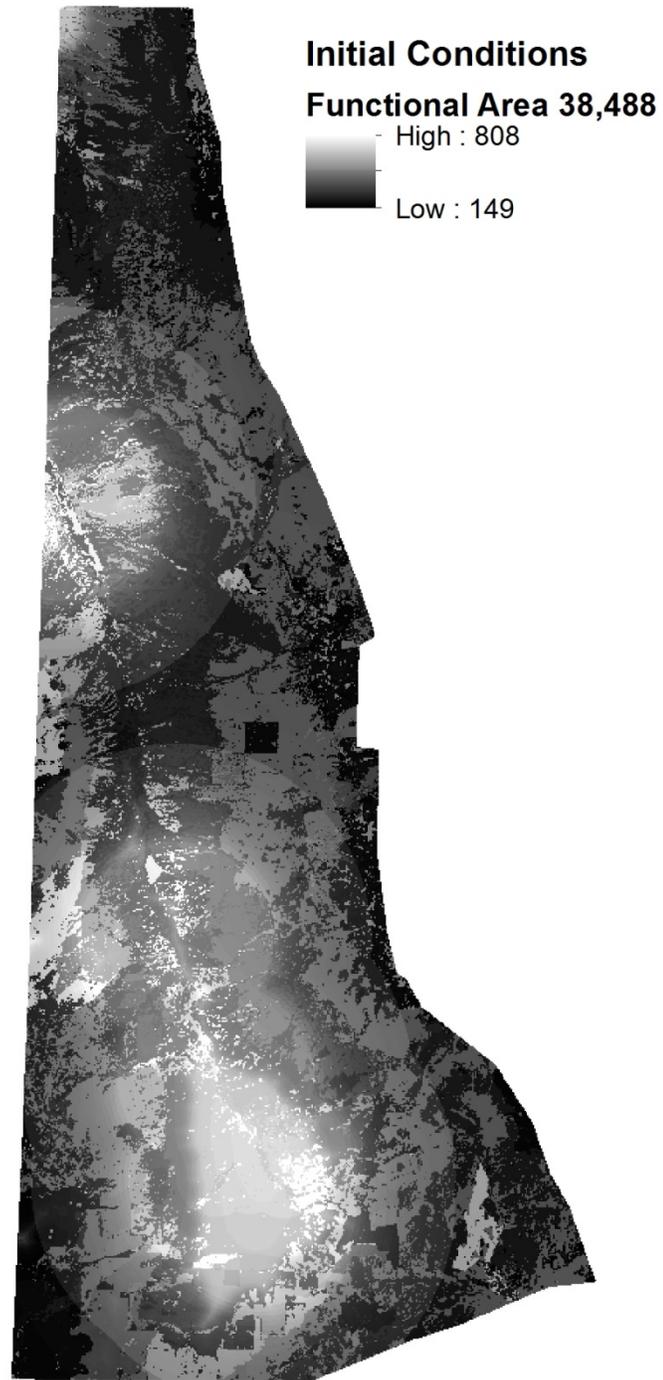


Figure 4. Spatial distribution of habitat suitability values for Greater sage-grouse at the current time in the Hamlin Valley Project Area.

Greater sage-grouse habitat suitability in the Black Mountains (Figure 5) is more diffuse than in Hamlin Valley. The darkest areas (i.e., least suitable) are predominantly covered with trees, either encroaching into shrublands or as true pinyon and juniper woodlands, or they are salt desert scrub communities at lower elevations.

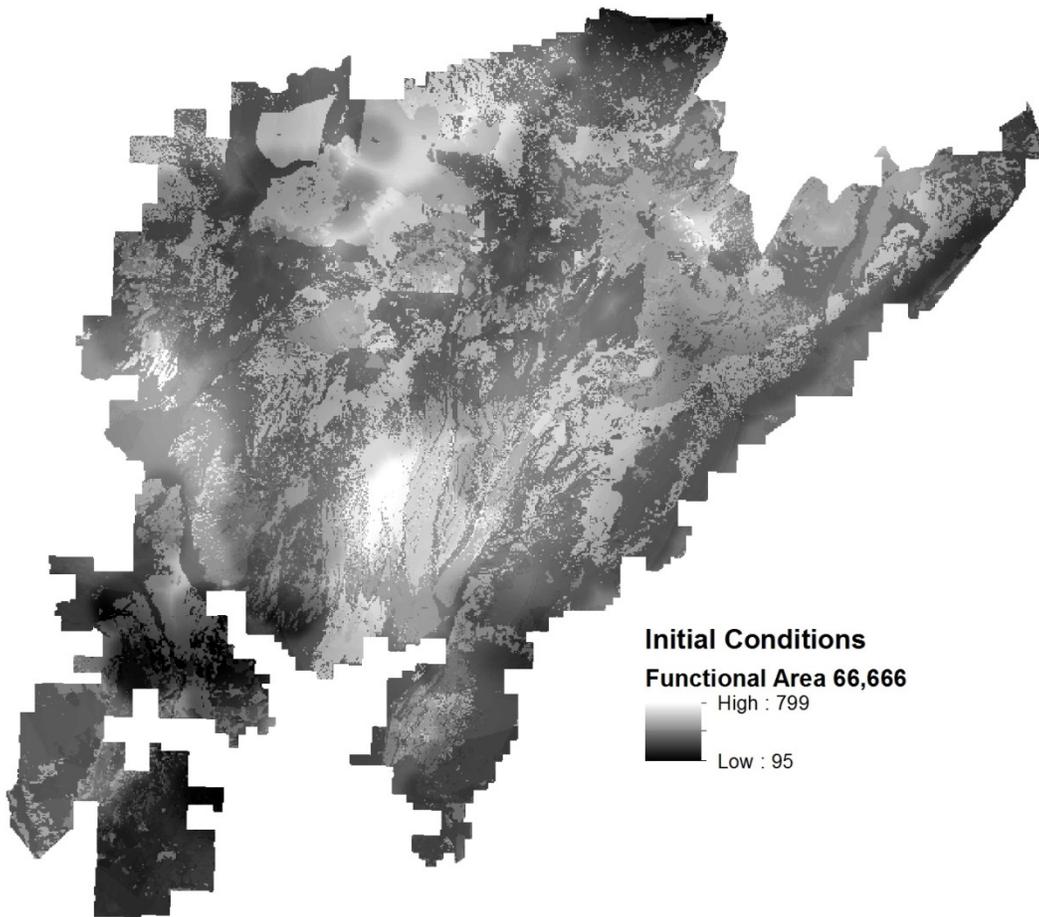


Figure 5. Spatial distribution of habitat suitability values for Greater sage-grouse at the current time in the Black Mountains Project Area.

Utah Prairie Dog: Habitat Suitability

The spatial distribution of habitat suitability values for Utah prairie dog at the current time in the Black Mountains project area is shown in Figure 6. Lighter/greener values represent better suitability, and darker/bluer values represent poorer suitability.

Higher suitability was centered on existing colonies by design. However, patches of vegetation with more shrub or tree cover reduced Utah prairie dog suitability even in proximity to the colony centers. The greenish areas representing higher suitability vegetation in Figure 6 show where Utah prairie dog are most likely to disperse to reach other colony sites. The greenish areas often are a smaller fraction of the concentric area around existing colonies.

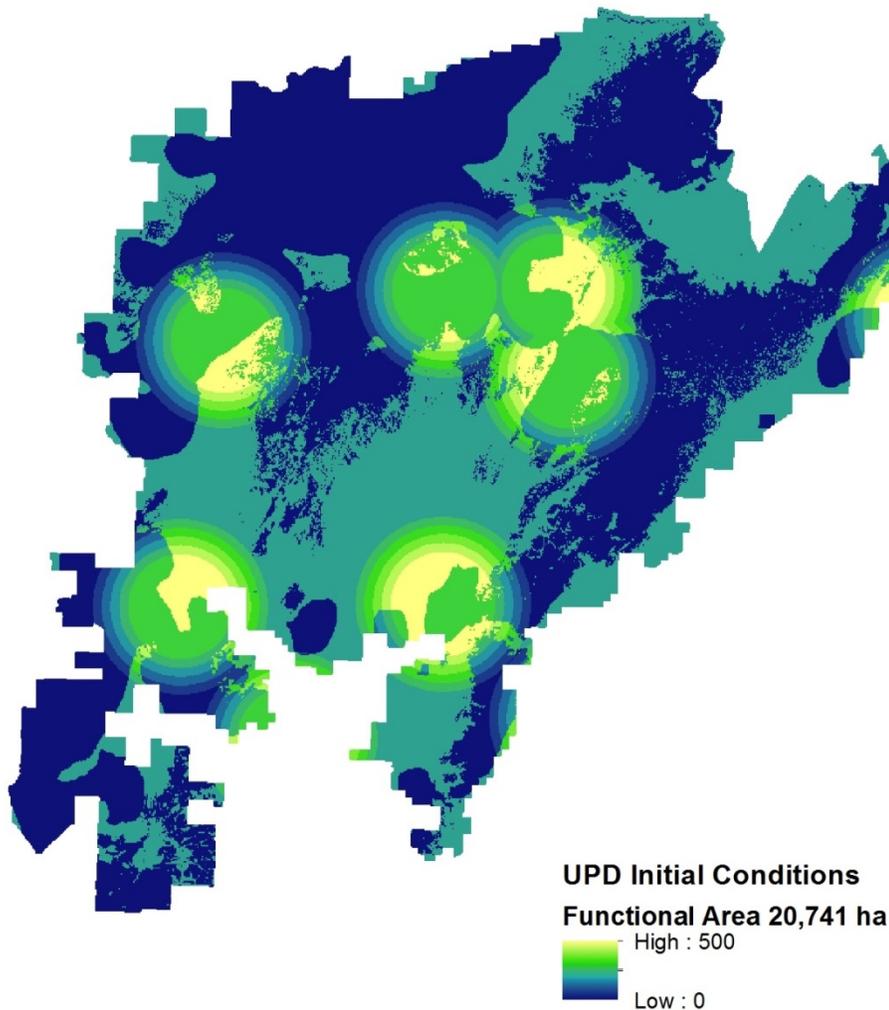


Figure 6. Spatial distribution of habitat suitability values for Utah prairie dog at the current time in the Black Mountains Project Area.

Predicted Future Condition – MINIMUM MANAGEMENT

Ecological Systems: Unified Ecological Departure

Results of model runs show various predicted changes, as measured by unified ecological departure, after 25 years under the scenario of MINIMUM MANAGEMENT. Future values of unified ecological departure for the MINIMUM MANAGEMENT scenario appear in Table 9, but only for those systems selected for management analyses (model runs were not done for the others). Several of the shrubland systems either show a decrease in condition (higher departure) in the future, or remain highly-departed from the present time into the future. Conversely, some forested systems actually show predicted improvement in condition (lower departure) in the future, for various reasons. A combined list of all vegetation classes in selected ecological systems on the District at the current time, and after 25 years under MINIMUM MANAGEMENT, appears in Appendix 9.

Table 9. Unified ecological departure at the current time, and as predicted after 25 years under MINIMUM MANAGEMENT, of ecological systems selected for management analyses in the Hamlin Valley and Black Mountains Project Areas.

Ecological System	Hamlin Valley		Black Mountains	
	Current	MIN MGMT 25 Years	Current	MIN MGMT 25 Years
Aspen Woodland	56	29	100	58
Black Sagebrush	97	100	84	98
Low Sagebrush	20	20	42	45
Montane Riparian	74	80	100	100
Montane Sagebrush Steppe	100	100	99	99
Pinyon-Juniper	34	31	34	31
Ponderosa Pine	43	30	—	—
Stansbury Cliffrose	—	—	71	74
Utah Serviceberry	46	81	35	67
Wet Meadow-Montane	19	36	65	34
Wyoming Big Sagebrush upland	58	67	100	100

Code to cell colors:	0-33	34-66	67-100
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Greater Sage-Grouse: Habitat Suitability

The spatial distribution of habitat suitability values for Greater sage-grouse as predicted after 25 years of MINIMUM MANAGEMENT is shown in Figure 7 for Hamlin Valley, and in Figure 8 for the Black Mountains. Lighter values represent better suitability and darker values represent poorer suitability.

Compared to the current situation (Figure 4), areas of higher habitat suitability shrank (darkened) in the north and central parts of Hamlin Valley, probably due to tree encroachment,

but intensified (though did not expand) in the southern part where introduced species seedings are most prevalent (Figure 7). As a result, functional acres increased from 38,488 at present, to 49,250 after 25 years of MINIMUM MANAGEMENT, primarily due to the contribution from the southern part of Hamlin Valley.



Figure 7. Spatial distribution of habitat suitability values for Greater sage-grouse after 25 years of MINIMUM MANAGEMENT in the Hamlin Valley Project Area.

Twenty-five years of MINIMUM MANAGEMENT caused the overall sage-grouse habitat suitability of the Black Mountains (Figure 8) to increase, compared with current conditions (Figure 5) – from 66,666 to 72,636 functional acres. However, local habitat suitability decreased especially in the central, northern and southern sections probably due to encroachment of shrublands by pinyon and juniper trees. Overall, many areas appear to have brightened (become more suitable), probably due to succession to shrubbier classes after earlier fires (before date of simulation). Although these classes do not contribute strongly to habitat suitability, they offer more sagebrush than early-succession classes.

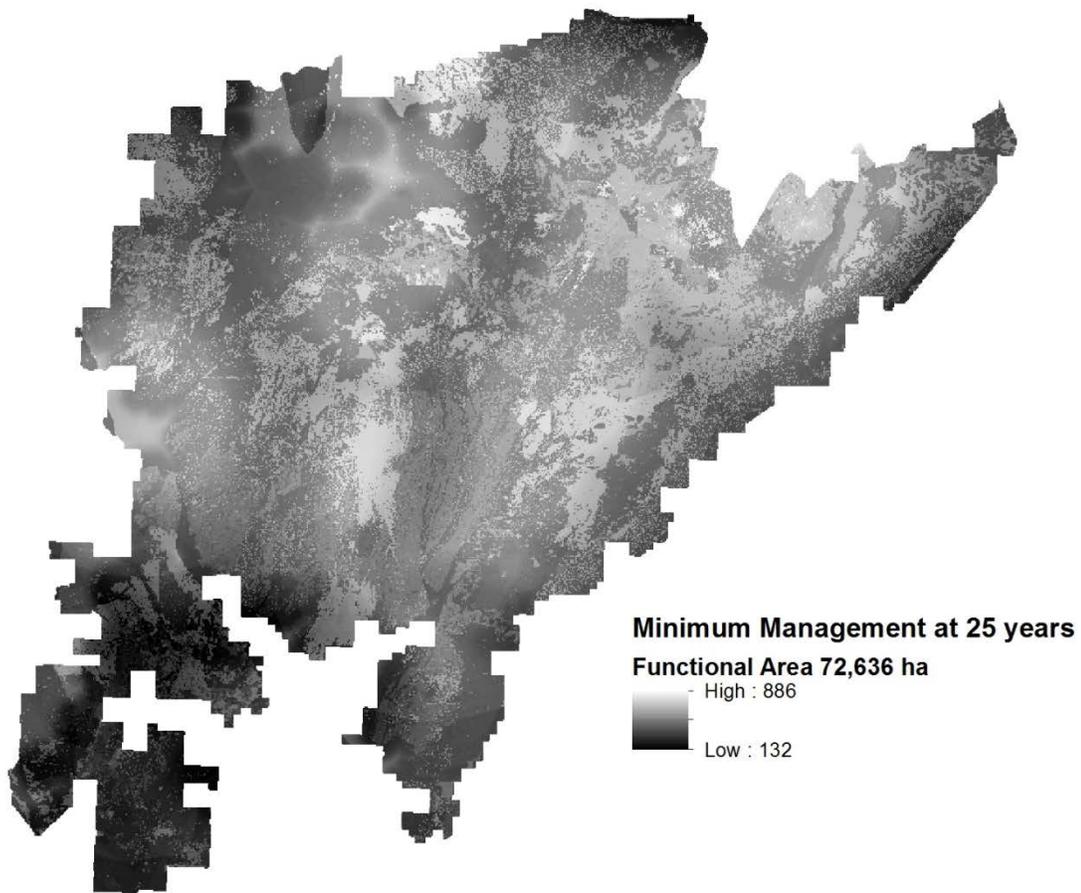


Figure 8. Spatial distribution of habitat suitability values for Greater sage-grouse after 25 years of MINIMUM MANAGEMENT in the Black Mountains Project Area.

Utah Prairie Dog: Habitat Suitability

The spatial distribution of habitat suitability values for Utah prairie dog as predicted after 25 years of MINIMUM MANAGEMENT in the Black Mountains project area is shown in Figure 9. Lighter/greener values represent better suitability, and darker/bluer values represent poorer suitability.

Unlike for Greater sage-grouse, Utah prairie dog habitat suitability slightly decreased after 25 years of MINIMUM MANAGEMENT (Figure 9) from current conditions (Figure 6) – from 20,741 to 19,759 functional acres. Comparison of Figures 6 and 9 reveals that MINIMUM MANAGEMENT adversely affected Utah prairie dog habitat suitability in mostly one northwestern colony area where sagebrush succession degraded prairie dog habitat. In other colony areas toward the east, small pinyon and juniper invasions appear to have degraded habitat suitability.

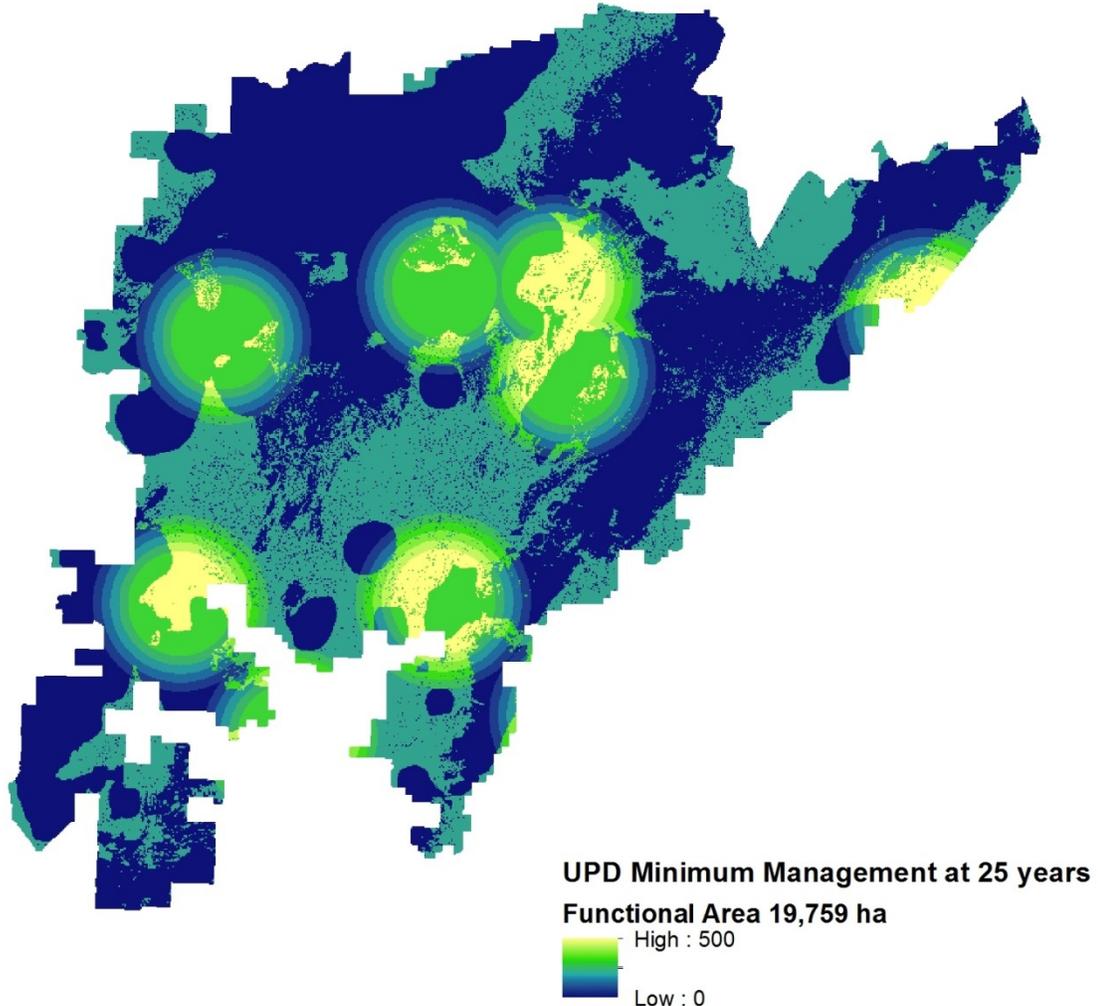


Figure 9. Spatial distribution of habitat suitability values for Utah prairie dog after 25 years of MINIMUM MANAGEMENT in the Black Mountains Project Area.

Predicted Future Condition – Active Management Scenarios

Introduction

For each ecological system selected for more detailed analyses (see Table 6), management actions or treatments were modeled under the two future Active Management scenarios of MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT (see Table 7). Management actions were identified to achieve the purposes of: (1) abating the most serious current and future problems that face the ecological systems or human infrastructure; and more generally (2) improving the condition of ecological systems that are currently in an undesirable (highly-departed) condition.

The MAXIMUM and PREFERRED MANAGEMENT scenarios for each ecological system were tested via computer simulations using ST-Sim software to determine how well they achieved the twin purposes above. Model-run outcomes are reported for unified ecological departure after 25 years – although technically these are the average of individual UED values from each of five model-run iterations. Also reported are the actual acres treated by each action over the 25-year period, and the total 25-year costs for implementation of the actions. Finally, Return On Investment (ROI) values are shown for the MAXIMUM MANAGEMENT scenario and the PREFERRED MANAGEMENT scenario, each relative to the baseline MINIMUM MANAGEMENT scenario.

In the sub-sections that follow, summary descriptions of these active-management modeling results are presented for each selected ecological system in each Project Area. Each system description includes text, tables and charts that together provide the following information:

1. Brief description of the system’s unified ecological departure and “problem” vegetation classes, both at present and after 25 years of MINIMUM MANAGEMENT;
2. Objectives (desired outcomes) for the system;
3. Management actions, including acres treated and cost, that are aimed at achieving the objectives under two future active management scenarios;
4. Summary of outcomes in terms of unified ecological departure (UED) and return on investment (ROI), plus one or more charts showing change in the “problem” class(es) via active management.

Following individual descriptions of the selected ecological systems, sub-sections briefly describe results in terms of Habitat Suitability for 25-year model runs of the PREFERRED MANAGEMENT scenario for Greater sage-grouse in Hamlin Valley, and for Greater sage-grouse and Utah prairie dog in the Black Mountains.

Following those individual system and species descriptions, a sub-section summarizes ROI results across all the systems, and for the two species in their whole Project Areas, and then a final section identifies areas for implementation of treatment actions.

Hamlin Valley: Aspen Woodland

In Hamlin Valley, the Aspen Woodland system exhibits moderate (56%) UED at the current time. Nearly three-fourths of this small system’s acres are within reference classes, with the remainder in the uncharacteristic Depleted class. This Depleted class is at risk of losing aspen clones permanently, thus inflating the current UED value. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED drops substantially (to 29%), for two main reasons: (1) some areas in the U:Depleted class have transitioned to the Montane Sagebrush Steppe ecological system as a result of clone loss (shows as lower UED due to “elimination” of the undesirable vegetation); and (2) non-management processes have converted part of the U:Depleted class into reference classes. Amounts of specific vegetation classes in the Aspen Woodland system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
ASP-A:Closed	7	—	118.6	0.3	0.3%	6.4%
ASP-B:Closed	23	—		6.5	5.5%	15.0%
ASP-C:Closed	43	—		67.0	56.5%	63.8%
ASP-D:Open	27	—		11.0	9.2%	9.5%
ASP-U:Depleted	0	0.00		33.8	28.5%	5.3%

The current predominance of the uncharacteristic Depleted class, which is a high-risk class, is of concern. Even though the relative amount of this class is much lower after 25 years of MINIMUM MANAGEMENT, its continued presence remains as a future concern.

Therefore the primary objective of management actions is to reduce the acreage of the high-risk Depleted class through treatments that will re-invigorate the deteriorating aspen clones, or at a minimum protect them from agents of further degradation and allow them to self-recover, thus moving those acres back into reference condition. The table below shows management actions and costs aimed at achieving this objective under two future active management scenarios: MAXIMUM and PREFERRED.

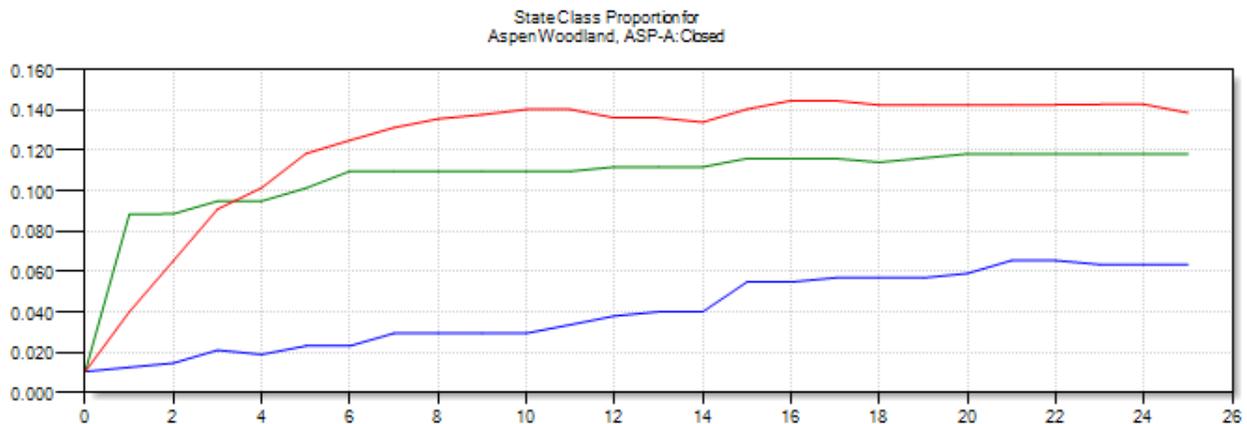
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)			25-Yr Total Cost
		Years 1-10	Years 11-25	Cost/Ac	
MAXIMUM	Chainsaw-Thinning	0.94	0	\$80	\$287,292
	Fence	1.40	0.97	\$10,000	
	RxFire	0.34	0	\$150	
	Small-Tree-Lopping	0.46	0	\$60	
PREFERRED	Chainsaw-Thinning	1.02	0	\$80	\$102,522
	Fence	1.02	0	\$10,000	

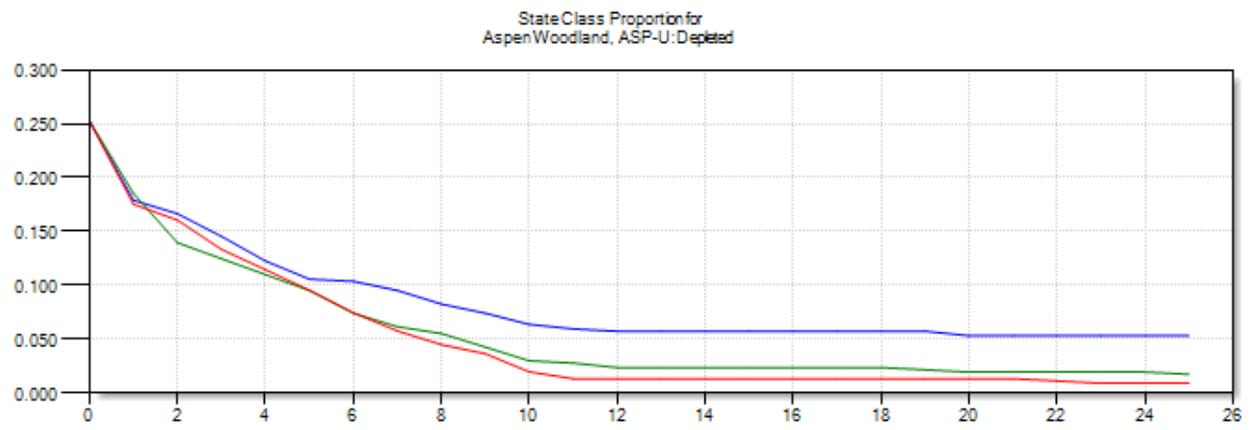
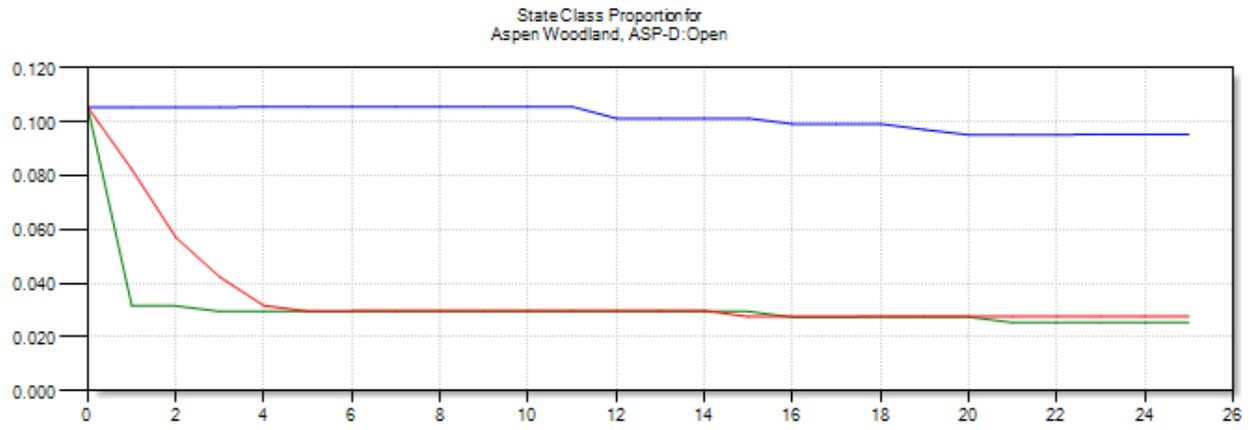
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 118.6	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	56%	29%	32%	31%
Cost			\$287,292	\$102,522
ROI - vs Minimum Mgmt			- 0.11	- 0.31
ROI - 95% Confidence Interval			± 0.11	± 0.76
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			No	

As mentioned above, the predicted UED value under MINIMUM MANAGEMENT after 25 years has decreased to where it is about the same as for both the MAXIMUM and PREFERRED MANAGEMENT scenarios. All three of these future improvements reflect the conversion of Depleted-class acres to reference classes – by virtue of active management treatments in the MAXIMUM and PREFERRED scenarios, and without such treatments in the MINIMUM scenario. The main difference between management and non-management is that the active management scenarios (MAXIMUM and PREFERRED) both result in a marked increase in the youngest reference class (A), which can then succeed to the B and C classes through time. Under these two active scenarios, loss of aspen clones to Montane Sagebrush Steppe is also less likely. On the other hand, the MINIMUM MANAGEMENT scenario retains most of the reference-class acres in the oldest D class, which remains vulnerable to becoming Depleted over time.

Given these results, the ROI values of the MAXIMUM and PREFERRED scenarios are both near zero (slightly negative), and not significantly different from each other at the 95% confidence level. Further, the model predicts that the MINIMUM MANAGEMENT scenario will result in very similar results (as measured by UED) to both of the active management scenarios – but for zero cost. However, the MINIMUM MANAGEMENT scenario results in the permanent loss of some aspen acres to Montane Sagebrush Steppe, which managers may consider unacceptable. Finally, charts below from the ST-Sim model output show the forecasted amounts of the A, D, and U:Depleted classes in the MINIMUM, PREFERRED and MAXIMUM scenarios.





■ Results for [819] - Minimum Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [877] - Preferred Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [820] - Maximum Management HV Spatial (15-Jun-2015 10:26 AM)

Hamlin Valley: Black Sagebrush

In Hamlin Valley, the Black Sagebrush system exhibits nearly complete (97%) UED at the current time. This very high departure at present results from out-of-balance amounts of reference classes, plus appreciable amounts of several uncharacteristic classes. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED becomes complete (100%), for the same reasons. Amounts of specific vegetation classes in the Black Sagebrush system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
BS-A:All	15	—	54,115.4	558.4	1.0%	0.8%
BS-B:Open	48	—		2,679.5	5.0%	2.6%
BS-C:Closed	25	—		1,450.8	2.7%	4.3%
BS-D:Open	12	—		22,885.5	42.3%	35.2%
BS-U:Annual Grass	0	0.00		419.5	0.8%	2.9%
BS-U:Depleted	0	0.00		380.1	0.7%	0.6%
BS-U:Early-Shrub	0	0.00		7.6	0.0%	0.4%
BS-U:SA	0	0.00		1,923.2	3.6%	5.2%
BS-U:SA+	0	0.00		0.0	0.0%	3.7%
BS-U:SAP	0	0.00		6,871.2	12.7%	5.6%
BS-U:SAP+	0	0.00		0.0	0.0%	0.5%
BS-U:SDI-A	0	9.00		0.0	0.0%	0.0%
BS-U:SDI-B	0	28.80		46.8	0.1%	0.1%
BS-U:SDI-C	0	15.00		0.0	0.0%	0.0%
BS-U:Seeded Native	0	15.00		0.0	0.0%	0.0%
BS-U:SI-A+AG	0	0.00		0.0	0.0%	0.0%
BS-U:SI-B+AG	0	0.00		0.0	0.0%	0.0%
BS-U:SI-C+AG	0	0.00		0.0	0.0%	0.0%
BS-U:TEA	0	0.00		16,892.8	31.2%	38.0%

Two classes with appreciable encroachment by juniper and pinyon pine comprise nearly three-fourths of the system's area at present: the late-open class (D), and the uncharacteristic tree-encroached class (U:TEA); the latter is a high-risk class. Annual grasses are a moderate concern at present, represented in the U:SAP and U:TEA classes that together comprise nearly half of the system's area at present. After 25 years of MINIMUM MANAGEMENT, the two tree-encroached classes (D and U:TEA) together still comprise about three-fourths of the system's area, whereas the amount of the U:SAP annual-grass class has actually decreased a small amount.

Therefore the primary objective of management actions is to reduce the acreage of classes defined by encroachment of juniper and pinyon pine. A secondary objective is to hold in check, and reduce if possible, classes defined by presence/abundance of annual grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

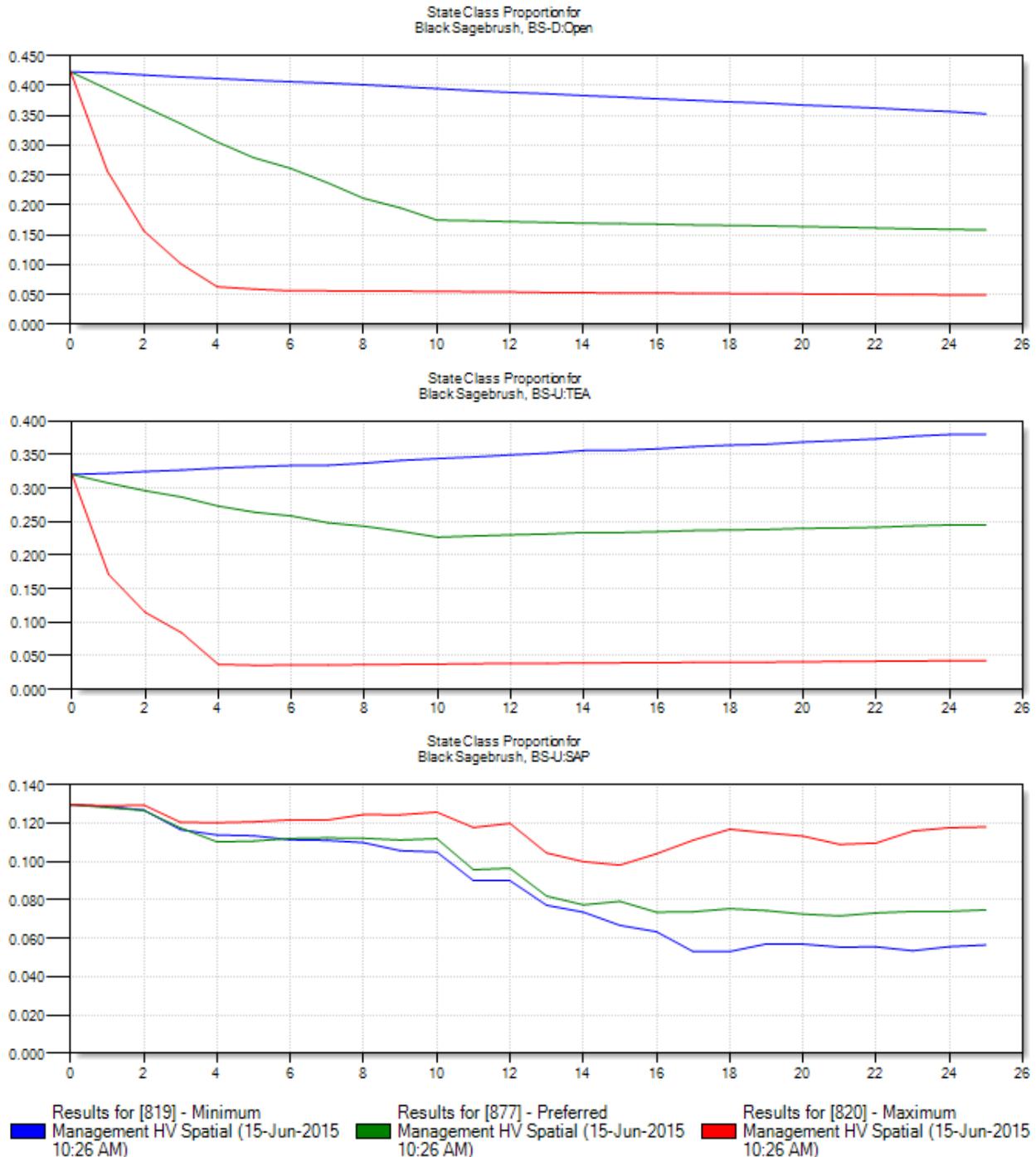
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	2xChaining+Native-Seed	8.86	0.55	\$230	
	2xChaining+Plateau+Seed	189.86	0.00	\$220	
	2xChaining+Seed	483.84	0.02	\$190	
	Chaining+Native-Seed	570.49	5.54	\$175	
	Chaining+Plateau+Seed	224.07	23.55	\$145	
	Chainsaw-Thinning	894.43	4.97	\$20	
	Forb+Grass-Native-Seeding	2799.33	2814.37	\$175	
	Herbicide-Plateau+Seed	218.46	5.91	\$110	
	Hypo-Hatchet-Spyke	323.00	4.39	\$25	
	Masticate+Herbicide+Seed	303.87	0.00	\$310	
	Masticate+Native-Seed	563.39	0.32	\$325	
	Masticate+Seed	301.69	0.00	\$270	
	Mastication	1.19	0.00	\$200	
	RxFire+Seed+Chain	405.74	0.00	\$235	
	Small-Tree-Lopping	2131.18	881.73	\$80	
	Spyke+Native-Seed	10.56	0.57	\$240	
	Thin	5353.35	6764.77	\$35	
Thin+Native-Seed	17.48	0.55	\$250		
					\$28,353,889
PREFERRED	2xChaining+Seed	391.94	0	\$190	
	Chaining+Native-Seed	689.73	0	\$175	
	Chaining+Plateau+Seed	235.12	0	\$145	
	Forb+Grass-Native-Seeding	45.89	0	\$175	
	Herbicide-Plateau+Seed	117.98	0	\$110	
	Masticate+Native-Seed	554.63	0	\$325	
	Masticate+Seed	214.94	0	\$270	
	Small-Tree-Lopping	0	51.68	\$80	
					\$4,947,612

The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 54,115.4	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	97%	100%	31%	66%
Cost			\$28,353,889	\$4,947,612
ROI - vs Minimum Mgmt			13.23	36.68
ROI - 95% Confidence Interval			± 0.88	± 0.85
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, the MAXIMUM MANAGEMENT scenario shows large improvement in UED, and the PREFERRED MANAGEMENT scenario shows moderate improvement in UED. These improvements under both active management scenarios largely reflect reductions in tree-encroached classes relative to the MINIMUM MANAGEMENT scenario.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves an improvement (reduction of UED) only about half as great as that of the MAXIMUM scenario – but for about one-sixth of the total cost of the MAXIMUM scenario. Further, the treatment-amount inputs to the MAXIMUM scenario were so large that the model “ran out of acres” for many treatments during the latter part of its 25-year run. Finally, charts below from the ST-Sim model output show the forecasted reductions in the D, U:TEA, and U:SAP classes in the PREFERRED and MAXIMUM scenarios.



Hamlin Valley: Low Sagebrush

In Hamlin Valley, the Low Sagebrush system exhibits low (20%) UED at the current time. More than nine-tenths of this system’s acres are in reference classes, and these are not far departed from their respective NRV values. The remaining acres are almost all within a single uncharacteristic class that is not high-risk. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED remains the same. Relative amounts of reference and uncharacteristic classes have shifted modestly toward the latter, but not enough to change the future UED. Amounts of specific vegetation classes in the Low Sagebrush system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
LS-A:All	10	—	2,227.9	8.8	0.4%	1.8%
LS-B:Open	37	—		595.5	26.7%	26.4%
LS-C:Closed	53	—		1,443.8	64.8%	53.6%
LS-U:Annual Grass	0	0.00		0.0	0.0%	0.7%
LS-U:Depleted	0	0.00		0.3	0.0%	0.5%
LS-U:Early-Shrub	0	0.00		9.6	0.4%	0.5%
LS-U:SA	0	0.00		0.0	0.0%	0.2%
LS-U:SA+	0	0.00		0.0	0.0%	0.0%
LS-U:SAP	0	0.00		160.8	7.2%	15.6%
LS-U:SAP+	0	0.00		0.0	0.0%	0.5%
LS-U:SDI-A	0	6.00		0.0	0.0%	0.0%
LS-U:SDI-B	0	22.20		0.0	0.0%	0.0%
LS-U:SDI-C	0	31.80		0.0	0.0%	0.0%
LS-U:Seeded Native	0	10.00		0.0	0.0%	0.0%
LS-U:SI-A+AG	0	0.00		0.0	0.0%	0.0%
LS-U:SI-B+AG	0	0.00		0.0	0.0%	0.0%
LS-U:SI-C+AG	0	0.00		0.0	0.0%	0.0%
LS-U:TA	0	0.00	0.0	0.0%	0.0%	
LS-U:TE	0	0.00	9.1	0.4%	0.2%	

Two moderate concerns within this system at the present time are a tendency toward encroachment by juniper and pinyon pine (excessive amount of the reference C class), and increase of annual grasses in habitats that still contain a native vegetation component (U:SAP class). After 25 years of MINIMUM MANAGEMENT, the reference C class has decreased, and the U:SAP class has increased, both by modest amounts.

Therefore the primary objective of management actions is to reduce the encroachment of juniper and pinyon pine. A secondary objective is to hold in check, and reduce if possible, the presence/abundance of annual grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	Chaining+Native-Seed	0.05	0.03	\$175	\$109,950
	RxFire	35.72	0.81	\$150	
	Small-Tree-Lopping	19.76	8.83	\$80	
	Spot-Herbicide+Native-Seed	2.13	2.47	\$225	
	Thin	37.27	3.44	\$35	
PREFERRED	Chaining+Native-Seed	0	0.01	\$175	\$69,747
	Small-Tree-Lopping	0	58.09	\$80	

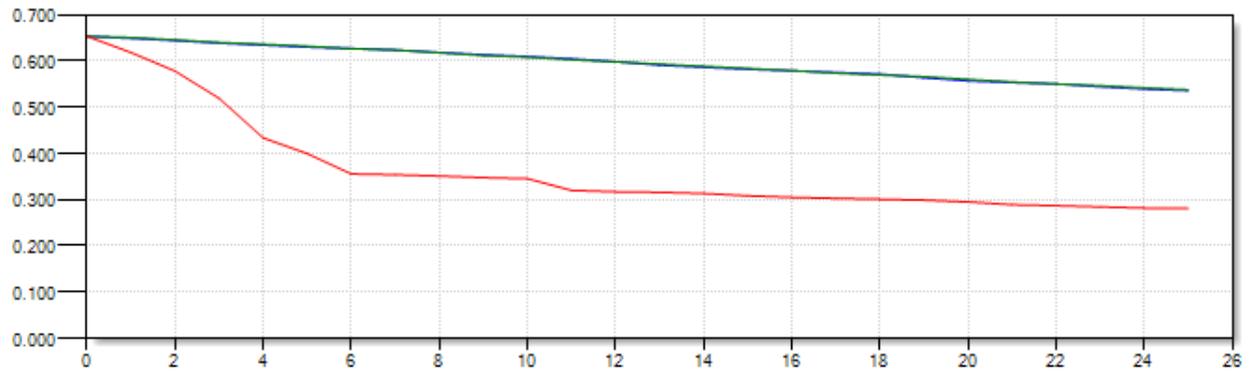
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 2,227.9	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	20%	20%	26%	20%
Cost			\$109,950	\$69,747
ROI - vs Minimum Mgmt			-11.69	-0.46
ROI - 95% Confidence Interval			± 2.85	± 1.95
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

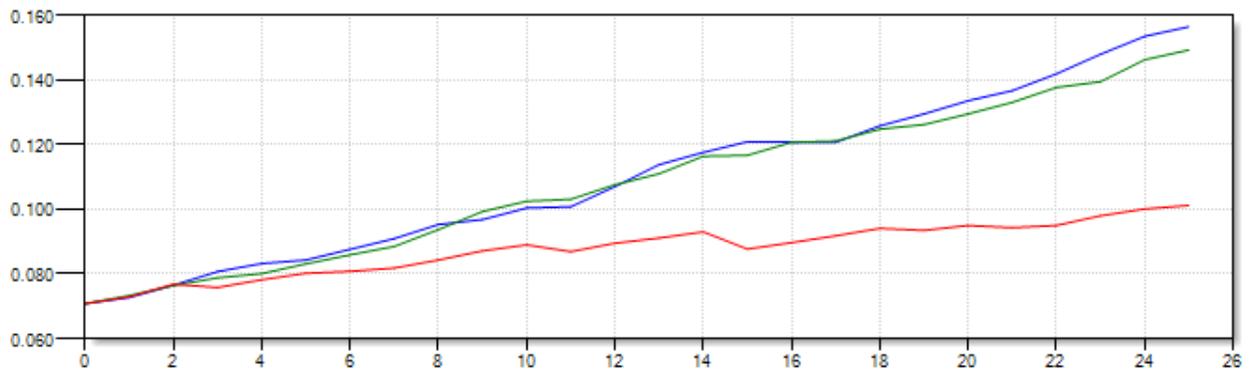
Compared with MINIMUM MANAGEMENT after 25 years, the PREFERRED MANAGEMENT scenario shows no change in UED, whereas the MAXIMUM MANAGEMENT scenario shows an apparent decrease in condition as indicated by a higher UED value, though it is still well within the good range. The MAXIMUM MANAGEMENT scenario actually achieves greater acreage of reference classes in total, but these are weighted toward the younger age classes, and their out-of-balance nature inflates the UED value somewhat. Overall there is little difference in predicted outcomes among these three scenarios.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level, though both are negative. Both of these active management scenarios achieve good results, though the PREFERRED scenario does so for about three-fifths of the total cost of the MAXIMUM scenario. However, the model predicts that the MINIMUM MANAGEMENT scenario will result in virtually identical results (as measured by UED) to both of the active management scenarios – but for zero cost. Finally, charts below from the ST-Sim model output show the forecasted amounts of the C and U:SAP classes in the MINIMUM, PREFERRED and MAXIMUM scenarios.

State Class Proportion for
Low Sagebrush, LS-C:Closed



State Class Proportion for
Low Sagebrush, LS-U:SAP



■ Results for [819] - Minimum Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [877] - Preferred Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [820] - Maximum Management HV Spatial (15-Jun-2015 10:26 AM)

Hamlin Valley: Montane Riparian

In Hamlin Valley, the Montane Riparian system exhibits relatively high UED (74%) at the current time. Though over half of the current acres are in reference classes, this relatively high departure results from the current mix of reference classes being out of balance from the NRV amounts. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED rises modestly (to 80%). The main driver of this higher future departure is an increase in amounts of several uncharacteristic classes, which are high-risk classes that inflate the unified departure value. Amounts of specific vegetation classes in the Montane Riparian system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
MR-A:All	14	—	178.7	0.5	0.3%	0.4%
MR-B:Open	25	—		98.5	55.1%	0.0%
MR-C:Closed	61	—		0.9	0.5%	37.3%
MR-U:Annual Grass	0	0.00		0.0	0.0%	0.0%
MR-U:Desertified	0	0.00		0.0	0.0%	15.0%
MR-U:EFT	0	0.00		0.0	0.0%	19.7%
MR-U:SAP	0	0.00		0.0	0.0%	0.3%
MR-U:SDA	0	0.00		0.0	0.0%	0.0%
MR-U:Seeded Native	0	0.00		0.0	0.0%	0.0%
MR-U:SFE	0	0.00		78.8	44.1%	27.3%
MR-U:TE	0	0.00		0.0	0.0%	0.0%

The current amount of the shrub-forb-encroached class (U:SFE), nearly half of the system’s acres, is a concern. After 25 years of MINIMUM MANAGEMENT, this class has shrunk to about one-fourth of the system’s acres. At that time, however, two other uncharacteristic classes have appeared that together comprise over a third of the system’s acres: the desertified and exotic-forb-tree classes, both of which are high-risk and thus of large future concern.

Therefore the primary objective of management actions is to reduce the acreage of classes defined by exotic trees and forbs, and by undesirable (but native) shrubs and forbs. A secondary objective, if resources allow, is to halt and (if possible) reverse/restore the acreage of incised stream channels represented by the desertified class. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)			25-Yr Total Cost
		Years 1-10	Years 11-25	Cost/Ac	
MAXIMUM	Chainsaw-Thinning	0	2.11	\$80	\$318,057
	Exotic-Control	0.07	0	\$360	
	Floodplain-Restoration	0.05	0.58	\$2,000	
	Small-Rock-Dam	0	0.71	\$500	
	Weed-Inventory+Treat	29.62	34.24	\$360	

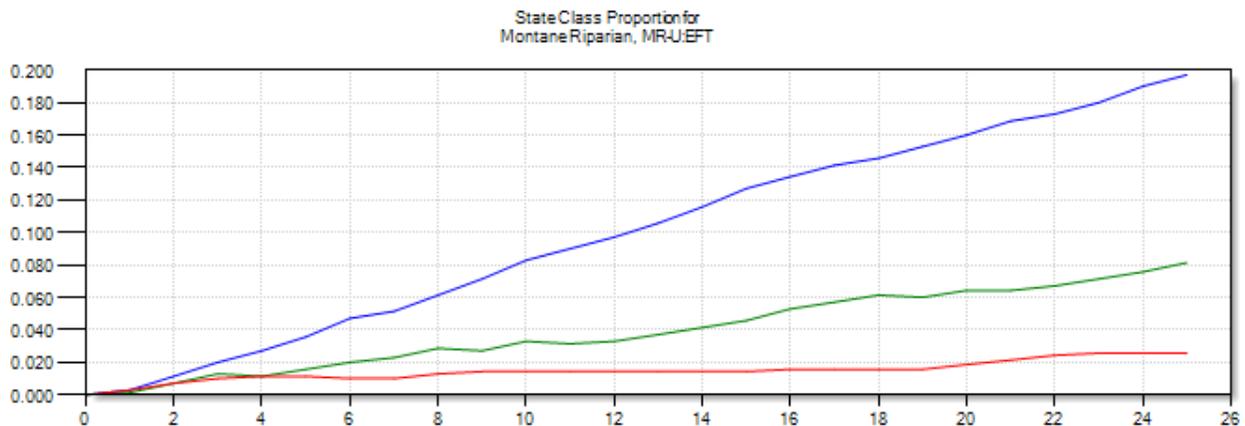
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
PREFERRED	Chainsaw-Thinning	0	1.92	\$80	\$65,161
	Exotic-Control	0.90	0.61	\$360	
	Weed-Inventory+Treat	6.47	6.12	\$360	

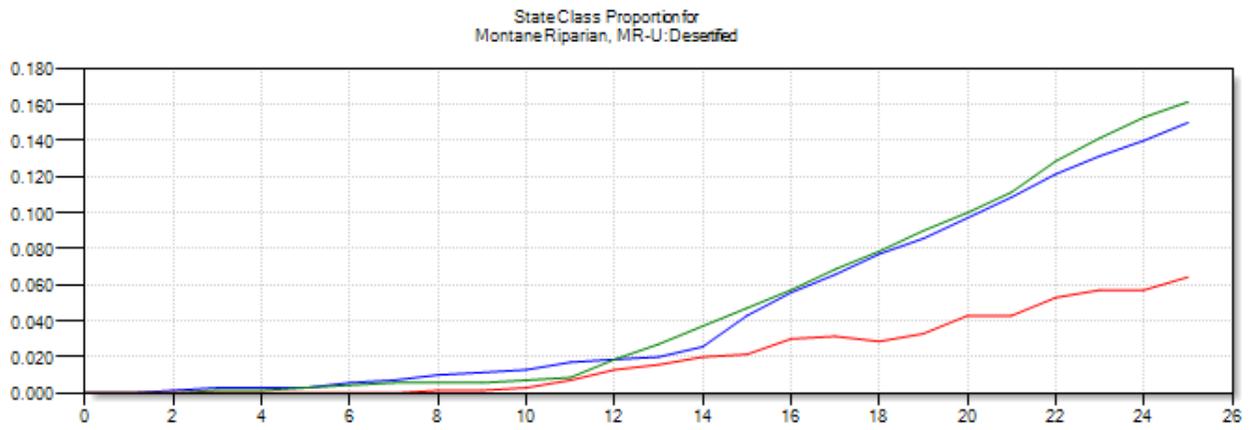
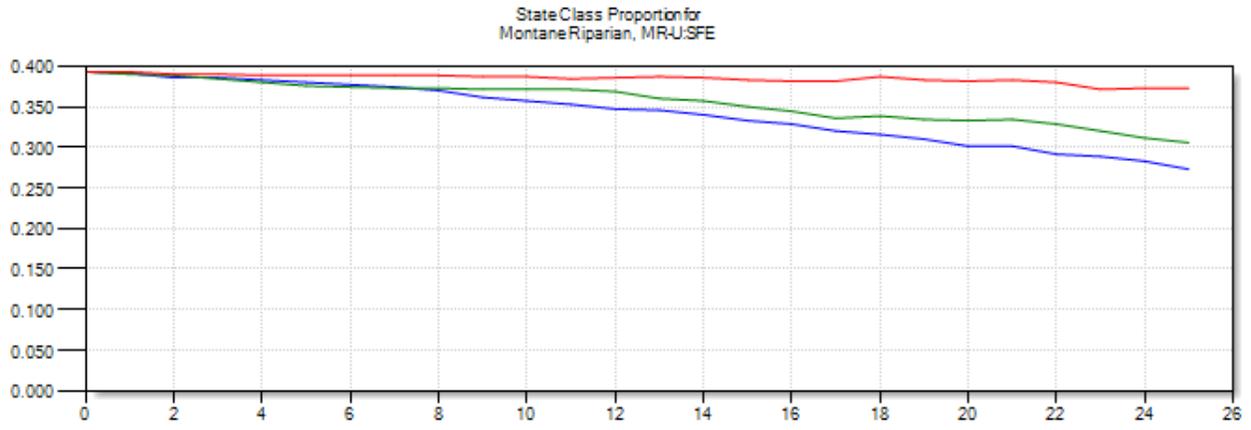
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 178.7	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	74%	80%	51%	67%
Cost			\$318,057	\$65,161
ROI - vs Minimum Mgmt			1.63	3.48
ROI - 95% Confidence Interval			± 0.16	± 1.30
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, the MAXIMUM and PREFERRED MANAGEMENT scenarios both show appreciable reduction of UED, with the MAXIMUM scenario predicting about twice as much improvement. Both of these active scenarios greatly reduce the high-risk U:EFT class. The MAXIMUM scenario performs better at holding the holding the U:Desertified class in check, whereas the PREFERRED scenario yields better reduction of the U:SFE class.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves an improvement (reduction of UED) only about half as great as that of the MAXIMUM scenario – but for about one-fifth of the total cost of the MAXIMUM scenario. Floodplain restoration is especially expensive. Charts below from the ST-Sim model output show the forecasted changes in the U:EFT, U:SFE, and U:Desertified classes in the PREFERRED and MAXIMUM scenarios.





■ Results for [819] - Minimum Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [877] - Preferred Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [820] - Maximum Management HV Spatial (15-Jun-2015 10:26 AM)

Hamlin Valley: Montane Sagebrush Steppe

In Hamlin Valley, the Montane Sagebrush Steppe system exhibits complete (100%) UED at the current time. This total departure at present results from almost four-fifths of the system's acres being in uncharacteristic classes, and the remaining reference-class acres being out of balance from NRV. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED remains complete (100%) for the same reasons, with an even larger relative amount of uncharacteristic classes. Amounts of specific vegetation classes in the Montane Sagebrush Steppe system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
MSS-A:All	22	—	98,208.7	2,941.0	3.0%	0.1%
MSS-B:Open	34	—		1,369.1	1.4%	1.7%
MSS-C:Closed	39	—		2,392.9	2.4%	4.0%
MSS-D:Open	3	—		8,935.1	9.1%	0.6%
MSS-E:Closed	2	—		4,681.5	4.8%	9.3%
MSS-U:Annual Grass	0	0.00		5,720.5	5.8%	7.8%
MSS-U:Depleted	0	0.00		367.3	0.4%	0.3%
MSS-U:Early-Shrub	0	0.00		1,358.7	1.4%	1.7%
MSS-U:SA	0	0.00		1,867.6	1.9%	1.1%
MSS-U:SA+	0	0.00		0.0	0.0%	0.2%
MSS-U:SAP	0	0.00		1,775.9	1.8%	1.9%
MSS-U:SAP+	0	0.00		0.0	0.0%	0.1%
MSS-U:SDI-A	0	13.20		5,015.5	5.1%	0.1%
MSS-U:SDI-B	0	20.40		65.0	0.1%	1.1%
MSS-U:SDI-C	0	23.40		87.3	0.1%	3.4%
MSS-U:SDI-D	0	1.80		0.0	0.0%	0.0%
MSS-U:Seeded Native	0	22.00		0.0	0.0%	0.0%
MSS-U:SI-A+AG	0	0.00		0.0	0.0%	0.0%
MSS-U:SI-B+AG	0	0.00		1.9	0.0%	0.1%
MSS-U:SI-C+AG	0	0.00		0.0	0.0%	0.4%
MSS-U:SI-D+AG	0	0.00		0.0	0.0%	0.0%
MSS-U:TEA	0	0.00	61,629.5	62.8%	66.0%	

The major concern in this system at the present time is tree encroachment by juniper and pinyon pine (class U:TEA), which is a high-risk class, and also includes a complement of annual grasses. Other classes defined by presence/abundance of annual grasses comprise about one-tenth of the system's acres at present. After 25 years of MINIMUM MANAGEMENT, the tree-encroached class (with annual grasses) has increased, whereas the other annual-grass classes remain relatively constant.

Therefore the objectives of management actions are to reduce the acreage of classes that are defined primarily by presence/abundance of encroaching conifers, and secondarily by annual grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

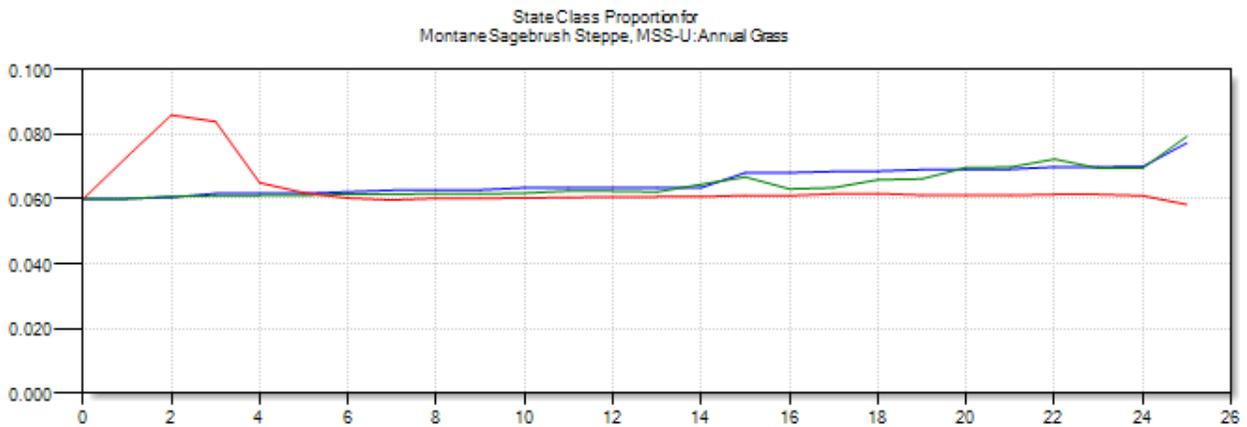
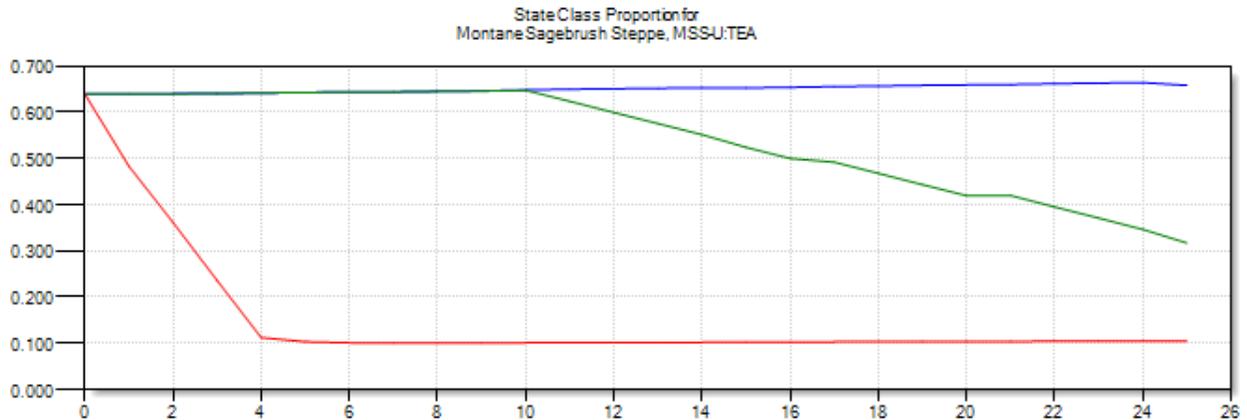
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	2xChaining+Native-Seed	4.70	0	\$230	
	Chaining+Native-Seed	238.92	3.89	\$175	
	Chaining+Plateau+Seed	164.14	15.93	\$185	
	Forb+Grass-Native-Seeding	9616.26	9286.85	\$175	
	Herbicide-Plateau+Seed	722.54	657.00	\$110	
	Hypo-Hatchet-Spyke	0	13.72	\$25	
	Masticate+Herbicide+Seed	2710.14	1.73	\$310	
	Masticate+Native-Seed	117.47	0.06	\$325	
	Mastication	411.00	2.71	\$200	
	RxFire	533.48	0.03	\$100	
	RxFire+Seed+Chain	3808.59	16.35	\$235	
	Small-Tree-Lopping	10.78	55.76	\$80	
	Spyke+Native-Seed	6.49	0.39	\$240	
	Thin	528.84	92.41	\$35	
	Thin+Native-Seed	13.78	0.36	\$250	
					\$63,385,247
PREFERRED	Chaining+Native-Seed	0	374.66	\$175	
	Forb+Grass-Native-Seeding	496.14	0	\$175	
	Herbicide-Plateau+Seed	0	386.49	\$110	
	RxFire	704.28	0	\$100	
	RxFire+Seed+Chain	0	2922.10	\$235	
					\$13,493,359

The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 98,208.7	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	100%	100%	65%	74%
Cost			\$63,385,247	\$13,493,359
ROI - vs Minimum Mgmt			5.40	18.89
ROI - 95% Confidence Interval			± 0.32	± 1.41
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, both the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios show appreciable improvement in UED, with the MAXIMUM scenario being slightly better (65% versus 74%). These improvements under both active management scenarios largely reflect reductions in the tree-encroached class (U:TEA) relative to the MINIMUM MANAGEMENT scenario.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves an improvement (reduction of UED) nearly as good as that of the MAXIMUM scenario – but for about one-fifth of the total cost of the MAXIMUM scenario. Further, the treatment-amount inputs to the MAXIMUM scenario were so large that the model “ran out of acres” for many treatments during the latter part of its 25-year run. Finally, charts below from the ST-Sim model output show the forecasted reductions in the U:TEA and U:Annual Grass classes in the PREFERRED and MAXIMUM scenarios.



Results for [819] - Minimum Management HV Spatial (15-Jun-2015 10:26 AM) Results for [877] - Preferred Management HV Spatial (15-Jun-2015 10:26 AM) Results for [820] - Maximum Management HV Spatial (15-Jun-2015 10:26 AM)

Hamlin Valley: Pinyon-Juniper

In Hamlin Valley, the Pinyon-Juniper system exhibits UED that is at the low end of the moderate range (34%) at the current time. About nine-tenths of this system’s acres are within reference classes, though these are fairly out of balance, and the remaining acres are mostly in the uncharacteristic Tree-Annual Grass (TA) class. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED improves slightly (to 31%), though the general amounts of reference and uncharacteristic classes have not changed substantially. Amounts of specific vegetation classes in the Pinyon-Juniper system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
PJ-A:All	3	—	46,891.4	298.8	0.6%	0.2%
PJ-B:Open	6	—		115.4	0.2%	0.9%
PJ-C:Open	25	—		0.0	0.0%	2.2%
PJ-D:Open	66	—		41,721.9	89.0%	83.1%
PJ-U:Annual Grass	0	0.00		651.9	1.4%	1.6%
PJ-U:Exotic Forb	0	0.00		0.0	0.0%	0.0%
PJ-U:SAP	0	0.00		0.0	0.0%	0.0%
PJ-U:SDI	0	60.00		0.0	0.0%	0.0%
PJ-U:SDI+AG	0	0.00		0.0	0.0%	0.0%
PJ-U:Seeded Native	0	0.00		0.0	0.0%	0.0%
PJ-U:TA	0	0.00		4,103.4	8.8%	11.4%

The main concern in this system is increasing density of juniper and pinyon pine trees in the oldest reference (D) class and in the uncharacteristic TA class. Therefore the primary objective is to thin trees within these two classes, which will reduce their density of trees but not otherwise convert the acres into different classes. The table below shows management actions and costs aimed at achieving this objective under two future active management scenarios: MAXIMUM and PREFERRED.

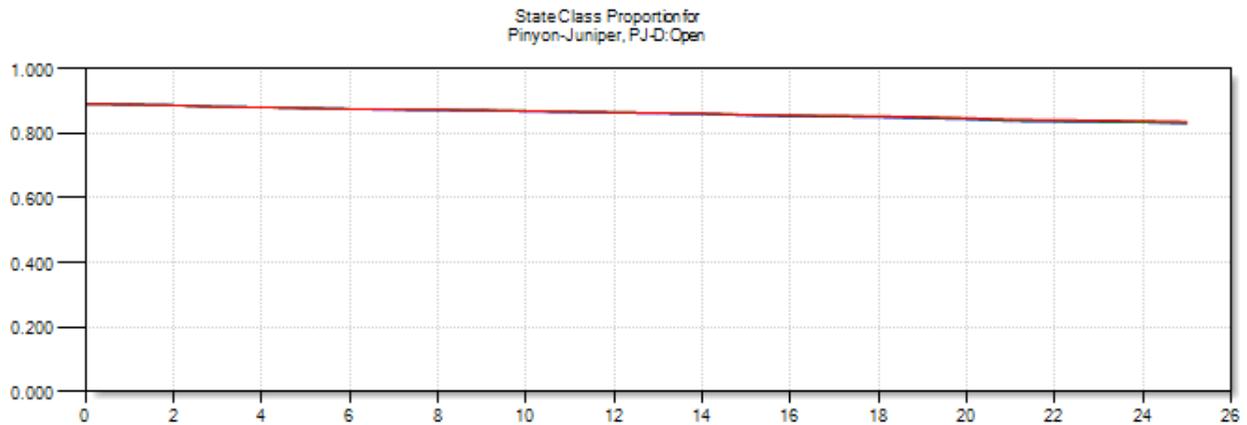
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)			25-Yr Total Cost
		Years 1-10	Years 11-25	Cost/Ac	
MAXIMUM	Aerial-Seed	1.60	9.64	\$20	\$5,372,830
	Chaining+Seed	0.58	2.76	\$120	
	Chainsaw-Thinning	339.49	338.96	\$80	
	Masticate+Seed	375.86	375.13	\$500	
PREFERRED	Chainsaw-Thinning	82.80	106.16	\$80	\$193,575

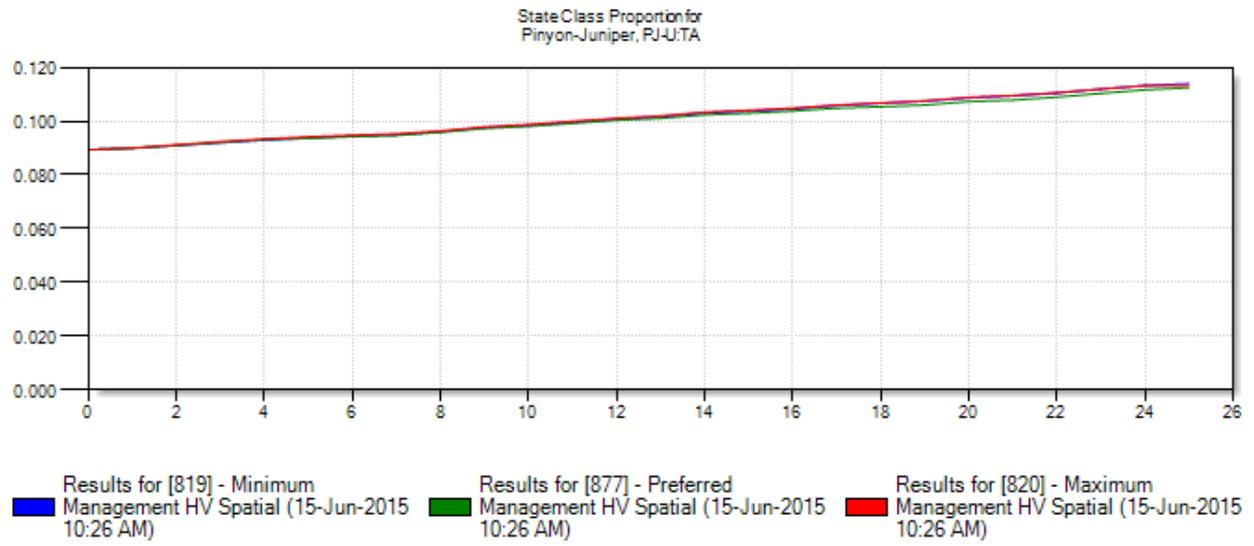
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 46,891.4	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	34%	31%	31%	32%
Cost			\$5,372,830	\$193,575
ROI - vs Minimum Mgmt			0.01	-3.84
ROI - 95% Confidence Interval			± 0.41	± 7.45
ROIs of Maximum and Preferred Significantly Different (95% CI)? →				No

The predicted UED value under MINIMUM MANAGEMENT after 25 years is nearly or quite the same as for the PREFERRED and MAXIMUM MANAGEMENT scenarios. All three of these future slight improvements (from Current) reflect the thinning of trees in older classes, without any class-conversions. These future improvements happen by virtue of active management treatments in the MAXIMUM and PREFERRED scenarios, and without such treatments in the MINIMUM scenario. There is little difference in predicted outcomes among these three scenarios.

Given these results, the ROI values of the MAXIMUM and PREFERRED scenarios are near zero or slightly negative, and are not significantly different from each other at the 95% confidence level. Further, the model predicts that the MINIMUM MANAGEMENT scenario will result in virtually identical results (as measured by UED) to both of the active management scenarios – but for zero cost, and without any in-class thinning. Finally, charts below from the ST-Sim model output show the forecasted amounts of the D and U:TA classes in the MINIMUM, PREFERRED and MAXIMUM scenarios.





Hamlin Valley: Ponderosa Pine

In Hamlin Valley, the Ponderosa Pine system exhibits moderate (43%) UED at the current time. All of this system’s acres are within reference classes, though these are somewhat out of balance. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED improves to 30%. Almost all of the acres remain in reference classes, though their proportions have shifted so as to be less departed from their NRV values. Amounts of specific vegetation classes in the Ponderosa Pine system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
PP-A:All	10	—	1,086.3	526.8	48.5%	0.7%
PP-B:Closed	9	—		6.3	0.6%	23.9%
PP-C:Open	25	—		323.4	29.8%	31.2%
PP-D:Open	52	—		229.8	21.2%	31.4%
PP-E:Closed	4	—		0.0	0.0%	11.0%
PP-U:Annual Grass	0	0.00		0.0	0.0%	0.1%
PP-U:TA	0	0.00		0.0	0.0%	1.9%

No particular concerns exist within this system at the present time. The preponderance of the youngest (A) class will succeed naturally into mid-age classes as time passes. After 25 years of MINIMUM MANAGEMENT, the closed (dense) mid- and late-age classes (B and E) have increased out of proportion to their NRV values, and constitute a potential fuels concern. Therefore the primary objective is to thin trees within these two classes, which will convert their acres into their more open counterpart classes (C and D, respectively). The table below shows management actions and costs aimed at achieving this objective under two future active management scenarios: MAXIMUM and PREFERRED.

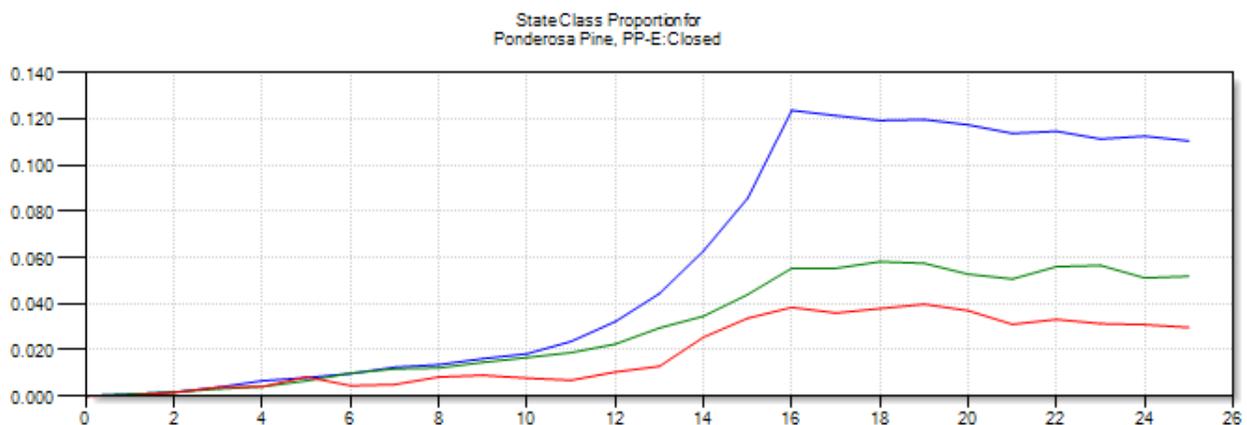
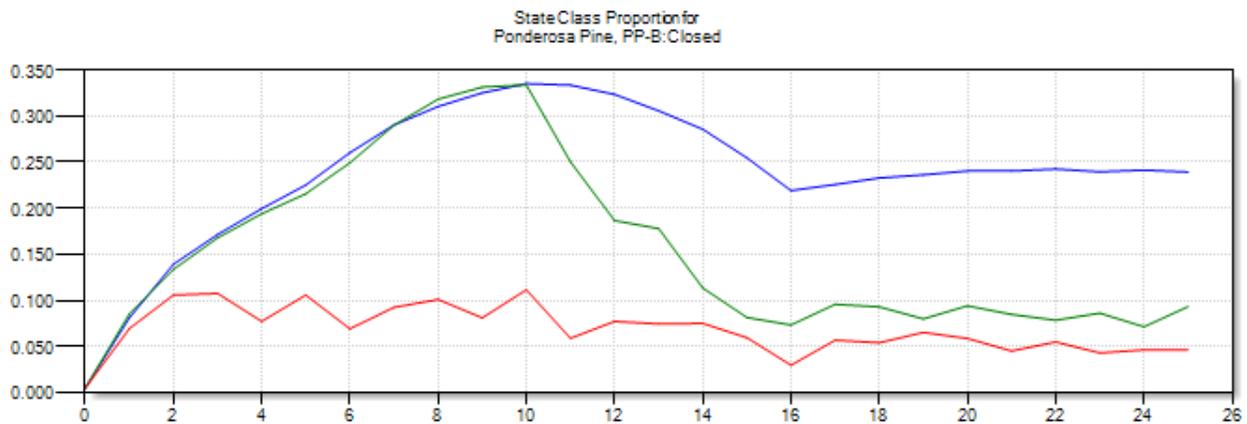
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)			25-Yr Total Cost
		Years 1-10	Years 11-25	Cost/Ac	
MAXIMUM	Chainsaw-Thinning	45.74	67.71	\$20	\$75,247
	RxFire	19.03	7.75	\$150	
PREFERRED	Chainsaw-Thinning	0	57.56	\$20	\$58,848
	RxFire	0	18.67	\$150	

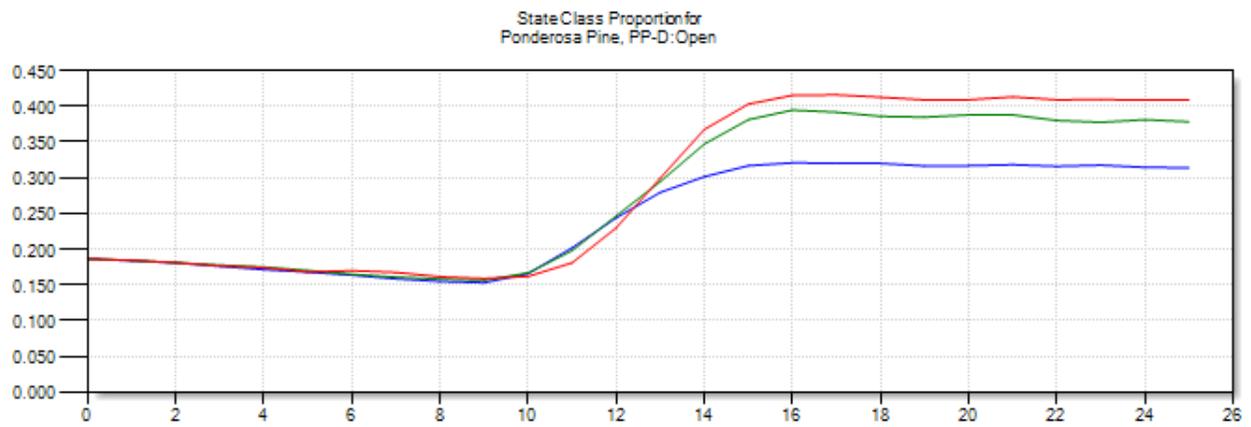
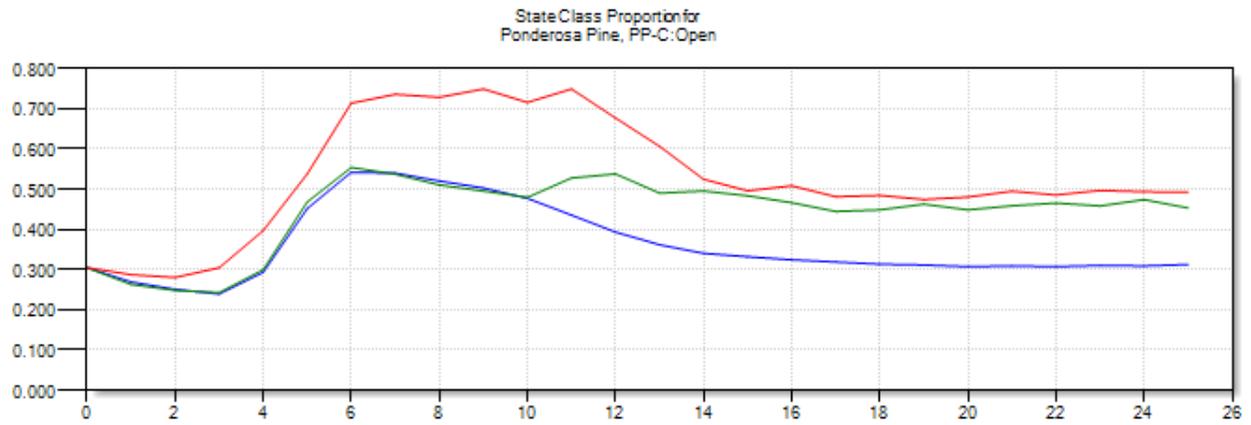
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 1,086.3	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	43%	30%	26%	24%
Cost			\$75,247	\$58,848
ROI - vs Minimum Mgmt			5.66	10.74
ROI - 95% Confidence Interval			± 4.66	± 3.28
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

The predicted UED value under MINIMUM MANAGEMENT after 25 years has decreased to where it is in the good range (30%), though as mentioned above the relative abundance of closed (dense) classes may constitute a fuels concern. Predicted UED values under the MAXIMUM and PREFERRED MANAGEMENT scenarios are slightly better, and reflect greater relative conversion of dense-class acres into open-class acres.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario actually achieves a slightly greater improvement (reduction of UED) than does the MAXIMUM scenario, and for about three-fourths of the total cost of the MAXIMUM scenario. Charts below from the ST-Sim model output show the forecasted changes in the closed classes (B and E) and the open classes (C and D) in the PREFERRED and MAXIMUM scenarios.





■ Results for [819] - Minimum Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [877] - Preferred Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [820] - Maximum Management HV Spatial (15-Jun-2015 10:26 AM)

Hamlin Valley: Utah Serviceberry

In Hamlin Valley, the Utah Serviceberry system exhibits moderate (46%) UED at the current time. More than four-fifths of this system’s acres are within reference classes, though these are fairly out of balance, being weighted toward older classes. The remaining acres are mostly in uncharacteristic tree-encroached (TA and TE) classes. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED increases greatly (to 81%). The main drivers of this higher future departure are greater proportion of the late-age reference class, and increase in the amounts of the uncharacteristic tree-encroached classes. Amounts of specific vegetation classes in the Utah Serviceberry system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
US-A:All	9	—	8,947.6	82.5	0.9%	0.3%
US-B:Closed	28	—		1,135.7	12.7%	1.8%
US-C:Closed	49	—		2,984.2	33.4%	14.7%
US-D:Open	14	—		3,310.5	37.0%	54.9%
US-U:Annual Grass	0	0.00		0.0	0.0%	0.7%
US-U:Depleted	0	0.00		0.0	0.0%	0.2%
US-U:Early-Shrub	0	0.00		0.0	0.0%	0.3%
US-U:SAP	0	0.00		144.9	1.6%	4.4%
US-U:SAP+	0	0.00		0.0	0.0%	0.2%
US-U:SDI-A	0	5.40		0.0	0.0%	0.0%
US-U:SDI-B	0	16.80		0.0	0.0%	0.0%
US-U:SDI-C	0	29.40		0.0	0.0%	0.0%
US-U:SDI-D	0	8.40		0.0	0.0%	0.0%
US-U:SI-A+AG	0	0.00		0.0	0.0%	0.0%
US-U:SI-B+AG	0	0.00		0.0	0.0%	0.0%
US-U:SI-C+AG	0	0.00		0.0	0.0%	0.0%
US-U:SI-D+AG	0	0.00		0.0	0.0%	0.0%
US-U:TA	0	0.00		480.9	5.4%	14.2%
US-U:TE	0	0.00		808.9	9.0%	8.4%

The major concern in this system at the present time is tree encroachment by juniper and pinyon pine, reflected by the preponderance of the late-age reference class (D), and by the presence of the U:TA and U:TE classes, which are both high-risk. After 25 years of MINIMUM MANAGEMENT, total acres within these three tree-encroached classes have increased appreciably.

Therefore the primary objective of management actions is to reduce the acreage of classes that are defined by presence/abundance of encroaching conifers. The table below shows management actions and costs aimed at achieving this objective under two future active management scenarios: MAXIMUM and PREFERRED.

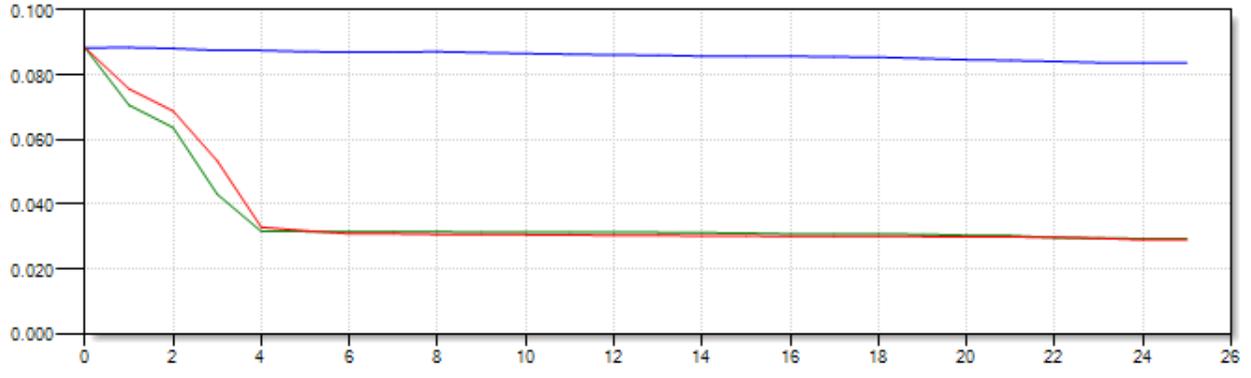
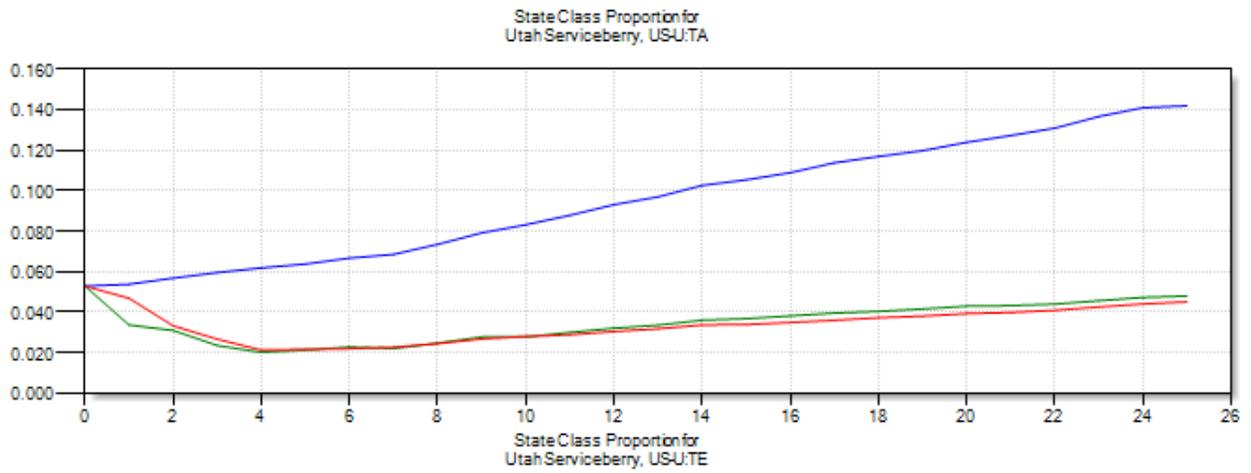
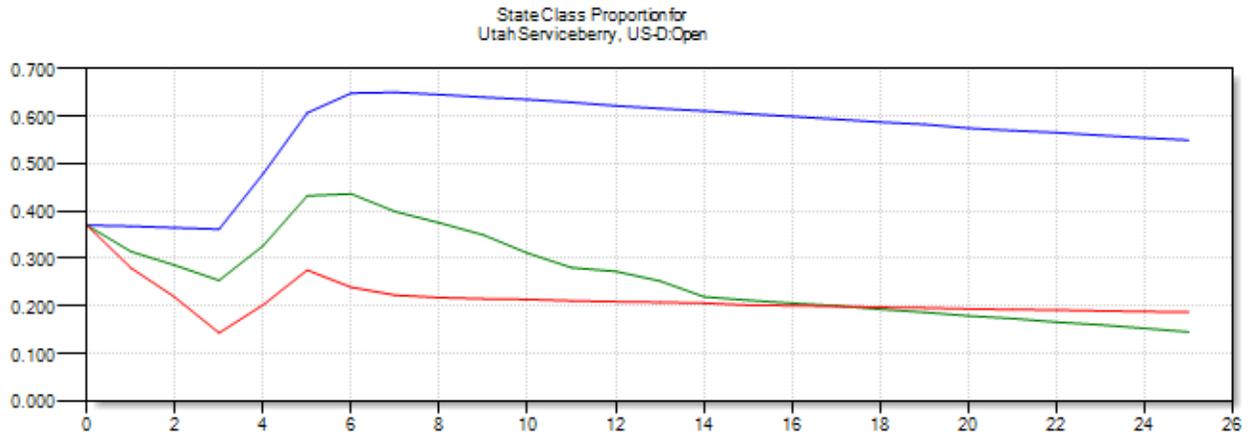
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	Chaining+Plateau+Native-Seed	3.71	0	\$260	\$855,823
	Chaining+Plateau+Seed	2.71	0.03	\$185	
	Chaining+Seed	4.63	0.68	\$120	
	Chainsaw-Thinning	152.61	0.00	\$20	
	Forb+Grass-Native-Seeding	64.58	65.37	\$175	
	Herbicide-Plateau+Seed	7.00	3.81	\$150	
	Masticate+Native-Seed	46.20	0	\$325	
	Masticate+Seed	40.54	0	\$270	
	RxFire	88.56	0	\$100	
	Small-Tree-Lopping	197.94	0.03	\$20	
	Thin+Herbicide+Native-Seed	21.07	8.64	\$320	
	Thin+Herbicide+Seed	1.28	0.32	\$240	
PREFERRED	Chainsaw-Thinning	183.27	11.35	\$20	\$451,663
	Masticate+Seed	93.67	0	\$270	
	RxFire	181.11	11.03	\$100	
	Small-Tree-Lopping	0	69.45	\$20	

The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 8,947.6	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	46%	81%	30%	30%
Cost			\$855,823	\$451,663
ROI - vs Minimum Mgmt			53.23	100.55
ROI - 95% Confidence Interval			± 4.11	± 5.41
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, both the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios show appreciable improvement in UED, to levels that are the same (each 30%). These improvements under both active management scenarios largely reflect reductions in tree-encroached classes relative to the MINIMUM MANAGEMENT scenario.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves an improvement (reduction of UED) identical to that of the MAXIMUM scenario – but for just over half of the total cost of the MAXIMUM scenario. Charts below from the ST-Sim model output show the forecasted reductions in the D, U:TA, and U:TE classes in the PREFERRED and MAXIMUM scenarios.



■ Results for [819] - Minimum Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [877] - Preferred Management HV Spatial (15-Jun-2015 10:26 AM)
 ■ Results for [820] - Maximum Management HV Spatial (15-Jun-2015 10:26 AM)

Hamlin Valley: Wet Meadow-Montane

In Hamlin Valley, the Wet Meadow-Montane system exhibits relatively low UED (19%) at the current time. About four-fifths of this system’s acres are within reference classes, and these are not far departed from their NRV values. The remaining acres are almost all confined to a single uncharacteristic class, U:SFE. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED rises appreciably (to 36%). The main drivers of this higher future departure are an increase in the overall amount of uncharacteristic classes, including several that are high-risk classes, and greater departure from NRV among the remaining reference classes. Amounts of specific vegetation classes in the Wet Meadow-Montane system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
WM-A:Open	3	—	143.8	3.4	2.4%	1.8%
WM-B:Closed	89	—		112.9	78.5%	30.9%
WM-C:Open	8	—		0.0	0.0%	38.1%
WM-U:Annual Grass	0	0.00		0.0	0.0%	1.8%
WM-U:Desertified	0	0.00		0.2	0.1%	1.1%
WM-U:Exotic Forb	0	0.00		0.0	0.0%	7.2%
WM-U:Hummocked	0	0.00		0.0	0.0%	3.7%
WM-U:SA	0	0.00		0.0	0.0%	0.0%
WM-U:SDI	0	0.00		0.0	0.0%	0.0%
WM-U:SFE	0	0.00		27.3	19.0%	15.6%
WM-U:TEA	0	0.00		0.0	0.0%	0.0%

The current amount of the shrub-forb-encroached class (U:SFE), about one-fifth of the system’s acres, is a moderate concern. After 25 years of MINIMUM MANAGEMENT, this class has shrunk slightly. At that time, however, two other uncharacteristic classes have appeared that together comprise more than 10% of the system’s acres: the exotic-forb and hummocked classes, both of which are high-risk and thus of larger future concern. Therefore the primary objectives of management actions are to reduce the acreage of classes defined by hummocking and by exotic forbs. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)			25-Yr Total Cost
		Years 1-10	Years 11-25	Cost/Ac	
MAXIMUM	Fence	2.98	3.00	\$8,000	\$776,263
	Thin	2.52	0.19	\$125	
	Thin+Herbicide+Native-Seed	0.94	0.08	\$320	
	Weed-Inventory+Treat	22.47	20.58	\$320	

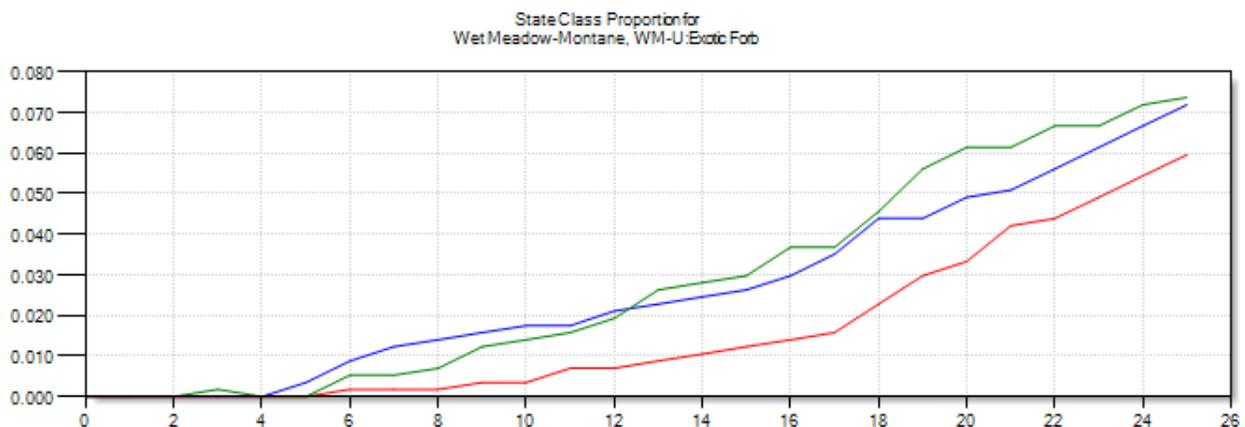
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
PREFERRED	Exotic-Control	0.05	0	\$360	\$293,017
	Fence	2.78	0	\$8,000	
	Weed-Inventory+Treat	9.13	8.51	\$320	

The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

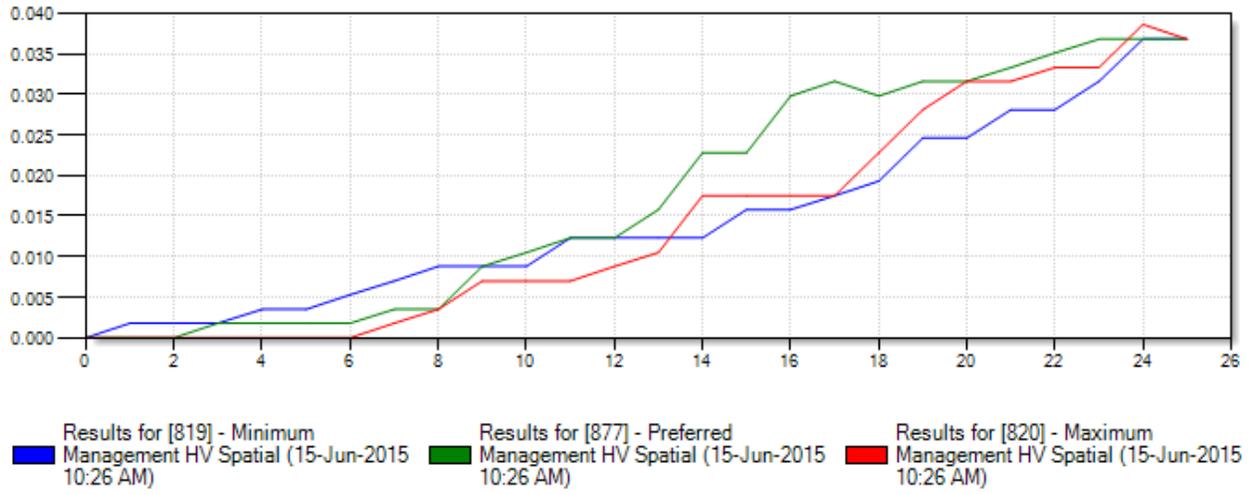
System Acres: 143.8	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	19%	36%	26%	35%
Cost			\$776,263	\$293,017
ROI - vs Minimum Mgmt			0.20	0.03
ROI - 95% Confidence Interval			± 0.10	± 0.34
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			No	

Compared with MINIMUM MANAGEMENT after 25 years, the MAXIMUM MANAGEMENT scenario shows appreciable reduction of UED, whereas the PREFERRED MANAGEMENT scenario remains about the same. The MAXIMUM MANAGEMENT scenario reduces the high-risk U:Exotic Forb class, whereas this class stays about the same under the PREFERRED scenario. All three future scenarios yield the same level of the high-risk U:Hummocked class.

The ROI values of the MAXIMUM and PREFERRED scenarios are both low, and are not significantly different from each other at the 95% confidence level. The MAXIMUM scenario achieves better improvement (reduction of UED) than the PREFERRED scenario – but for nearly three times the cost of the PREFERRED scenario. Further, the model predicts that the MINIMUM MANAGEMENT scenario will result in virtually identical results (as measured by UED) to the PREFERRED scenario – but for zero cost. Charts below from the ST-Sim model output show the forecasted amounts of the U:Exotic Forb and U:Hummocked classes in the MINIMUM, PREFERRED and MAXIMUM scenarios.



State Class Proportion for
Wet Meadow-Montane, WM-U-Hummocked



Hamlin Valley: Wyoming Big Sagebrush upland

In Hamlin Valley, the Wyoming Big Sagebrush upland system exhibits moderate (58%) UED at the current time. About one-fifth of this system’s acres are within reference classes. The remaining acres are spread among several uncharacteristic classes, some of which are high-risk classes (such as U:TEA) whereas others have “allowable” thresholds (such as several seeded classes). After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED increases slightly (to 67%). This higher future departure results from a small decrease in total acres of reference classes, and shifts in uncharacteristic class acres among the high-risk and allowable categories. Amounts of specific vegetation classes in the Wyoming Big Sagebrush upland system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
WSup-A:All	14	—	65,340.5	40.5	0.1%	0.6%
WSup-B:Open	29	—		3,274.8	5.0%	0.3%
WSup-C:Closed	42	—		9,219.9	14.1%	14.4%
WSup-D:Open	6	—		961.1	1.5%	1.3%
WSup-E:Closed	9	—		182.9	0.3%	1.2%
WSup-U:Annual Grass	0	0.00		211.1	0.3%	2.0%
WSup-U:Depleted	0	0.00		673.0	1.0%	1.1%
WSup-U:Early-Shrub	0	0.00		207.9	0.3%	0.4%
WSup-U:SA	0	0.00		3,424.2	5.2%	6.1%
WSup-U:SA+	0	0.00		0.0	0.0%	1.4%
WSup-U:SAP	0	0.00		11,752.5	18.0%	12.5%
WSup-U:SAP+	0	0.00		0.0	0.0%	3.0%
WSup-U:SDI-A	0	8.40		598.8	0.9%	0.1%
WSup-U:SDI-B	0	17.40		21,079.9	32.3%	0.5%
WSup-U:SDI-C	0	25.20		7,395.2	11.3%	41.5%
WSup-U:SDI-D	0	3.60		0.0	0.0%	1.5%
WSup-U:Seeded Native	0	14.00		0.0	0.0%	0.0%
WSup-U:SI-A+AG	0	0.00		206.8	0.3%	0.0%
WSup-U:SI-B+AG	0	0.00		0.0	0.0%	0.8%
WSup-U:SI-C+AG	0	0.00		0.0	0.0%	0.6%
WSup-U:SI-D+AG	0	0.00		0.0	0.0%	0.0%
WSup-U:TEA	0	0.00	6,111.9	9.4%	10.6%	

The major concern in this system at the present time is tree encroachment by juniper and pinyon pine (class U:TEA), which is a high-risk class, and also includes a complement of annual grasses. Other classes defined by presence/abundance of annual grasses, with or without a native-species component, comprise nearly one-fourth of the system’s acres at present. After 25 years of MINIMUM MANAGEMENT, the tree-encroached class (with annual grasses) has increased slightly, whereas the other annual-grass classes remain relatively constant.

Therefore the objectives of management actions are to reduce the acreage of classes that are defined primarily by presence/abundance of encroaching conifers, and secondarily by annual grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	2xChaining+Native-Seed	1.38	0.02	\$230	
	Chaining+Native-Seed	46.06	9.40	\$175	
	Chaining+Plateau+Seed	21.09	7.75	\$185	
	Chaining+Seed	275.90	134.48	\$120	
	Forb+Grass-Native-Seeding	3343.62	3558.28	\$175	
	Herbicide-Plateau+Seed	195.86	58.73	\$110	
	Hypo-Hatchet-Spyke	152.71	33.69	\$25	
	Masticate+Herbicide+Seed	101.97	0.00	\$310	
	Masticate+Native-Seed	21.33	3.58	\$325	
	Mastication	14.65	20.84	\$200	
	RxFire+Seed+Chain	329.03	0.36	\$235	
	Small-Tree-Lopping	450.57	170.56	\$60	
	Spyke+Native-Seed	3.92	0.86	\$240	
	Thin	317.94	681.95	\$35	
	Thin+Herbicide+Native-Seed	0.02	0.47	\$265	
	Thin+Native-Seed	7.56	0.61	\$250	
					\$18,480,009
PREFERRED	Chaining+Native-Seed	64.42	0	\$175	
	Chaining+Seed	430.98	0	\$120	
	Forb+Grass-Native-Seeding	508.03	0	\$175	
	Herbicide-Plateau+Seed	232.52	0	\$110	
	RxFire+Seed+Chain	272.68	0	\$235	
	Small-Tree-Lopping	233.69	52.76	\$60	
					\$2,599,352

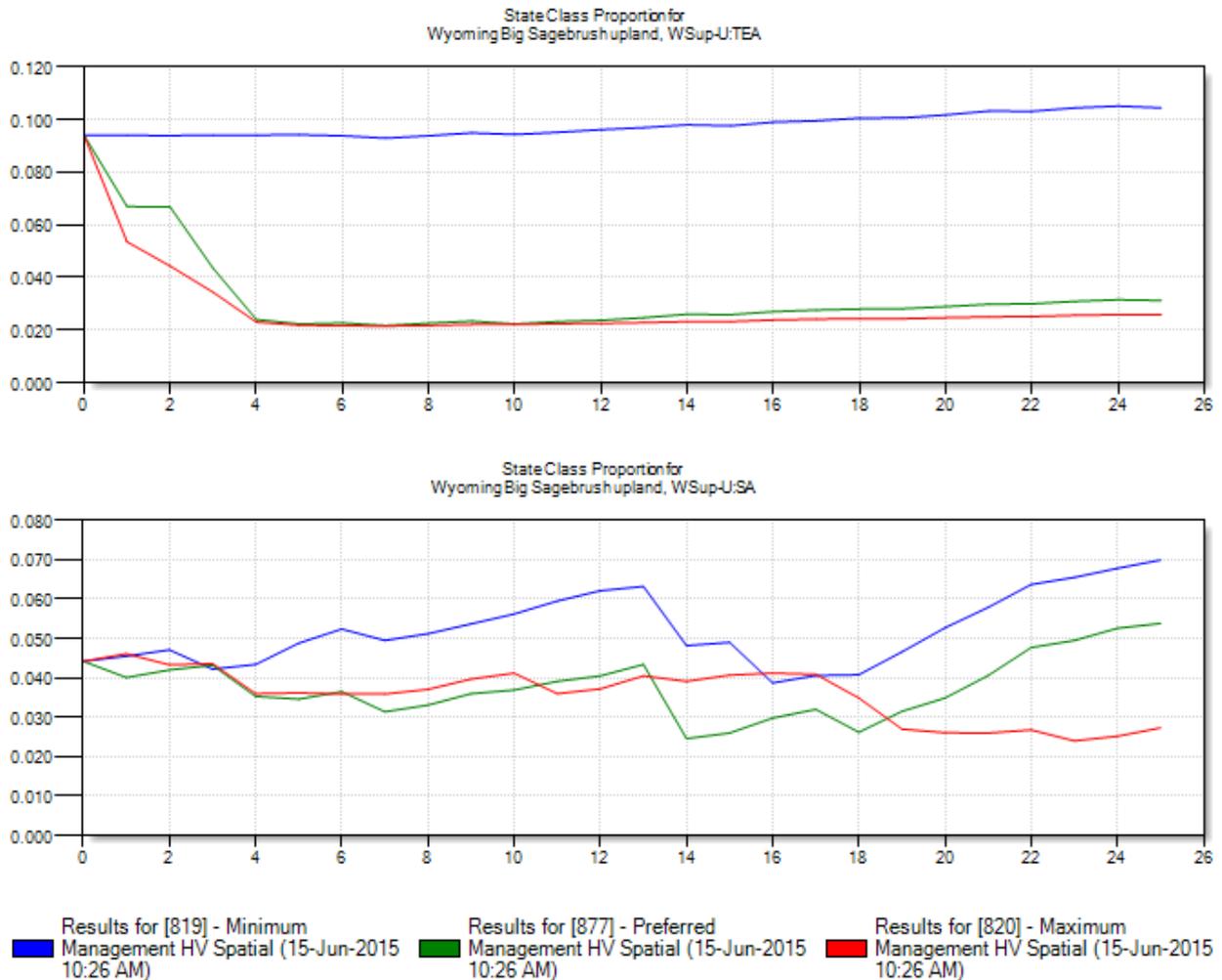
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 65,340.5	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	58%	67%	47%	54%
Cost			\$18,480,009	\$2,599,352
ROI - vs Minimum Mgmt			7.15	32.90
ROI - 95% Confidence Interval			± 0.37	± 3.19
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, both the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios show appreciable improvement in UED, with the MAXIMUM

scenario being slightly better (47% versus 54%). These improvements under both active management scenarios largely reflect reductions in the tree-encroached class (U:TEA) relative to the MINIMUM MANAGEMENT scenario.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves an improvement (reduction of UED) nearly as good as that of the MAXIMUM scenario – but for about one-seventh of the total cost of the MAXIMUM scenario. Further, the treatment-amount inputs to the MAXIMUM scenario were so large that the model “ran out of acres” for many treatments during the latter part of its 25-year run. Finally, charts below from the ST-Sim model output show the forecasted reductions in the U:TEA and U:SA classes in the PREFERRED and MAXIMUM scenarios.



Hamlin Valley: Greater Sage-Grouse Habitat Suitability

The spatial distribution of habitat suitability values for Greater sage-grouse as predicted after 25 years of PREFERRED MANAGEMENT in the Hamlin Valley project area is shown in Figure 10. Lighter values represent better suitability and darker values represent poorer suitability. Habitat suitability increased under PREFERRED MANAGEMENT to 51,141 functional acres (Figure 10) versus the MINIMUM MANAGEMENT value of 49,250 functional acres (Figure 7). The main contribution of PREFERRED MANAGEMENT was to broaden more suitable habitat upslope toward the east and west. However, 25 years after creation of seedings was insufficient time to allow succession to vegetation classes supporting mid-succession sagebrush used by sage-grouse.



Figure 10. Spatial distribution of habitat suitability values for Greater sage-grouse after 25 years of PREFERRED MANAGEMENT in the Hamlin Valley Project Area.

Black Mountains: Black Sagebrush

In the Black Mountains, the Black Sagebrush system exhibits high (84%) UED at the current time. Only about one-third of this system's acres are within reference classes. The remaining acres are spread among multiple uncharacteristic classes, several of which are high-risk. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED becomes nearly complete (98%), with even greater area of uncharacteristic classes. Amounts of specific vegetation classes in the Black Sagebrush system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
BS-A:All	15	—	62,371.4	2,016.0	3.2%	0.9%
BS-B:Open	48	—		5,281.5	8.5%	10.3%
BS-C:Closed	25	—		6,032.2	9.7%	7.3%
BS-D:Open	12	—		8,164.4	13.1%	9.7%
BS-U:Annual Grass	0	0.00		1,237.4	2.0%	4.1%
BS-U:Depleted	0	0.00		9,395.7	15.1%	11.7%
BS-U:Early-Shrub	0	0.00		325.7	0.5%	1.5%
BS-U:SA	0	0.00		4,574.4	7.3%	13.2%
BS-U:SA+	0	0.00		0.0	0.0%	7.8%
BS-U:SAP	0	0.00		17,581.9	28.2%	11.8%
BS-U:SAP+	0	0.00		0.0	0.0%	1.6%
BS-U:SDI-A	0	5.25		40.0	0.1%	0.0%
BS-U:SDI-B	0	16.80		178.0	0.3%	1.3%
BS-U:SDI-C	0	8.75		35.1	0.1%	0.1%
BS-U:Seeded Native	0	15.00		0.0	0.0%	0.0%
BS-U:SI-A+AG	0	0.00		194.9	0.3%	0.0%
BS-U:SI-B+AG	0	0.00		416.5	0.7%	0.0%
BS-U:SI-C+AG	0	0.00		9.7	0.0%	0.0%
BS-U:TEA	0	0.00		6,888.2	11.0%	18.8%

A major concern within this system at present is encroachment by juniper and pinyon pine, specifically represented by the high-risk U:TEA class. Annual grasses are a moderate concern at present, represented by classes that together comprise about two-fifths of the system's area at present. After 25 years of MINIMUM MANAGEMENT, the tree-encroached U:TEA class has increased, whereas the amount of the U:SAP annual-grass class has decreased by a moderate amount.

Therefore the primary objective of management actions is to reduce the acreage of classes defined by encroachment of juniper and pinyon pine. A secondary objective is to hold in check, and reduce if possible, classes defined by presence/abundance of annual grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

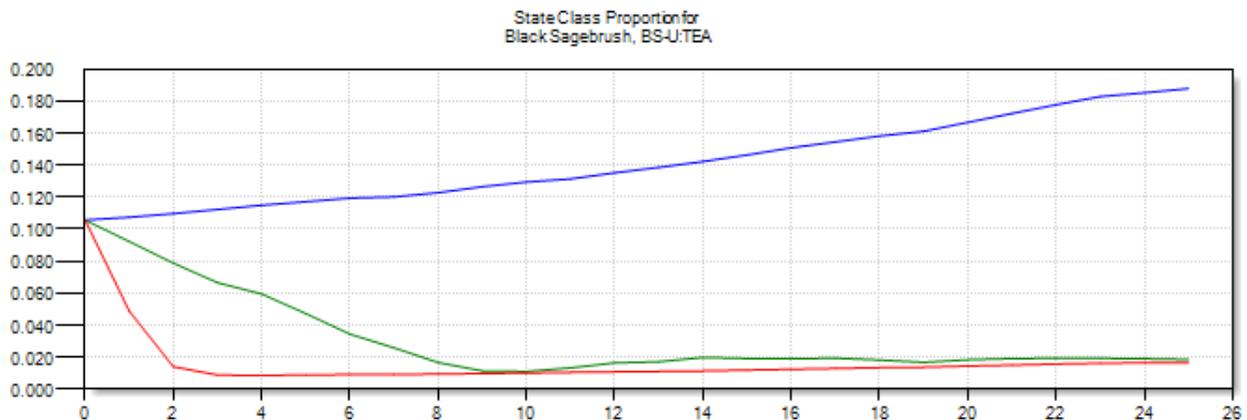
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	2xChaining+Native-Seed	132.71	0.13	\$230	
	2xChaining+Plateau+Seed	180.56	0	\$220	
	2xChaining+Seed	164.43	0	\$190	
	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	2675.08	2654.46	\$350	
	Aerial-Spyke+Aerial-Seed+Chain-Harrow	736.56	1117.47	\$200	
	Chaining+Native-Seed	400.95	61.65	\$175	
	Chaining+Plateau+Seed	136.92	195.97	\$145	
	Chainsaw-Thinning	238.19	5.33	\$20	
	Forb+Grass-Native-Seeding	2023.95	4636.05	\$175	
	Herbicide-Plateau+Seed	95.32	84.51	\$110	
	Hypo-Hatchet-Spyke	595.70	2.47	\$25	
	Masticate+Herbicide+Seed	69.94	0	\$310	
	Masticate+Native-Seed	209.23	0.26	\$325	
	Masticate+Seed	152.39	0.03	\$270	
	Mastication	48.87	0	\$200	
	RxFire+Seed+Chain	88.58	0	\$235	
	Small-Tree-Lopping	2589.88	828.67	\$80	
	Spyke+Native-Seed	505.18	0.71	\$240	
	Thin	2407.51	2109.67	\$35	
	Thin+Native-Seed	257.76	0.58	\$250	
					\$55,224,025
PREFERRED	2xChaining+Plateau+Seed	190.51	0	\$220	
	2xChaining+Seed	182.23	0	\$190	
	Herbicide-Plateau+Seed	150.67	0	\$110	
	Masticate+Herbicide+Seed	177.26	141.49	\$310	
	Masticate+Native-Seed	0	417.54	\$325	
	Masticate+Seed	195.26	0	\$270	
	Small-Tree-Lopping	0	438.46	\$80	
	Thin	55.12	0	\$35	
					\$5,243,421

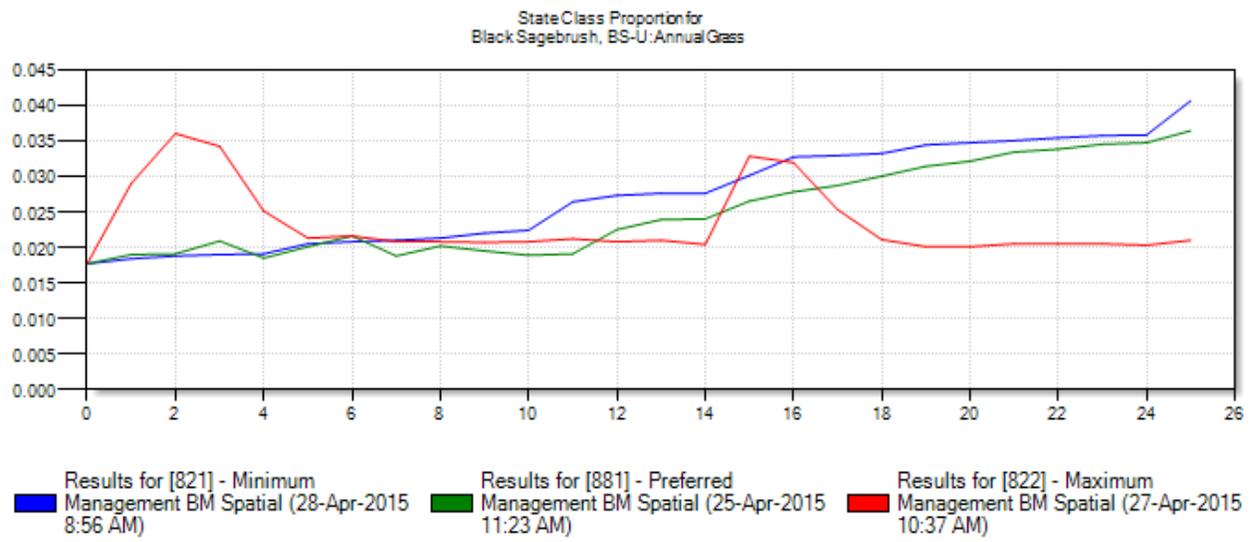
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 62,371.5	Current	Scenarios – 25 Years (mean of 5 replicates)		
		MINIMUM	MAXIMUM	PREFERRED
Unified Ecological Departure	84%	98%	43%	79%
Cost			\$55,224,025	\$5,243,421
ROI - vs Minimum Mgmt			6.30	22.91
ROI - 95% Confidence Interval			± 0.36	± 2.27
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, the MAXIMUM MANAGEMENT scenario shows large improvement in UED, and the PREFERRED MANAGEMENT scenario shows moderate improvement in UED (down to 43% and 79%, respectively). These improvements under both active management scenarios largely reflect reductions in the tree-encroached U:TEA class relative to the MINIMUM MANAGEMENT scenario. The MAXIMUM MANAGEMENT scenario also shows substantial reductions in several other high-risk uncharacteristic classes that are not achieved in the PREFERRED scenario.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves an improvement (reduction of UED) only about a third as great as that of the MAXIMUM scenario – but for about one-tenth of the total cost of the MAXIMUM scenario. Further, the treatment-amount inputs to the MAXIMUM scenario were so large that the model “ran out of acres” for many treatments during the latter part of its 25-year run. In particular, the PREFERRED scenario achieved keeping the area of the U:Annual Grass class in check compared to the MINIMUM MANAGEMENT scenario, because the creation of annual grassland is partly the outcome of failed management actions. Without use of herbicide and introduced-species seed to convert annual grasslands to introduced-species seedings, the U:Annual Grass class would have been much larger. Finally, charts below from the ST-Sim model output show the forecasted changes in the U:TEA, U:SAP, and U:Annual Grass classes in the MINIMUM, PREFERRED, and MAXIMUM scenarios.





Black Mountains: Low Sagebrush

In the Black Mountains, the Low Sagebrush system exhibits moderate (42%) UED at the current time. About half of this system’s acres are in reference classes. The remaining acres are mostly split between two uncharacteristic classes that are not high-risk. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED increases slightly (to 45%). Relative amounts of reference and uncharacteristic classes have shifted modestly toward the latter, but not enough to cause much increase in future UED. Amounts of specific vegetation classes in the Low Sagebrush system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
LS-A:All	10	—	799.1	18.2	2.3%	0.9%
LS-B:Open	37	—		110.2	13.8%	15.1%
LS-C:Closed	53	—		266.4	33.3%	28.2%
LS-U:Annual Grass	0	0.00		0.0	0.0%	2.0%
LS-U:Depleted	0	0.00		0.0	0.0%	0.2%
LS-U:Early-Shrub	0	0.00		0.0	0.0%	0.2%
LS-U:SA	0	0.00		0.0	0.0%	0.2%
LS-U:SA+	0	0.00		0.0	0.0%	0.0%
LS-U:SAP	0	0.00		194.9	24.4%	19.4%
LS-U:SAP+	0	0.00		0.0	0.0%	7.9%
LS-U:SDI-A	0	3.50		158.6	19.8%	0.2%
LS-U:SDI-B	0	12.95		17.0	2.1%	21.8%
LS-U:SDI-C	0	18.55		26.6	3.3%	3.3%
LS-U:Seeded Native	0	10.00		0.0	0.0%	0.0%
LS-U:SI-A+AG	0	0.00		0.0	0.0%	0.0%
LS-U:SI-B+AG	0	0.00		2.4	0.3%	0.0%
LS-U:SI-C+AG	0	0.00		0.0	0.0%	0.0%
LS-U:TA	0	0.00	4.8	0.6%	0.5%	
LS-U:TE	0	0.00	0.0	0.0%	0.0%	

A moderate concern within this system at the present time is the presence of annual grasses in habitats that still contain a native vegetation component (U:SAP class). After 25 years of MINIMUM MANAGEMENT, this has decreased slightly.

Therefore the primary objective of management actions is to hold in check, and reduce if possible, the presence/abundance of annual grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	1.62	3.15	\$350	
	Chaining+Native-Seed	1.11	2.08	\$175	
	RxFire	0	4.97	\$150	
	Small-Tree-Lopping	27.19	1.23	\$80	
	Spot-Herbicide+Native-Seed	6.13	8.48	\$225	
	Thin	0	6.86	\$35	
					\$110,032
PREFERRED	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0	11.93	\$350	
	Chaining+Native-Seed	0	9.09	\$175	
	Spot-Herbicide+Native-Seed	0	4.23	\$225	
					\$100,070

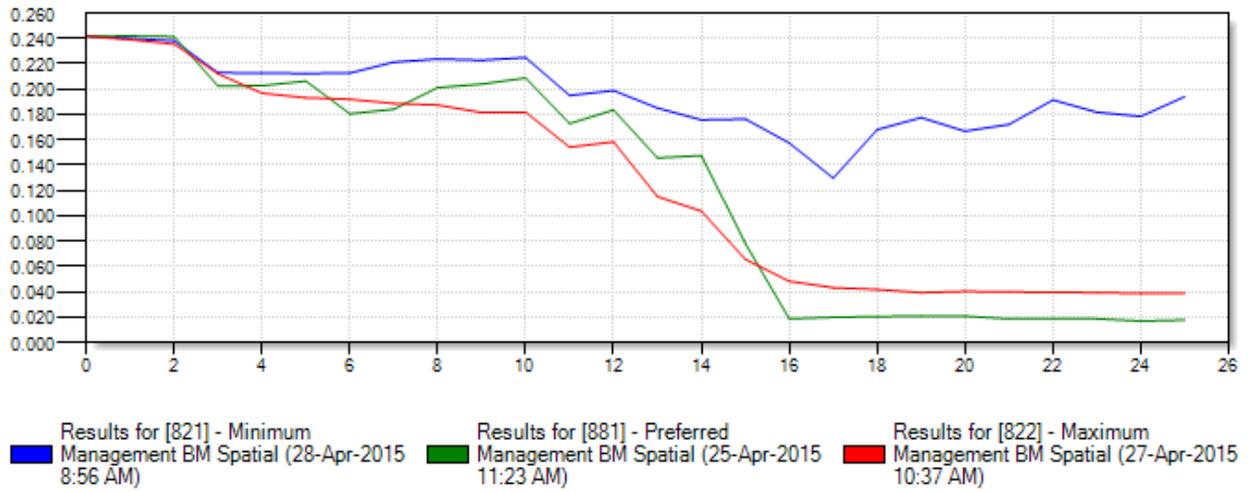
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 799.1	Current	Scenarios – 25 Years (mean of 5 replicates)		
		MINIMUM	MAXIMUM	PREFERRED
Unified Ecological Departure	42%	45%	28%	18%
Cost			\$110,032	\$100,070
ROI - vs Minimum Mgmt			12.60	21.82
ROI - 95% Confidence Interval			± 2.36	± 1.97
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, the two active management scenarios show appreciable improvement in UED, both into the good range. The PREFERRED MANAGEMENT scenario actually shows a greater improvement than the MAXIMUM MANAGEMENT scenario (UED down to 18% versus 28%, respectively). The MAXIMUM MANAGEMENT scenario actually achieves greater acreage of reference classes in total, but these are weighted toward the younger age classes, and their out-of-balance nature inflates its UED value somewhat. In terms of ecological condition there is not much difference between the PREFERRED and MAXIMUM scenarios.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. Both of these active management scenarios achieve good results, though the PREFERRED scenario does so for slightly lower cost than the MAXIMUM scenario. Finally, the chart below from the ST-Sim model output shows the forecasted amounts of the U:SAP class in the MINIMUM, PREFERRED and MAXIMUM scenarios.

State Class Proportion for
Low Sagebrush, LS-U:SAP



Black Mountains: Montane Riparian

In the Black Mountains, the Montane Riparian system exhibits complete (100%) UED at the current time. This total departure at present reflects the fact that nearly all of the system’s acres are in uncharacteristic classes. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED remains complete (100%) for the same reasons. Amounts of specific vegetation classes in the Montane Riparian system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
MR-A:All	14	—	124.7	1.2	1.0%	0.7%
MR-B:Open	25	—		2.4	1.9%	0.7%
MR-C:Closed	61	—		0.0	0.0%	2.6%
MR-U:Annual Grass	0	0.00		0.0	0.0%	0.0%
MR-U:Desertified	0	0.00		1.2	1.0%	0.9%
MR-U:EFT	0	0.00		86.0	68.9%	77.6%
MR-U:SAP	0	0.00		1.2	1.0%	0.0%
MR-U:SDA	0	0.00		0.0	0.0%	0.0%
MR-U:Seeded Native	0	0.00		0.0	0.0%	0.0%
MR-U:SFE	0	0.00		32.7	26.2%	19.8%
MR-U:TE	0	0.00		0.0	0.0%	0.0%

The major concern in this system at present is the predominance of the exotic-forb-tree (U:EFT) class, which is high-risk. Of secondary concern is the current amount of the shrub-forb-encroached class (U:SFE). After 25 years of MINIMUM MANAGEMENT, the high-risk U:EFT class has increased further, whereas the U:SFE class has decreased somewhat.

Therefore the objectives of management actions are to reduce the acreage of classes defined primarily by exotic trees and forbs, and secondarily by undesirable (but native) shrubs and forbs. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

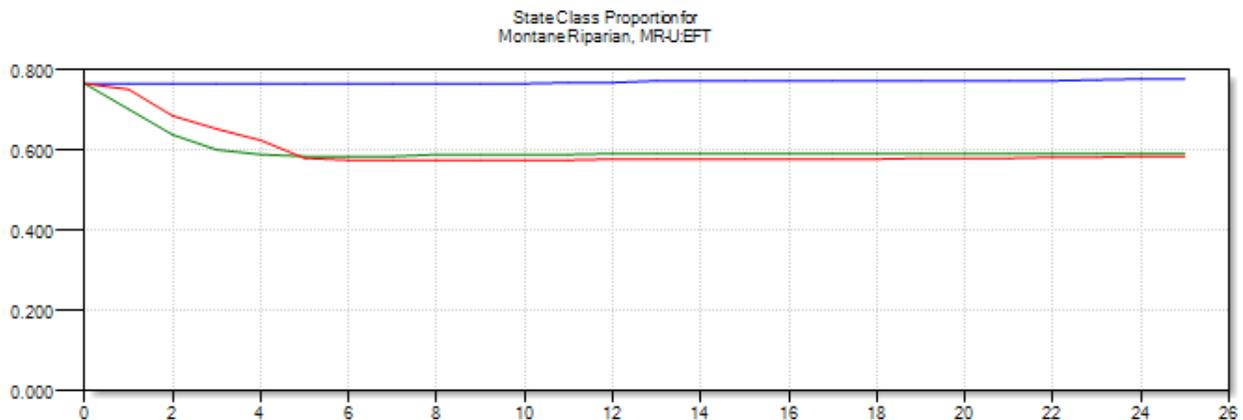
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)			25-Yr Total Cost
		Years 1-10	Years 11-25	Cost/Ac	
MAXIMUM	Chainsaw-Thinning	0	0.08	\$80	\$109,395
	Exotic-Control	2.57	0	\$360	
	Floodplain-Restoration	0	0.02	\$2,000	
	Small-Rock-Dam	0.02	0.03	\$500	
	Weed-Inventory+Treat	10.56	12.29	\$360	
PREFERRED	Chainsaw-Thinning	0	0.08	\$80	\$101,747
	Exotic-Control	2.98	0	\$360	
	Weed-Inventory+Treat	11.91	9.88	\$360	

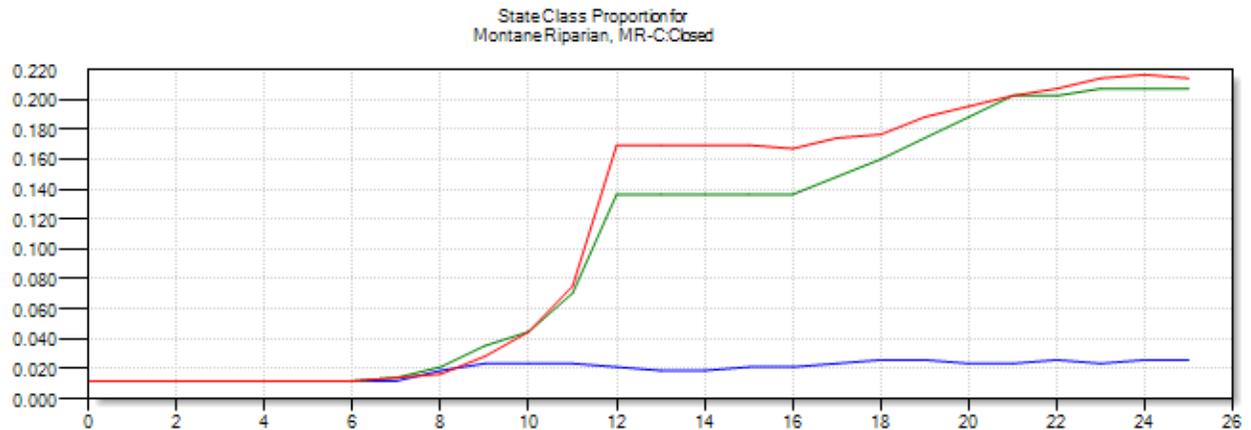
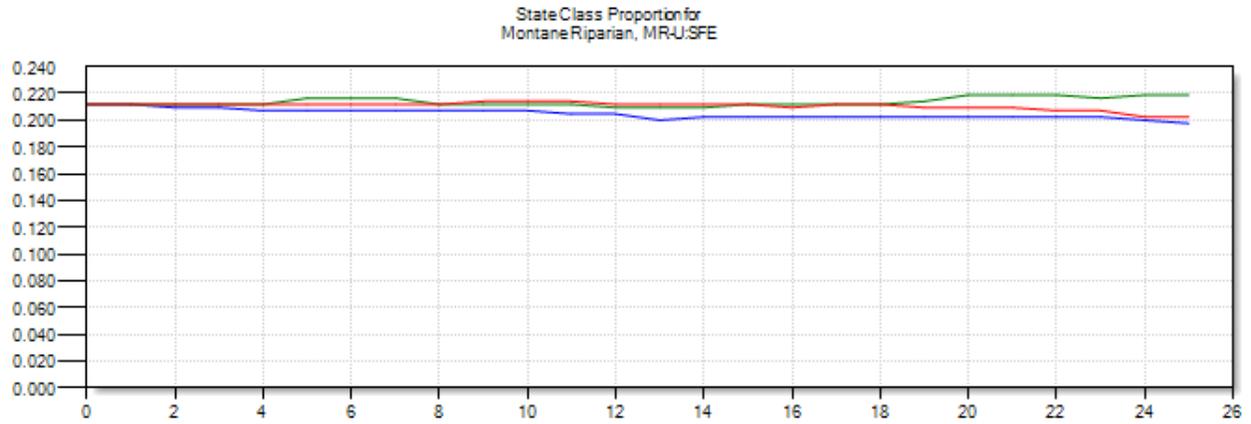
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 124.7	Current	Scenarios – 25 Years (mean of 5 replicates)		
		MINIMUM	MAXIMUM	PREFERRED
Unified Ecological Departure	100%	100%	100%	100%
Cost			\$109,395	\$101,747
ROI - vs Minimum Mgmt			0.00	0.00
ROI - 95% Confidence Interval			± 0.00	± 0.00
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			No	

Compared with MINIMUM MANAGEMENT after 25 years, neither the MAXIMUM nor PREFERRED MANAGEMENT scenarios show any improvement as measured by UED: both future active management scenarios remain fully (100%) departed. Looking more finely, however, the MAXIMUM and PREFERRED scenarios both achieve some reduction of the high-risk U:EFT class, in about the same amount, with the treated acres mostly returning to the reference C class. The two active management scenarios achieve virtually no change in the U:SFE class relative to MINIMUM MANAGEMENT.

ROI values of the MAXIMUM and PREFERRED scenarios are basically meaningless for this system, because the three future scenarios are all predicted to remain fully departed. For slightly lower cost, the PREFERRED scenario achieves about the same result as the MAXIMUM scenario, in terms of UED but more importantly in terms of reducing the U:EFT class. Charts below from the ST-Sim model output show the forecasted changes in the U:EFT, U:SFE, and reference C classes in the MINIMUM, PREFERRED, and MAXIMUM scenarios.





■ Results for [821] - Minimum Management BM Spatial (28-Apr-2015 8:56 AM)
 ■ Results for [881] - Preferred Management BM Spatial (25-Apr-2015 11:23 AM)
 ■ Results for [822] - Maximum Management BM Spatial (27-Apr-2015 10:37 AM)

Black Mountains: Montane Sagebrush Steppe

In the Black Mountains, the Montane Sagebrush Steppe system exhibits nearly complete (99%) UED at the current time. This near-total departure at present results from more than four-fifths of the system's acres being in multiple uncharacteristic classes, including several that are high-risk. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED remains nearly complete (99%) for the same reasons, with a larger relative amount of uncharacteristic classes. Amounts of specific vegetation classes in the Montane Sagebrush Steppe system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
MSS-A:All	22	—	38,280.3	507.3	1.3%	0.4%
MSS-B:Open	34	—		458.9	1.2%	1.9%
MSS-C:Closed	39	—		3,659.0	9.6%	8.8%
MSS-D:Open	3	—		1,021.9	2.7%	2.0%
MSS-E:Closed	2	—		313.6	0.8%	0.8%
MSS-U:Annual Grass	0	0.00		1,017.1	2.7%	8.1%
MSS-U:Depleted	0	0.00		843.9	2.2%	1.7%
MSS-U:Early-Shrub	0	0.00		136.8	0.4%	0.6%
MSS-U:SA	0	0.00		1,345.2	3.5%	2.2%
MSS-U:SA+	0	0.00		0.0	0.0%	0.7%
MSS-U:SAP	0	0.00		5,448.6	14.2%	10.8%
MSS-U:SAP+	0	0.00		0.0	0.0%	2.1%
MSS-U:SDI-A	0	7.70		4,431.5	11.6%	0.1%
MSS-U:SDI-B	0	11.90		127.1	0.3%	13.6%
MSS-U:SDI-C	0	13.65		802.8	2.1%	2.8%
MSS-U:SDI-D	0	1.05		7.3	0.0%	0.4%
MSS-U:Seeded Native	0	22.00		0.0	0.0%	0.0%
MSS-U:SI-A+AG	0	0.00		1,747.2	4.6%	0.0%
MSS-U:SI-B+AG	0	0.00		220.4	0.6%	1.0%
MSS-U:SI-C+AG	0	0.00		333.0	0.9%	0.2%
MSS-U:SI-D+AG	0	0.00	8.5	0.0%	0.1%	
MSS-U:TEA	0	0.00	15,850.5	41.4%	41.9%	

The major concern in this system at the present time is tree encroachment by juniper and pinyon pine (class U:TEA), which is a high-risk class, and also includes a complement of annual grasses. Other classes defined by presence/abundance of annual grasses comprise about one-fifth of the system's acres at present. After 25 years of MINIMUM MANAGEMENT, the tree-encroached class (with annual grasses) remains at about the same level, whereas the other annual-grass classes have increased slightly in total.

Therefore the objectives of management actions are to reduce the acreage of classes that are defined primarily by presence/abundance of encroaching conifers, and secondarily by annual

grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

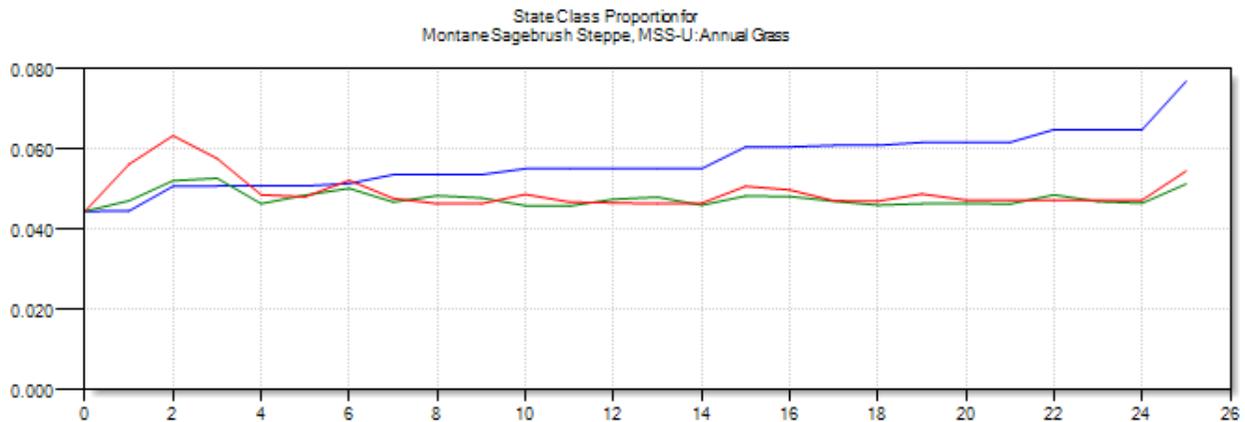
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	2xChaining+Native-Seed	0.46	0	\$230	
	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	60.15	60.25	\$350	
	Aerial-Spyke+Aerial-Seed+Chain-Harrow	7.80	141.55	\$200	
	Chaining+Native-Seed	62.21	9.82	\$175	
	Chaining+Plateau+Seed	43.86	10.24	\$185	
	Chaining+Seed	0	0.02	\$120	
	Forb+Grass-Native-Seeding	2868.66	3683.49	\$175	
	Herbicide-Plateau+Seed	198.50	190.15	\$110	
	Hypo-Hatchet-Spyke	114.18	0.03	\$25	
	Masticate+Herbicide+Seed	777.90	0.21	\$310	
	Masticate+Native-Seed	9.59	0	\$325	
	Mastication	1.55	0.13	\$200	
	RxFire	45.79	0	\$100	
	RxFire+Seed+Chain	772.74	7.14	\$235	
	Small-Tree-Lopping	152.78	16.56	\$80	
	Spyke+Native-Seed	48.12	0.37	\$240	
	Thin	16.18	45.32	\$35	
Thin+Native-Seed	37.78	0.50	\$250		
					\$21,165,912
PREFERRED	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	47.17	0	\$350	
	Aerial-Spyke+Aerial-Seed+Chain-Harrow	15.57	152.27	\$200	
	Herbicide-Plateau+Seed	201.16	185.43	\$110	
	Masticate+Native-Seed	0	13.08	\$325	
	RxFire+Seed+Chain	818.05	615.80	\$235	

The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

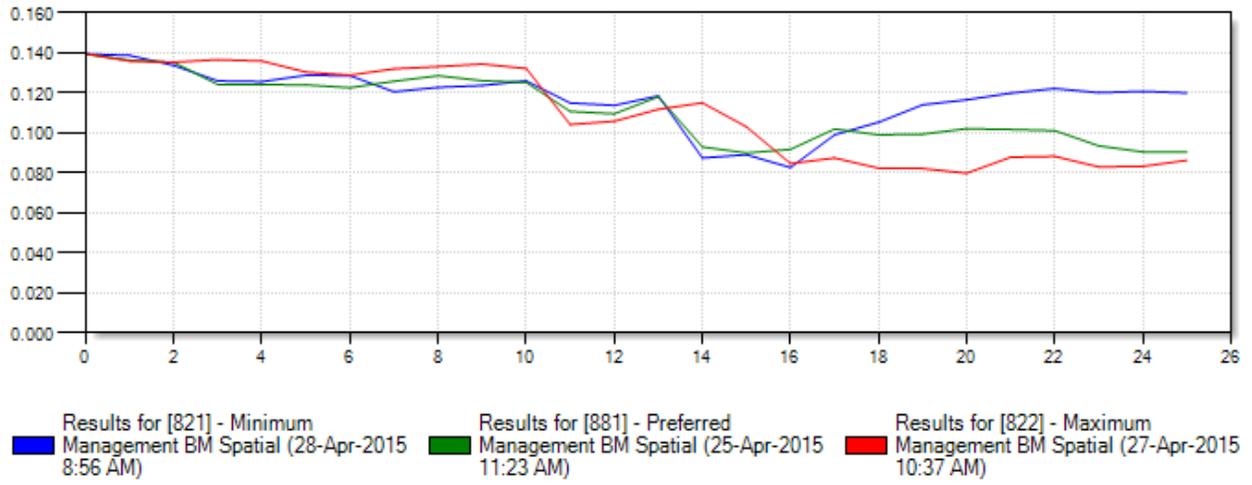
System Acres: 38,280.3	Current	Scenarios – 25 Years (mean of 5 replicates)		
		MINIMUM	MAXIMUM	PREFERRED
Unified Ecological Departure	99%	99%	71%	74%
Cost			\$21,165,912	\$5,336,551
ROI - vs Minimum Mgmt			5.11	18.41
ROI - 95% Confidence Interval			± 0.17	± 0.31
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, both the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios show appreciable improvement in UED, with the MAXIMUM scenario being just slightly better (71% versus 74%). These improvements under both active management scenarios largely reflect reductions in the tree-encroached class (U:TEA) relative to the MINIMUM MANAGEMENT scenario.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves an improvement (reduction of UED) nearly as good as that of the MAXIMUM scenario – but for about one-fourth of the total cost of the MAXIMUM scenario. Further, the treatment-amount inputs to the MAXIMUM scenario were so large that the model “ran out of acres” for many treatments during the latter part of its 25-year run. Finally, charts below from the ST-Sim model output show the forecasted reductions in the U:TEA, U:Annual Grass, and U:SAP classes in the PREFERRED and MAXIMUM scenarios.



StateClass Proportion for
Montane Sagebrush Steppe, MSS-U:SAP



Black Mountains: Pinyon-Juniper

In the Black Mountains, the Pinyon-Juniper system exhibits UED that is at the low end of the moderate range (34%) at the current time. About three-fourths of this system’s acres are within reference classes, though these are almost wholly in the oldest class, and the remaining acres are mostly in the uncharacteristic Tree-Annual Grass (TA) class. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED improves slightly (to 31%), though the general amounts of reference and uncharacteristic classes have not changed substantially. Amounts of specific vegetation classes in the Pinyon-Juniper system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
PJ-A:All	3	—	36,488.4	33.9	0.1%	0.2%
PJ-B:Open	6	—		2.4	0.0%	0.8%
PJ-C:Open	25	—		79.9	0.2%	2.2%
PJ-D:Open	66	—		27,992.3	76.7%	72.7%
PJ-U:Annual Grass	0	0.00		81.1	0.2%	1.1%
PJ-U:Exotic Forb	0	0.00		0.0	0.0%	0.0%
PJ-U:SAP	0	0.00		0.0	0.0%	0.0%
PJ-U:SDI	0	35.00		29.1	0.1%	0.1%
PJ-U:SDI+AG	0	0.00		0.0	0.0%	0.0%
PJ-U:Seeded Native	0	3.00		0.0	0.0%	0.0%
PJ-U:TA	0	0.00		8,269.7	22.7%	22.9%

The main concern in this system is increasing density of juniper and pinyon pine trees in the oldest reference (D) class and in the uncharacteristic TA class. Therefore the primary objective is to thin trees within these two classes, which will reduce their density of trees but not otherwise convert the acres into different classes. The table below shows management actions and costs aimed at achieving this objective under two future active management scenarios: MAXIMUM and PREFERRED.

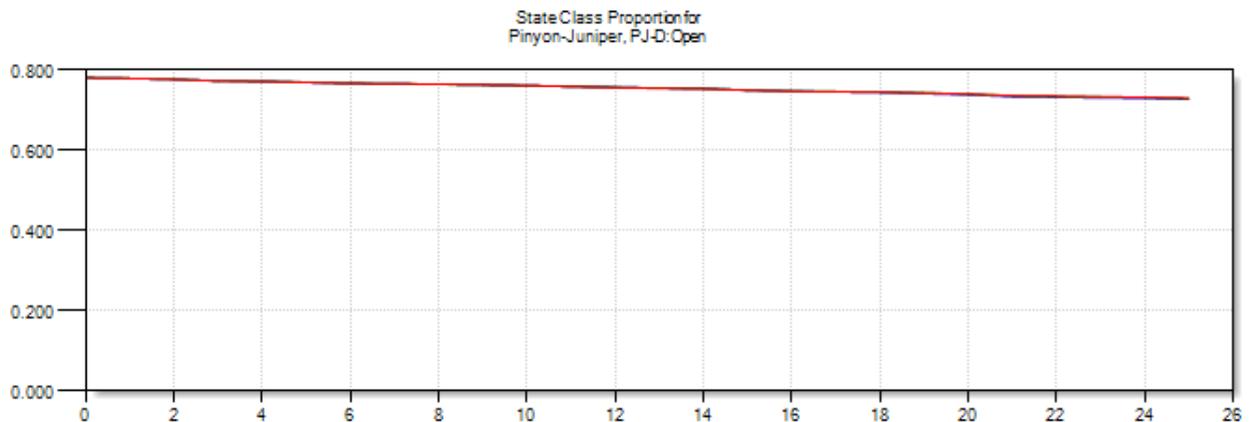
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)			25-Yr Total Cost
		Years 1-10	Years 11-25	Cost/Ac	
MAXIMUM	Aerial-Seed	8.33	9.62	\$20	\$4,625,733
	Chaining+Seed	2.25	0.45	\$120	
	Chainsaw-Thinning	263.04	255.85	\$80	
	Masticate+Seed	333.53	324.56	\$500	
PREFERRED	Chainsaw-Thinning	160.19	158.12	\$80	\$317,873

The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

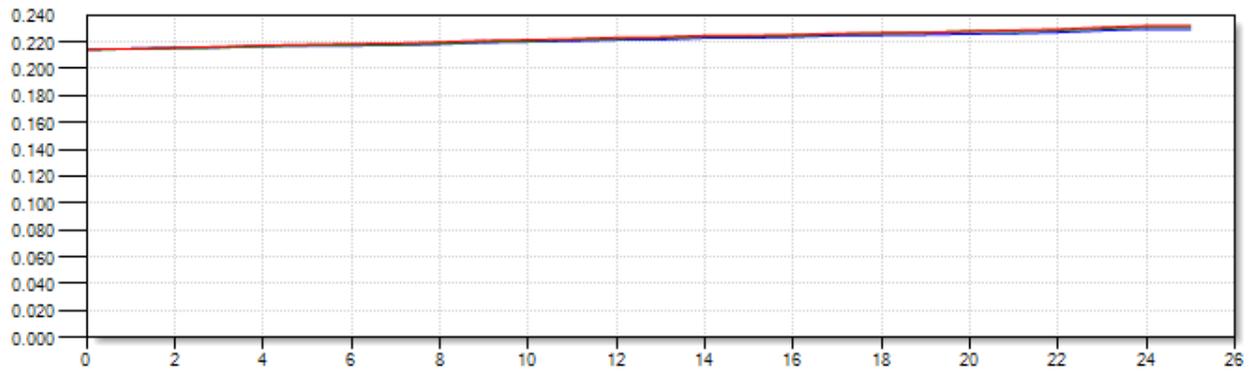
System Acres: 36,488.4	Current	Scenarios – 25 Years (mean of 5 replicates)		
		MINIMUM	MAXIMUM	PREFERRED
Unified Ecological Departure	34%	31%	30%	31%
Cost			\$4,625,733	\$317,873
ROI - vs Minimum Mgmt			0.64	-0.23
ROI - 95% Confidence Interval			± 0.13	± 1.39
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			No	

The predicted UED value under MINIMUM MANAGEMENT after 25 years is nearly or quite the same as for the PREFERRED and MAXIMUM MANAGEMENT scenarios. All three of these future slight improvements (from Current) reflect the thinning of trees in older classes, without any class-conversions. These future improvements happen by virtue of active management treatments in the MAXIMUM and PREFERRED scenarios, and without such treatments in the MINIMUM scenario. There is little difference in predicted outcomes among these three scenarios.

Given these results, the ROI values of the MAXIMUM and PREFERRED scenarios are near zero or slightly negative, and are not significantly different from each other at the 95% confidence level. Further, the model predicts that the MINIMUM MANAGEMENT scenario will result in virtually identical results (as measured by UED) to both of the active management scenarios – but for zero cost, and without any in-class thinning. Finally, charts below from the ST-Sim model output show the forecasted amounts of the D and U:TA classes in the MINIMUM, PREFERRED and MAXIMUM scenarios.



StateClass Proportion for
Pinyon-Juniper, PJ:J:TA



Results for [821] - Minimum Management BM Spatial (28-Apr-2015 8:56 AM) Results for [881] - Preferred Management BM Spatial (25-Apr-2015 11:23 AM) Results for [822] - Maximum Management BM Spatial (27-Apr-2015 10:37 AM)

Black Mountains: Stansbury Cliffrose

In the Black Mountains, the Stansbury Cliffrose system exhibits relatively high UED (71%) at the current time. About two-fifths of this system’s acres are in reference classes. The remaining acres are mostly split between two uncharacteristic classes, one of which is high-risk. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED increases very slightly (to 74%). Relative amounts of reference and uncharacteristic classes have shifted slightly toward the latter, but not enough to cause much increase in future UED. Amounts of specific vegetation classes in the Stansbury Cliffrose system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
SC-A:All	9	—	2,070.5	81.1	3.9%	0.3%
SC-B:Closed	37	—		360.8	17.4%	19.9%
SC-C:Closed	54	—		374.1	18.1%	15.9%
SC-U:Annual Grass	0	0.00		486.7	23.5%	2.6%
SC-U:Depleted	0	0.00		0.0	0.0%	0.1%
SC-U:Early-Shrub	0	0.00		0.0	0.0%	0.2%
SC-U:SAP	0	0.00		622.3	30.1%	31.0%
SC-U:SAP+	0	0.00		0.0	0.0%	19.1%
SC-U:SDI-A	0	3.15		23.0	1.1%	0.0%
SC-U:SDI-B	0	12.95		36.3	1.8%	4.0%
SC-U:SDI-C	0	18.90		0.0	0.0%	0.2%
SC-U:Seeded Native	0	9.00		0.0	0.0%	0.0%
SC-U:SI-A+AG	0	0.00		31.5	1.5%	0.0%
SC-U:SI-B+AG	0	0.00		0.0	0.0%	0.0%
SC-U:SI-C+AG	0	0.00		0.0	0.0%	0.3%
SC-U:TEA	0	0.00		54.5	2.6%	6.5%

A moderate concern within this system at the present time is the presence/abundance of annual grasses, in classes that both do and do not retain a native vegetation component. After 25 years of MINIMUM MANAGEMENT, the total acreage of such annual-grass classes remains about the same, though acreage amounts have shifted among them.

Therefore the primary objective of management actions is to hold in check, and reduce if possible, the presence/abundance of annual grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	Chaining+Native-Seed	1.07	0.61	\$230	
	Herbicide-Plateau	3.24	0.11	\$10	
	Masticate+Herbicide+Native-Seed	26.64	2.11	\$625	
	Small-Tree-Lopping	0.05	0	\$20	
	Spot-Herbicide+Native-Seed	2.88	3.92	\$225	
	Spyke+Plateau+Native-Seed	12.45	0.18	\$250	
					\$242,740
PREFERRED	Spot-Herbicide+Native-Seed	3.73	0	\$225	
					\$6,992

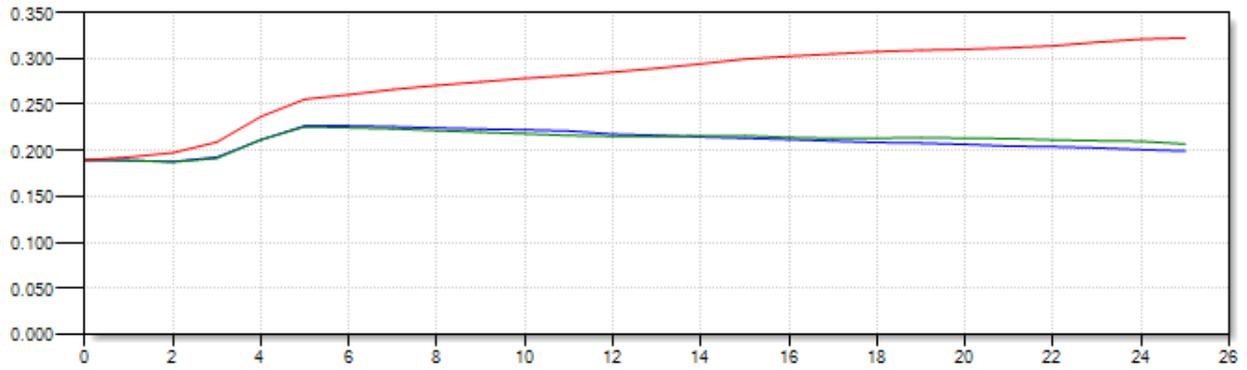
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 2,070.5	Current	Scenarios – 25 Years (mean of 5 replicates)		
		MINIMUM	MAXIMUM	PREFERRED
Unified Ecological Departure	71%	74%	50%	71%
Cost			\$242,740	\$8,391
ROI - vs Minimum Mgmt			20.51	36.85
ROI - 95% Confidence Interval			± 3.30	± 42.80
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			No	

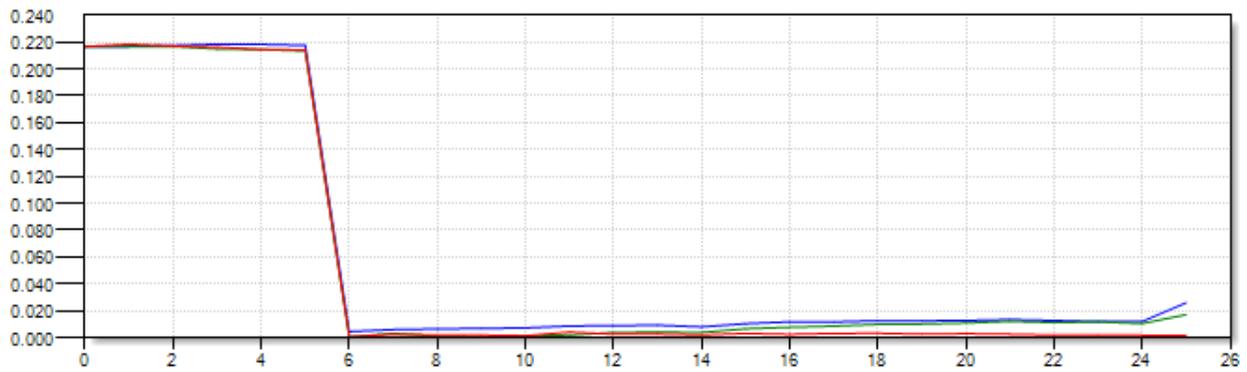
Compared with MINIMUM MANAGEMENT after 25 years, the MAXIMUM MANAGEMENT scenario shows substantial improvement in UED, and the PREFERRED MANAGEMENT scenario shows only minimal improvement (down to 50% and 71%, respectively). These improvements under both active management scenarios reflect relatively modest reductions in the annual-grass classes relative to the MINIMUM MANAGEMENT scenario. The MAXIMUM MANAGEMENT scenario also shows an increase in the reference B class that is not achieved in the PREFERRED scenario.

The ROI values of the MAXIMUM and PREFERRED scenarios are not significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves minimal improvement (as measured by UED) for minimal cost, whereas the MAXIMUM scenario achieves better results for correspondingly greater cost – over thirty times the cost of the PREFERRED scenario, though not large in absolute terms. Finally, charts below from the ST-Sim model output show the forecasted changes in the reference B, U: Annual Grass, U:SAP, and U:SAP+ classes in the MINIMUM, PREFERRED, and MAXIMUM scenarios.

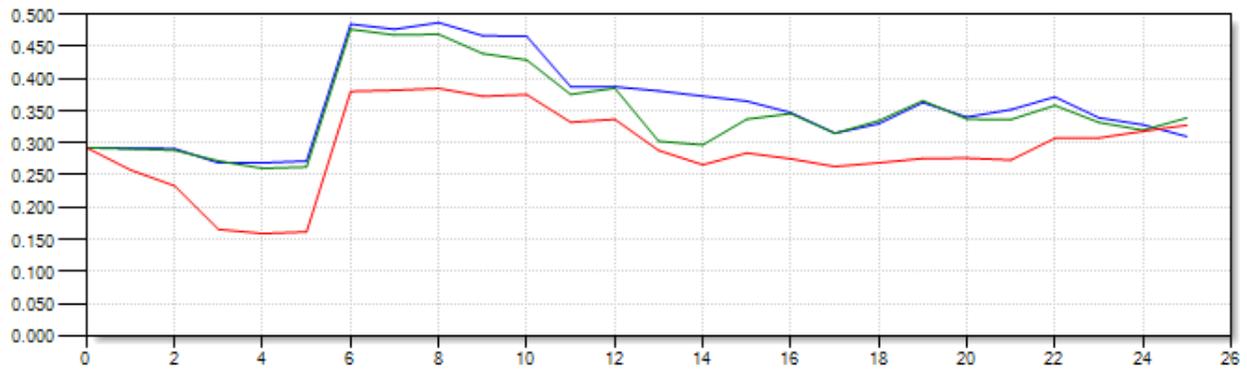
State Class Proportion for
Stansbury Cliffrose, SC-B:Closed



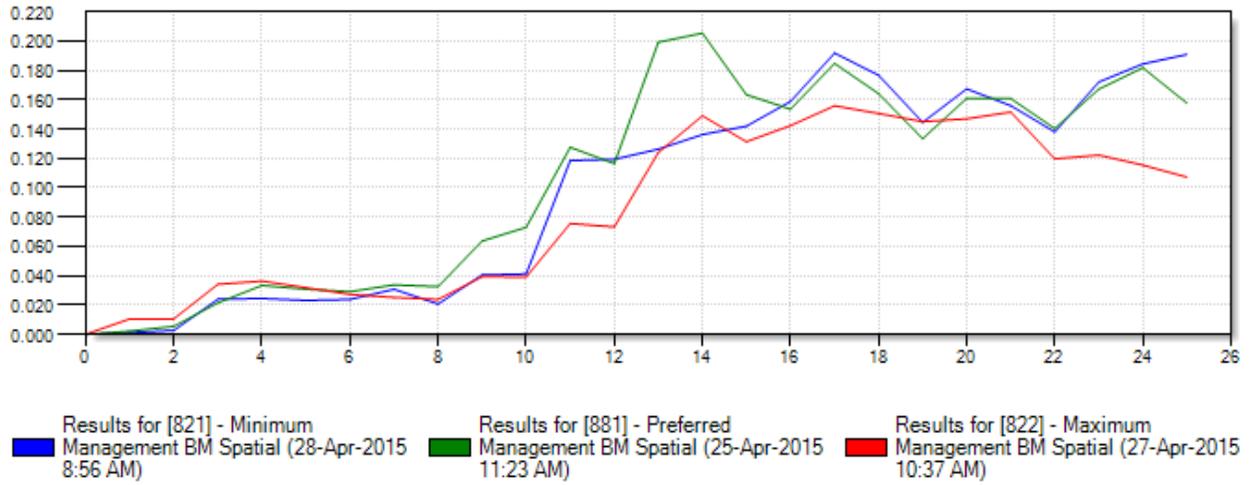
State Class Proportion for
Stansbury Cliffrose, SC-U:Annual Grass



State Class Proportion for
Stansbury Cliffrose, SCU:SAP



StateClass Proportion for
Stansbury Cliffrose, SCU:SAP+



Black Mountains: Utah Serviceberry

In the Black Mountains, the Utah Serviceberry system exhibits UED near the low end of the moderate range (35%) at the current time. About three-fourths of this system's acres are in reference classes. The remaining acres are mostly in the uncharacteristic U:SAP class, which is not high-risk. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED increases appreciably (to 67%). The main drivers of this higher future departure are greater proportion of the late-age reference class, and increases in amounts of uncharacteristic classes, some of which are high-risk. Amounts of specific vegetation classes in the Utah Serviceberry system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
US-A:All	9	—	1,018.3	127.1	12.5%	0.5%
US-B:Closed	28	—		147.7	14.5%	2.1%
US-C:Closed	49	—		291.8	28.7%	25.1%
US-D:Open	14	—		199.8	19.6%	38.7%
US-U:Annual Grass	0	0.00		0.0	0.0%	2.3%
US-U:Depleted	0	0.00		0.0	0.0%	0.2%
US-U:Early-Shrub	0	0.00		0.0	0.0%	0.4%
US-U:SAP	0	0.00		211.9	20.8%	15.0%
US-U:SAP+	0	0.00		0.0	0.0%	4.6%
US-U:SDI-A	0	3.15		0.0	0.0%	0.0%
US-U:SDI-B	0	9.80		2.4	0.2%	0.0%
US-U:SDI-C	0	17.15		0.0	0.0%	0.2%
US-U:SDI-D	0	4.90		0.0	0.0%	0.0%
US-U:SI-A+AG	0	0.00		0.0	0.0%	0.0%
US-U:SI-B+AG	0	0.00		0.0	0.0%	0.0%
US-U:SI-C+AG	0	0.00		0.0	0.0%	0.0%
US-U:SI-D+AG	0	0.00		0.0	0.0%	0.0%
US-U:TA	0	0.00		0.0	0.0%	8.1%
US-U:TE	0	0.00		37.5	3.7%	3.0%

Two moderate concerns within this system at the present time are a tendency toward encroachment by juniper and pinyon pine (elevated amount of the reference D class), and increase of annual grasses in habitats that still contain a native vegetation component (U:SAP class). After 25 years of MINIMUM MANAGEMENT, the reference D class has nearly doubled, and two high-risk classes characterized by conifer encroachment constitute more than 10% of the system's acres. Other classes defined by annual grasses have also increased in coverage.

Therefore the primary objective of management actions is to reduce the encroachment of juniper and pinyon pine. A secondary objective is to hold in check, and reduce if possible, the presence/abundance of annual grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

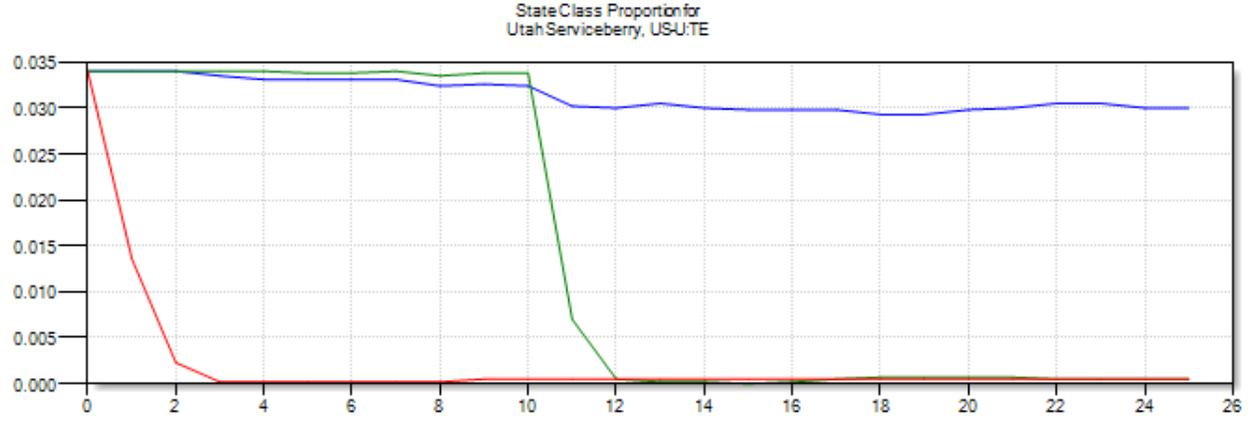
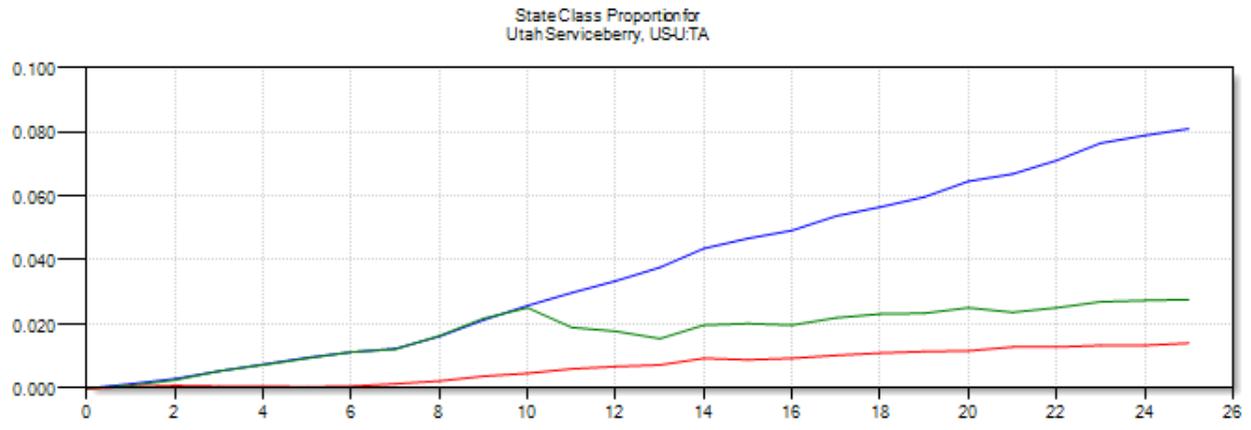
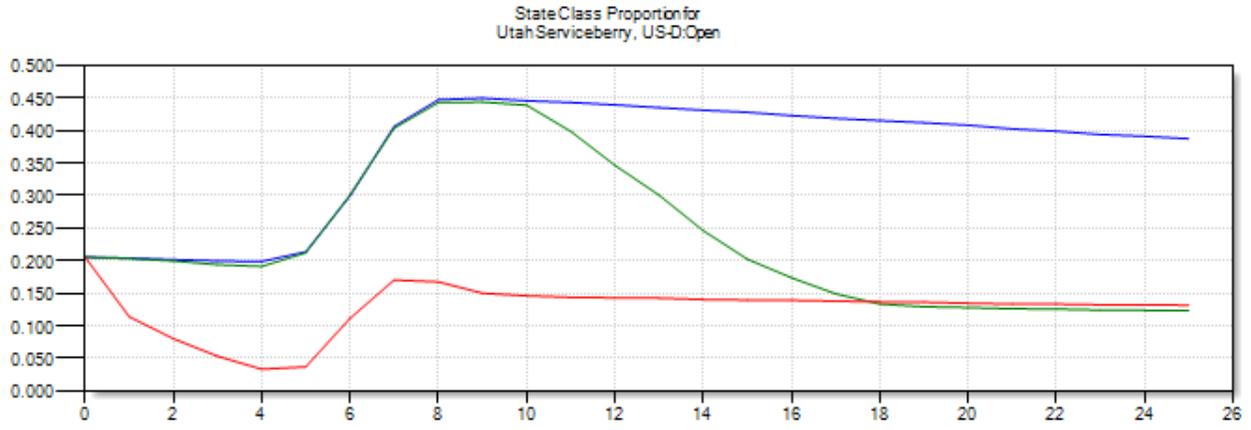
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	Chaining+Plateau+Native-Seed	7.29	0	\$260	
	Chaining+Plateau+Seed	0.02	0.05	\$185	
	Chaining+Seed	0.36	0.18	\$120	
	Chainsaw-Thinning	13.51	0	\$20	
	Forb+Grass-Native-Seeding	4.55	6.01	\$175	
	Herbicide-Plateau+Seed	0.31	0.60	\$150	
	Masticate+Native-Seed	0.92	0	\$325	
	Masticate+Seed	2.74	0	\$270	
	RxFire	8.16	0	\$100	
	Small-Tree-Lopping	21.67	0	\$20	
	Thin+Herbicide+Native-Seed	5.13	2.86	\$320	
	Thin+Herbicide+Seed	0.02	0.26	\$240	
					\$102,144
PREFERRED	Chainsaw-Thinning	0	18.63	\$20	
	Herbicide-Plateau+Seed	0	1.49	\$150	
	Masticate+Native-Seed	0	4.76	\$325	
	RxFire	2.32	1.58	\$100	
					\$34,643

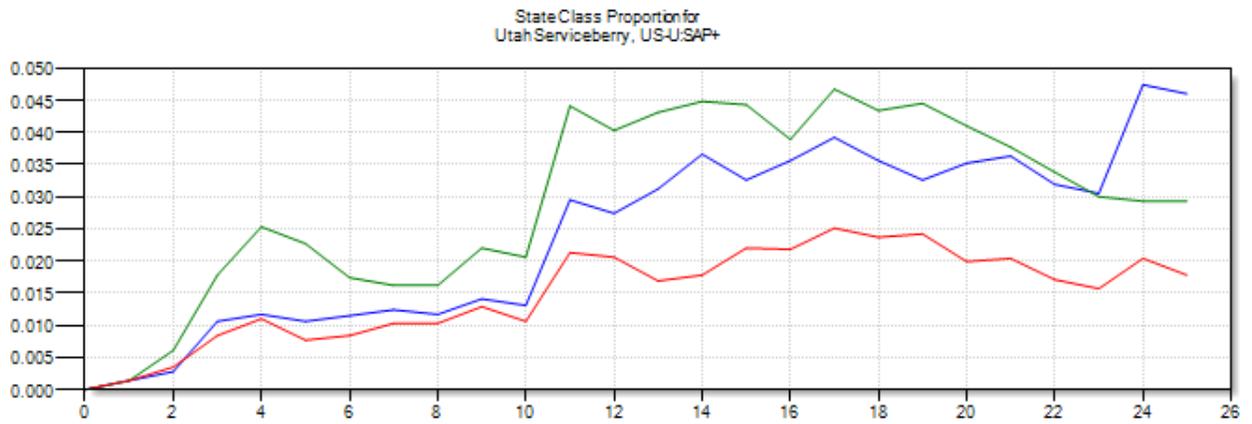
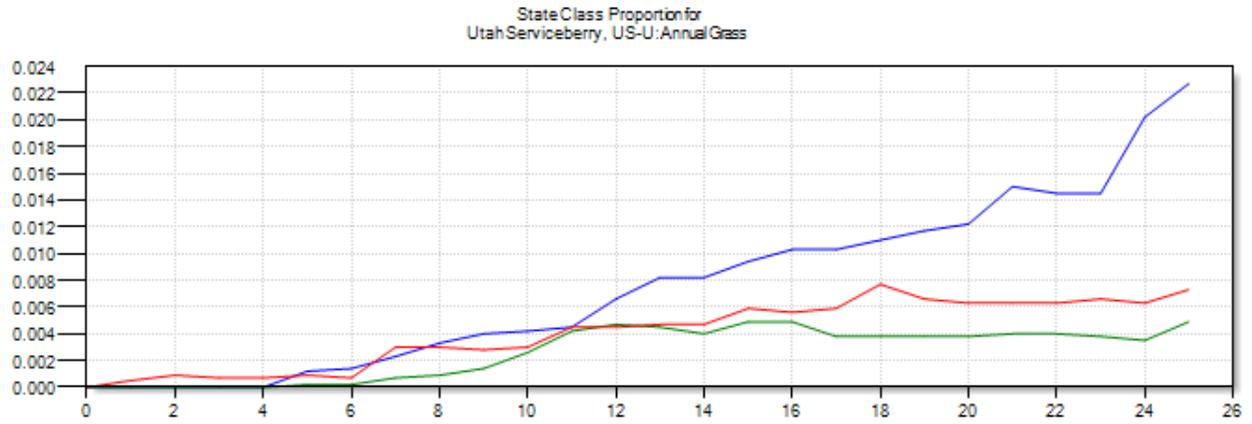
The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 1,018.3	Current	Scenarios – 25 Years (mean of 5 replicates)		
		MINIMUM	MAXIMUM	PREFERRED
Unified Ecological Departure	35%	67%	29%	31%
Cost			\$102,144	\$34,643
ROI - vs Minimum Mgmt			38.61	108.43
ROI - 95% Confidence Interval			± 5.55	± 12.12
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, both the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios show appreciable improvement in UED, to levels that are nearly the same (29% and 31%), in the good range. These improvements under both active management scenarios reflect reductions in both tree-encroached classes and annual-grass classes, relative to the MINIMUM MANAGEMENT scenario.

The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves an improvement (reduction of UED) almost identical to that of the MAXIMUM scenario – but for about one-third of the total cost of the MAXIMUM scenario. Charts below from the ST-Sim model output show the forecasted reductions in the D, U:TA, U:TE, U:Annual Grass, and U:SAP+ classes in the PREFERRED and MAXIMUM scenarios.





■ Results for [821] - Minimum Management BM Spatial (28-Apr-2015 8:56 AM)
 ■ Results for [881] - Preferred Management BM Spatial (25-Apr-2015 11:23 AM)
 ■ Results for [822] - Maximum Management BM Spatial (27-Apr-2015 10:37 AM)

Black Mountains: Wet Meadow-Montane

In the Black Mountains, the Wet Meadow-Montane system exhibits UED near the high end of the moderate range (65%) at the current time. About two-fifths of this system’s acres are within a single mid-age reference class. The remaining acres are mostly within one uncharacteristic class, U:SFE. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED improves appreciably (to 34%). This lower future departure derives mainly from increase in reference-class amounts, though uncharacteristic classes comprise about one-fourth of the system’s acres. Amounts of specific vegetation classes in the Wet Meadow-Montane system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
WM-A:Open	3	—	50.9	0.0	0.0%	0.0%
WM-B:Closed	89	—		19.4	38.1%	49.1%
WM-C:Open	8	—		0.0	0.0%	24.6%
WM-U:Annual Grass	0	0.00		0.0	0.0%	0.0%
WM-U:Desertified	0	0.00		0.0	0.0%	0.0%
WM-U:Exotic Forb	0	0.00		3.6	7.1%	15.4%
WM-U:Hummocked	0	0.00		0.0	0.0%	0.6%
WM-U:SA	0	0.00		0.0	0.0%	0.0%
WM-U:SDI	0	0.00		0.0	0.0%	0.0%
WM-U:SFE	0	0.00		27.8	54.7%	10.3%
WM-U:TEA	0	0.00		0.0	0.0%	0.0%

Two moderate concerns at the present time are the presence of exotic forbs represented by the U:Exotic Forb class, which is high-risk; and more than half of the system’s acres within the shrub-forb-encroached class (U:SFE), which is not high-risk. After 25 years of MINIMUM MANAGEMENT, the exotic forb class has more than doubled, whereas the U:SFE class has shrunk quite a bit.

Therefore the objectives of management actions are to reduce the acreage of classes defined primarily by exotic forbs, and secondarily by undesirable (but native) shrubs and forbs. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)			25-Yr Total Cost
		Years 1-10	Years 11-25	Cost/Ac	
MAXIMUM	Exotic-Control	0.44	0	\$360	\$340,646
	Fence	1.16	1.45	\$8,000	
	Thin	0.92	0.03	\$125	
	Weed-Inventory+Treat	9.08	8.64	\$320	

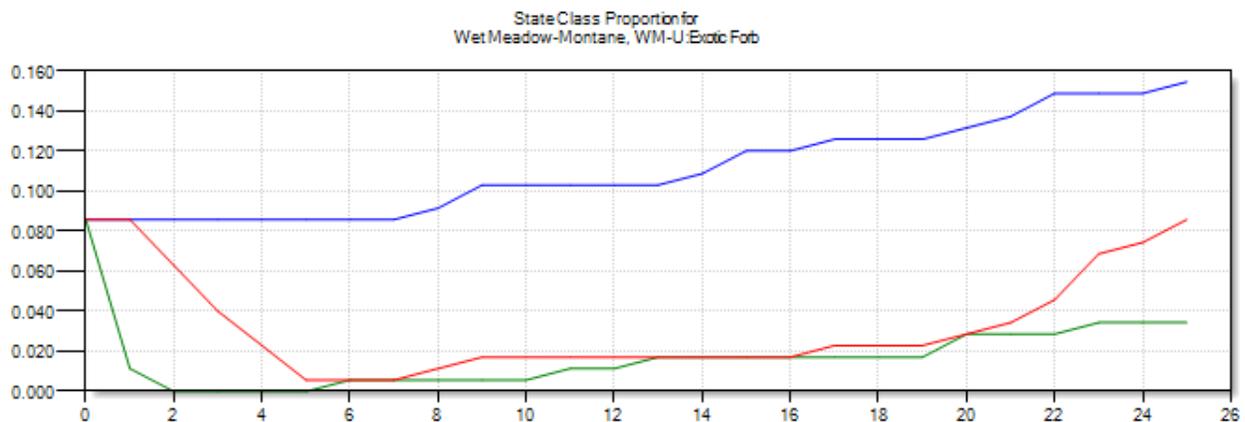
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
PREFERRED	Exotic-Control	0.41	0	\$360	\$330,901
	Fence	1.26	1.45	\$8,000	
	Weed-Inventory+Treat	7.75	6.15	\$320	

The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

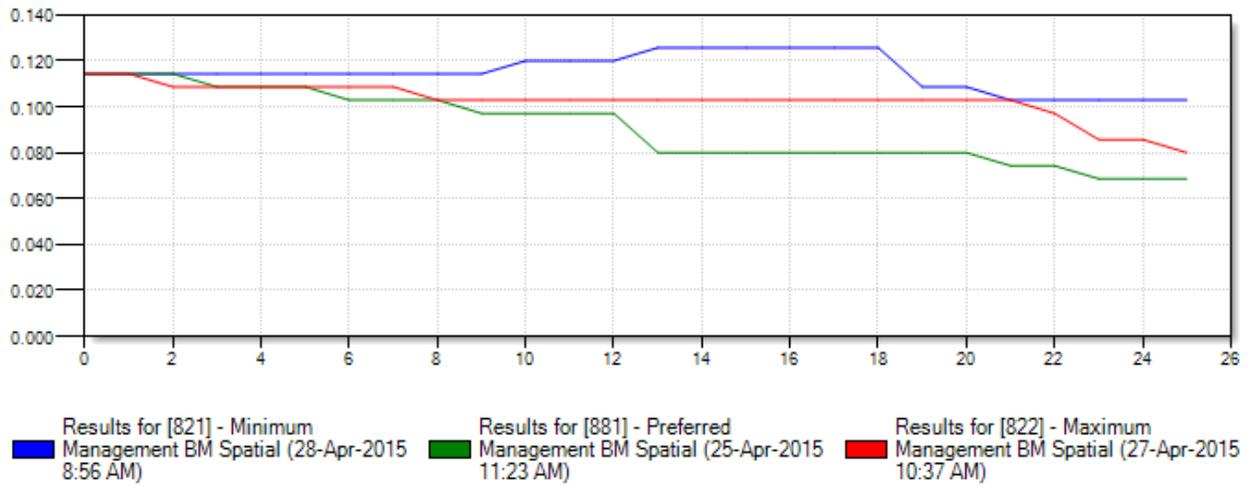
System Acres: 50.9	Current	Scenarios – 25 Years (mean of 5 replicates)		
		MINIMUM	MAXIMUM	PREFERRED
Unified Ecological Departure	65%	34%	21%	12%
Cost			\$340,646	\$330,901
ROI - vs Minimum Mgmt			0.20	0.34
ROI - 95% Confidence Interval			± 0.11	± 0.04
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, both of the active management scenarios show substantial reduction (improvement) of UED, down into the good range; the PREFERRED scenario actually shows about twice the level of improvement as the MAXIMUM scenario. Both active management scenarios reduce the high-risk U:Exotic Forb class and the U:SFE class.

The ROI values of the MAXIMUM and PREFERRED scenarios are both low, on account of the small size of this system, and are significantly different from each other at the 95% confidence level. The PREFERRED scenario actually achieves better improvement (reduction of UED) than the MAXIMUM scenario – and for slightly lower cost than the MAXIMUM scenario. Charts below from the ST-Sim model output show the forecasted reductions in the U:Exotic Forb and U:SFE classes in the PREFERRED and MAXIMUM scenarios.



State Class Proportion for
WetMeadow-Montane, WMU:SFE



Black Mountains: Wyoming Big Sagebrush upland

In the Black Mountains, the Wyoming Big Sagebrush upland system exhibits complete (100%) UED at the current time. This total departure at present results from about nine-tenths of the system's acres being in multiple uncharacteristic classes, including several that are high-risk. After 25 years in a regime of MINIMUM MANAGEMENT, the predicted UED remains complete (100%) for the same reasons, with a slight increase in the relative amount of reference classes. Amounts of specific vegetation classes in the Wyoming Big Sagebrush upland system at the current time, and after 25 years of MINIMUM MANAGEMENT, are shown in the table below:

Vegetation Class (Yellow = High Risk)	Ref %	Allow. Thresh%	CURRENT			MIN MGMT 25 Years
			System Ac	Class Ac	Class %	Class %
WSup-A:All	14	—	197,690.5	8,228.5	4.2%	0.4%
WSup-B:Open	29	—		2,292.0	1.2%	8.8%
WSup-C:Closed	42	—		7,493.6	3.8%	3.7%
WSup-D:Open	6	—		1,823.4	0.9%	0.6%
WSup-E:Closed	9	—		339.0	0.2%	0.9%
WSup-U:Annual Grass	0	0.00		21,405.6	10.8%	17.1%
WSup-U:Depleted	0	0.00		2,637.1	1.3%	1.3%
WSup-U:Early-Shrub	0	0.00		5,536.9	2.8%	3.3%
WSup-U:SA	0	0.00		14,789.8	7.5%	8.8%
WSup-U:SA+	0	0.00		0.0	0.0%	2.7%
WSup-U:SAP	0	0.00		71,309.5	36.1%	20.8%
WSup-U:SAP+	0	0.00		0.0	0.0%	7.4%
WSup-U:SDI-A	0	4.90		13,872.0	7.0%	0.1%
WSup-U:SDI-B	0	10.15		1,043.7	0.5%	3.5%
WSup-U:SDI-C	0	14.70		787.0	0.4%	1.6%
WSup-U:SDI-D	0	2.10		7.3	0.0%	0.0%
WSup-U:Seeded Native	0	14.00		0.0	0.0%	0.0%
WSup-U:SI-A+AG	0	0.00		10,449.1	5.3%	0.0%
WSup-U:SI-B+AG	0	0.00		2,139.5	1.1%	0.1%
WSup-U:SI-C+AG	0	0.00		834.2	0.4%	0.0%
WSup-U:SI-D+AG	0	0.00	389.9	0.2%	0.0%	
WSup-U:TEA	0	0.00	32,312.4	16.3%	19.0%	

A major concern in this system at the present time is tree encroachment by juniper and pinyon pine (class U:TEA), which is a high-risk class, and also includes a complement of annual grasses. Other classes defined by presence/abundance of annual grasses comprise more than half of the system's acres at present, and collectively are also a major concern. After 25 years of MINIMUM MANAGEMENT, the tree-encroached class (with annual grasses) has increased slightly, and the other annual-grass classes have also increased slightly in total. Therefore the primary objectives of management actions are to reduce the acreage of classes that are defined by presence/abundance of encroaching conifers, and/or of annual grasses. The table below shows management actions and costs aimed at achieving these objectives under two future active management scenarios: MAXIMUM and PREFERRED.

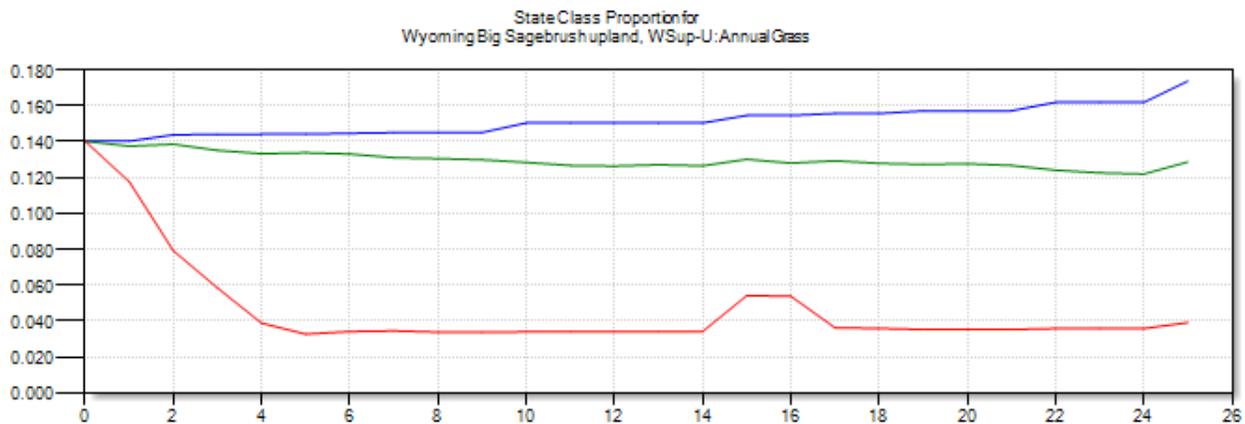
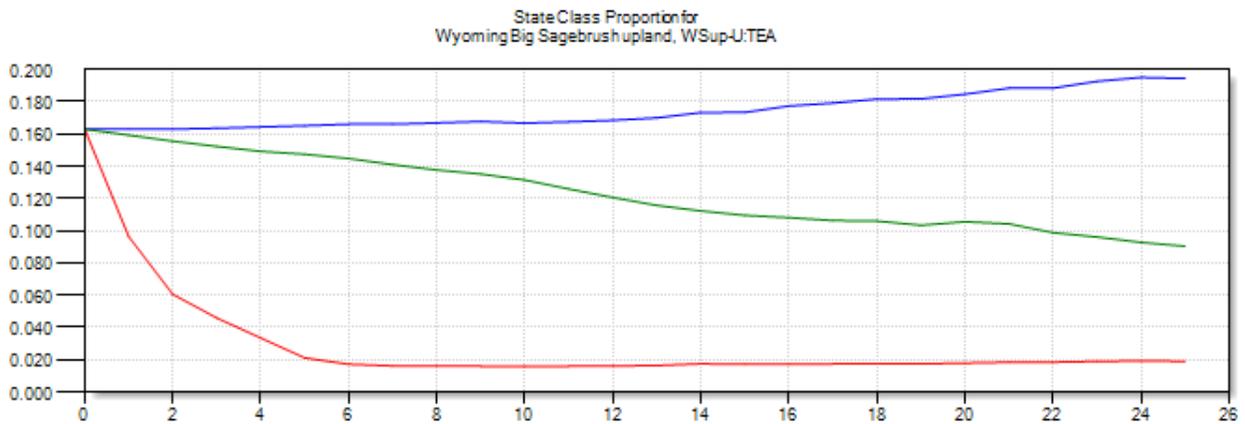
Scenario	Treatment or Mgmt Action	Acres/Year (Avg of 5 runs)		Cost/Ac	25-Yr Total Cost
		Years 1-10	Years 11-25		
MAXIMUM	2xChaining+Native-Seed	16.27	0.02	\$230	
	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	1029.77	74.60	\$350	
	Aerial-Spyke+Aerial-Seed+Chain-Harrow	859.63	2266.66	\$200	
	Chaining+Native-Seed	67.73	17.21	\$175	
	Chaining+Plateau+Seed	1296.47	222.03	\$185	
	Chaining+Seed	997.30	167.30	\$120	
	Forb+Grass-Native-Seeding	10508.68	16406.10	\$175	
	Herbicide-Plateau+Seed	2800.27	941.01	\$110	
	Hypo-Hatchet-Spyke	635.39	461.09	\$25	
	Masticate+Herbicide+Seed	964.29	0	\$310	
	Masticate+Native-Seed	58.14	20.10	\$325	
	Mastication	142.08	33.60	\$200	
	RxFire+Seed+Chain	1453.99	17.34	\$235	
	Small-Tree-Lopping	1210.09	1798.20	\$60	
	Spyke+Native-Seed	45.21	0.16	\$240	
	Thin	154.74	207.32	\$35	
	Thin+Herbicide+Native-Seed	1.02	0.63	\$265	
	Thin+Native-Seed	50.30	0.31	\$250	
					\$93,504,355
PREFERRED	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	50.49	48.87	\$350	
	Aerial-Spyke+Aerial-Seed+Chain-Harrow	461.05	479.55	\$200	
	Chaining+Native-Seed	313.02	0	\$175	
	Chaining+Seed	381.99	1084.52	\$120	
	Herbicide-Plateau+Seed	917.12	845.28	\$110	
	RxFire+Seed+Chain	520.26	0	\$235	
	Small-Tree-Lopping	171.28	426.63	\$60	
	Thin	33.93	0	\$35	
					\$9,876,247

The table below summarizes predicted outcomes in terms of UED and total cost after 25 years of these two active management scenarios, along with their Current and MINIMUM values.

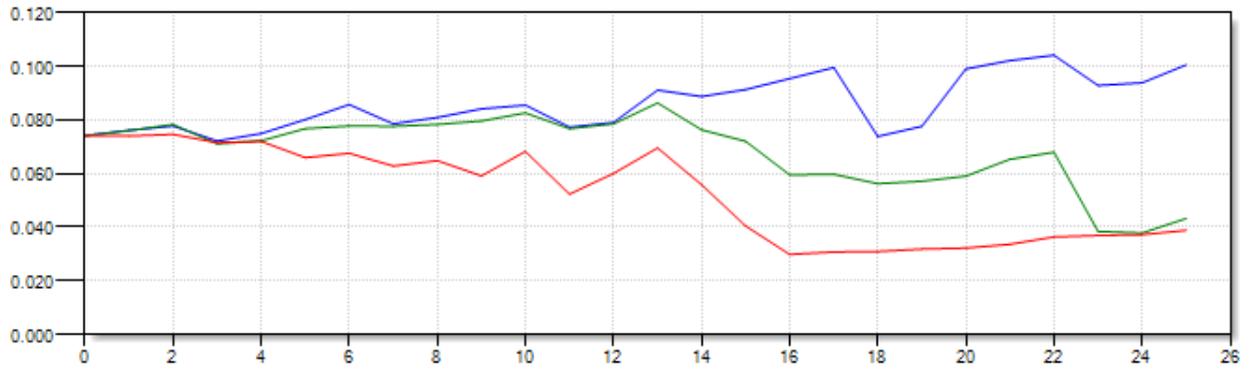
System Acres: 197,690.5	Current	Scenarios – 25 Years (mean of 5 replicates)		
		Minimum	Maximum	Preferred
Unified Ecological Departure	100%	100%	75%	88%
Cost			\$93,504,355	\$9,876,247
ROI - vs Minimum Mgmt			5.39	23.33
ROI - 95% Confidence Interval			± 0.27	± 2.12
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			Yes	

Compared with MINIMUM MANAGEMENT after 25 years, both the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios show improvement in UED, with the MAXIMUM scenario predicting about twice as much improvement. These improvements under both active management scenarios reflect reductions in classes defined by both tree-encroachment and presence/abundance of annual grasses, relative to the MINIMUM MANAGEMENT scenario.

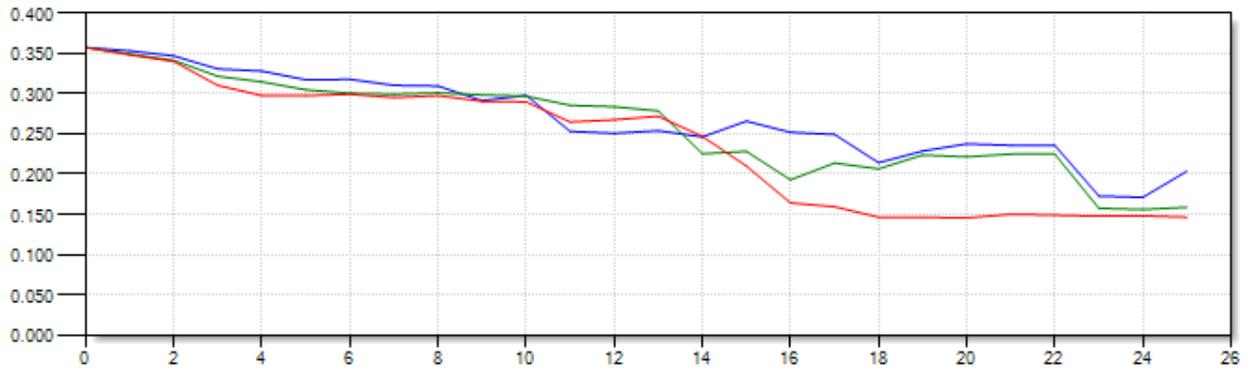
The ROI values of the MAXIMUM and PREFERRED scenarios are significantly different from each other at the 95% confidence level. The PREFERRED scenario achieves an improvement (reduction of UED) about half as great as that of the MAXIMUM scenario – but for about one-tenth of the total cost of the MAXIMUM scenario. Further, the treatment-amount inputs to the MAXIMUM scenario were so large that the model “ran out of acres” for many treatments during the latter part of its 25-year run. Finally, charts below from the ST-Sim model output show the forecasted reductions in the U:TEA, U:Annual Grass, U:SA, and U:SAP classes in the PREFERRED and MAXIMUM scenarios.



State Class Proportion for WyomingBig Sagebrushupland, WSup-U:SA



State Class Proportion for WyomingBig Sagebrushupland, WSup-U:SA



■ Results for [821] - Minimum Management BM Spatial (28-Apr-2015 8:56 AM)
 ■ Results for [881] - Preferred Management BM Spatial (25-Apr-2015 11:23 AM)
 ■ Results for [822] - Maximum Management BM Spatial (27-Apr-2015 10:37 AM)

Black Mountains: Greater Sage-Grouse Habitat Suitability

The spatial distribution of habitat suitability values for Greater sage-grouse as predicted after 25 years of PREFERRED MANAGEMENT in the Black Mountains project area is shown in Figure 11. Lighter values represent better suitability and darker values represent poorer suitability.

Habitat suitability increased under PREFERRED MANAGEMENT to 73,564 functional acres (Figure 11) versus the MINIMUM MANAGEMENT value of 72,636 functional acres (Figure 8). Reasons for this slight improvement to habitat suitability are difficult to isolate, as management was widely distributed by removing young and old trees, and seeding annual grasslands to seedlings that eventually mature to classes with sagebrush.

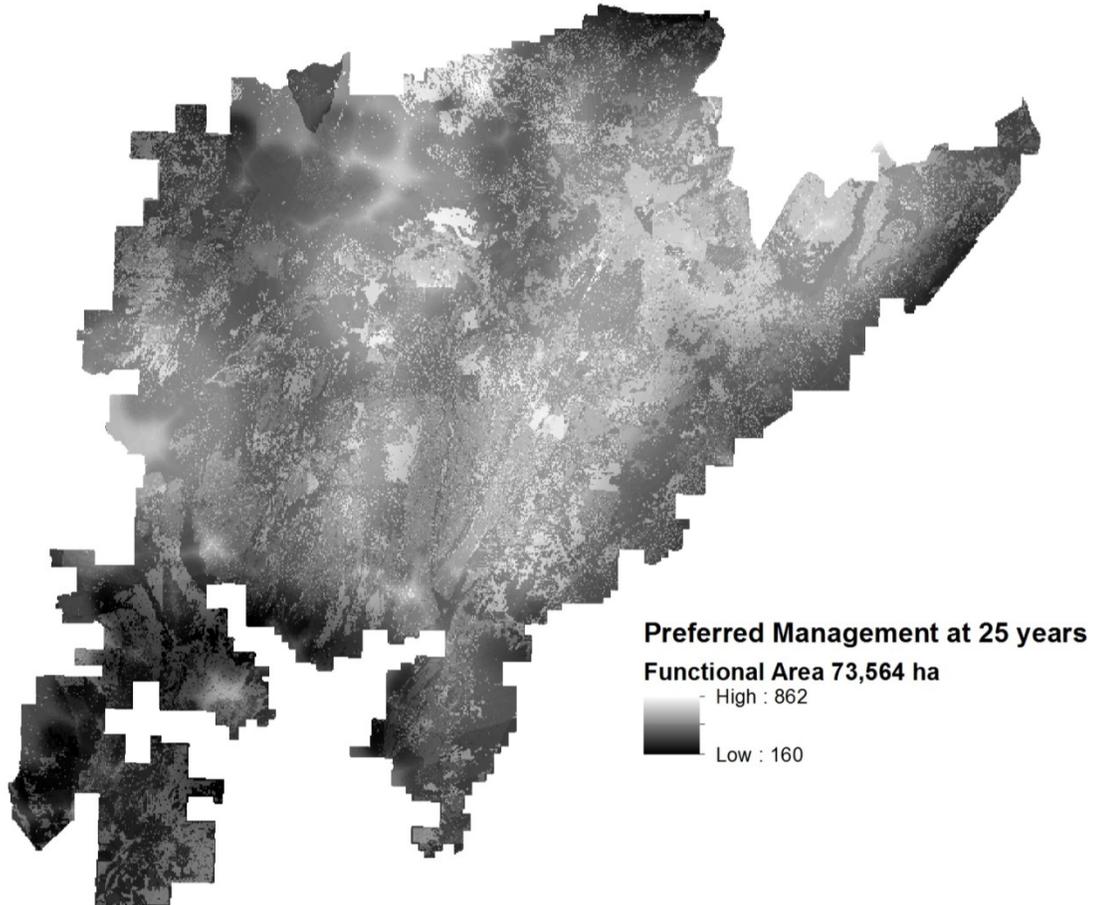


Figure 11. Spatial distribution of habitat suitability values for Greater sage-grouse after 25 years of PREFERRED MANAGEMENT in the Black Mountains Project Area.

Black Mountains: Utah Prairie Dog Habitat Suitability

The spatial distribution of habitat suitability values for Utah prairie dog as predicted after 25 years of PREFERRED MANAGEMENT in the Black Mountains project area is shown in Figure 12. Lighter/greener values represent better suitability, and darker/bluer values represent poorer suitability.

Utah prairie dog habitat suitability is lower after 25 years of PREFERRED MANAGEMENT (Figure 12) compared with MINIMUM MANAGEMENT (Figure 9) – 15,502 versus 19,759 functional acres, respectively. The reason for the lower PREFERRED scenario value is not obvious, as a large number of acres were treated to improve colonies through shrub removal and seeding to the early succession phase.

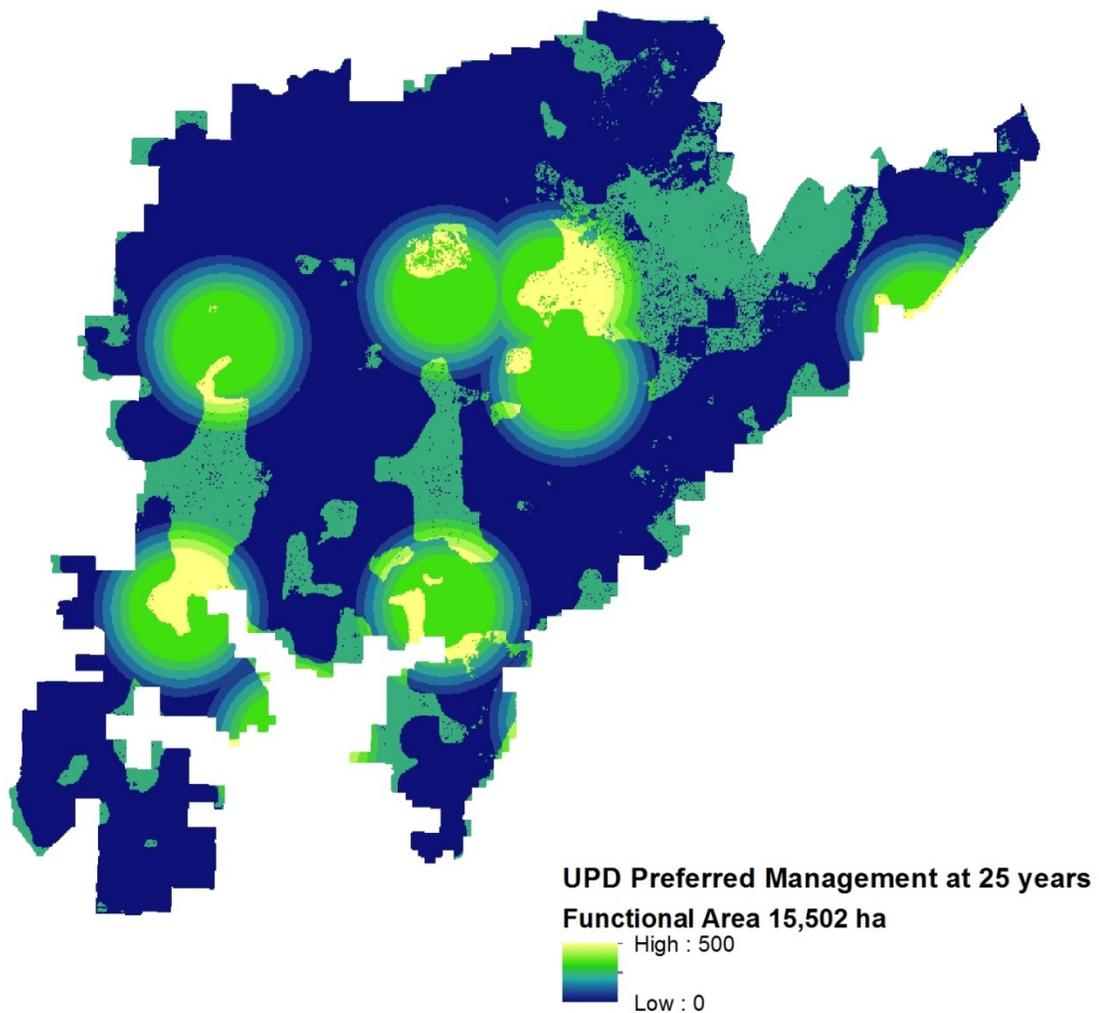


Figure 12. Spatial distribution of habitat suitability values for Utah prairie dog after 25 years of PREFERRED MANAGEMENT in the Black Mountains Project Area.

Comparison of Species' Habitat Suitability Across Management Scenarios

In prior sections, the maps of habitat suitability for Greater sage-grouse and Utah prairie dog were shown individually and separately under different management scenarios. For example, the spatial distribution of habitat suitability values for Greater sage-grouse in Hamlin Valley was shown at the current time in Figure 4, after 25 years of MINIMUM MANAGEMENT in Figure 7, and after 25 years of PREFERRED MANAGEMENT in Figure 10. The three figures on the pages that follow show those maps of habitat suitability values together, i.e., for Current, MINIMUM MANAGEMENT and PREFERRED MANAGEMENT, for Greater sage-grouse in Hamlin Valley (Figure 13), Greater sage-grouse in the Black Mountains (Figure 14), and for Utah prairie dog in the Black Mountains (Figure 15).

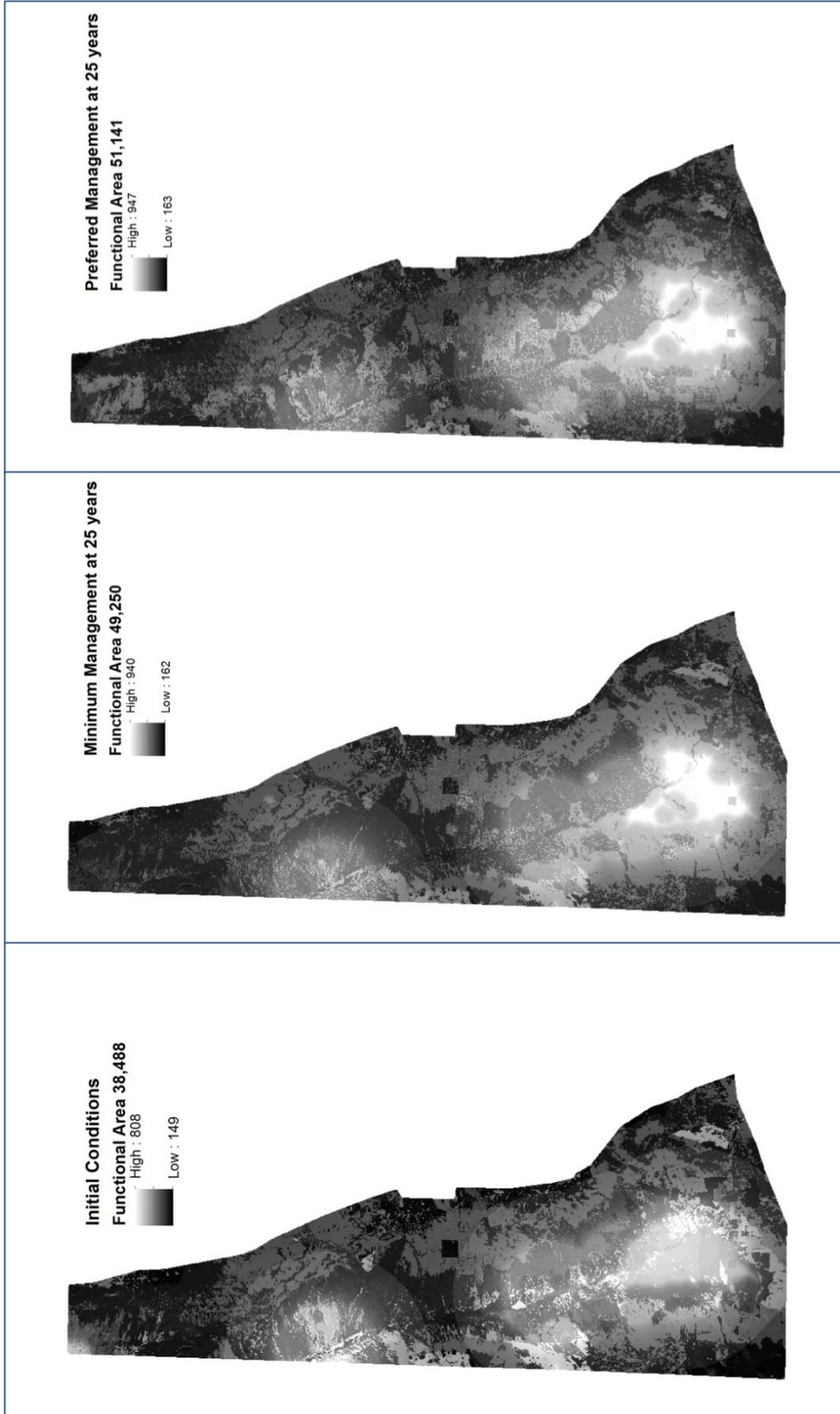


Figure 13. Spatial distribution of habitat suitability values for Greater sage-grouse in the Hamlin Valley Project Area at the current time, after 25 years of MINIMUM MANAGEMENT, and after 25 years of PREFERRED MANAGEMENT.

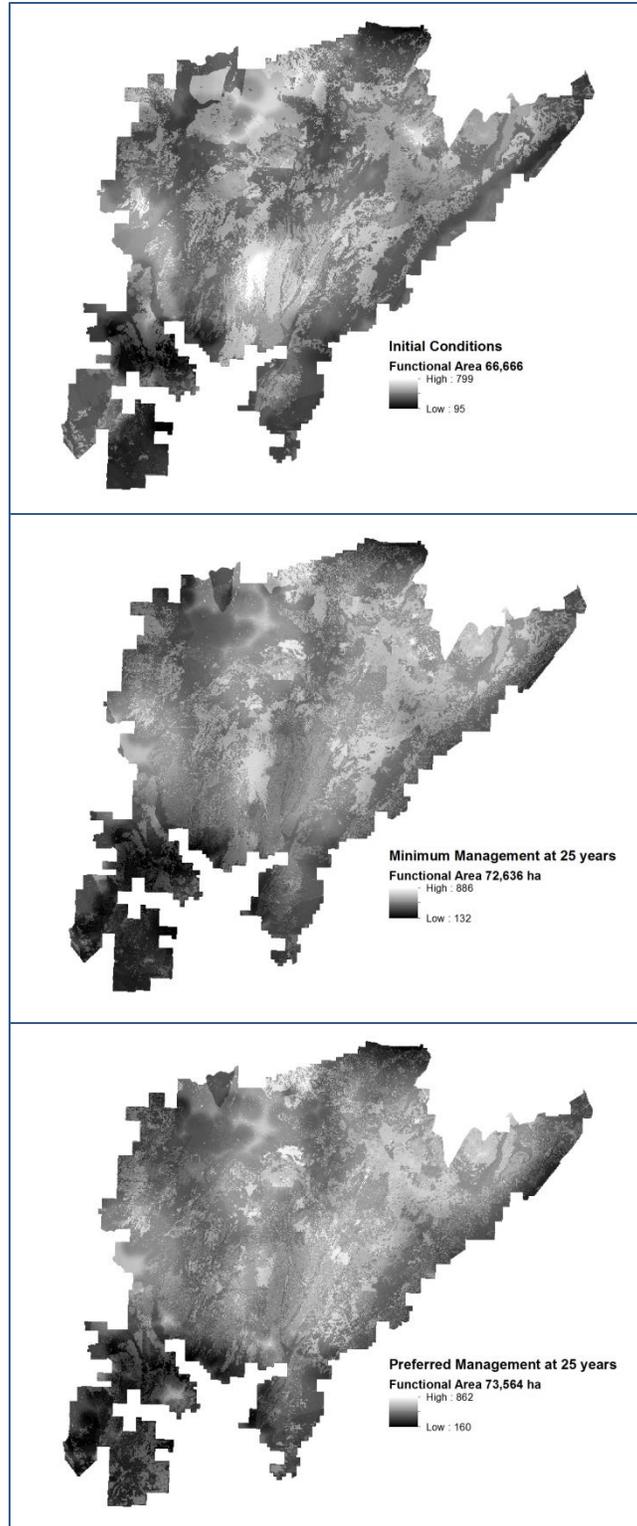


Figure 14. Spatial distribution of habitat suitability values for Greater sage-grouse in the Black Mountains Project Area at the current time, after 25 years of MINIMUM MANAGEMENT, and after 25 years of PREFERRED MANAGEMENT.

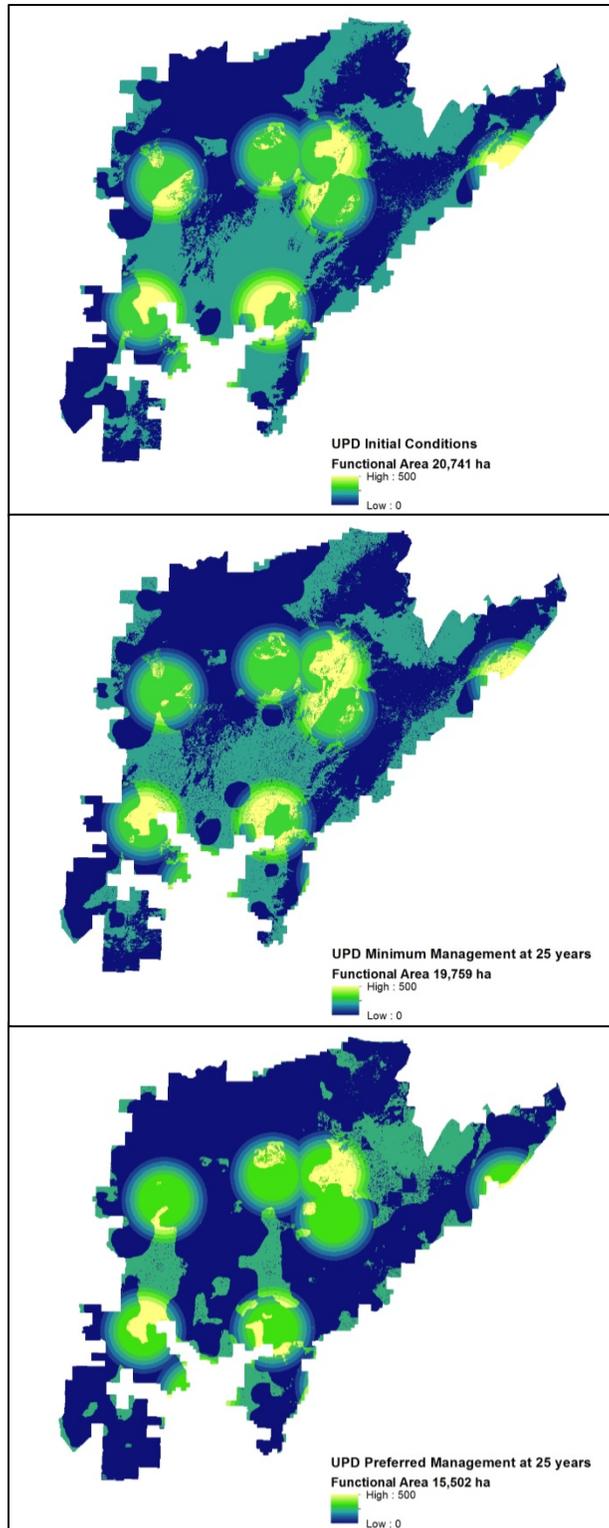


Figure 15. Spatial distribution of habitat suitability values for Utah prairie dog in the Black Mountains Project Area at the current time, after 25 years of MINIMUM MANAGEMENT, and after 25 years of PREFERRED MANAGEMENT.

Prioritizing Actions: Return On Investment

Ecological Systems

In preceding sections, ROI values were compared between the MAXIMUM MANAGEMENT and PREFERRED MANAGEMENT scenarios within individual ecological systems.

At a broader level, the ROI measure may also be used to compare future active management forecasts among ecological systems. Among-system ROI values may be a useful tool for managers to decide where to allocate scarce resources among many possible choices (ecological systems) on public lands managed by the CCFO. Recall that the ROI metric is basically a benefit-to-cost ratio, where the benefit is measured as the improvement in unified ecological departure predicted to result from (modeled) management actions over 25 years. The size (areal extent) of the ecological system is a factor in the numerator of the ROI equation (see page 37), meaning that large, extensive systems will have an area-wide “benefit” advantage over small systems. However, with large size comes high total cost – the denominator of the ROI equation – that reduces the large-size benefit, and results in system-ROI values that do not differ too greatly in magnitude from each other.

Of course, managers may select management actions and treatment areas based upon additional factors beyond a benefit/cost ratio. Such additional factors could include availability of financial resources, public-safety concerns, regulatory constraints, and other ecological, multiple-use or societal objectives.

Among-system ROI values are shown in Table 10 for the Hamlin Valley and Black Mountains Project Areas. In each Project Area the ecological systems are arranged in descending order of the ROI value, and 95% Confidence Interval ranges are also shown. The value for each system in Table 10 is the ROI of the PREFERRED MANAGEMENT scenario, so that “like” results are being compared.

In general, the ecological systems of both Project Areas group into several categories of ROI value for similar reasons.

The very high ROI value for Utah Serviceberry reflects problems that are not too severe at present but are predicted to worsen under MINIMUM MANAGEMENT – yet the predicted improvement under PREFERRED MANAGEMENT is great, for moderate (or even low) cost. The small to moderate size of the Utah Serviceberry system kept its ROI value from being even higher, though with larger size there would be increasing cost that would have tempered a higher ROI value.

The relatively high ROI values of three sagebrush systems – Black, Wyoming, and Montane – generally reflect a combination of problems that are severe at present, and/or are predicted to become or remain so under MINIMUM MANAGEMENT. Predicted improvements under PREFERRED MANAGEMENT are moderate to substantial, though for very large costs. These three sagebrush

Table 10. ROI values for ecological systems under the PREFERRED MANAGEMENT scenario in the Hamlin Valley and Black Mountains Project Areas.

HAMLIN VALLEY		BLACK MOUNTAINS	
Ecological System	ROI* ± 95% CI	Ecological System	ROI* ± 95% CI
Utah Serviceberry	100.55 ± 5.41	Utah Serviceberry	108.43 ± 12.12
Black Sagebrush	36.68 ± 0.85	Stansbury Cliffrose	36.85 ± 42.80
Wyoming Big Sagebrush upland	32.90 ± 3.19	Wyoming Big Sagebrush upland	23.33 ± 2.12
Montane Sagebrush Steppe	18.89 ± 1.41	Black Sagebrush	22.91 ± 2.27
Ponderosa Pine	10.74 ± 3.28	Low Sagebrush	21.82 ± 1.97
Montane Riparian	3.48 ± 1.30	Montane Sagebrush Steppe	18.41 ± 0.31
Wet Meadow-Montane	0.03 ± 0.34	Wet Meadow-Montane	0.34 ± 0.04
Aspen Woodland	-0.31 ± 0.76	Montane Riparian	0.00 ± 0.00
Low Sagebrush	-0.46 ± 1.95	Pinyon-Juniper	-0.23 ± 1.39
Pinyon-Juniper	-3.84 ± 7.45	Aspen Woodland	—
Stansbury Cliffrose	—	Ponderosa Pine	—

* Mean value of five replicates.

systems are by far the costliest in both Project Areas, yet their ROI values are relatively high because their considerable costs are spread across their extensive areas – these sagebrush systems are also the three largest in both Project Areas.

The Stansbury Cliffrose system in the Black Mountains appears to have high ROI, with relatively severe problems now and under MINIMUM MANAGEMENT that the PREFERRED scenario does little to fix. Further, its ROI value in Table 10 (36.85) is the average of five model-run replicates that vary enormously from each other, as shown by the large confidence interval of that mean value (± 42.80). Therefore not much stock can be put in the apparent high ROI of this system.

The Low Sagebrush system has moderate size in Hamlin Valley, where its problems now and under MINIMUM MANAGEMENT are low. Because its MINIMUM MANAGEMENT baseline is already good, even the relatively low treatments costs aimed at “improving” it yield a minimal ROI value (the mean of the five replicates is actually slightly negative). In the Black Mountains the Low Sagebrush system is small, and its problems now and under MINIMUM MANAGEMENT are moderate. Predicted improvement under PREFERRED MANAGEMENT is good, for moderate cost, thus yielding a relatively high ROI value that is comparable to those of the three large sagebrush systems.

The Ponderosa Pine system in Hamlin Valley is relatively small. Its problems are not too severe at present, and are actually predicted to improve under MINIMUM MANAGEMENT. Further improvement under PREFERRED MANAGEMENT treatments is not great, though with the MINIMUM MANAGEMENT baseline already being good, there was not much room for great improvement through management. Treatment costs are only moderate, however, and do yield conversion of dense-class acres into open-class acres that reflect ecological improvement at a scale finer than that “seen” by UED.

The Aspen Woodland system in Hamlin Valley is small. Problems in Aspen Woodland may appear not to be too severe at present, with a predicted improvement under MINIMUM MANAGEMENT, but this improvement masks the loss of aspen clones which is not captured in UED. Predicted future condition under the PREFERRED MANAGEMENT scenario actually decreases slightly as measured by UED, thus yielding a slightly negative ROI value. Treatment costs are moderate, however, and the PREFERRED scenario does result in a marked increase in the youngest reference class (A), which can then succeed to the B and C classes through time. On the other hand, MINIMUM MANAGEMENT retains most of the reference-class acres in the oldest D class, which remains vulnerable to becoming Depleted over time and may result in clone loss. Again, these predicted active-management results reflect ecological improvement at a scale finer than that “seen” by UED.

The wetter systems in both Project Areas, Montane Riparian and Wet Meadow-Montane, are all small. The Montane Riparian system has problems that are severe at present, and that are predicted to remain so under MINIMUM MANAGEMENT. These problems mostly involve presence and spread of exotic-invasive forbs and trees that are difficult to reverse. Treatments under the PREFERRED MANAGEMENT scenario yield modest improvement (Hamlin Valley) or no improvement (Black Mountains) as measured by UED, though the offending exotic species are reduced or held in check somewhat. These results come for moderate costs that are commensurate with the small size of the Montane Riparian systems, all of which result in minimal or zero ROI.

The small Wet Meadow-Montane systems have similar exotic species problems that generally cost more per unit of area than Montane Riparian in order to improve or at least hold in check. ROI values for Wet Meadow-Montane are thus near zero in both Project Areas.

Finally, the Pinyon-Juniper system is large in both Project Areas. Its problems are moderate at present, and predicted to remain so under MINIMUM MANAGEMENT. These problems mostly involve increasing density of trees within reference classes – a condition that is not “penalized” by the UED measure (i.e. UED will not increase on that account). Treatments under the PREFERRED MANAGEMENT scenario to thin pinyon and juniper trees in older reference classes bear a moderate cost for virtually no benefit, as measured by change in UED, thus yielding slightly negative ROI values. However, yet again these predicted active-management results reflect ecological or public-safety improvements at a scale finer than that “seen” by UED.

Greater Sage-Grouse and Utah Prairie Dog

The concept of Return On Investment can also be applied to the two wildlife species analyzed by this project. Table 11 shows ROI values of the PREFERRED MANAGEMENT scenario for the Greater sage-grouse and Utah prairie dog across the whole Project Areas in which they occur. The ROI calculations were done per the formulas on page 37, using the metric of Habitat Suitability. Because the 25-year total costs for the PREFERRED scenario in each whole landscape are large, on the order of \$20 million apiece, each ROI value resulting from the raw formula was multiplied by a large constant so that the ROI values in Table 11 are at an order of magnitude that is sensible for making comparisons.

Table 11. ROI values under the PREFERRED MANAGEMENT scenario for Greater sage-grouse in Hamlin Valley, Greater sage-grouse in Black Mountains, and Utah prairie dog in Black Mountains.

Species - Project Area	Model-Run Iteration					Mean	95% C.I.
	1	2	3	4	5		
GRSG - Hamlin Valley							
Habitat Suitability: MIN	0.425	0.424	0.423	0.424	0.425	0.424	
Habitat Suitability: PREF	0.442	0.443	0.440	0.441	0.445	0.442	
Cost (All Systems): PREF	\$19,688,249	\$22,864,301	\$23,422,317	\$22,871,166	\$22,528,251	\$22,274,857	
ROI: PREF vs MIN	8.635	8.310	7.258	7.433	8.878	8.103	0.63
GRSG - Black Mountains							
Habitat Suitability: MIN	0.503	0.502	0.502	0.499	0.504	0.502	
Habitat Suitability: PREF	0.509	0.517	0.516	0.512	0.509	0.513	
Cost (All Systems): PREF	\$21,094,459	\$20,876,397	\$21,034,088	\$21,495,166	\$22,337,366	\$21,367,495	
ROI: PREF vs MIN	2.844	7.185	6.656	6.048	2.238	4.994	2.00
UPD - Black Mountains							
Habitat Suitability: MIN	0.137	0.138	0.137	0.135	0.136	0.137	
Habitat Suitability: PREF	0.107	0.111	0.112	0.111	0.111	0.110	
Cost (All Systems): PREF	\$21,094,459	\$20,876,397	\$21,034,088	\$21,495,166	\$22,337,366	\$21,367,495	
ROI: PREF vs MIN	-13.973	-13.030	-11.648	-11.367	-11.276	-12.259	1.04
SUMMARY							
	Species - Project Area		ROI±95% CI				
	GRSG – Hamlin Valley		8.103 ± 0.63				
	GRSG – Black Mountains		4.994 ± 2.00				
	UPD – Black Mountains		-12.259 ± 1.04				

Comparisons may be done among the three ROI values shown in the SUMMARY portion of Table 11. The ROI value for Greater sage-grouse in Hamlin Valley is greater than the ROI for that species in the Black Mountains, and this difference is significant at the 95% confidence level. However, ROI comparisons at this scale may not readily translate into decisions of where to allocate management resources – for example, the CCFO may not choose to devote 100% of its sage-grouse management efforts to Hamlin Valley (and thus none to the Black Mountains) strictly on the basis of these ROI results. The ROI value for Utah prairie dog in the Black Mountains is substantially negative, because predicted results of the active PREFERRED scenario are worse (in terms of prairie dog habitat suitability) than results of the “no action” MINIMUM MANAGEMENT scenario. This is probably because the various management actions that comprise the PREFERRED scenario in the Black Mountains were focused primarily on improving future conditions in that area’s ecological systems (as measured by Unified Ecological Departure), and secondarily on improving future conditions for Greater sage-grouse (as measured by its habitat suitability index). In short, what is good for ecological systems and for Greater sage-grouse may not simultaneously be good for Utah prairie dog. Adjustment of management actions to achieve better predicted results for Utah prairie dog may come at the expense of somewhat diminished future conditions for ecological systems and Greater sage-grouse across the whole Black Mountains project area.

Areas of Implementation

The discussions in the preceding section on **Predicted Future Condition – Active Management Scenarios** made reference to various concerns or problems that affected ecological systems, both at present and after 25 years under a regime of MINIMUM MANAGEMENT. The discussions then identified particular management actions (treatments) that were incorporated into model runs so as to reduce those problems. This section now summarizes those treatment selections via a set of maps.

Overall, six types of problems were substantial or widespread enough to merit summary attention here:

1. Tree encroachment (juniper and pinyon pine) of two types: scattered young “Christmas-tree” size trees, and dense mature trees.
2. Annual grasses, primarily cheatgrass.
3. Degraded or depleted shrubland understories.
4. Exotic forbs.
5. Loss of aspen clone.
6. Excessive shrub cover in association with habitat occupied by Utah prairie dogs.

Each of these problems was addressed by one or more specific treatments in the active-management model runs. Table 12 shows the management treatments that had substantial areal coverage or frequency-of-use in the PREFERRED MANAGEMENT scenario, within either or both of the two Project Areas.

Table 12. Management treatments aimed at addressing particular “problems” within ecological systems of the two Project Areas.

Management Action/Treatment	Hamlin Valley	Black Mountains
2xChaining+Plateau+Seed		X
2xChaining+Seed	X	X
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow		X
Aerial-Spyke+Aerial-Seed+Chain-Harrow		X
Chaining+Native-Seed	X	X
Chaining+Plateau+Seed	X	
Chaining+Seed		X
Herbicide-Plateau+Seed	X	X
Masticate+Herbicide+Seed		X
Masticate+Native-Seed	X	X
Masticate+Seed	X	X
RxFire	X	
RxFire+Seed+Chain	X	X
Small-Tree-Lopping	X	X

The maps on the following 21 pages, Figures 16-36, display results of the spatial output of Treatments in Table 12, from the ST-Sim 25-year modeling runs of the PREFERRED MANAGEMENT scenario in the two Project Areas. Table 13 below is an index to these 21 maps in the same format as that of Table 12.

Table 13. Index to Figures that show management treatments within ecological systems of the two Project Areas.

Management Action/Treatment	Hamlin Valley	Black Mountains
2xChaining+Plateau+Seed		Figure 25
2xChaining+Seed	Figure 16	Figure 26
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow		Figure 27
Aerial-Spyke+Aerial-Seed+Chain-Harrow		Figure 28
Chaining+Native-Seed	Figure 17	Figure 29
Chaining+Plateau+Seed	Figure 18	
Chaining+Seed		Figure 30
Herbicide-Plateau+Seed	Figure 19	Figure 31
Masticate+Herbicide+Seed		Figure 32
Masticate+Native-Seed	Figure 20	Figure 33
Masticate+Seed	Figure 21	Figure 34
RxFire	Figure 22	
RxFire+Seed+Chain	Figure 23	Figure 35
Small-Tree-Lopping	Figure 24	Figure 36

This mapping of potential treatment areas identified by ST-Sim spatial modeling is intended to inform implementation deliberations by CCFO managers and staff. The mapped treatment areas include all of the locations identified by the model, of which managers may only need to select a subset. These maps could also be useful to identify economies of scale, in situations where different ecological systems share the same treatments in proximity to one another.

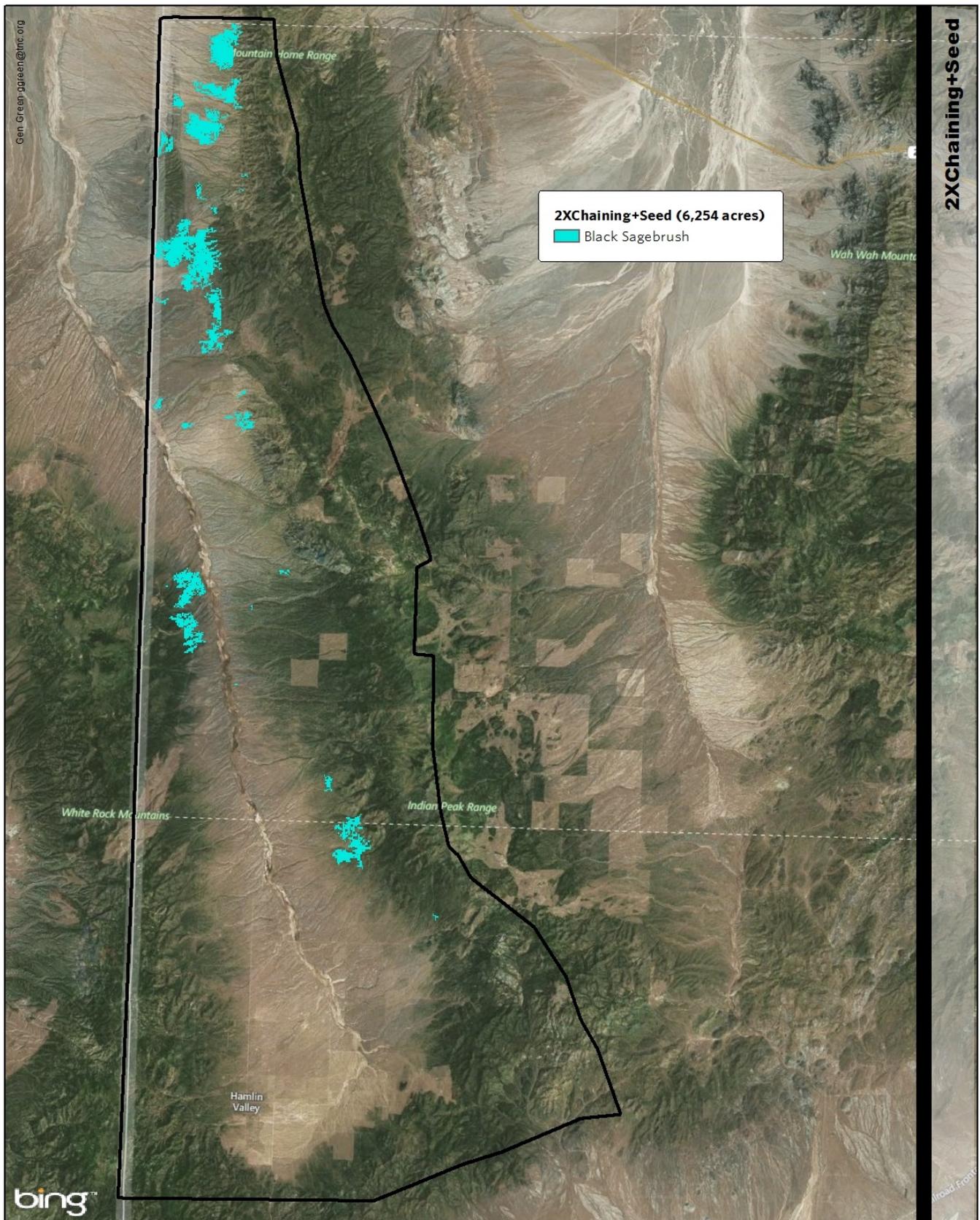


Figure 16. Locations where the ST-Sim model applied the treatment of 2xChaining+Seed in Hamlin Valley in the PREFERRED MANAGEMENT scenario.

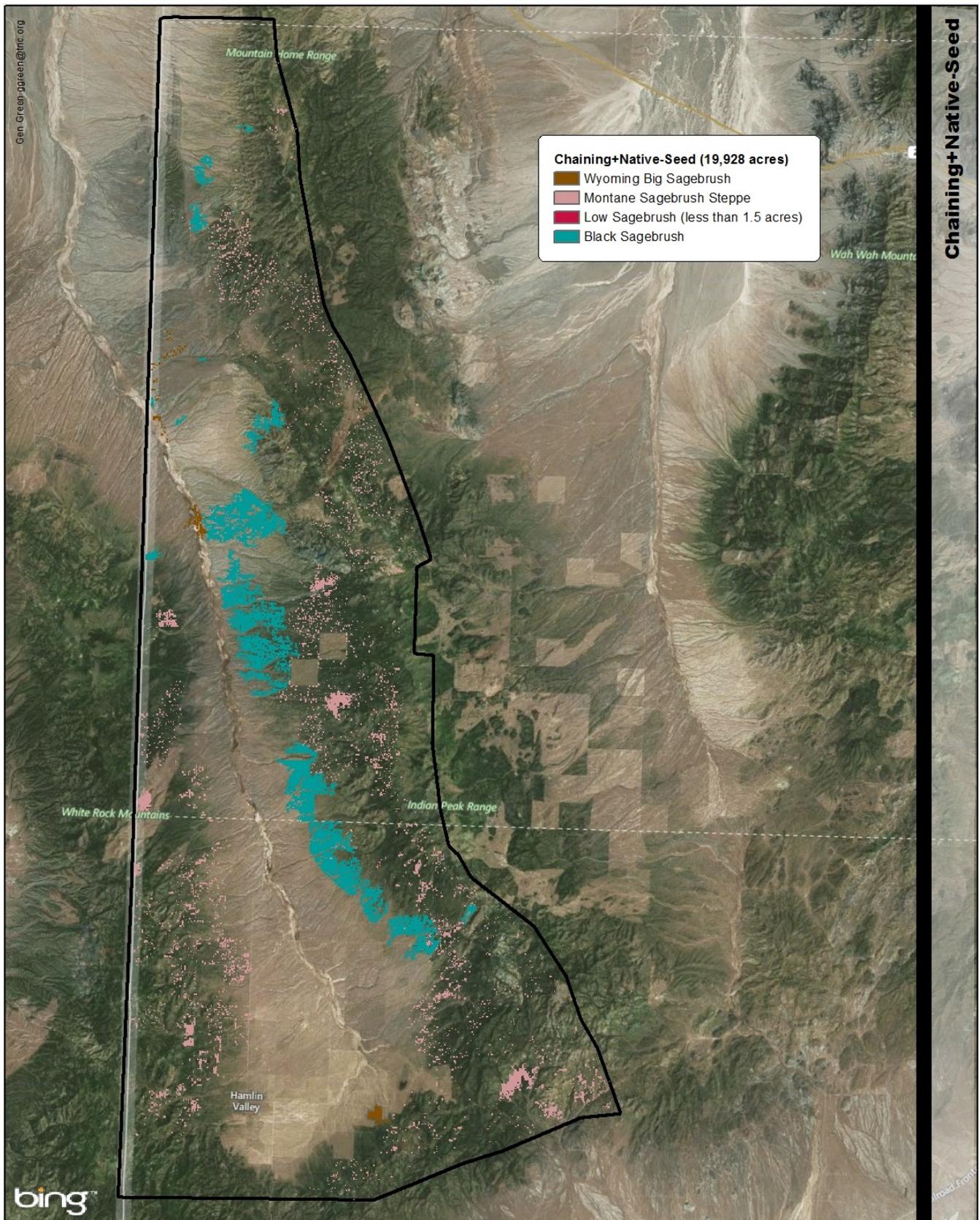


Figure 17. Locations where the ST-Sim model applied the treatment of Chaining+Native-Seed in Hamlin Valley in the PREFERRED MANAGEMENT scenario.

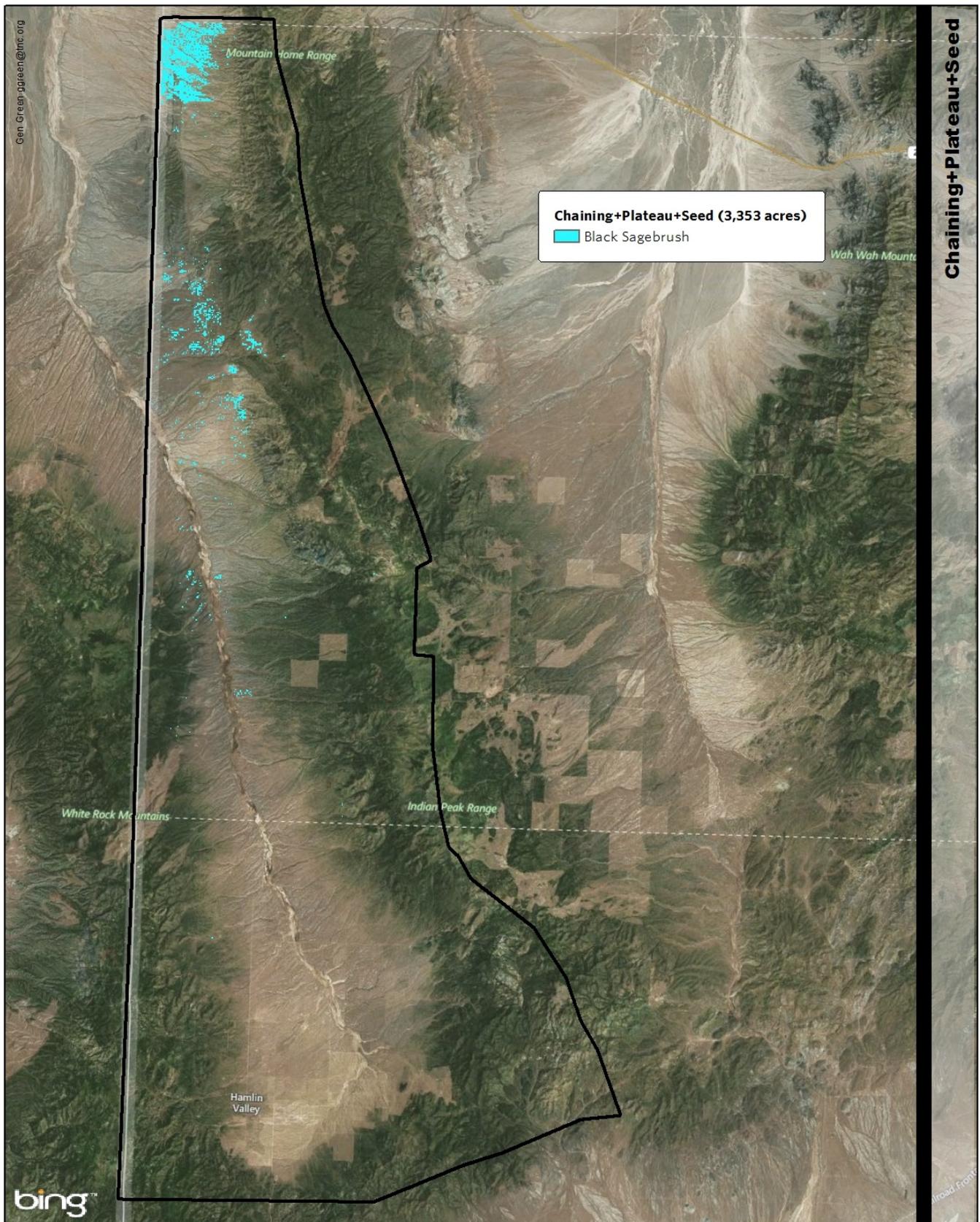


Figure 18. Locations where the ST-Sim model applied the treatment of Chaining+Plateau+Seed in Hamlin Valley in the PREFERRED MANAGEMENT scenario.

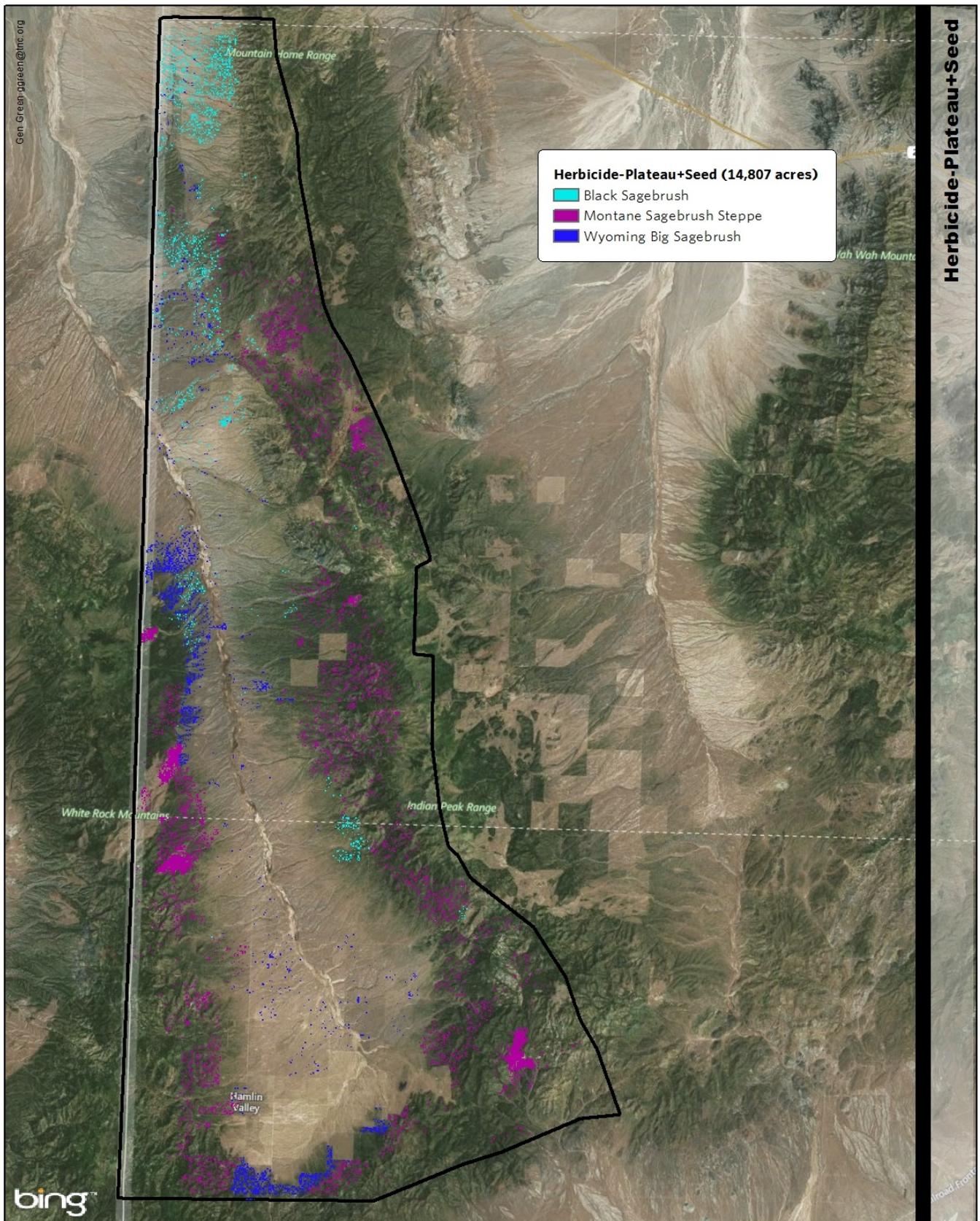


Figure 19. Locations where the ST-Sim model applied the treatment of Herbicide-Plateau+Seed in Hamlin Valley in the PREFERRED MANAGEMENT scenario.

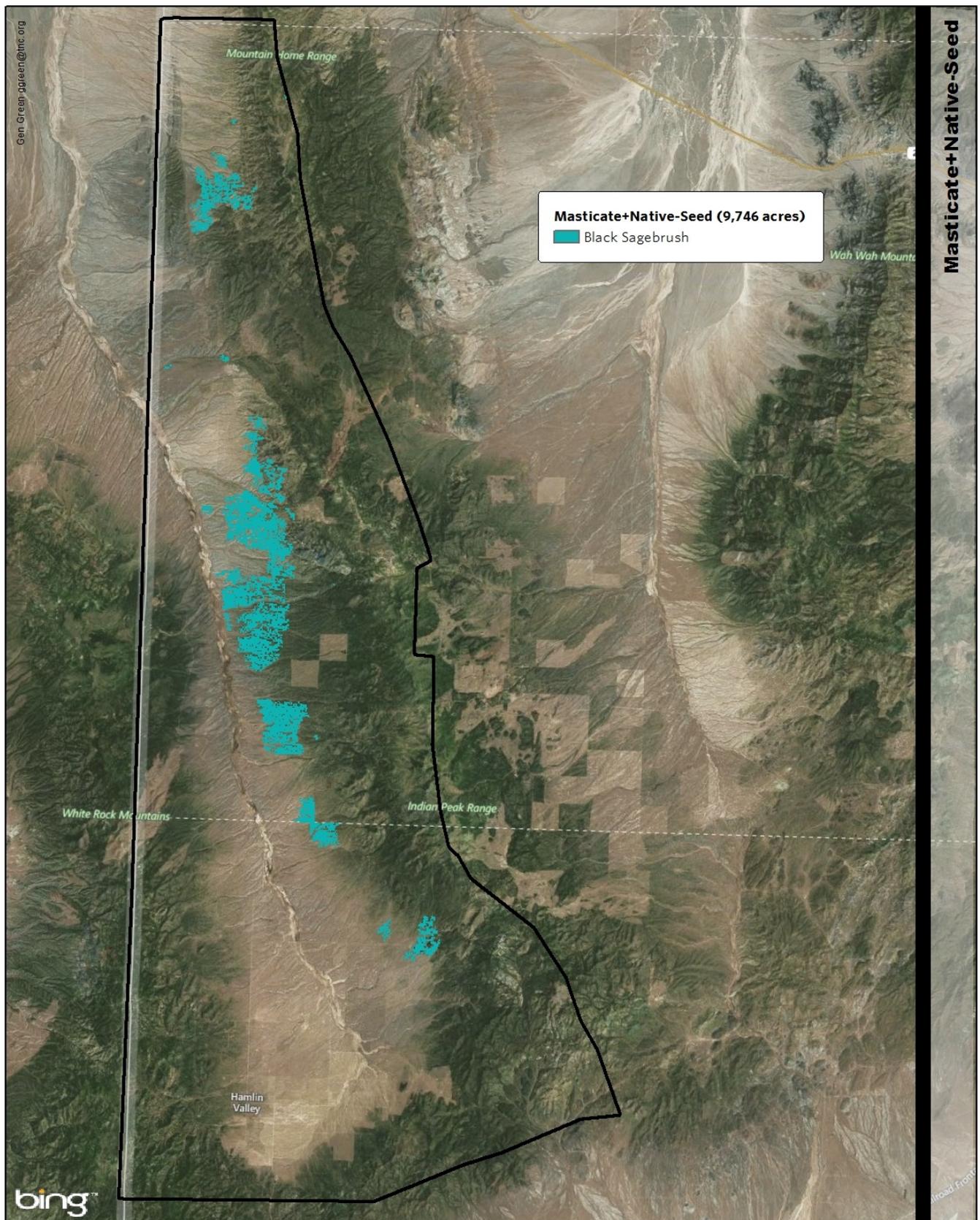


Figure 20. Locations where the ST-Sim model applied the treatment of Masticate+Native-Seed in Hamlin Valley in the PREFERRED MANAGEMENT scenario.

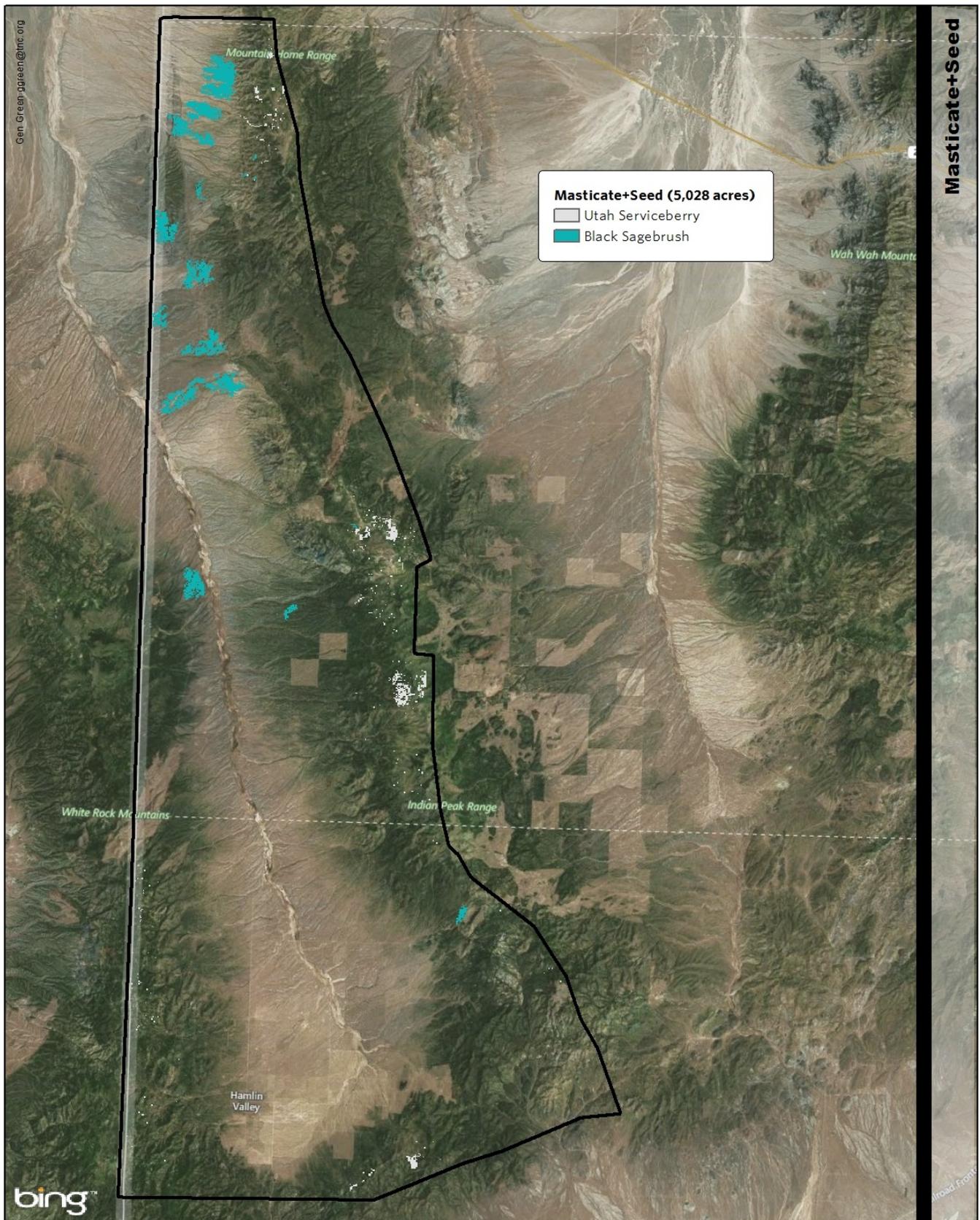


Figure 21. Locations where the ST-Sim model applied the treatment of Masticate+Seed in Hamlin Valley in the PREFERRED MANAGEMENT scenario.

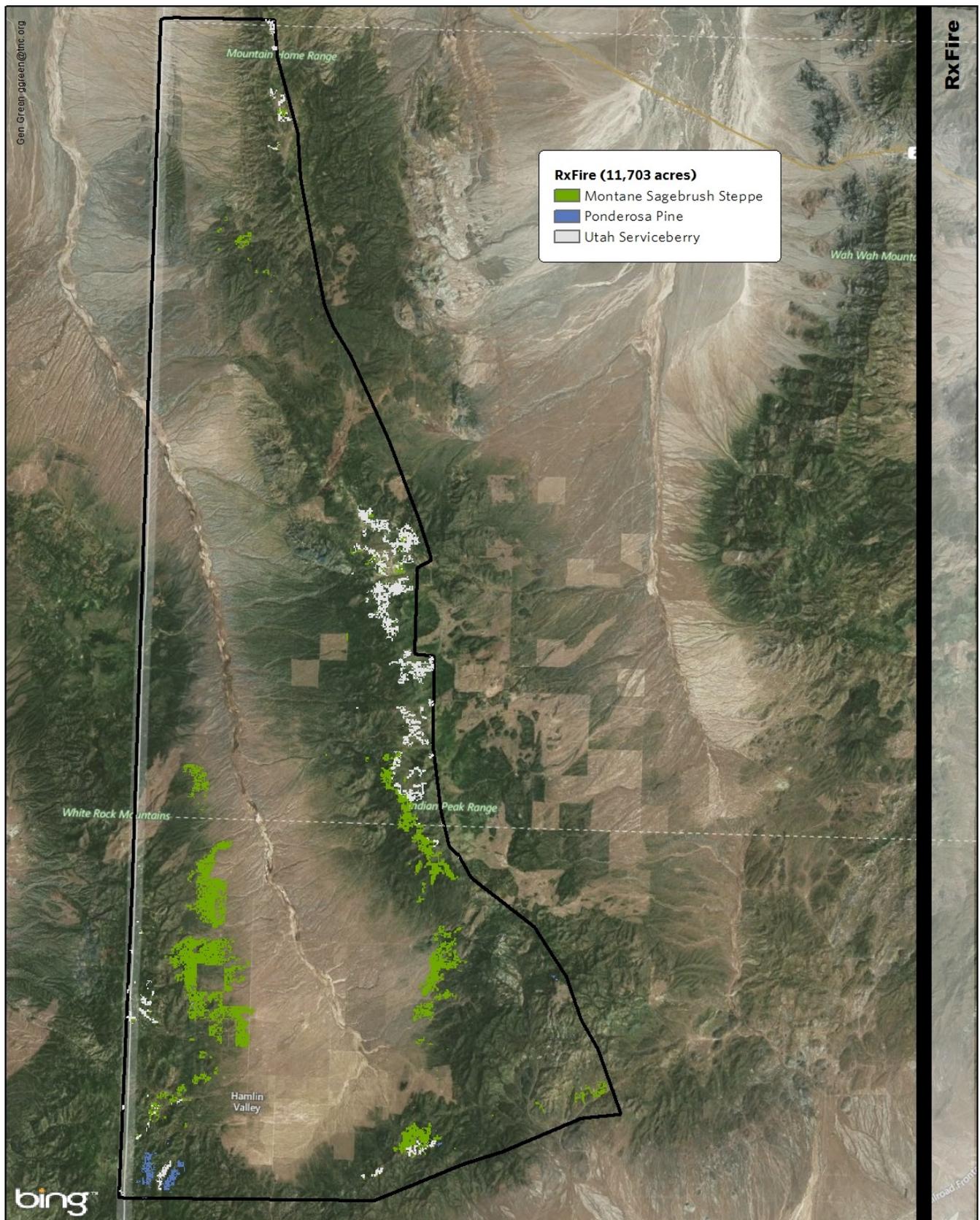


Figure 22. Locations where the ST-Sim model applied the treatment of RxFire in Hamlin Valley in the PREFERRED MANAGEMENT scenario.

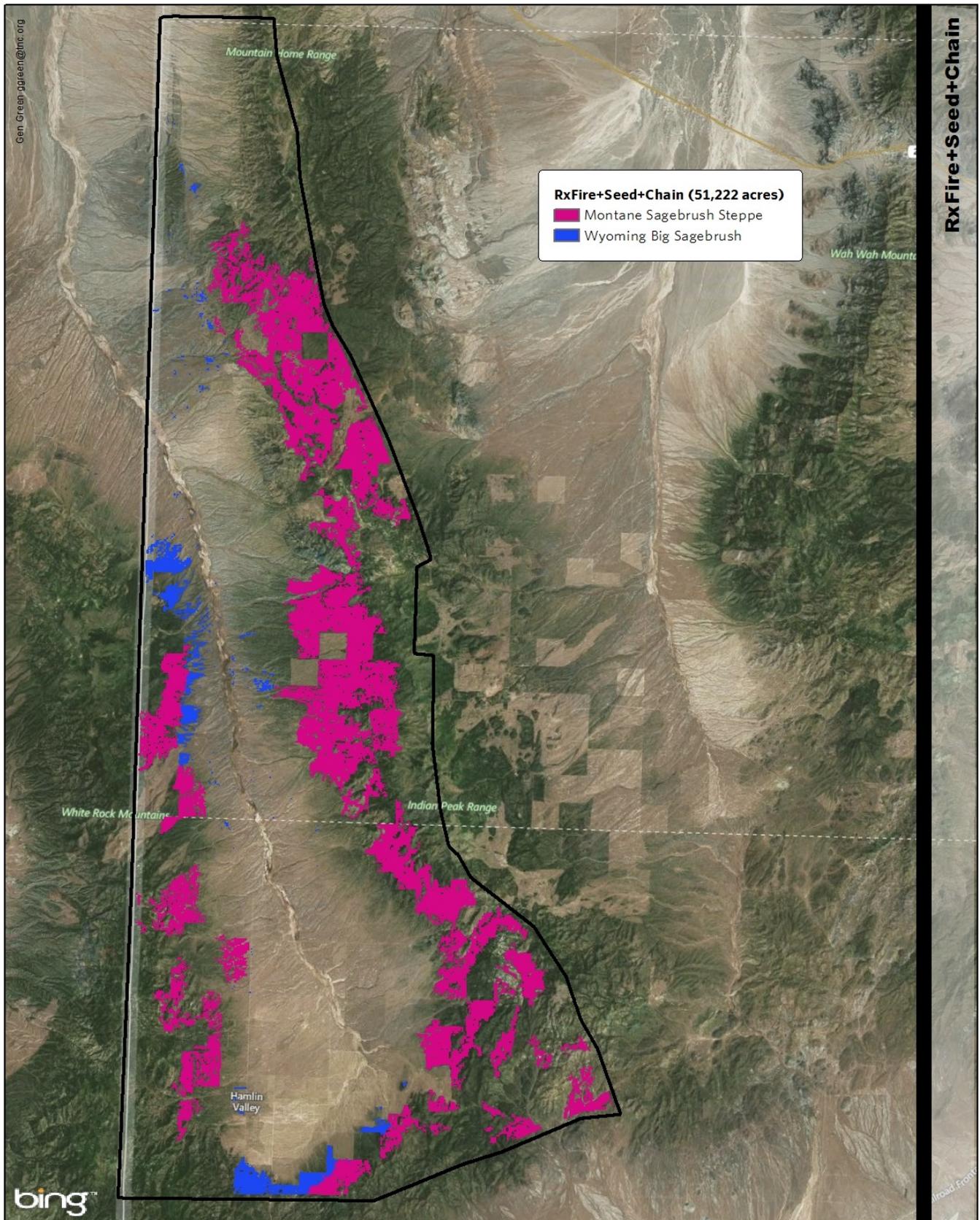


Figure 23. Locations where the ST-Sim model applied the treatment of RxFire+Seed+Chain in Hamlin Valley in the PREFERRED MANAGEMENT scenario.

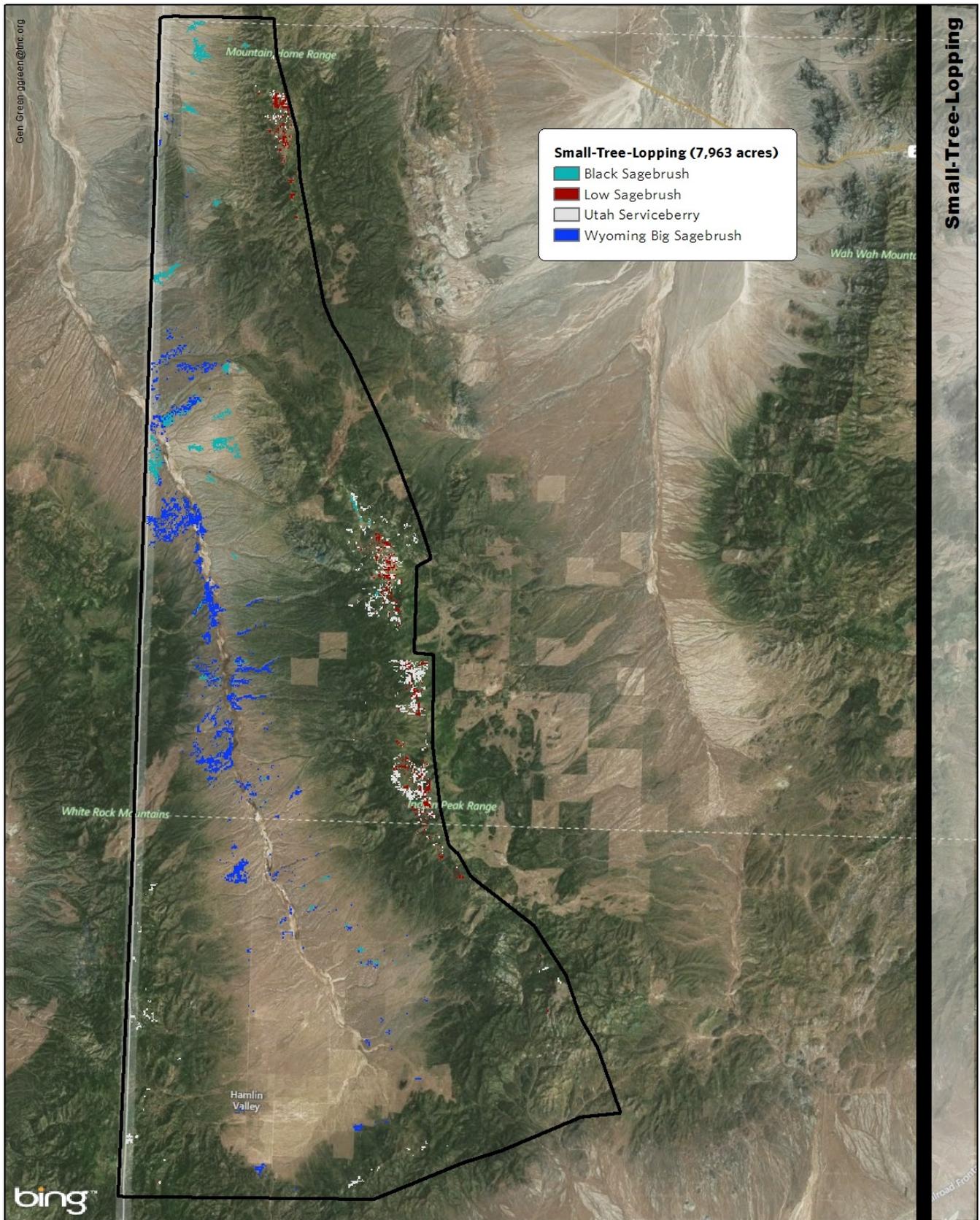


Figure 24. Locations where the ST-Sim model applied the treatment of Small-Tree-Lopping in Hamlin Valley in the PREFERRED MANAGEMENT scenario.

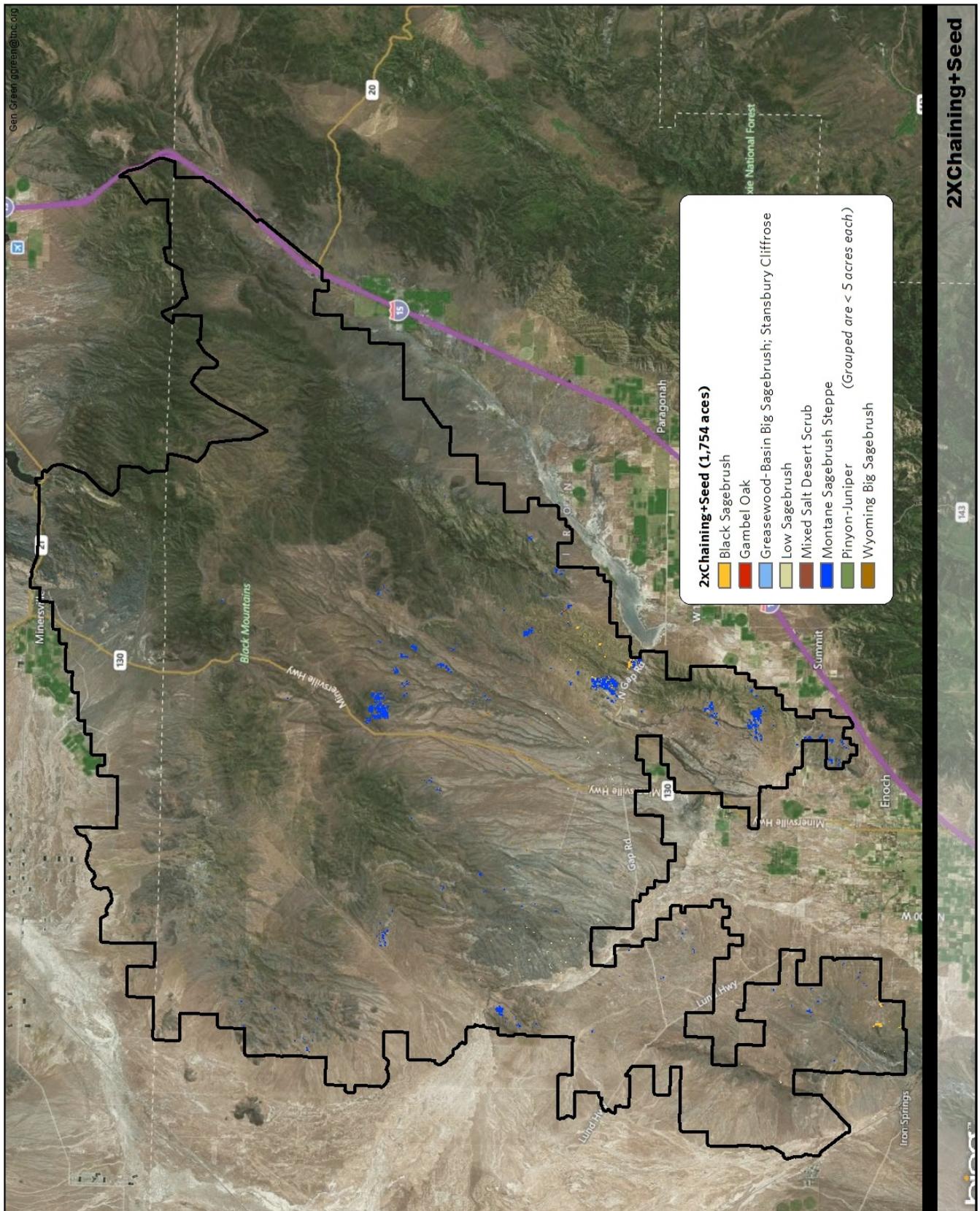


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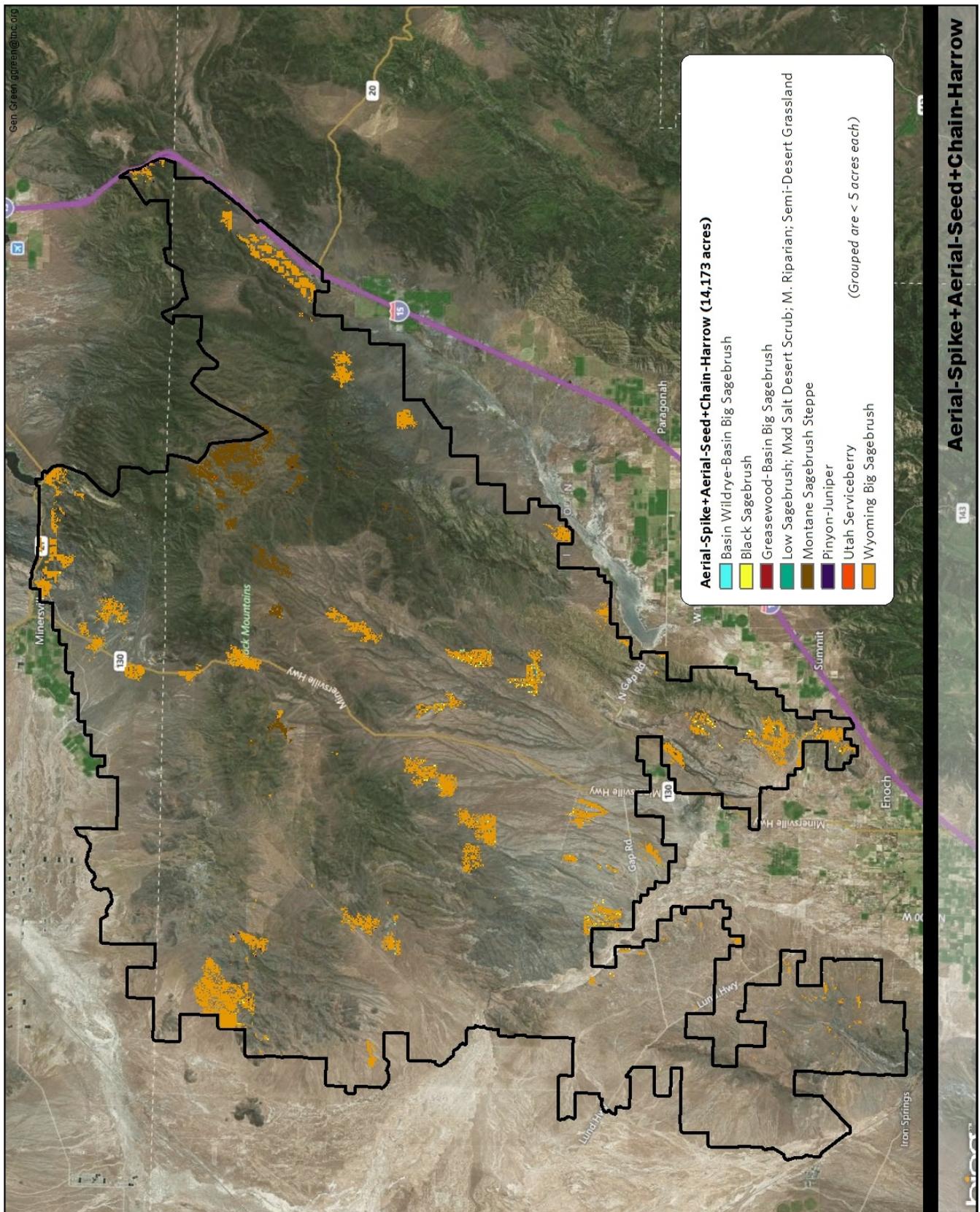


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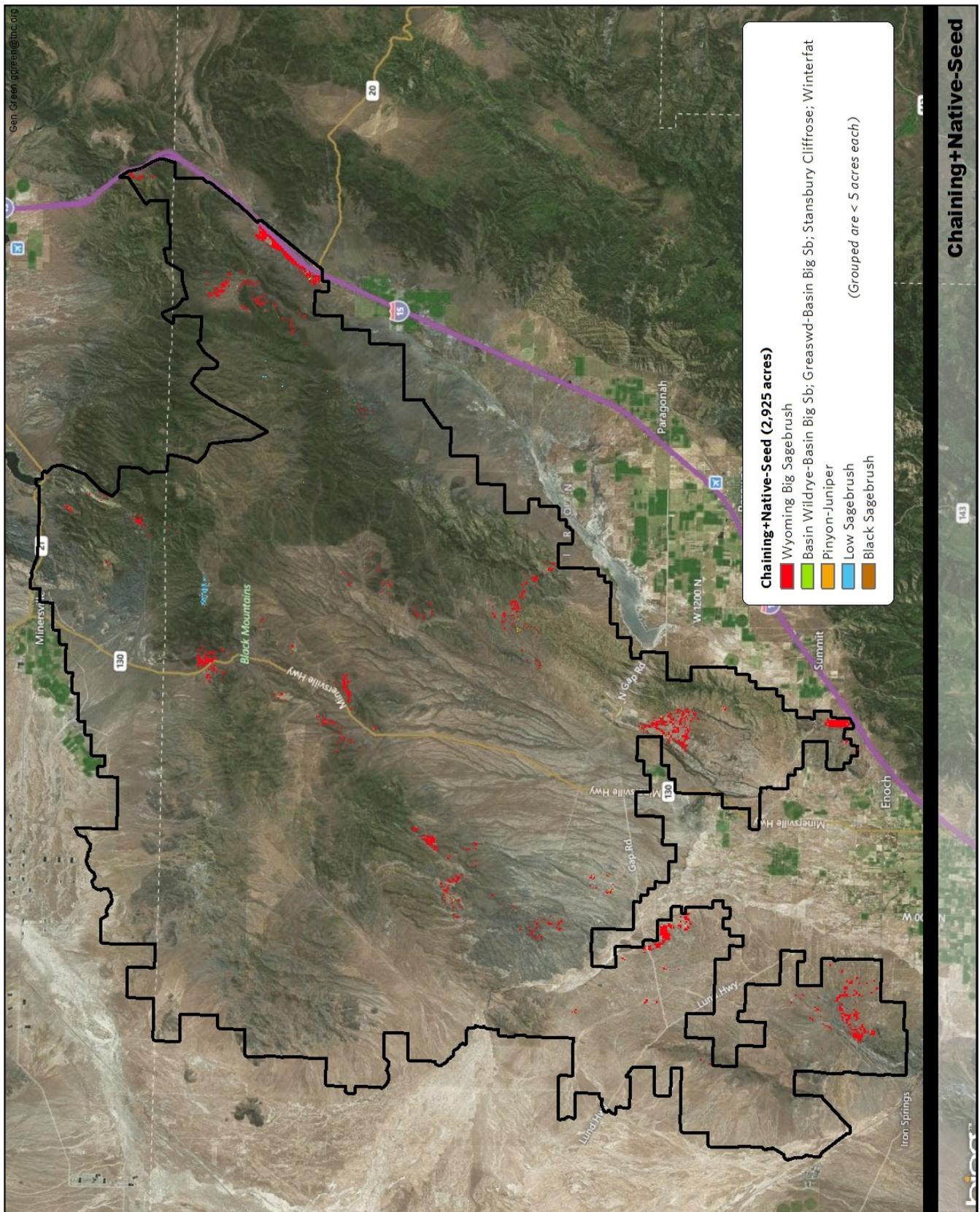


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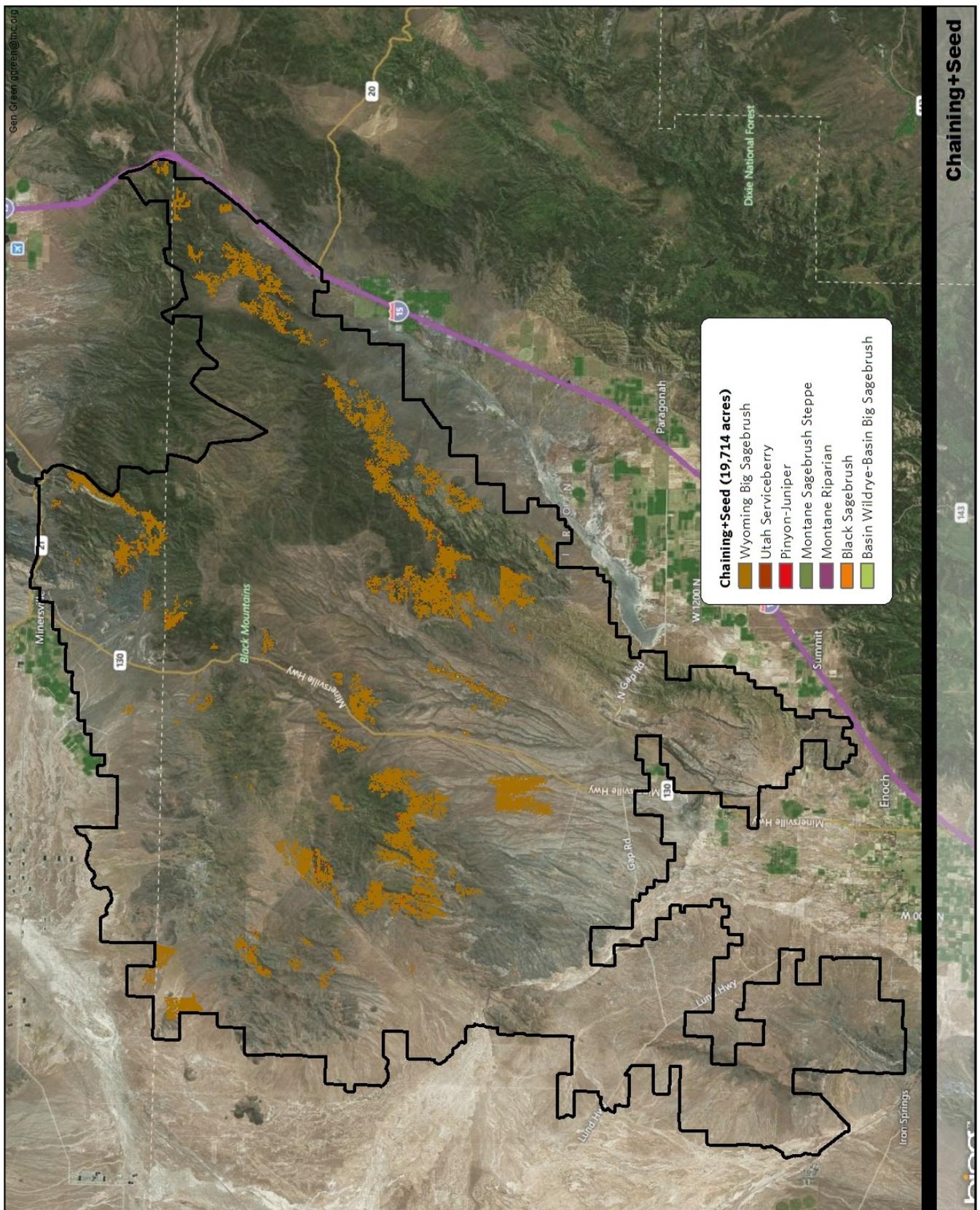


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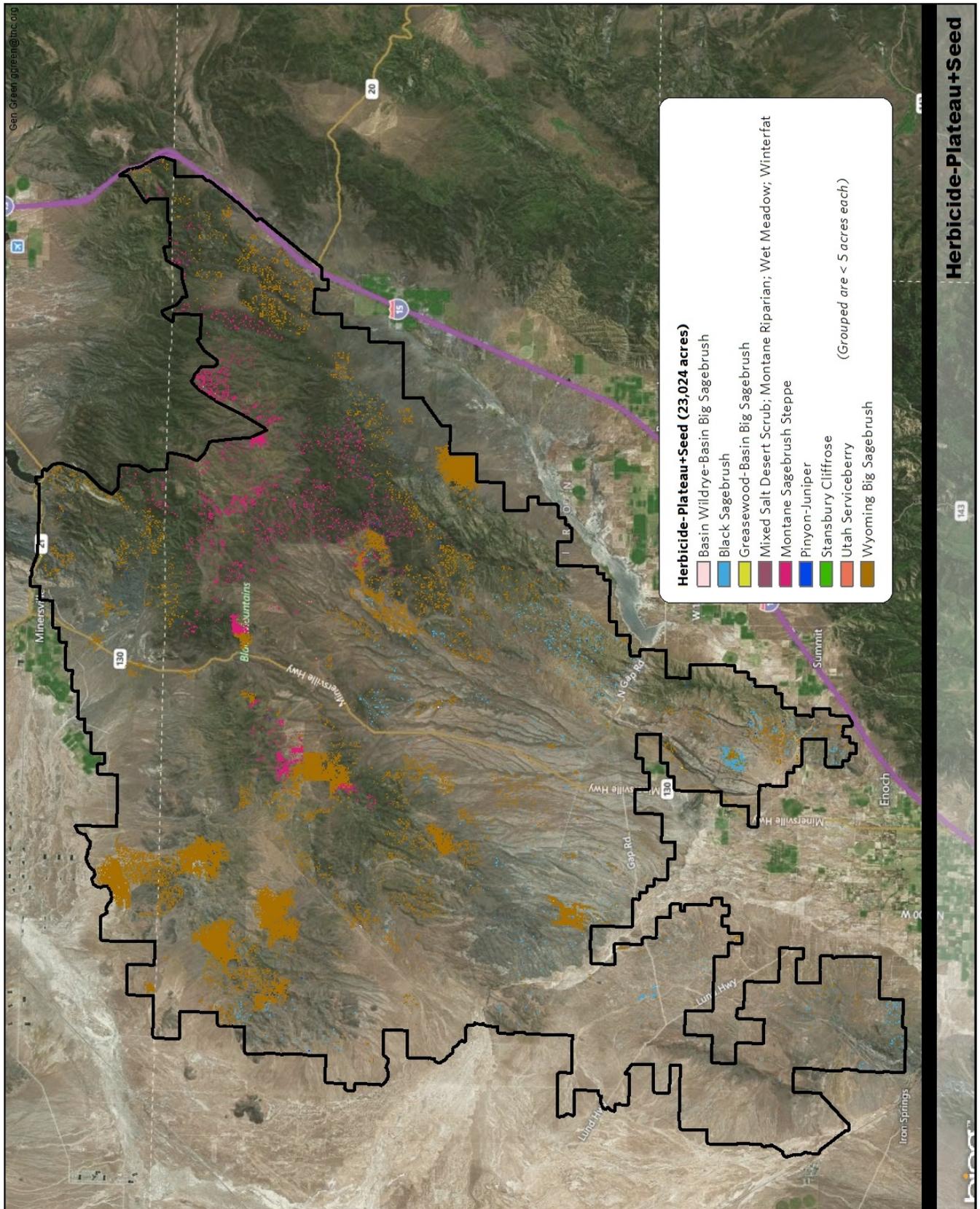


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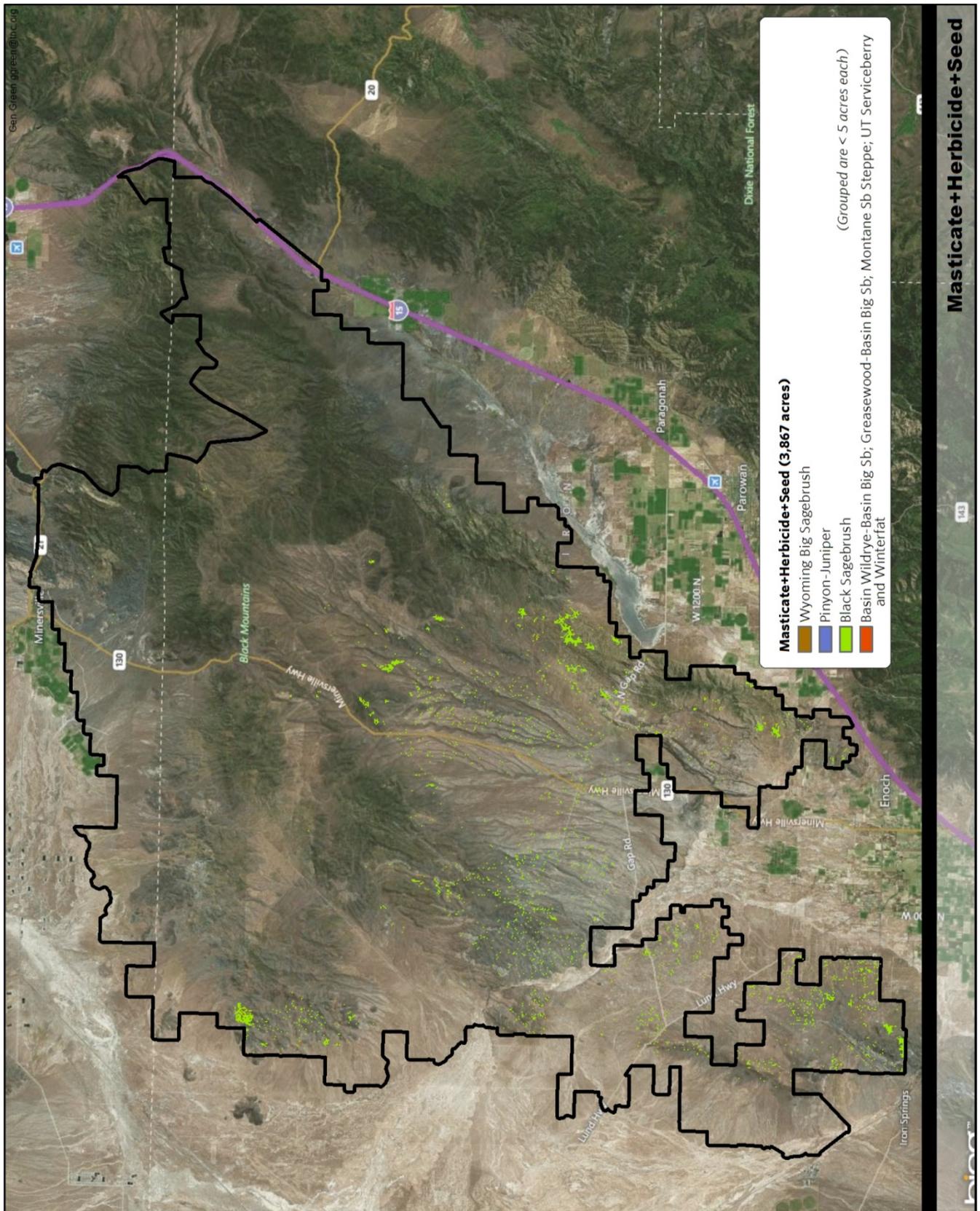


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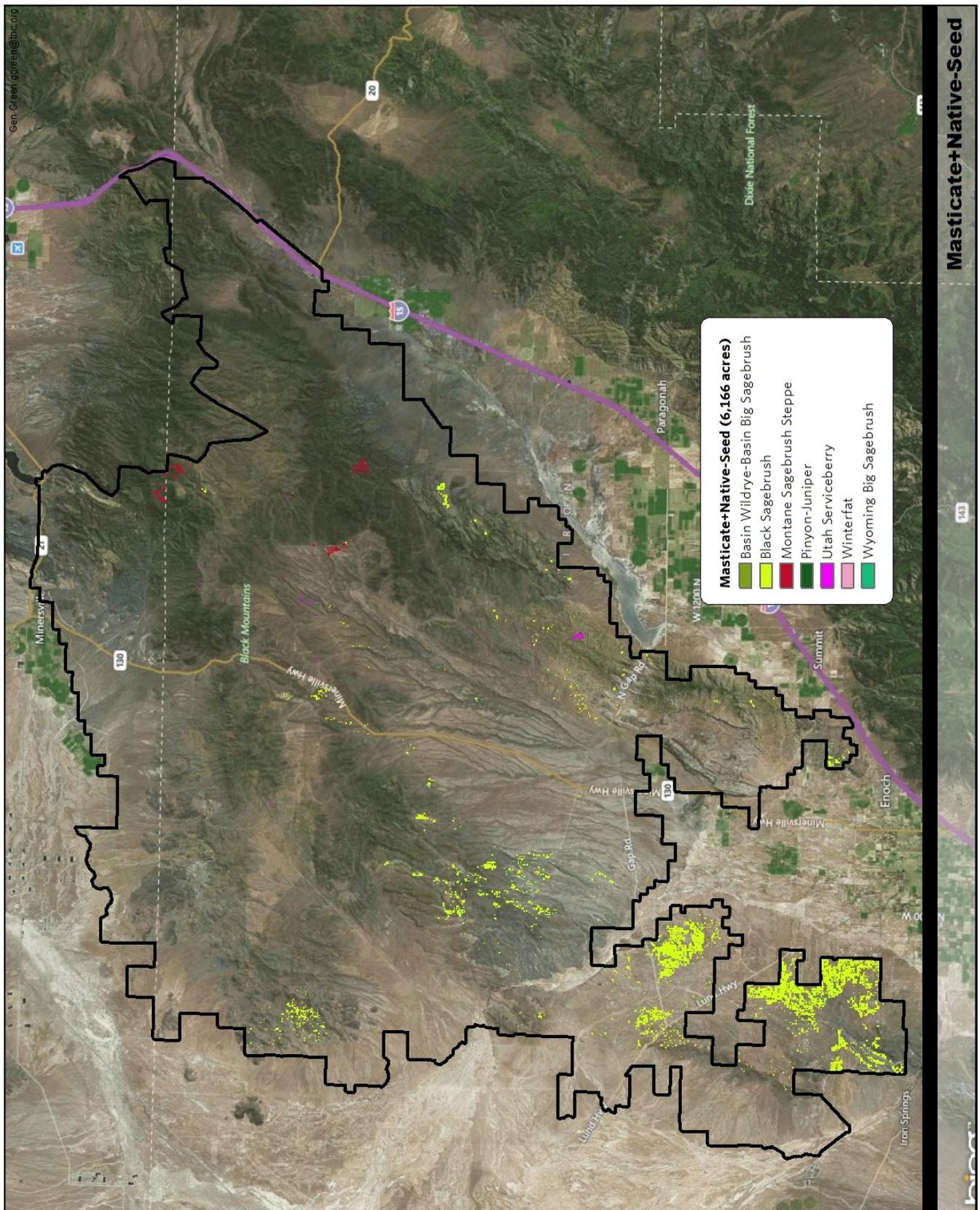


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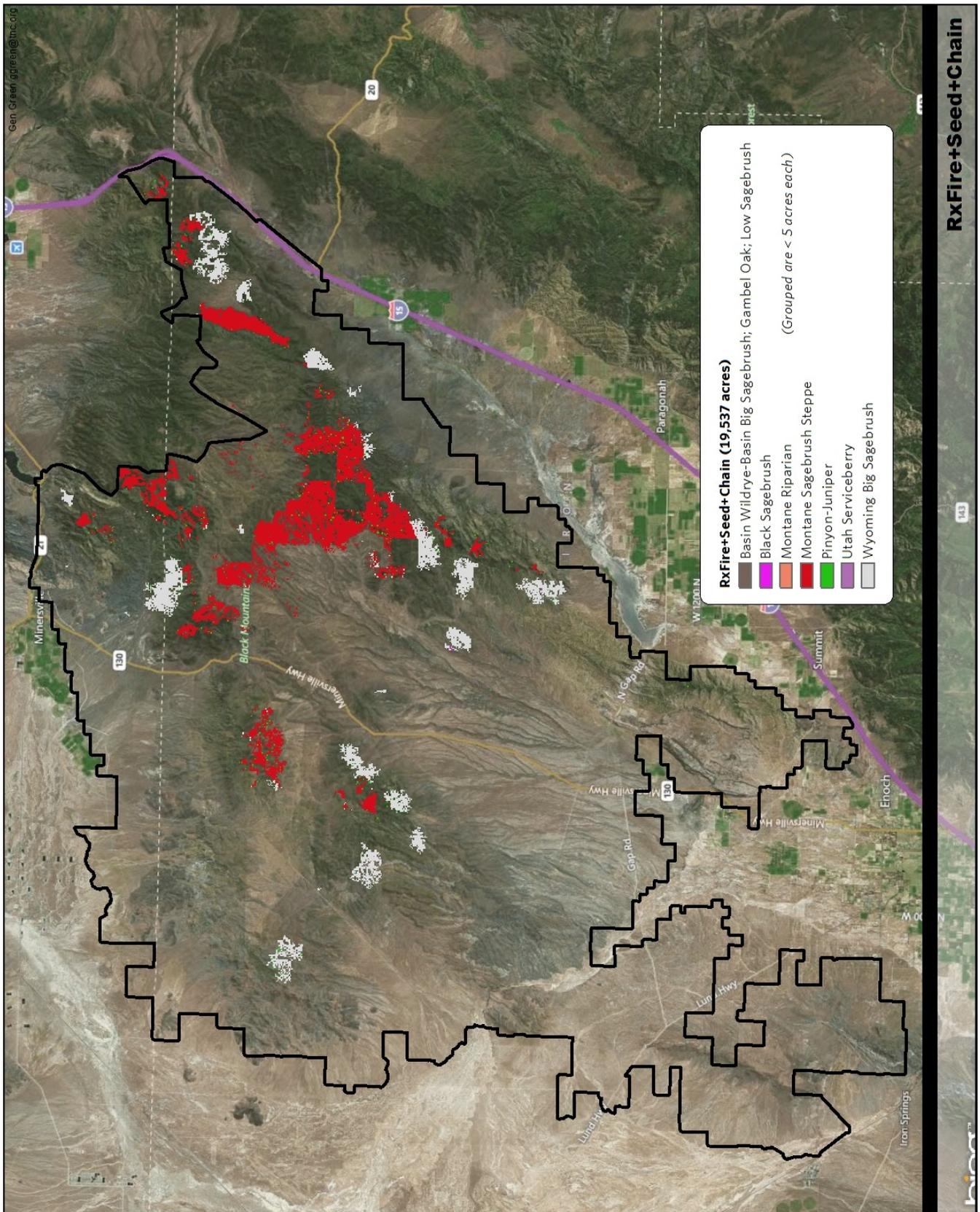


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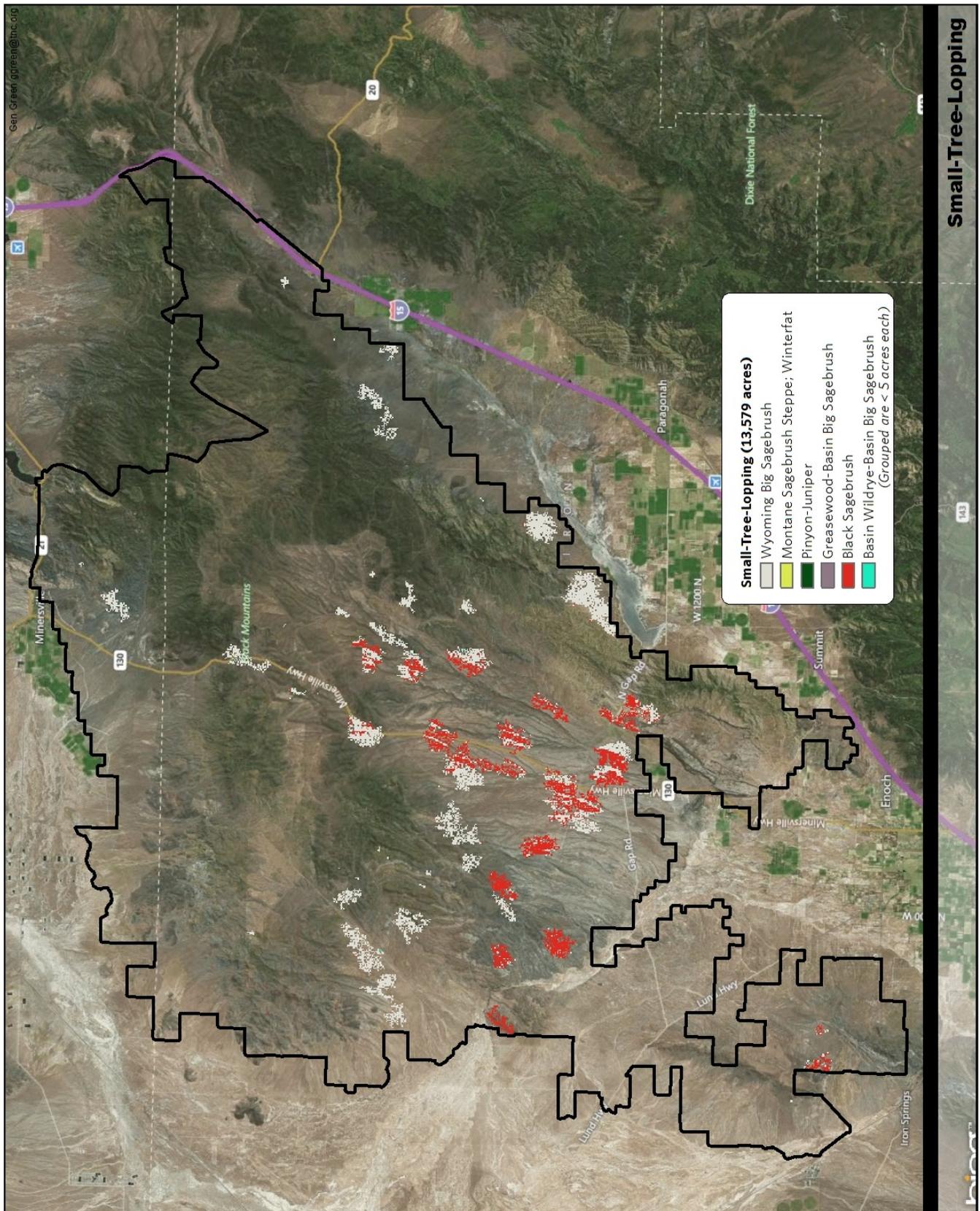


Figure 36. Locations where the ST-Sim model applied the treatment of Small-Tree-Lopping in the Black Mountains in the PREFERRED MANAGEMENT scenario.

Key Conclusions

Key conclusions of the Landscape Conservation Forecasting™ assessment in the BLM Cedar City Field Office are summarized below:

1. The Hamlin Valley and Black Mountains Project Areas, encompassing about 630,000 acres (255,000 ha) combined, are largely undeveloped landscapes that support a diversity of ecological systems in the southeastern part of the Great Basin ecoregion.
2. Twenty-six ecological systems were identified in the two Project Areas, and they and their component vegetation classes were mapped to a high degree of accuracy and precision via interpretation of satellite imagery.
3. Eleven of the ecological systems were selected for detailed modeling analyses based on their size, current and likely future condition (degree of ecological departure), and/or other features of importance to the CCFO.
4. Analyses of habitat suitability were done for two species, Greater sage-grouse and Utah prairie dog, at the present time and as modeled in the future under several different types of management scenarios.
5. At present, many ecological systems in the two Project Areas are in fair to poor condition, as indicated by high values of the metric of unified ecological departure, although this metric allows for a limited area of introduced-species seedings to be considered beneficial. This is especially true of systems that cover extensive areas, are readily accessible, and/or support various multiple land uses.
6. For the most part, conditions after 25 years of “MINIMUM MANAGEMENT” (no active treatments or management) are forecasted to remain moderately to highly departed – especially in large, accessible systems with multiple land uses.
7. Most of the poor ecological conditions (high departure values) in ecological systems can be attributed to six types of problems that are substantial or widespread across the two Project Areas: (1) encroachment by juniper and pinyon pine trees; (2) annual grasses, primarily cheatgrass; (3) degraded or depleted shrubland understories; (4) exotic forbs; (5) loss of aspen clone; and (6) excessive shrub cover in association with habitat occupied by Utah prairie dogs.
8. Return On Investment values are high or moderately high for most shrubland ecological systems in the two Project Areas (e.g., Utah serviceberry, several types of sagebrush). In general, such systems face moderate to severe problems that can be costly to address, but treatments do achieve some predicted improvement (i.e., the problems are not intractable), and the large total costs are spread over very large acreages.

9. Return On Investment values are generally near zero in systems that are small and also face substantial problems that are costly to address (e.g., Montane Riparian, Wet Meadow, Aspen Woodland). Treatments may still be desirable in such cases so as to keep problems in check and forestall wholesale degradation.
10. Some ecological systems with low ROI (e.g., Ponderosa Pine, Pinyon-Juniper) may realize treatment-induced benefits that are not “seen” by the UED metric, so that desirable ecological or public-safety outcomes may still be achieved via treatments.
11. The ROI value (of the PREFERRED MANAGEMENT scenario) for Greater sage-grouse in Hamlin Valley is greater than the ROI for that species in the Black Mountains, and this difference is significant at the 95% confidence level. The ROI value for Utah prairie dog in the Black Mountains is substantially negative, because predicted results of the active PREFERRED scenario are worse (in terms of prairie dog habitat suitability) than results of the “no action” MINIMUM MANAGEMENT scenario. Adjustment of management actions to achieve better predicted results for Utah prairie dog may come at the expense of somewhat diminished future conditions for ecological systems and Greater sage-grouse across the whole Black Mountains project area.
12. Managers may select management actions and treatment areas based upon additional factors beyond ROI values. Such additional factors could include availability of financial resources, public-safety concerns, regulatory constraints, and other multiple-use or societal objectives.
13. Spatial simulation maps of the future identify areas of most probable implementation of the more commonly used management actions.

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Appendix 1

Descriptions of Ecological Systems (Biophysical Settings) and their Vegetation Classes BLM Cedar City Field Office: Hamlin Valley and Black Mountains

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Aspen Woodland (ASP)

1011

Overview: The Aspen Woodland BpS is dominated by Populus tremuloides 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 maintaining the relative cover of conifers to <25%. Where the BpS is adjacent to conifers, an occasional conifer seedling may occur, but conifers 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 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 **Early:** 10-100% cover of aspen <5m; 0-9 yrs

B **Mid1-closed:** 40-99% cover of aspen <5-10m; 10-39 yrs

C **Late1-closed:** 40-99% cover of aspen 10-25m; few conifers in mid-story; >39 yrs

D **Late1-open:** 10-39% cover of aspen 10-25 m; conifers may be present but less than 25% relative cover; >99 yrs

U-Depleted **Depleted-Open:** 10-39% cover of older aspen 10-25m; no or little aspen regeneration; mountain big sagebrush common in understory; few conifers in mid-story

U-NAS **No-Aspen:** very few aspen stems present; dead clone of aspen, dead boles may be visible on the ground; 5-50% cover of mountain big sagebrush/mountain shrub; <50% herbaceous cover

Aspen-Mixed Conifer (ASM)

1061

Overview: The Aspen-Mixed Conifer BpS is perhaps the most widespread aspen type in Utah and is commonly called “seral aspen.” Populus tremuloides 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.

1 **Early:** 10-100% cover aspen <5m; mountain snowberry and Ribes common; 0-9 yrs

2 **Mid1-closed:** 40-99% cover aspen <5-10m; mountain snowberry and Ribes common; 10-39 yrs

4 **Late1-closed:** 40-99% cover aspen 10-24m; conifer saplings visible in mid-story; mountain snowberry and Ribes common; 40-79 yrs

5 **Late1-open:** 10-39% cover aspen 10-25 m; 10-25% mixed conifer cover 5-10 m; mountain snowberry and Ribes common; >80 yrs

6 **Late2-closed:** 40-80% cover of mixed conifer 10-50m; <40% cover of aspen 10-25m; mountain snowberry and Ribes present; >100 yrs

U-NAS **No-Aspen:** >50% white fir and Douglas-fir cover; aspen absent or in trace amount; dead aspen boles may be present

Basin Wildrye (BW)
1080bw

Overview: The Basin Wildrye BpS is a Great Basin grassland dominated by basin wildrye (Elymus cinereus). 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 **Early:** 5-20% cover of basin wildrye; 0-10 yrs
- B **Mid-closed:** 21-80% cover of basin wildrye; <11% shrub cover; 11-75 yrs
- C **Late-open:** 11-20% cover of big sagebrush and rabbitbrush; <75% cover of basin wildrye; >75 yrs
- U-Annual Grass **Annual-Grass:** 5-40% cover of cheatgrass
- U-Depleted **Depleted:** >20% cover of native shrubs, especially basin big sagebrush and rabbitbrush; <5% basin wildrye; >20% mineral soil and litter cover
- U-Early-Shrub **Early-Shrub:** >20% cover of rabbitbrush species; native grasses present
- U-Exotic Forb **Exotic-Forb:** 5-100% exotic forbs (knapweed, tall whitetop, purple loosestrife)
- U-SAP **Shrub-Annual-Grass-Perennial-Grass:** 5-14% cover of cheatgrass; >10% cover of native shrubs; ≥0% basin wildrye
- U-SAP+ **Shrub-Annual-Grass-Perennial-Grass+:** ≥15% cover of cheatgrass; >10% cover of native shrubs; ≥0% basin wildrye
- U-SDI **Seeded-Introduced:** >10% seeded introduced grasses, forbs, and shrubs
- U-SDI+AG **Seeded-Introduced+Annual-Grass:** >10% seeded introduced grasses, forbs, and shrubs, ≥5% cover of cheatgrass
- U-Seeded Native **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-TEA **Tree-Encroached-Annual-Grass:** ≥10% cover of conifers; ≥0% (i.e., absent to common) cover annual grasses

Big Sagebrush semi-desert (BSsd)

1080bssd

Overview: The Big Sagebrush semi-desert BpS is a semi-desert 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.

- A **Early:** ≥20% cover of native grasses (bottlebrush and Indian ricegrass); <10% shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; mineral soil abundant; 0-4 yrs
- B **Mid-closed:** 10-29% cover of basin big sagebrush and rabbitbrush; ≥20% native grass cover; 5-39 yrs
- C **Late-open:** ≥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
- U-Annual Grass **Annual-Grass:** >10% cheatgrass cover; <10% shrubs, especially rabbitbrush and snakeweed; native grasses may be present
- U-Depleted **Depleted:** >30% cover of basin big sagebrush, rabbitbrush, and rabbitbrush; <5% native grass cover; >20% mineral soil and litter cover
- U-Early-Shrub **Early-Shrub:** >20% cover of rabbitbrush species; native grasses present
- U-SA **Shrub-Annual-Grass:** 5-14% cover of cheatgrass; >10% cover of basin big sagebrush and other shrubs; <5% native grasses
- U-SA+ **Shrub-Annual-Grass:** ≥15% cover of cheatgrass; >10% cover of basin big sagebrush and other shrubs; <5% native grasses
- U-SAP **Shrub-Annual-Grass-Perennial-Grass:** 5-14% cover of cheatgrass; >10% cover of basin big sagebrush and other shrubs; ≥5% native grasses
- U-SAP+ **Shrub-Annual-Grass-Perennial-Grass+:** ≥15% cover of cheatgrass; >10% cover of basin big sagebrush and other shrubs; ≥5% native grasses
- U-SDI-A **Seeded-Introduced-Early:** >10% seeded introduced grasses and shrubs; <10% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; <5% cheatgrass cover
- U-SDI-B **Seeded-Introduced-Mid:** >10% seeded introduced grasses and shrubs; 10-29% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; <5% cheatgrass cover
- U-SDI-C **Seeded-Introduced-Late:** >10% seeded introduced grasses and shrubs; ≥30% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; <5% cheatgrass cover
- U-Seeded Native **Seeded-Native:** >10% seeded native grasses, forbs, and shrubs; <5% cheatgrass cover
- U-SI-A+AG **Seeded-Introduced-Early+Annual-Grass:** >10% seeded introduced grasses and shrubs; <10% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; ≥5% cover of cheatgrass;
- U-SI-B+AG **Seeded-Introduced-Mid+Annual-Grass:** >10% seeded introduced grasses and shrubs; 10-29% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; ≥5% cover of cheatgrass
- U-SI-C+AG **Seeded-Introduced-Late+Annual-Grass:** >10% seeded introduced grasses and shrubs; ≥30% native shrub (various rabbitbrushes, snakeweed, and basin big sagebrush) cover; ≥5% cover of cheatgrass
- U-TEA **Tree-Encroached-Annual-Grass:** ≥10% cover of conifers; <20% cover of shrubs; **either** <5% cheatgrass cover **AND** <5% native grass cover **OR** ≥5% cheatgrass cover **AND** ≥5% native grass cover

**Black Sagebrush (BS)
1079an**

Overview: 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 **Early:** <10% cover rabbitbrush; 10-40% cover of grass; <50% cover mineral soil; 0-25 yrs
- B **Mid-open:** 10-19% cover of black sagebrush and rabbitbrush; 10-30% grass cover; <40% cover of mineral soil; 25-119 yrs
- C **Late-closed:** 1-10% pinyon-juniper sapling cover; 20-30% cover of black sagebrush; 10-30% cover of grasses; 120-194 yrs
- D **Late-open:** 10-40% cover of pinyon or juniper 3-8m tall; <10% black sagebrush cover; <10% grass cover; >195 yrs
- U-Annual Grass **Annual-Grass:** >10% cover of cheatgrass; <10% cover of shrubs
- U-Depleted **Depleted:** 20-50% cover of black sagebrush; <5% herbaceous cover; <10% pinyon or juniper sapling cover
- U-Early-Shrub **Early-Shrub:** 10-40% cover rabbitbrush species
- U-SA **Shrub-Annual-Grass:** 5-14% cheatgrass cover; 10-50% cover of black sagebrush; <5% cover of native grass; <10% pinyon or juniper sapling cover
- U-SA+ **Shrub-Annual-Grass+:** ≥15% cheatgrass cover; 10-50% cover of black sagebrush; <5% cover of native grass; <10% pinyon or juniper sapling cover
- U-SAP **Shrub-Annual-Grass-Perennial-Grass:** 5-14% cheatgrass cover; 20-50% cover of black sagebrush; >5% cover of native grass; <10% pinyon or juniper sapling cover
- U-SAP+ **Shrub-Annual-Grass-Perennial-Grass+:** ≥15% cheatgrass cover; 20-50% cover of black sagebrush; >5% cover of native grass; <10% pinyon or juniper sapling cover
- U-SDI-A **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% cheatgrass cover
- U-SDI-B **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% cheatgrass cover
- U-SDI-C **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% cheatgrass cover
- U-Seeded Native **Seeded:** >5% seeded native
- U-SI-A+AG **Seeded-Introduced-Early+Annual-Grass:** >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% cheatgrass cover
- U-SI-B+AG **Seeded-Introduced-Mid+Annual-Grass:** >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% cheatgrass cover
- U-SI-C+AG **Seeded-Introduced-Late+Annual-Grass:** >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% cheatgrass cover.
- U-TEA **Tree-Encroached-Annual-Grass:** >10% mature pinyon or juniper cover 3-8m tall; <5% shrub cover; **either** <5% native herbaceous cover **and** <5% cheatgrass; **OR** ≥5% cheatgrass **and** >0% native herbaceous cover

Curl-leaf Mountain Mahogany (CMM)

1062

*Overview: 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. Curleaf mountain mahogany (*Cercocarpus ledifolius*) 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 (*Chrysothamnus nauseosus*) 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 curleaf mountain mahogany, although chaparral species such as manzanita (*Arctostaphylos patula*), tobaccobrush (*Ceanothus velutinus*), and green ephedra (*Ephedra viridis*) 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 (*Leptodactylon pungens*).*

- A **Early:** <70% cover of mountain mahogany; other shrubs (snowberry, rabbitbrush) and grasses may be present; 0-20 yrs
- B **Mid-open:** 10-30% cover mountain mahogany and other shrubs; 20-60 yrs
- C **Mid-closed:** 30-70% cover of mountain mahogany, other shrubs (snowberry, rabbitbrush, big sagebrush, bitterbrush, black sagebrush) abundant; 60-150 yrs
- D **Late-open:** 10-30% cover of mountain mahogany; big sagebrush, black sagebrush, bitterbrush; grasses abundant; occasional ponderosa pine possible; 150+ yrs
- E **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 Grass **Annual-Grass:** ≥10% cheatgrass cover; mountain mahogany largely absent; ≤80% cover of mineral soil, bedrock, and rock
- U-TA **Tree-Annual-Grass:** >5% cheatgrass cover; >10% cover of mountain mahogany; 40% cover of mineral soil, bedrock, and rock

Desert Wash (DWA)

1154w

Overview: The Desert Wash BpS comprises intermittent to dry desert drainages with mostly subsurface flow whose banks are deeply incised. 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 desert almond, bursage, bladdersage, burrobrush, big sagebrush, Anderson's wolfberry, snakeweed, rabbitbrush, big galleta, bush muhly, Indian ricegrass, and squirreltail.

- A **Early:** 20-50% cover may be gravel, sands, and/or flood debris; 10-19% cover of desert almond, burrobrush, rabbitbrush, desert willows present; 5-15% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); forbs present to abundant; 0-5 yrs
- B **Mid-closed:** 20-50% cover of desert almond, bursage, bladdersage, burrobrush, big sagebrush, Anderson's wolfberry, rabbitbrush; 5-10% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); forbs present to abundant; <30% of gravel and rocks; 5-19 yrs
- C **Late-closed:** 30-50% cover of bursage, burrobrush, desert almond, bladdersage, big sagebrush, Anderson's wolfberry, rabbitbrush, 5-10% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); forbs present to abundant; <10% of gravel and rocks; >20 yrs
- U-Bare Ground **Bare-Ground:** mineral soil exposed by human-caused disturbances
- U-Early-Shrub **Early-Shrub:** 20-50% cover of cholla, snakeweed or rabbitbrush species
- U-EFT **Exotic-Forb-Tree:** >5% cover of salt cedar or exotic forbs (knapweed, tall whitetop); 0-50% cover of bursage, burrobrush, big sagebrush, Anderson's wolfberry, rabbitbrush, desert almond.
- U-SA **Shrub-Annual-Grass:** 5-14% exotic species (*Bromus rubens*, *Bromus tectorum*, *Erodium cicutarium*) cover; 0-50% small trees and shrubs; <5% cover of native grasses; mineral soil may be common

- U-SA+ **Shrub-Annual-Grass+**: ≥15% exotic species (*Bromus rubens*, *Bromus tectorum*, *Erodium cicutarium*) cover; 0-50% small trees and shrubs; <5% cover of native grasses; mineral soil may be common
- U-SAP **Shrub-Annual-Grass-Perennial-Grass**: 5-14% exotic species (*Bromus rubens*, *Bromus tectorum*, *Erodium cicutarium*) cover; 0-50% small trees and shrubs, ≥5% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); mineral soil may be common
- U-SAP+ **Shrub-Annual-Grass-Perennial-Grass+**: ≥15% exotic species (*Bromus rubens*, *Bromus tectorum*, *Erodium cicutarium*) cover; 0-50% small trees and shrubs, ≥5% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); mineral soil may be common

Four-Wing Saltbush (FWS)

1081fws

Overview: 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 **Early**: ≥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 **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 **Late1-open**: >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 **Annual-Grass**: ≥10% cheatgrass cover; <5% shrub cover; native grass may be present to common
- U-Depleted **Depleted**: 5-20% cover of four-wing saltbush, basin big sagebrush, or rabbitbrush; <10% native grass; <5% cheatgrass cover
- U-Early-Shrub **Early-Shrub**:
- U-SAP **Shrub-Annual-Grass**: 5-14% cheatgrass cover; ≥5% cover of four-wing saltbush, basin big sagebrush, or rabbitbrush; native grass may be present to common
- U-SAP+ **Shrub-Annual-Grass+**: ≥15% cheatgrass cover; ≥5% cover of four-wing saltbush, basin big sagebrush, or rabbitbrush; ; native grass may be present to common
- U-SDI **Seeded-Introduced**: >10% seeded introduced grasses and shrub species (crested wheatgrass and forage kochia); <5% cheatgrass cover; native shrubs may be present to common
- U-SDI+AG **Seeded-Introduced+Annual-Grass**: >10% seeded introduced grasses and shrub species (crested wheatgrass and forage kochia); ≥5% cheatgrass cover; native shrubs may be present to common
- U-Seeded Native **Seeded-Native**: >10% native grass and four-wing saltbush seed mix cover; <5% cheatgrass cover

Gambel Oak-Mountain Shrub (GOMS)

1107

Overview: The Gambel Oak-Mountain Shrub BpS is one of three mountain shrub types. 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 **Early:** 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 **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 **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 **Shrub-Annual-Grass-Perennial-Grass:** 5-14% non-native grass cover between oak patches; >5% cover of Gambel oak; native herbaceous cover usually present to abundant between oak patches
- U-SAP+ **Shrub-Annual-Grass-Perennial-Grass+:** ≥15% non-native grass cover between oak patches; >5% cover of Gambel oak; native herbaceous cover usually present to abundant between oak patches.

Greasewood-Basin Big Sagebrush (GW)

1153

Overview: 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 Sarcobatus vermiculatus (greasewood). Atriplex confertifolia (shadscale) may be present or co-dominant. An herbaceous layer, if present, is usually dominated by salt-tolerant graminoids. There may be inclusions of Sporobolus airoides (alkali sacaton), Distichlis spicata (saltgrass), and basin wildrye (Elymus cinereus). 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 **Early:** >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 **Mid-closed:** >5% cover of mature greasewood with other shrubs possible (basin big sagebrush); >5% herbaceous cover of inland salt grass, alkali sacaton, or basin wildrye; mineral soil may be common; >4 years
- U-Annual Grass **Annual-Grass:** >10% cover of cheatgrass; <5% cover of mature greasewood and other shrubs
- U-SAP **Shrub-Annual-Perennial-Grass:** 5-14% cheatgrass cover; >5% cover of mature greasewood or basin big sagebrush; native grasses may be present to common; >4 years
- U-SAP+ **Shrub-Annual-Perennial-Grass+:** >15% cheatgrass cover; >5% cover of mature greasewood or basin big sagebrush; native grasses may be present to common; >4 years
- U-SDI **Seeded-Introduced:** >10% seeded introduced grasses (usually Russian wheatgrass), forbs, and shrubs; greasewood and other shrubs may be present to common; <5% cheatgrass cover
- U-SDI+AG **Seeded-Introduced+Annual-Grass:** >10% seeded introduced grasses (usually Russian wheatgrass), forbs, and shrubs; greasewood and other shrubs may be present to common; ≥5% cheatgrass cover.
- U-Seeded Native **Seeded-Native:** >10% cover of native; greasewood and other shrubs may be present to common

Juniper Savanna (JUN)

1115

Overview: The Juniper Savanna BpS was historically noted by the first explorers on the Spanish Trail. This ecological system is typically found at lower 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, badland environments 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. The vegetation is typically open savanna, 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), 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 edulis and Pinus monophylla.

- A **Early-open:** ≤10% herbaceous cover; charred stumps and trunks should be visible; 0-9 yrs.
- B **Mid1-open:** 10-20% herbaceous cover; 5-10% cover big sagebrush, black sagebrush, or bitterbrush <1.0m, 10-29 yrs..
- C **Mid2-open:** 11-20% cover of young (<100 yrs old) juniper <5m; >10% herbaceous cover; 10-20% shrub cover; 30-99 yrs.
- D **Late-open:** ≥20% cover of juniper <5m-9m; >10% herbaceous cover; 5-10% shrub cover; ≥100 yrs.

U-Annual Grass **Annual-Grass:** >10% cheatgrass cover; dead juniper visible.

U-Early-Shrub **Early-Shrub:** ≥10% cover rabbitbrush and snakeweed species.

U-SAP **Shrub-Annual-Perennial-Grass:** >5% cheatgrass; 5-20% cover big sagebrush, black sagebrush, or bitterbrush <1.0m, <40% herbaceous cover.

U-TA **Tree-Annual-Grass:** ≥20% cover of juniper <5m-9m, 5-10% shrub cover, >5% cheatgrass cover; ≥30 yrs.

Limber-Bristlecone Pine (LB)

1020

Overview: 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 **Early:** 0-10% limber and bristlecone pine cover 0-5m tall; abundant mineral soil or talus cover; sparse ground cover; 0-99 yrs
- B **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 **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

Low Sagebrush (LS)

1079aa

Overview: The Low Sagebrush BpS is found primarily in the Beaver County portion of the project area. Low sagebrush (Artemisia arbuscula) 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 (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.). Utah juniper (Juniperus osteosperma), more than singleleaf pinyon (Pinus monophylla), may occasionally establish in low sagebrush's harsh soils; however, low sagebrush does not generally support trees.

- A **Early:** <10% cover rabbitbrush and other shrubs; >10% cover of grass; <50% cover mineral soil; 0-24 yrs
- B **Mid-open:** 10-19% cover of low sagebrush and rabbitbrush; >10% grass cover; <40% cover of mineral soil; 25-119 yrs
- C **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 Grass **Annual-Grass:** >10% cover of cheatgrass; <10% cover of shrubs (primarily rabbitbrush and snakeweed)
- U-Depleted **Depleted:** >20% cover of low sagebrush; <5% herbaceous cover; <3% mature juniper (maybe pinyon) cover; ≤5% pinyon or juniper sapling cover
- U-Early-Shrub **Early-Shrub:** 10-40% cover rabbitbrush species
- U-SA **Shrub-Annual-Grass:** 5-14% cheatgrass 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+ **Shrub-Annual-Grass+:** ≥15% cheatgrass 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 **Shrub-Annual-Grass-Perennial-Grass:** 5-14% cheatgrass 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+ **Shrub-Annual-Grass-Perennial-Grass+:** ≥15% cheatgrass cover; >10% cover of low sagebrush; >5% cover of native grass; <3% mature juniper (maybe pinyon) cover; ≤5% pinyon or juniper sapling cover
- U-SDI-A **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% cheatgrass cover
- U-SDI-B **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% cheatgrass cover
- U-SDI-C **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% cheatgrass cover
- U-Seeded Native **Seeded-Native:** >5% seeded native grass and forb species; <10% cover of shrubs; <5% cheatgrass cover.
- U-SI-A+AG **Seeded-Introduced-Early+Annual-Grass:** >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% cheatgrass cover
- U-SI-B+AG **Seeded-Introduced-Mid+Annual-Grass:** >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% cheatgrass cover
- U-SI-C+AG **Seeded-Introduced-Late+Annual-Grass:** >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% cheatgrass cover.
- U-TA **Tree-Annual-Grass:** ≥3% mature pinyon or juniper cover; <10% low sagebrush and other shrub cover; ≥5% cheatgrass; >0% native herbaceous cover
- U-TE **Tree-Encroached:** ≥3% mature pinyon or juniper cover; <10% low sagebrush and other shrub cover; <5% native herbaceous cover; <5% cheatgrass

Mixed Conifer (MC)

1052

Overview: 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 (Abies concolor) and Douglas-fir (Pseudotsuga menziesii) are most common canopy dominants, but ponderosa pine (Pinus ponderosa), Engelmann spruce (Picea engelmannii), limber pine (Pinus flexilis), and bristlecone pine (Pinus longeva) 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 **Early:** 0-15% cover of tree/shrub/grass; <5m; 0-29 yrs
- B **Mid1-closed:** 35-100% cover of conifers <24m; 30-99 yrs
- C **Mid1-open:** 0-35% cover of conifers <24m; 30-99 yrs
- D **Late1-open:** 0-35% cover of conifers 25-49m; >100 yrs
- E **Late1-closed:** 35-100% cover of conifers 25-49m; >100 yrs

U-Annual Grass **Annual-Grass:** saplings plus >10% annual grass cover

U-TA **Tree-Annual-Grass:** any class A-E plus >5% annual grass cover

Mixed Salt Desert (MSD)

1081

Overview: 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 bunch grass 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.

- A **Early:** 0-5% cover of young *Atriplex* spp. or other shrubs; Indian ricegrass and squirreltail common; 0-5 yrs
- B **Late1-open:** >5% cover *Atriplex* spp. or other shrubs; Indian ricegrass and squirreltail present to common; ≥6 yrs
- C **Late2-open:** >5% cover budsage <0.25m; Indian ricegrass and squirreltail present to common; ≥6 years

U-Annual Grass **Annual-Grass:** ≥5% cheatgrass cover; <5% shrub cover

U-Early-Shrub **Early-Shrub:** ≥10% cover rabbitbrush and snakeweed species.

- U-SAP **Shrub-Annual-Grass-Perennial-Grass:** 5-15% non-native annual species cover; ≥5% cover of *Atriplex* spp. or other shrubs; native grasses may be present to common.
- U-SAP+ **Shrub-Annual-Grass-Perennial-Grass+:** >15% non-native annual species cover; ≥5% cover of *Atriplex* spp. or other shrubs; native grasses may be present to common.
- U-SDI **Seeded-Introduced:** >10% seeded introduced grasses, forbs, and shrubs; <5% cheatgrass cover; shrubs may be present to common
- U-SDI+AG **Seeded-Introduced+Annual-Grass:** >10% seeded introduced grasses and shrubs; ≥5% cheatgrass cover; shrubs may be present to common.
- U-Seeded Native **Seeded-Native:** >10% native seed mix cover; <5% cheatgrass cover

Montane Riparian (MR)

1154

Overview: 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 may keep the water table just below ground surface, and are favored substrates for cottonwood and willow. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Surface water is generally high for variable periods. Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Codominant and diagnostic species include willow, buffaloberry, cottonwood, velvet ash, and conifers. Vegetation is very heterogeneous and diverse along river reaches.

- A **Early:** 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 **Mid-closed:** 31-100% cover of tall shrubs (willows, buffaloberry) and small trees (velvet ash, conifers) and small cottonwood trees; <20% gravel, rock, and boulders; 5-19yrs
- C **Late-closed:** 31-100% cover of cottonwood, willow, conifers and other trees 10-24m; <20% gravel, rock, and boulders; >20 yrs
- U-Annual Grass **Annual-Grass:** >10% cover of cheatgrass on dry incised banks; < 10% shrub cover
- U-Desertified **Desertified:** Incised river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush, snakeweed, rabbitbrush); >5% native grass cover
- U-EFT **Exotic-Forb-Tree:** >10% cover of exotic forb or tree species (knapweed, tall whitetop, thistles, purple loosestrife, salt cedar, or Russian olive)
- U-SAP **Shrub-Annual-Grass-Perennial-Grass:** Incised river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush); >5% cheatgrass cover; >5% native grass cover; ≤20% cover of pinyon-juniper
- U-SDA **Seeded-Annual-Grass:** Incised river/creek with >20% introduced grass species cover; >5% cheatgrass cover; pinyon-juniper may be present
- U-Seeded Native **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 ASPG or even AS)
- U-SFE **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-TE **Tree-Encroached:** Incised river/creek with >20% cover of pinyon or juniper; highly variable cover of riparian shrubs and cottonwood; degree of incision none to pronounced

Montane Sagebrush Steppe (MSS)

1126

Overview: 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 Artemisia tridentata ssp. vaseyana, 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 **Early:** 10-80% grass and forb cover; 0-10% canopy of mountain sage, mountain brush; 0-12 yrs
- B **Mid-open:** 11-30% cover of mountain sage, mountain shrub; >50% herbaceous cover; 13-38 yrs
- C **Mid-closed:** >30% cover of mountain sage (dominant) and mountain brush; 25-50% herbaceous cover; <10% conifer sapling cover; 39+ yrs
- D **Late-open:** 10-30% cover pinyon-juniper <3m; 25-40% cover of mountain sage (dominant) and mountain brush; >10% herbaceous cover; 80-129 yrs
- E **Late-closed:** >30% pinyon-juniper cover ≥3m; 6-20% shrub cover; >10% herbaceous cover; 130+ yrs
- U-Annual Grass **Annual-Grass:** >10% cover of cheatgrass; snakeweed or rabbitbrush may be present
- U-Depleted **Depleted:** >20% cover of mountain sage (dominant) and mountain brush; <5% herbaceous cover; <30% conifer sapling cover; litter and mineral soil common
- U-Early-Shrub **Early-Shrub:** >20% cover of snakeweed or rabbitbrush species
- U-SA **Shrub-Annual-Grass:** 5-14% cheatgrass cover; >10% cover of mountain sage (dominant) and mountain brush; ≤5% cover of native grass; <30% conifer sapling cover
- U-SA+ **Shrub-Annual-Grass+:** ≥15% cheatgrass cover; >10% cover of mountain sage (dominant) and mountain brush; ≤5% cover of native grass; <30% conifer sapling cover
- U-SAP **Shrub-Annual-Grass-Perennial-Grass:** 5-14% cheatgrass cover; 11-50% cover of mountain sage (dominant) and mountain brush; occasional blackbrush above Mojave Desert slopes; >5% cover of native grass; <30% conifer sapling covers
- U-SAP+ **Shrub-Annual-Grass-Perennial-Grass+:** ≥15% cheatgrass cover; >10% cover of mountain sage (dominant) and mountain brush; >5% cover of native grass; <30% conifer sapling cover
- U-SDI-A **Seeded-Introduced-Early:** >10% seeded introduced grasses and shrubs; 0-10% canopy of mountain sage, mountain brush; native grasses present to common; <5% cover of cheatgrass
- U-SDI-B **Seeded-Introduced-Mid-open:** >10% seeded introduced grasses and shrubs; 11-30% cover of mountain sage and mountain shrub; native grasses present to common; <5% cover of cheatgrass
- U-SDI-C **Seeded-Introduced-Mid-Closed:** >5% seeded introduced grasses and shrubs; >30% cover of mountain sage and mountain shrub; native grasses present to common; <10% conifer sapling cover; <5% cover of cheatgrass
- U-SDI-D **Seeded-Introduced-Late-Open:** >5% seeded introduced grasses and shrubs; 10-30% conifer cover; 25-40% cover of mountain sage and mountain shrub; native grasses present to common; <5% cover of cheatgrass
- U-Seeded Native **Seeded-Native:** >10% seeded native grasses, forbs, and shrubs
- U-SI-A+AG **Seeded-Introduced-Early+Annual-Grass:** >10% seeded introduced grasses and shrubs; 0-10% canopy of mountain sage, mountain brush; native grasses present to common; ≥5% cover of cheatgrass
- U-SI-B+AG **Seeded-Introduced-Mid-Open+Annual-Grass:** >10% seeded introduced grasses and shrubs; 11-30% cover of mountain sage and mountain shrub; native grasses present to common; ≥5% cover of cheatgrass
- U-SI-C+AG **Seeded-Introduced-Mid-Closed+Annual-Grass:** >5% seeded introduced grasses and shrubs; >30% cover of mountain sage and mountain shrub; native grasses present to common; <10% conifer sapling cover; ≥5% cover of cheatgrass
- U-SI-D+AG **Seeded-Introduced-Late-Open+Annual-Grass:** >5% seeded introduced grasses and shrubs; 10-30% conifer cover; 25-40% cover of mountain sage and mountain shrub; native grasses present to common; ≥5% cover of cheatgrass.

- U-TEA **Tree-Encroached-Annual-Grass:** >20% pinyon-juniper cover 3-8m tall; <5% shrub cover; <5% herbaceous cover; <5% cheatgrass cover **OR** >20% pinyon-juniper cover 3-8m tall; ≥5% cheatgrass cover; ≥5% shrub cover; ≥5% herbaceous cover

Pinyon-Juniper (PJ)

1019

Overview: The Pinyon-Juniper 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 **Early-open:** 5-20% herbaceous cover; charred stumps and trunks; 0-9 yrs
- B **Mid1-open:** 11-30% cover big sagebrush, black sagebrush, or bitterbrush <1.0m, 10-40% herbaceous cover; 10-29 yrs
- C **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 **Late-open:** 21-60% cover of pinyon and/or juniper <5m-9m, 10-40% shrub cover, <20% herbaceous cover; ≥100 yrs
- U-Annual Grass **Annual-Grass:** >10% cheatgrass cover; dead pinyon or juniper visible.
- U-Exotic Forb **Exotic-Forb:** 5-100% exotic forbs (e.g., thistles, knapweed).
- U-SAP **Shrub-Annual-Grass-Perennial-Grass:** >5% cheatgrass; 11-30% cover big sagebrush, black sagebrush, or bitterbrush <1.0m, <40% herbaceous cover
- U-SDI **Seeded-Introduced:** >10% seeded introduced grass and forbs; <5% cover of cheatgrass
- U-SDI+AG **Seeded-Introduced+Annual-Grass:** >10% seeded introduced grass and forbs; ≥5% cover of cheatgrass.
- U-Seeded Native **Seeded-Native:** >10% seeded native grasses, forbs, and shrubs; <5% cheatgrass cover.
- U-TA **Tree-Annual-Grass:** 20-60% cover of pinyon and/or juniper <5m-9m, 10-40% shrub cover, >5% cheatgrass cover; ≥30 yrs

Ponderosa Pine (PP)

1054

Overview: 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. Pinus ponderosa is the predominant conifer; Pseudotsuga menziesii, Pinus edulis, Pinus monophylla, and Juniperus spp. may be present in the tree canopy. The understory is usually shrubby, with Artemisia nova, Artemisia tridentata, Arctostaphylos patula, Arctostaphylos uva-ursi, Cercocarpus montanus, Cercocarpus ledifolius, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Symphoricarpos oreophilus, Prunus virginiana, Amelanchier alnifolia, and Rosa spp. common species. Pseudoroegneria spicata and species of Hesperostipa, Achnatherum, Festuca, Muhlenbergia, and Bouteloua are some of the common grasses. Pinus ponderosa / Arctostaphylos patula represents the extreme with typically a high percentage of rock and bare soil present.

- A **Early:** 5-60% cover of shrub/grass; conifer seedlings can be abundant <5m; 0-39yrs
- B **Mid-closed:** 31-60% cover of ponderosa pine, pinyon, juniper, Douglas-fir, and white fir 5-10m; dense shrub cover possible; 40-159 yrs
- C **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
- D **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
- E **Late-closed:** 31-80% cover of ponderosa pine, Douglas-fir, pinyon, juniper, and white fir 11-50m; mountain snowberry common; ≥160 yrs
- U-Annual Grass **Annual-Grass:** saplings plus >10% annual grass cover
- U-TA **Tree-Annual-Grass:** Any class A,B,C,D,E plus >5% annual grass cover

Semi-Desert Grassland (SDG)

1135

Overview: 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 (Stipa hymenoides) 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	Early: <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	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-Depleted	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	Early Shrub: 10-30% cover of rabbitbrush; 10-30% bare ground cover; <10% native grass cover; sandy soil cover may be high
U-SAP	Shrub-Annual-Perennial-Grass: 5-14% cover of 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+	Shrub-Annual-Perennial-Grass+: ≥15% cover of 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-SDI	Seeded-Introduced: >10% cover of introduced seeded grass species; <5% cover of cheatgrass; sagebrush and other shrubs may be present; sandy soil cover may be moderately high
U-SDI+AG	Seeded-Introduced+Annual-Grass: >10% cover of introduced seeded grass species; ≥5% cover of annual grasses; sagebrush and other shrubs may be present; sandy soil cover may be moderately high
U-Seeded Native	Seeded-Native: >10% seeded native grasses, forbs, and shrubs; <5% cheatgrass cover.
U-TEA	Tree-Encroached-Annual-Grass: >20% mature pinyon-juniper cover; <5% cover of shrubs; either <5% cover native grasses AND <5% cover of cheatgrass OR ≥5% cover of cheatgrass AND ≥5% cover native grasses; sandy soil cover may be moderately high

Stansbury Cliffrose (SC)

1086sc

Overview: The Stansbury Cliffrose BpS is one of three mountain shrub types, where Stansbury cliffrose (Purshia mexicana) 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	Early: 0-10% canopy of Stansbury cliffrose or desert bitterbrush (often resprouting); 10-80% grass and forb cover; 0-12 yrs
B	Mid-open: 11-20% cover of Stansbury cliffrose or desert bitterbrush; >25% herbaceous cover;<10% conifer sapling cover; 13-79 yrs
C	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 Grass	Annual-Grass: >10% cover of 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-Depleted	Depleted: >20% cover of Stansbury cliffrose or desert bitterbrush; <5% herbaceous cover; <10% conifer sapling cover
U-Early-Shrub	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	Shrub-Annual-Grass-Perennial-Grass: 5-14% non-native grass cover; >5% cover of Stansbury cliffrose or desert bitterbrush; native herbaceous cover usually present; trees may be present
U-SAP+	Shrub-Annual-Grass-Perennial-Grass+: ≥15% non-native grass cover; >5% cover of Stansbury cliffrose or desert bitterbrush; native herbaceous cover usually present; trees may be present
U-SDI-A	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 cheatgrass
U-SDI-B	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 cheatgrass
U-SDI-C	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 cheatgrass
U-Seeded Native	Seeded-Native: >10% seeded native grasses, forbs, and shrubs; <5% cheatgrass cover.
U-SI-A+AG	Seeded-Introduced-Early+Annual-Grass: >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 cheatgrass
U-SI-B+AG	Seeded-Introduced-Mid-open+Annual-Grass: >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 cheatgrass
U-SI-C+AG	Seeded-Introduced-Late-open+Annual-Grass: >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 cheatgrass
U-TEA	Tree-Encroached-Annual-Grass: >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.

Utah Serviceberry (US)

1086us

Overview: The Utah Serviceberry BpS is one of three mountain shrub types, where Utah serviceberry (Amelanchier utahensis) 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 Amelanchier utahensis, Cercocarpus montanus, Purshia tridentata, Rhus trilobata, Ribes cereum, Symphoricarpos oreophilus, or Yucca glauca. In Utah, true mountain mahogany (Cercocarpus montanus) is a resprouting shrub that sometimes dominates this ecological system, whereas Ribes, Acer, mountain ash (Sorbus scopulina), and Chrysothamnus are less common. Artemisia tridentata ssp. vaseyana and Holodiscus are more common shrubs on dry sites in Utah and the Great Basin. Grasses are represented as species of Muhlenbergia spp., Bouteloua spp., Stipa spp., and Elymus spicatus. 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. Cercocarpus montanus 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.

A	Early: 0-10% canopy of serviceberry, antelope bitterbrush, or true mountain mahogany; 10-80% grass and forb cover; 0-4 yrs
B	Mid-open: 11-30% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; >50% herbaceous cover; 5-19 yrs
C	Mid-closed: 31-50% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; 25-50% herbaceous cover; <10% conifer sapling cover; 20-79 yrs
D	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
U-Annual Grass	Annual-Grass: ≥10% cover of cheatgrass; snakeweed or rabbitbrush may be present.
U-Depleted	Depleted: 31-50% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; <5% herbaceous cover; <10% conifer sapling cover
U-Early-Shrub	Early-Shrub: 20-50% cover rabbitbrush species

U-SAP	Shrub-Annual-Grass-Perennial-Grass: 5-14% non-native grass cover; 5-40% cover of mountain shrubs; native herbaceous cover usually present; trees may be present
U-SAP+	Shrub-Annual-Grass-Perennial-Grass+: ≥15% non-native grass cover; 5-40% cover of mountain shrubs; native herbaceous cover usually present; trees may be present
U-SDI-A	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 cheatgrass
U-SDI-B	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 cheatgrass
U-SDI-C	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 cheatgrass
U-SDI-D	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 cheatgrass
U-SI-A+AG	Seeded-Introduced-Early+Annual-Grass: >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 cheatgrass
U-SI-B+AG	Seeded-Introduced-Mid-open+Annual-Grass: >10% seeded introduced grass and shrubs; 11-30% cover of serviceberry, antelope bitterbrush, or true mountain mahogany; >50% herbaceous cover; ≥5% cover of cheatgrass
U-SI-C+AG	Seeded-Introduced-Mid-closed+Annual-Grass: >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 cheatgrass
U-SI-D+AG	Seeded-Introduced-Late-open+Annual-Grass: >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 cheatgrass
U-TA	Tree-Annual-Grass: 10-20% pinyon pine-juniper cover 3-8m; ≥5% cover of non-native annual grasses and forbs; 25-40% cover of snowberry, antelope bitterbrush, or true mountain mahogany; <30% herbaceous cover
U-TE	Tree-Encroached: >21% pinyon pine-juniper cover 3-8m; <5% shrub cover; <5% herbaceous cover

Wet Meadow-Alkali Sacaton (WMas)

1145as

Overview: The Wet Meadow-Alkali Sacaton 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 (Sporobolus airoides) dominates, although inland saltgrass (Distichlis spicata) may co-dominate on some soils. Black greasewood and four-wing saltbush may be present at low abundance.

A	Early-open: 10-60% alkali sacaton or inland saltgrass cover; 0-2 yrs
B	Mid-closed: 61-100% alkali sacaton or inland saltgrass cover; 3-22 yrs
C	Late-open: 5-10% shrub (greasewood and four-wing saltbush) cover; 60-80% alkali sacaton or inland saltgrass cover; >22 yrs
U-AGPG	Annual-Grass-Perennial-Grass: <10% cover of native shrubs; ≥10% alkali sacaton or inland saltgrass cover; ≥5 cheatgrass cover; >10% mineral soil cover
U-Annual Grass	Annual-Grass: >10% cover of cheatgrass; <10% alkali sacaton or inland saltgrass cover; <10% shrub cover; >10% mineral soil cover
U-Depleted	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	Exotic-Forb: >5% exotic forbs (tall whitetop, knapweed, purple loosestrife, Russian thistle)
U-SAP	Shrub-Annual-Grass-Perennial-Grass: ≥10% cover of native shrubs; >10% alkali sacaton or inland saltgrass cover; ≥5 cheatgrass cover; >10% mineral soil cover

Wet Meadow-Montane (WM)

1145wm

Overview: 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 **Early-open:** 10-60% herbaceous cover – mostly graminoids; 0-2 yrs
- B **Mid-closed:** 61-100% herbaceous cover – mostly graminoids; 3-22 yrs
- C **Late-open:** 5-10% tree-shrub (willow, Wood's rose, sagebrush, aspen) cover; 60-80% herbaceous cover – mostly graminoids; >22 yrs
- U-Annual Grass **Annual-Grass (on incised meadow):** >5% cover of cheatgrass; < 10% shrub cover
- U-Desertified **Desertified (= incised):** Entrenched water table with 10-50% cover of sagebrush
- U-Exotic Forb **Exotic-Forb:** >5% exotic forbs (knapweed, purple loosestrife, thistles)
- U-Hummocked **Hummocked:** Trampled by ungulates; graminoids present to common in and out of holes created by ungulate hoofs.
- U-SA **Shrub-Annual-Grass (on incised meadow):** >10% cover of native shrubs; <5% native grass cover; 5-30% cover of cheatgrass
- U-SDI **Seeded-Introduced:** ≥10% cover of introduced undesirable forage species (e.g., smooth brome); >10% native graminoid cover
- U-SFE **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-TEA **Tree-Encroached-Annual-Grass (on incised meadow):** >20% conifer cover 10-25m; <5% shrub cover; <5% native herbaceous cover; ≥0% cover of cheatgrass

Winterfat (WF)

1081wf

*Overview: 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 (*Krascheninnikovia lanata*) 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 **Early:** >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 **Mid1-open:** 5-20% cover winterfat, rabbitbrush, and other desert shrubs <0.5m; >10% native grass cover; 50-149 yrs
- C **Late1-closed:** >20% cover winterfat, rabbitbrush, and other salt desert shrubs; >5% grass cover; >150 yrs
- U-Annual Grass **Annual-Grass:** >10% cheatgrass cover; <5% cover of native shrubs
- U-Depleted **Depleted:** >5% cover of winterfat or other shrubs; ≤5% native grass cover; ≤5% cheatgrass cover; ≤5% exotic forb cover
- U-Exotic Forb **Exotic-Forb:** >5% cover halogeton or exotic mustards; <10% cover of cheatgrass; >50% mineral soil
- U-SA **Shrub-Annual-Grass:** 5-14% cheatgrass cover; >5% cover of winterfat or other shrubs; ≤5% native grass cover
- U-SA+ **Shrub-Annual-Grass+:** ≥15% cheatgrass cover; >5% cover of winterfat or other shrubs; ≤5% native grass cover
- U-SAP **Shrub-Annual-Grass-Perennial-Grass:** 5-14% cheatgrass cover; >5% cover of winterfat or other shrubs; >5% native grass cover
- U-SAP+ **Shrub-Annual-Grass-Perennial-Grass+:** ≥15% cheatgrass cover; >5% cover of winterfat or other shrubs; >5% native grass cover
- U-SDI **Seeded-Introduced:** ≥5% introduced species (crested wheatgrass, forage kochia) seed mix cover; <5% cheatgrass cover
- U-SDI+AG **Seeded-Introduced+Annual-Grass:** ≥5% introduced species (crested wheatgrass, forage kochia) seed mix cover; ≥5% cheatgrass cover
- U-Seeded Native **Seeded-Native:** ≥10% native grass species seed mix cover; <5% cheatgrass cover

Wyoming Big Sagebrush upland (WSup)

1080

Overview: 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 (Pinus monophyla and Pinus edulis) and juniper (generally Juniperus osteosperma) are present, occasionally reaching 50% canopy cover in areas that have escaped fire.

- A **Early:** 10-25% herbaceous cover; <10% cover of rabbitbrush species; <10% cover of Wyoming big sagebrush; 0-20 yrs
- B **Mid-open:** 11-20% cover of Wyoming big sagebrush; 10-25% herbaceous cover; 20-60 yrs
- C **Late1-closed:** >20% cover of Wyoming big sagebrush; 10-20% native herbaceous cover; 60-100 yrs;
- D **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 **Late2-closed:** >20% pinyon or juniper cover <10m tall; <10% cover of Wyoming big sagebrush; ~5% native herbaceous cover; 150+ yrs
- U-Annual Grass **Annual-Grass:** >10% cover of cheatgrass
- U-Depleted **Depleted:** >20% cover of big sage (dominant); <5% herbaceous cover; <30% conifer sapling cover; litter and mineral soil common
- U-Early-Shrub **Early-Shrub:** >10% cover rabbitbrush species
- U-SA **Shrub-Annual-Grass:** 5-14% cover cheatgrass; ≥10% Wyoming big sagebrush <0.5m; scattered pinyon-juniper saplings may be present; native grasses rare
- U-SA+ **Shrub-Annual-Grass+:** ≥15% cover cheatgrass; ≥10% Wyoming big sagebrush <0.5m; scattered pinyon-juniper saplings may be present; native grasses rare
- U-SAP **Shrub-Annual-Grass-Perennial-Grass:** 5-14% cover cheatgrass; ≥10% Wyoming big sagebrush <0.5m; 5-20% cover native grasses; scattered pinyon-juniper saplings may be present
- U-SAP+ **Shrub-Annual-Grass-Perennial-Grass+:** ≥15% cover cheatgrass; ≥10% Wyoming big sagebrush <0.5m; 5-20% cover native grasses; scattered pinyon-juniper saplings may be present
- U-SDI-A **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 cheatgrass
- U-SDI-B **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 cheatgrass
- U-SDI-C **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 cheatgrass
- U-SDI-D **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 cheatgrass
- U-Seeded Native **Seeded-Native:** >10% seeded native grasses, forbs, and shrubs; <5% cheatgrass cover.
- U-SI-A+AG **Seeded-Introduced-Early+Annual-Grass:** ≥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 cheatgrass

U-SI-B+AG	Seeded-Introduced-Mid-open+Annual-Grass: ≥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 cheatgrass
U-SI-C+AG	Seeded-Introduced-Late1-closed+Annual-Grass: ≥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 cheatgrass
U-SI-D+AG	Seeded-Introduced-Late2-open+Annual-Grass: ≥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 cheatgrass
U-TEA	Tree-Encroached-Annual-Grass: 11-60% cover of trees 5-9m; cheatgrass may be present to abundant; native grasses absent or trace amounts

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Closed	Aspen Woodland	ASP-A:Closed	Wild-Horse-Grazing	0.0100	0.9990			2	Yes		
Aspen Woodland	ASP-A:Closed	Aspen Woodland	ASP-A:Closed	Cattle+Sheep-Grazing	0.0500	0.9900	3			Yes	12	
Aspen Woodland	ASP-A:Closed	Aspen Woodland	ASP-A:Closed	Fence	0.0100					No	12	
Aspen Woodland	ASP-A:Closed	Aspen Woodland	ASP-A:Closed	NativeGrazing	0.0020					Yes		
Aspen Woodland	ASP-A:Closed	Aspen Woodland	ASP-A:Closed	ReplacementFire	0.0033					Yes		
Aspen Woodland	ASP-A:Closed	Montane Sagebrush Steppe	MSS-A:All	Cattle+Sheep-Grazing	0.0500	0.0100	3			Yes	12	
Aspen Woodland	ASP-A:Closed	Montane Sagebrush Steppe	MSS-A:All	Wild-Horse-Grazing	0.0100	0.0010				Yes		
Aspen Woodland	ASP-B:Closed	Aspen Woodland	ASP-A:Closed	ReplacementFire	0.0033	1.0000		39		Yes		
Aspen Woodland	ASP-B:Closed	Aspen Woodland	ASP-B:Closed	Cattle+Sheep-Grazing	0.0500	0.0010			1	No	12	
Aspen Woodland	ASP-B:Closed	Aspen Woodland	ASP-B:Closed	Cattle+Sheep-Grazing	0.0500	0.9990				No	12	
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-A:Closed	Chainsaw-Thinning	0.0000					Yes		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-A:Closed	Insect/Disease	0.0050	0.2000				Yes		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-A:Closed	ReplacementFire	0.0033					Yes		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-A:Closed	RxFire	0.0000	0.7000				Yes		
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-C:Closed	Cattle+Sheep-Grazing	0.0500	0.0010			1	No	12	
Aspen Woodland	ASP-C:Closed	Aspen Woodland	ASP-C:Closed	Cattle+Sheep-Grazing	0.0500	0.9990				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	0.0000	0.3000				No		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-A:Closed	Chainsaw-Thinning	0.0100					Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-A:Closed	Senescence	0.0100		150			Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-D:Open	Small-Tree-Lopping	0.0100					Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-A:Closed	ReplacementFire	0.0166					Yes		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-A:Closed	RxFire	0.0100	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	0.0500	0.9990				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	0.0100	0.3000				No		
Aspen Woodland	ASP-D:Open	Aspen Woodland	ASP-U:Depleted	Cattle+Sheep-Grazing	0.0500	0.0010				No	12	
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-B:Closed	Natural-Recovery	1.0000	0.8000				Yes	9	
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-C:Closed	Natural-Recovery	1.0000	0.2000				Yes	9	
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-A:Closed	Chainsaw-Thinning	0.0100	0.9000				Yes	12	
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-A:Closed	Drought	0.0056	0.8000				Yes		
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-A:Closed	Insect/Disease	0.0033	0.9000				Yes		
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-A:Closed	ReplacementFire	0.0200	0.9000				Yes		
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-A:Closed	RxFire	0.0100	0.6300				Yes	12	
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-U:Depleted	Cattle+Sheep-Grazing	0.0500	0.9990				No	12	
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-U:Depleted	Fence	0.0100					No	12	
Aspen Woodland	ASP-U:Depleted	Aspen Woodland	ASP-U:Depleted	RxFire	0.0100	0.3000				No	12	
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-A:All	ReplacementFire	0.0200	0.1000				Yes		
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-A:All	RxFire	0.0100	0.0700				Yes	12	
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-B:Open	Cattle+Sheep-Grazing	0.0500	0.0010				Yes	12	
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-B:Open	Chainsaw-Thinning	0.0100	0.0500				Yes	12	
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-B:Open	Drought	0.0056	0.1000				Yes		
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-B:Open	Insect/Disease	0.0033	0.0500				Yes		
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-C:Closed	Cattle+Sheep-Grazing	0.0500	0.0010				Yes	12	
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-C:Closed	Chainsaw-Thinning	0.0100	0.0500				Yes	12	
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-C:Closed	Drought	0.0056	0.1000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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	Montane Sagebrush Steppe	MSS-C:Closed	Insect/Disease	0.0033	0.0500				Yes		
Aspen Woodland	ASP-U:Depleted	Montane Sagebrush Steppe	MSS-C:Closed	LosingClone	0.1000		250			Yes		
Aspen-Mixed Conifer	1-Early:All	Aspen-Mixed Conifer	1-Early:All	Fence	0.0100					No	12	
Aspen-Mixed Conifer	1-Early:All	Aspen-Mixed Conifer	1-Early:All	Wild-Horse-Grazing	0.0100	0.9990			2	Yes		
Aspen-Mixed Conifer	1-Early:All	Aspen-Mixed Conifer	1-Early:All	Cattle+Sheep-Grazing	0.0500	0.9900	3		1	No	12	
Aspen-Mixed Conifer	1-Early:All	Aspen-Mixed Conifer	1-Early:All	NativeGrazing	0.0020	0.0500				Yes		
Aspen-Mixed Conifer	1-Early:All	Aspen-Mixed Conifer	1-Early:All	NativeGrazing	0.0020	0.9500				Yes		
Aspen-Mixed Conifer	1-Early:All	Mixed Conifer	MC-A:All	Cattle+Sheep-Grazing	0.0500	0.0100	3			No	12	
Aspen-Mixed Conifer	1-Early:All	Mixed Conifer	MC-A:All	Wild-Horse-Grazing	0.0100	0.0010				Yes		
Aspen-Mixed Conifer	2-Mid:Closed	Aspen-Mixed Conifer	1-Early:All	ReplacementFire	0.0010	1.0000				Yes		
Aspen-Mixed Conifer	2-Mid:Closed	Aspen-Mixed Conifer	2-Mid:Closed	Cattle+Sheep-Grazing	0.0500	0.0010			1	No	12	
Aspen-Mixed Conifer	2-Mid:Closed	Aspen-Mixed Conifer	2-Mid:Closed	Cattle+Sheep-Grazing	0.0500	0.9990				No	12	
Aspen-Mixed Conifer	4-Late:Closed	Aspen-Mixed Conifer	4-Late:Closed	Cattle+Sheep-Grazing	0.0500	0.0010			1	No	12	
Aspen-Mixed Conifer	4-Late:Closed	Aspen-Mixed Conifer	4-Late:Closed	Cattle+Sheep-Grazing	0.0500	0.9990				No	12	
Aspen-Mixed Conifer	4-Late:Closed	Aspen-Mixed Conifer	1-Early:All	Insect/Disease	0.0050	0.2000				Yes		
Aspen-Mixed Conifer	4-Late:Closed	Aspen-Mixed Conifer	1-Early:All	MixedFire	0.0200	0.2500				Yes		
Aspen-Mixed Conifer	4-Late:Closed	Aspen-Mixed Conifer	2-Mid:Closed	Insect/Disease	0.0050	0.8000			-1	No		
Aspen-Mixed Conifer	4-Late:Closed	Aspen-Mixed Conifer	4-Late:Closed	MixedFire	0.0200	0.7500				Yes		
Aspen-Mixed Conifer	5-Late:Open	Aspen-Mixed Conifer	5-Late:Open	Insect/Disease	0.0050	1.0000	80	99	1	No		
Aspen-Mixed Conifer	5-Late:Open	Aspen-Mixed Conifer	1-Early:All	ReplacementFire	0.0219	1.0000	80	99		Yes		
Aspen-Mixed Conifer	5-Late:Open	Aspen-Mixed Conifer	1-Early:All	RxFire	0.0100	0.7000	80	99		Yes		
Aspen-Mixed Conifer	5-Late:Open	Aspen-Mixed Conifer	4-Late:Closed	Chainsaw-Thinning	0.0100	1.0000	80	99		Yes		
Aspen-Mixed Conifer	5-Late:Open	Aspen-Mixed Conifer	4-Late:Closed	MixedFire	0.0024	1.0000	80	99		Yes		
Aspen-Mixed Conifer	5-Late:Open	Aspen-Mixed Conifer	5-Late:Open	RxFire	0.0100	0.3000	80	99		No		
Aspen-Mixed Conifer	6-Late:Closed	Aspen-Mixed Conifer	1-Early:All	Chainsaw-Thinning	0.0100	0.1000	150			Yes		
Aspen-Mixed Conifer	6-Late:Closed	Aspen-Mixed Conifer	1-Early:All	ReplacementFire	0.0166	1.0000	100			Yes		
Aspen-Mixed Conifer	6-Late:Closed	Aspen-Mixed Conifer	1-Early:All	RxFire	0.0100	0.7000	100			Yes		
Aspen-Mixed Conifer	6-Late:Closed	Aspen-Mixed Conifer	4-Late:Closed	Chainsaw-Thinning	0.0100	0.9000	150			Yes		
Aspen-Mixed Conifer	6-Late:Closed	Aspen-Mixed Conifer	5-Late:Open	Insect/Disease	0.0056	1.0000	100			Yes		
Aspen-Mixed Conifer	6-Late:Closed	Aspen-Mixed Conifer	6-Late:Closed	RxFire	0.0100	0.3000	100			No		
Aspen-Mixed Conifer	6-Late:Closed	Mixed Conifer	MC-E:Closed	LosingClone	0.1000	1.0000	250			Yes		
Basin Wildrye	BW-A:Open	Basin Wildrye	BW-A:Open	Cattle+Sheep-Grazing	0.0400	0.9900	2	9	1	No		
Basin Wildrye	BW-A:Open	Basin Wildrye	BW-A:Open	ReplacementFire	0.0200	1.0000		9		Yes		
Basin Wildrye	BW-A:Open	Basin Wildrye	BW-A:Open	Weed-Inventory+Treat	0.0100	1.0000		9		No	3	
Basin Wildrye	BW-A:Open	Basin Wildrye	BW-U:Early-Shrub	Cattle+Sheep-Grazing	0.0400	0.0100	2	9		No		
Basin Wildrye	BW-A:Open	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0010	1.0000	5	9		Yes	5	
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-A:Open	ReplacementFire	0.0250					Yes		
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-B:Closed	Cattle+Sheep-Grazing	0.0400	0.9950			1	No		
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-B:Closed	Drought	0.0056					Yes		
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-B:Closed	Weed-Inventory+Treat	0.0100					No	3	
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-U:Early-Shrub	Cattle+Sheep-Grazing	0.0400	0.0050				No		
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0010					Yes	5	
Basin Wildrye	BW-B:Closed	Basin Wildrye	BW-U:SAP	2xChaining+Seed	0.0100					No		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-A:Open	Masticate+Native-Seed	0.0100	0.9500	75			Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-A:Open	Thin	0.0100					Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:Early-Shrub	Masticate+Native-Seed	0.0100	0.0500	75			Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-A:Open	ReplacementFire	0.0150		75			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-A:Open	RxFire	0.0100		75			Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-B:Closed	Drought	0.0056	0.1000	75			Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-C:Open	Cattle+Sheep-Grazing	0.0400	0.9950	75		1	No		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-C:Open	Drought	0.0056	0.9000	75			Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-C:Open	Small-Tree-Lopping	0.0100		100			Yes		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-C:Open	Weed-Inventory+Treat	0.0100		75			No	3	
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:Depleted	Cattle+Sheep-Grazing	0.0400	0.0050	75			No		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0010		75			Yes	5	
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:SAP	AG-Invasion	0.0020		75			No		
Basin Wildrye	BW-C:Open	Basin Wildrye	BW-U:TEA	Tree-Encroachment	0.0200		150			Yes		
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:Annual Grass	Chaining+Native-Seed	0.0100	0.2000			3	Yes		
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.0500			3	Yes		
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:SDI	Chaining+Plateau+Seed	0.0100	0.9000			3	Yes		
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:SDI+AG	Chaining+Plateau+Seed	0.0100	0.0500			3	Yes		
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:SDI+AG	Herbicide-Plateau+Seed	0.0100	0.1000			3	Yes		
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:Seeded Native	Chaining+Native-Seed	0.0100	0.8000			3	Yes		
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:Annual Grass	Herbicide-Plateau+Seed	0.0100	0.1000			3	Yes		
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:Annual Grass	Weed-Inventory+Treat	0.0100	1.0000				No	3	
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0010	1.0000				Yes	5	
Basin Wildrye	BW-U:Annual Grass	Basin Wildrye	BW-U:SDI	Herbicide-Plateau+Seed	0.0100	0.8000			3	Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Depleted	Small-Tree-Lopping	0.0100		75			Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Early-Shrub	Spyke+Native-Seed	0.0100	0.2000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Early-Shrub	Thin+Native-Seed	0.0100	0.1000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.9000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Seeded Native	Spyke+Native-Seed	0.0100	0.8000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Seeded Native	Thin+Native-Seed	0.0100	0.9000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Depleted	Drought	0.0056	0.9000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Depleted	Weed-Inventory+Treat	0.0100					No	3	
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Early-Shrub	Drought	0.0056	0.1000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Early-Shrub	Masticate+Native-Seed	0.0100	0.2000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Early-Shrub	ReplacementFire	0.0100					Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0010					Yes	5	
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:SAP	AG-Invasion	0.0020					No		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:Seeded Native	Masticate+Native-Seed	0.0100	0.8000				Yes		
Basin Wildrye	BW-U:Depleted	Basin Wildrye	BW-U:TEA	Tree-Invasion	0.0080		75			Yes		
Basin Wildrye	BW-U:Early-Shrub	Basin Wildrye	BW-U:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Basin Wildrye	BW-U:Early-Shrub	Basin Wildrye	BW-U:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.8000				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	0.0100	0.3000				Yes		
Basin Wildrye	BW-U:Early-Shrub	Basin Wildrye	BW-U:SAP	AG-Invasion	0.0010					No		
Basin Wildrye	BW-U:Early-Shrub	Basin Wildrye	BW-U:Seeded Native	Thin+Herbicide+Native-Seed	0.0100	0.7000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Early-Shrub	Basin Wildrye	BW-U:TEA	Tree-Invasion	0.0080		100			Yes		
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-U:Seeded Native	Exotic-Control+Native-Seed	0.0100	0.6000	10			Yes		20
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-A:Open	Exotic-Control+Native-Seed	0.0100	0.6000		9		Yes		20
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-U:Exotic Forb	Cattle+Sheep-Grazing	0.0400		3		1	No		
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-U:Exotic Forb	Exotic-Control+Native-Seed	0.0100	0.4000				Yes		20
Basin Wildrye	BW-U:Exotic Forb	Basin Wildrye	BW-U:Exotic Forb	ReplacementFire	0.0200	1.0000				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Small-Tree-Lopping	0.0100		100			Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.8000				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SDI+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000						
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-A:Open	ReplacementFire	0.0150	0.0500				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Annual Grass	ReplacementFire	0.0150	0.9500				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Early-Shrub	Masticate+Herbicide+Native-Seed	0.0100	0.1000	75			Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0010					Yes	5	
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Drought	0.0056	0.9000				Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Masticate+Herbicide+Native-Seed	0.0100	0.1000	75			Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:SAP	Weed-Inventory+Treat	0.0100					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	0.0100	0.8000	75			Yes		
Basin Wildrye	BW-U:SAP	Basin Wildrye	BW-U:TEA	Tree-Invasion	0.0080		100			Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP+	Small-Tree-Lopping	0.0100		100			Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.8000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SDI+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SDI+AG	Masticate+Herbicide+Seed	0.0100	0.1000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Grass	Cattle+Sheep-Grazing	0.0400	0.0050				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Grass	Masticate+Herbicide+Seed	0.0100	0.1000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Annual Grass	ReplacementFire	0.0250					Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0010					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	0.0400	0.9950			1	No		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP+	Drought	0.0056	0.9000				No		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:SAP+	Weed-Inventory+Treat	0.0100					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:SDI	Masticate+Herbicide+Seed	0.0100	0.8000				Yes		
Basin Wildrye	BW-U:SAP+	Basin Wildrye	BW-U:TEA	Tree-Invasion	0.0080		100			Yes		
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050				Yes		
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-U:SDI	Forb+Grass-Native-Seeding	0.0100					No		
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-U:SDI	Thin	0.0100		74			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SDI	Basin Wildrye	BW-U:SDI	Wild-Horse-Grazing	0.0100	0.9950			1	No		
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-A:Open	Natural-Recovery	0.0001	1.0000	5	9		No	10	
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-B:Closed	Natural-Recovery	0.0010	1.0000	10	74		No	10	
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-C:Open	Natural-Recovery	0.0100	1.0000	75			No	10	
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0010	1.0000	5			No	5	
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-U:SDI	Cattle+Sheep-Grazing	0.0400	0.0050	3			Yes		
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-U:SDI	Cattle+Sheep-Grazing	0.0400	0.9950	3		1	No		
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-U:SDI	ReplacementFire	0.0050	1.0000				Yes		
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-U:SDI	Weed-Inventory+Treat	0.0100	1.0000				No	3	
Basin Wildrye	BW-U:SDI	Basin Wildrye	BW-U:SDI+AG	AG-Invasion	0.0010	1.0000				No		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000	74					
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000	74			Yes		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	Forb+Grass-Native-Seeding	0.0100					No		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	Thin	0.0100		74			Yes		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	WaterWithdrawal	0.0020	0.9990			1	No		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	Wild-Horse-Grazing	0.0100				1	No		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:Exotic Forb	Exotic-Invasion	0.0010					No	5	
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI	Competition	0.2000		75			No	3	
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI	Competition	0.3000		10	74		No	3	
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI	Competition	0.3300			9		Yes	3	
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI	Masticate+Herbicide+Seed	0.0100	0.9500	75			Yes		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	Cattle+Sheep-Grazing	0.0400		3		1	No		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	Masticate+Herbicide+Seed	0.0100	0.0500	75			Yes		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	ReplacementFire	0.0050					Yes		
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	Weed-Inventory+Treat	0.0100					No	3	
Basin Wildrye	BW-U:SDI+AG	Basin Wildrye	BW-U:SDI+AG	Wet-Year	0.1000					No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-A:Open	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 Grass	AG-Invasion	0.0010	1.0000		74		No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Early-Shrub	Cattle+Sheep-Grazing	0.0400		3	5		No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Early-Shrub	Cattle+Sheep-Grazing	0.0400	0.0050	6			No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Early-Shrub	Wild-Horse-Grazing	0.0100			5		No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050	6			No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:SAP	AG-Invasion	0.0050	1.0000	75			No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:SAP+	Cattle+Sheep-Grazing	0.0400	0.9950	6		1	No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Seeded Native	Drought	0.0056	0.1000				No		
Basin Wildrye	BW-U:Seeded Native	Basin Wildrye	BW-U:Seeded Native	Drought	0.0056	0.9000				Yes		
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	Wild-Horse-Grazing	0.0100	0.9950	6		1	No		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Annual Grass	Drought	0.0056	0.0500	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Annual Grass	Masticate+Herbicide+Native-Seed	0.0100	0.1000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Annual Grass	Masticate+Herbicide+Seed	0.0100	0.1000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Annual Grass	ReplacementFire	0.0080	0.5000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Early-Shrub	Drought	0.0056	0.0500	75			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:TEA	Basin Wildrye	BW-U:Early-Shrub	Masticate+Herbicide+Native-Seed	0.0100	0.1000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Early-Shrub	ReplacementFire	0.0080	0.5000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:SDI	Masticate+Herbicide+Seed	0.0100	0.8000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:SDI+AG	Masticate+Herbicide+Seed	0.0100	0.1000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:Seeded Native	Masticate+Herbicide+Native-Seed	0.0100	0.8000	75			Yes		
Basin Wildrye	BW-U:TEA	Basin Wildrye	BW-U:TEA	Drought	0.0056	0.9000	75			Yes		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-A:All	Cattle+Sheep-Grazing	0.0200	0.9900	3	9	1	No		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-A:All	ReplacementFire	0.0020	1.0000		9		Yes		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-U:Annual Grass	AG-Invasion	0.0050	1.0000		9		No		
Big Sagebrush semi-desert	BSsd-A:All	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Cattle+Sheep-Grazing	0.0200	0.0100	3	9		No		
Big Sagebrush semi-desert	BSsd-B:Closed	Big Sagebrush semi-desert	BSsd-A:All	Drought	0.0056	0.1000	10	39		Yes		
Big Sagebrush semi-desert	BSsd-B:Closed	Big Sagebrush semi-desert	BSsd-A:All	ReplacementFire	0.0083	1.0000	10	39		Yes		
Big Sagebrush semi-desert	BSsd-B:Closed	Big Sagebrush semi-desert	BSsd-B:Closed	Cattle+Sheep-Grazing	0.0200	0.9990	10	39	1	No		
Big Sagebrush semi-desert	BSsd-B:Closed	Big Sagebrush semi-desert	BSsd-B:Closed	Drought	0.0056	0.9000	10	39		Yes		
Big Sagebrush semi-desert	BSsd-B:Closed	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Cattle+Sheep-Grazing	0.0200	0.0010	10	39		No		
Big Sagebrush semi-desert	BSsd-B:Closed	Big Sagebrush semi-desert	BSsd-U:SAP	AG-Invasion	0.0050	1.0000	10	39		No		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-A:All	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					Yes		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-A:All	ReplacementFire	0.0083					Yes		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-A:All	Spyke	0.0100					Yes		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-A:All	Thin	0.0100					Yes		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-A:All	Thin+Herbicide+Native-Seed	0.0100					Yes		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-A:All	Thin+Native-Seed	0.0100					Yes		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-B:Closed	Drought	0.0056	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-C:Open	Cattle+Sheep-Grazing	0.0200	0.9990			1	No		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-C:Open	Drought	0.0056	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-U:Depleted	Cattle+Sheep-Grazing	0.0200	0.0010				No		
Big Sagebrush semi-desert	BSsd-C:Open	Big Sagebrush semi-desert	BSsd-U:SAP	AG-Invasion	0.0050					No		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Cattle+Sheep-Grazing	0.0200		3		1	No		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Chaining+Native-Seed	0.0100	0.5000		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.1000		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Herbicide-Plateau+Seed	0.0100	0.1500		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:Annual Grass	ReplacementFire	0.1000	1.0000		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:SDI-A	Chaining+Plateau+Seed	0.0100	0.7500		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.7000		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Chaining+Native-Seed	0.0100	0.5000		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Chaining+Plateau+Seed	0.0100	0.1500		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Annual Grass	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Herbicide-Plateau+Seed	0.0100	0.1500		3		Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Depleted	Drought	0.0056	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	2xChaining+Native-Seed	0.0100	0.2000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.4000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Drought	0.0056	0.1000				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	Spyke+Native-Seed	0.0100	0.4000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Thin+Native-Seed	0.0100	0.2000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:SA	AG-Invasion	0.0050					No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Depleted	Big Sagebrush semi-desert	BSsd-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Seeded Native	2xChaining+Native-Seed	0.0100	0.8000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Chaining+Native-Seed	0.0100	0.6000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Spyke+Native-Seed	0.0100	0.6000				Yes		
Big Sagebrush semi-desert	BSsd-U:Depleted	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Thin+Native-Seed	0.0100	0.8000				Yes		
Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.4000				Yes		
Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Big Sagebrush semi-desert	BSsd-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				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:SA	Big Sagebrush semi-desert	BSsd-C:Open	2xChaining+Plateau+Seed	0.0100	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:Annual Grass	ReplacementFire	0.0100	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SA	Cattle+Sheep-Grazing	0.0200				1	No		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SA	Drought	0.0056	0.9000			1	Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SDI-A	2xChaining+Plateau+Seed	0.0100	0.8000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	2xChaining+Plateau+Seed	0.0100	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				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 Grass	2xChaining+Plateau+Seed	0.0100	0.1500				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:Annual Grass	ReplacementFire	0.0150					Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SA+	Cattle+Sheep-Grazing	0.0200				1	No		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SA+	Drought	0.0056	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SDI-A	2xChaining+Plateau+Seed	0.0100	0.7000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	2xChaining+Plateau+Seed	0.0100	0.1500				Yes		
Big Sagebrush semi-desert	BSsd-U:SA+	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				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 Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SA	Cattle+Sheep-Grazing	0.0200	0.0010				No		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SAP	Cattle+Sheep-Grazing	0.0200	0.9990			1	No		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:Annual Grass	ReplacementFire	0.0100	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP	Big Sagebrush semi-desert	BSsd-U:SAP	Drought	0.0056	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 Grass	2xChaining+Plateau+Seed	0.0100	0.1500				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SDI-A	2xChaining+Plateau+Seed	0.0100	0.7000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	2xChaining+Plateau+Seed	0.0100	0.1500				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:Annual Grass	ReplacementFire	0.0150	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SA+	Cattle+Sheep-Grazing	0.0200	0.0010				No		
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+	Cattle+Sheep-Grazing	0.0200	0.9990				1	No	
Big Sagebrush semi-desert	BSsd-U:SAP+	Big Sagebrush semi-desert	BSsd-U:SAP+	Drought	0.0056	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:SDI-A	Big Sagebrush semi-desert	BSsd-A:All	Natural-Recovery	0.0001	1.0000	5	9		No	10	
Big Sagebrush semi-desert	BSsd-U:SDI-A	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Cattle+Sheep-Grazing	0.0200	0.0050	3	9		Yes		
Big Sagebrush semi-desert	BSsd-U:SDI-A	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050				No		
Big Sagebrush semi-desert	BSsd-U:SDI-A	Big Sagebrush semi-desert	BSsd-U:SDI-A	Cattle+Sheep-Grazing	0.0200	0.9950	3	9	1	No		
Big Sagebrush semi-desert	BSsd-U:SDI-A	Big Sagebrush semi-desert	BSsd-U:SDI-A	Drought	0.0056	0.1000				9	Yes	
Big Sagebrush semi-desert	BSsd-U:SDI-A	Big Sagebrush semi-desert	BSsd-U:SDI-A	Drought	0.0056	0.9000				9	-1	No
Big Sagebrush semi-desert	BSsd-U:SDI-A	Big Sagebrush semi-desert	BSsd-U:SDI-A	Forb+Grass-Native-Seeding	0.0100						No	
Big Sagebrush semi-desert	BSsd-U:SDI-A	Big Sagebrush semi-desert	BSsd-U:SDI-A	ReplacementFire	0.0020					9	Yes	
Big Sagebrush semi-desert	BSsd-U:SDI-A	Big Sagebrush semi-desert	BSsd-U:SDI-A	Wild-Horse-Grazing	0.0100	0.9950				1	No	
Big Sagebrush semi-desert	BSsd-U:SDI-A	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	AG-Invasion	0.0050	1.0000				9	No	
Big Sagebrush semi-desert	BSsd-U:SDI-B	Big Sagebrush semi-desert	BSsd-B:Closed	Natural-Recovery	0.0010	1.0000	9	39		No	10	
Big Sagebrush semi-desert	BSsd-U:SDI-B	Big Sagebrush semi-desert	BSsd-U:SDI-A	Drought	0.0056	0.1000	9	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SDI-B	Big Sagebrush semi-desert	BSsd-U:SDI-A	ReplacementFire	0.0020		9	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SDI-B	Big Sagebrush semi-desert	BSsd-U:SDI-B	Cattle+Sheep-Grazing	0.0200		9	39	1	No		
Big Sagebrush semi-desert	BSsd-U:SDI-B	Big Sagebrush semi-desert	BSsd-U:SDI-B	Drought	0.0056	0.9000	9	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SDI-B	Big Sagebrush semi-desert	BSsd-U:SDI-B	Forb+Grass-Native-Seeding	0.0100						No	
Big Sagebrush semi-desert	BSsd-U:SDI-B	Big Sagebrush semi-desert	BSsd-U:SDI-B	Wild-Horse-Grazing	0.0100		9	39	1	No		
Big Sagebrush semi-desert	BSsd-U:SDI-B	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	AG-Invasion	0.0050	1.0000	9	39		No		
Big Sagebrush semi-desert	BSsd-U:SDI-C	Big Sagebrush semi-desert	BSsd-C:Open	Natural-Recovery	0.0100	1.0000				No	10	
Big Sagebrush semi-desert	BSsd-U:SDI-C	Big Sagebrush semi-desert	BSsd-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100					Yes		
Big Sagebrush semi-desert	BSsd-U:SDI-C	Big Sagebrush semi-desert	BSsd-U:SDI-A	ReplacementFire	0.0020	1.0000				Yes		
Big Sagebrush semi-desert	BSsd-U:SDI-C	Big Sagebrush semi-desert	BSsd-U:SDI-A	Thin	0.0100					Yes		
Big Sagebrush semi-desert	BSsd-U:SDI-C	Big Sagebrush semi-desert	BSsd-U:SDI-B	Drought	0.0056	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SDI-C	Big Sagebrush semi-desert	BSsd-U:SDI-C	Cattle+Sheep-Grazing	0.0200					1	No	
Big Sagebrush semi-desert	BSsd-U:SDI-C	Big Sagebrush semi-desert	BSsd-U:SDI-C	Drought	0.0056	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:SDI-C	Big Sagebrush semi-desert	BSsd-U:SDI-C	Forb+Grass-Native-Seeding	0.0100					No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SDI-C	Big Sagebrush semi-desert	BSsd-U:SDI-C	Wild-Horse-Grazing	0.0100				1	No		
Big Sagebrush semi-desert	BSsd-U:SDI-C	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	AG-Invasion	0.5000	0.1590				No		
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:Closed	Natural-Recovery	0.3300	1.0000	10	39		No	5	
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-C:Open	Natural-Recovery	0.3300	1.0000	40			No	5	
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Cattle+Sheep-Grazing	0.0200	0.0500	3			Yes		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Drought	0.0056	0.1000				No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Wild-Horse-Grazing	0.0100			5		No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050	6			No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:SAP	AG-Invasion	0.0050	1.0000				No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Cattle+Sheep-Grazing	0.0200	0.9500	3		1	No		
Big Sagebrush semi-desert	BSsd-U:Seeded Native	Big Sagebrush semi-desert	BSsd-U:Seeded Native	Drought	0.0056	0.9000			-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	Wild-Horse-Grazing	0.0100	0.9950	6		1	No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Cattle+Sheep-Grazing	0.0200	0.0010	3	9		No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0050		9		No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SDI-A	Competition	0.3330	1.0000		9		No	3	
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Cattle+Sheep-Grazing	0.0200	0.9990	3	9	1	No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Drought	0.0056	0.1000		9		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Drought	0.0056	0.9000		9	-1	No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Forb+Grass-Native-Seeding	0.0100					No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	ReplacementFire	0.0050	1.0000		9		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Wet-Year	0.1000	1.0000		9		No		
Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Wild-Horse-Grazing	0.0100	0.9950		9	1	No		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SDI-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-A+AG	Drought	0.0056	0.1000	10	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	ReplacementFire	0.0050	1.0000	10	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Cattle+Sheep-Grazing	0.0200		10	39	1	No		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Drought	0.0056	0.9000	10	39		Yes		
Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Forb+Grass-Native-Seeding	0.0100					No		
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	0.0100		10	39	1	No		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SDI-C	Competition	0.2000	1.0000				No	3	
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-A+AG	Thin	0.0100					Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-B+AG	Drought	0.0056	0.1000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Drought	0.0056	0.9000				Yes		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Forb+Grass-Native-Seeding	0.0100					No		
Big Sagebrush semi-desert	BSsd-U:SI-C+AG	Big Sagebrush semi-desert	BSsd-U:SI-C+AG	ReplacementFire	0.0050	1.0000				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	0.0100				1	No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-A:All	Cattle+Sheep-Grazing	0.0300	0.9900	3	24	1	No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-A:All	Drought	0.0056	1.0000		24	-1	No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-A:All	ReplacementFire	0.0040	1.0000		24		Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-A:All	Black Sagebrush	BS-U:Annual Grass	AG-Invasion	0.0001	1.0000		9		No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0100	3	24		No		
Black Sagebrush	BS-A:All	Black Sagebrush	BS-U:SAP	AG-Invasion	0.0010	1.0000	10	24		No		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-B:Open	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-B:Open	Thin	0.0100					Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-A:All	Drought	0.0056	0.1000				Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-A:All	ReplacementFire	0.0067					Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-B:Open	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-B:Open	Drought	0.0056	0.9000				Yes		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-U:Depleted	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Black Sagebrush	BS-B:Open	Black Sagebrush	BS-U:SAP	AG-Invasion	0.0050					No		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-A:All	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-A:All	Thin	0.0100					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	Drought	0.0056	0.1000				Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-C:Closed	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-C:Closed	Drought	0.0056	0.9000				Yes		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-C:Closed	Small-Tree-Lopping	0.0100					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:Depleted	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Black Sagebrush	BS-C:Closed	Black Sagebrush	BS-U:SAP	AG-Invasion	0.0050					No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-B:Open	Chaining+Native-Seed	0.0100	0.7000				Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:Early-Shrub	Chaining+Native-Seed	0.0100	0.3000				Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:TEA	Tree-Encroachment	0.0200	1.0000	250			No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-A:All	Masticate+Native-Seed	0.0100	0.2000	121			Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-A:All	ReplacementFire	0.0067	1.0000	121			Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-B:Open	Masticate+Native-Seed	0.0100	0.8000	121			Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-C:Closed	Chainsaw-Thinning	0.0100	1.0000	121			Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-C:Closed	Drought	0.0056	0.1000	121			Yes		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-D:Open	Cattle+Sheep-Grazing	0.0300	0.9990	121		2	No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-D:Open	Drought	0.0056	0.9000	121		5	No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:TEA	AG-Invasion	0.0050	1.0000	121			No		
Black Sagebrush	BS-D:Open	Black Sagebrush	BS-U:TEA	Cattle+Sheep-Grazing	0.0300	0.0010	121			No		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:Annual Grass	Chaining+Native-Seed	0.0100	0.5000		3		Yes		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:Annual Grass	Herbicide-Plateau+Seed	0.0100	0.1000		3		Yes		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.8000		3		Yes		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:Seeded Native	Chaining+Native-Seed	0.0100	0.5000		3		Yes		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:SI-A+AG	Herbicide-Plateau+Seed	0.0100	0.1000		3		Yes		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:Annual Grass	Cattle+Sheep-Grazing	0.0300		3		1	No		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.1500		3		Yes		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:SDI-A	Chaining+Plateau+Seed	0.0100	0.7000		3		Yes		
Black Sagebrush	BS-U:Annual Grass	Black Sagebrush	BS-U:SI-A+AG	Chaining+Plateau+Seed	0.0100	0.1500		3		Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Depleted	2xChaining+Native-Seed	0.0100	0.1000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Depleted	Chaining+Native-Seed	0.0100	0.4000						
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Depleted	Spyke+Native-Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	2xChaining+Native-Seed	0.0100	0.1000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.3000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	Spyke+Native-Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	Thin+Native-Seed	0.0100	0.3000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:SDI-A	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Seeded Native	2xChaining+Native-Seed	0.0100	0.8000						
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Seeded Native	Chaining+Native-Seed	0.0100	0.6000						
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Depleted	Drought	0.0056	0.9000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Depleted	Small-Tree-Lopping	0.0100		120			Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Early-Shrub	Drought	0.0056	0.1000				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:SA	AG-Invasion	0.0050					No		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Seeded Native	Spyke+Native-Seed	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:Depleted	Black Sagebrush	BS-U:Seeded Native	Thin+Native-Seed	0.0100	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:Early-Shrub	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.3000				Yes		
Black Sagebrush	BS-U:Early-Shrub	Black Sagebrush	BS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:Early-Shrub	Black Sagebrush	BS-U:Early-Shrub	ReplacementFire	0.0067					Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SI-A+AG	Chaining+Plateau+Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:Annual Grass	ReplacementFire	0.0100					Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SA	Cattle+Sheep-Grazing	0.0300				1	No		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SA	Drought	0.0056	0.9000				Yes		
Black Sagebrush	BS-U:SA	Black Sagebrush	BS-U:SA	Small-Tree-Lopping	0.0100		120			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:SDI-A	Chaining+Plateau+Seed	0.0100	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 Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.2000				Yes		
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+	Hypo-Hatchet-Spyke	0.0100	0.1000	150			No		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Hypo-Hatchet-Spyke	0.0100	0.9000	150			Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Mastication	0.0100		150			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SA+	Wet-Year	0.1000					No		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SDI-A	Chaining+Plateau+Seed	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SI-A+AG	Chaining+Plateau+Seed	0.0100	0.1000				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:Annual Grass	ReplacementFire	0.0150					Yes		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Drought	0.0056	0.9000			-1	No		
Black Sagebrush	BS-U:SA+	Black Sagebrush	BS-U:SA+	Small-Tree-Lopping	0.0100		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-A:All	Drought	0.0056	0.0100				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Annual Grass	Chaining+Plateau+Seed	0.0000	0.1500				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Hypo-Hatchet-Spyke	0.0100	0.1000	120			No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Hypo-Hatchet-Spyke	0.0100	0.9000	120		11	Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SDI-A	Chaining+Plateau+Seed	0.0000	0.7000				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SI-A+AG	Chaining+Plateau+Seed	0.0000	0.1500				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Annual Grass	Drought	0.0056	0.0900				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:Annual Grass	ReplacementFire	0.0100					Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SA	Cattle+Sheep-Grazing	0.0300	0.0010	50		1	No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Cattle+Sheep-Grazing	0.0300	0.0010		49	3	No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Cattle+Sheep-Grazing	0.0300	0.9990	10		1	No		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Drought	0.0056	0.9000				Yes		
Black Sagebrush	BS-U:SAP	Black Sagebrush	BS-U:SAP	Small-Tree-Lopping	0.0100		120			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:TEA	Tree-Invasion	0.0050		120			Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
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+	Hypo-Hatchet-Spyke	0.0100	0.1000	150			No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Hypo-Hatchet-Spyke	0.0100	0.9000	150			Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Mastication	0.0100	0.2000	150			No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Mastication	0.0100	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:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:Annual Grass	ReplacementFire	0.0150					Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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+	Black Sagebrush	BS-U:SA+	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SA+	Cattle+Sheep-Grazing	0.0300	0.9990	50			No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Cattle+Sheep-Grazing	0.0300	0.9990		49	1	No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Drought	0.0056	0.9000			-1	No		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:SAP+	Small-Tree-Lopping	0.0100		120			Yes		
Black Sagebrush	BS-U:SAP+	Black Sagebrush	BS-U:TEA	Tree-Invasion	0.0050		120			Yes		
Black Sagebrush	BS-U:SDI-A	Black Sagebrush	BS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010				No		
Black Sagebrush	BS-U:SDI-A	Black Sagebrush	BS-U:SDI-A	Forb+Grass-Native-Seeding	0.0100					No	5	
Black Sagebrush	BS-U:SDI-A	Black Sagebrush	BS-U:SDI-A	Wild-Horse-Grazing	0.0100	0.9990			1	No		
Black Sagebrush	BS-U:SDI-A	Black Sagebrush	BS-A:All	Natural-Recovery	0.0001	1.0000	5			No	10	
Black Sagebrush	BS-U:SDI-A	Black Sagebrush	BS-U:SDI-A	Cattle+Sheep-Grazing	0.0300	0.0500	3			Yes		
Black Sagebrush	BS-U:SDI-A	Black Sagebrush	BS-U:SDI-A	Cattle+Sheep-Grazing	0.0300	0.9500	3		1	No		
Black Sagebrush	BS-U:SDI-A	Black Sagebrush	BS-U:SDI-A	Drought	0.0056	1.0000			-1	No		
Black Sagebrush	BS-U:SDI-A	Black Sagebrush	BS-U:SDI-A	ReplacementFire	0.0010	1.0000				Yes		
Black Sagebrush	BS-U:SDI-A	Black Sagebrush	BS-U:SI-A+AG	AG-Invasion	0.0010	1.0000				No		
Black Sagebrush	BS-U:SDI-B	Black Sagebrush	BS-U:SDI-B	Forb+Grass-Native-Seeding	0.0100					No	5	
Black Sagebrush	BS-U:SDI-B	Black Sagebrush	BS-U:SDI-B	Wild-Horse-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:SDI-B	Black Sagebrush	BS-B:Open	Natural-Recovery	0.0010					No	10	
Black Sagebrush	BS-U:SDI-B	Black Sagebrush	BS-U:SDI-A	ReplacementFire	0.0010					Yes		
Black Sagebrush	BS-U:SDI-B	Black Sagebrush	BS-U:SDI-B	Cattle+Sheep-Grazing	0.0300				1	No		
Black Sagebrush	BS-U:SDI-B	Black Sagebrush	BS-U:SDI-B	Drought	0.0056				-1	No		
Black Sagebrush	BS-U:SDI-B	Black Sagebrush	BS-U:SI-B+AG	AG-Invasion	0.0010					No		
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-U:SDI-A	Thin	0.0100					Yes		
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-U:SDI-C	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100					Yes		
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-U:SDI-C	Forb+Grass-Native-Seeding	0.0100					No	5	
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-U:SDI-C	Wild-Horse-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-C:Closed	Natural-Recovery	0.0100					No	10	
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-U:SDI-A	ReplacementFire	0.0010					Yes		
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-U:SDI-C	Cattle+Sheep-Grazing	0.0300				1	No		
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-U:SDI-C	Drought	0.0056				-1	No		
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-U:SDI-C	Small-Tree-Lopping	0.0100		150			Yes		
Black Sagebrush	BS-U:SDI-C	Black Sagebrush	BS-U:SI-C+AG	AG-Invasion	0.0010					No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Depleted	Wild-Horse-Grazing	0.0100	0.0010	25			No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010	6			No		
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	0.0010	6	24		No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Seeded Native	Cattle+Sheep-Grazing	0.0300	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		1	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 Grass	AG-Invasion	0.0050	1.0000		24		No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300		3	5		No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:SAP	AG-Invasion	0.0050	1.0000	25			No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Seeded Native	Drought	0.0056	1.0000			-1	No		
Black Sagebrush	BS-U:Seeded Native	Black Sagebrush	BS-U:Seeded Native	ReplacementFire	0.0020	1.0000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Annual Grass	Wild-Horse-Grazing	0.0100	0.0010		24		No		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Wild-Horse-Grazing	0.0100	0.9990		24	1	No		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SDI-A	Competition	1.0000	1.0000		24		No	3	
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Cattle+Sheep-Grazing	0.0300	0.0500	3	24		Yes		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Cattle+Sheep-Grazing	0.0300	0.9500	3	24	1	No		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Drought	0.0056	1.0000		24	-1	No		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	ReplacementFire	0.0050	1.0000		24		Yes		
Black Sagebrush	BS-U:SI-A+AG	Black Sagebrush	BS-U:SI-A+AG	Wet-Year	0.1000	1.0000		24		No		
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B+AG	Wild-Horse-Grazing	0.0100		25	119	1	No		
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SDI-B	Competition	1.0000	1.0000	25	119		No	3	
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-A+AG	ReplacementFire	0.0050	1.0000	25	199		Yes		
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B+AG	Cattle+Sheep-Grazing	0.0300		25	119	1	No		
Black Sagebrush	BS-U:SI-B+AG	Black Sagebrush	BS-U:SI-B+AG	Drought	0.0056	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+AG	Black Sagebrush	BS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000				Yes		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-A+AG	Thin	0.0100					Yes		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Wild-Horse-Grazing	0.0100				1	No		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SDI-C	Competition	1.0000	1.0000				No	3	
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-A+AG	ReplacementFire	0.0050	1.0000				Yes		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Cattle+Sheep-Grazing	0.0300				1	No		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Drought	0.0056	1.0000			-1	No		
Black Sagebrush	BS-U:SI-C+AG	Black Sagebrush	BS-U:SI-C+AG	Small-Tree-Lopping	0.0100	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:TEA	Black Sagebrush	BS-U:Annual Grass	2xChaining+Plateau+Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Grass	2xChaining+Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Grass	Masticate+Seed	0.0100	0.2000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Grass	RxFire+Seed+Chain	0.0100	0.1000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SDI-A	2xChaining+Plateau+Seed	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SDI-A	2xChaining+Seed	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SDI-A	Masticate+Seed	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SDI-A	RxFire+Seed+Chain	0.0100	0.5000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	2xChaining+Plateau+Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	2xChaining+Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	Masticate+Herbicide+Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	Masticate+Seed	0.0100	0.2000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:SI-A+AG	RxFire+Seed+Chain	0.0100	0.1000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:TEA	RxFire+Seed+Chain	0.0100	0.3000				No		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Grass	Drought	0.0056	0.0500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Grass	Masticate+Herbicide+Seed	0.0100	0.1500				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Annual Grass	ReplacementFire	0.0067	1.0000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:Early-Shrub	Drought	0.0056	0.0500				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:TEA	Black Sagebrush	BS-U:SDI-A	Masticate+Herbicide+Seed	0.0100	0.7000				Yes		
Black Sagebrush	BS-U:TEA	Black Sagebrush	BS-U:TEA	Drought	0.0056	0.9000				Yes		
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-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	1.0000	60	149		Yes		
Curl-leaf Mountain Mahogany	CMM-C:Closed	Curl-leaf Mountain Mahogany	CMM-D:Open	AlternateBpS-CMM	0.0050	1.0000	60	149		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:TA	AG-Invasion	0.0050	1.0000	60			No		
Curl-leaf Mountain Mahogany	CMM-E:Closed	Curl-leaf Mountain Mahogany	CMM-A:All	ReplacementFire	0.0020	1.0000	150			Yes		
Curl-leaf Mountain Mahogany	CMM-E:Closed	Curl-leaf Mountain Mahogany	CMM-U:TA	AG-Invasion	0.0010	1.0000	150			No		
Curl-leaf Mountain Mahogany	CMM-U:Annual Grass	Curl-leaf Mountain Mahogany	CMM-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Curl-leaf Mountain Mahogany	CMM-U:TA	Curl-leaf Mountain Mahogany	CMM-U:Annual Grass	ReplacementFire	0.0070	1.0000	60			Yes		
Desert Wash	DWA-A:All	Desert Wash	DWA-A:All	Cattle+Sheep-Grazing	0.0200	0.9900	3		1	No		
Desert Wash	DWA-A:All	Desert Wash	DWA-A:All	Flash-Flood	0.0075	1.0000				Yes		
Desert Wash	DWA-A:All	Desert Wash	DWA-A:All	Weed-Inventory+Treat	0.0100	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	0.0200	0.0100	3			No		
Desert Wash	DWA-A:All	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0050	1.0000				Yes	5	
Desert Wash	DWA-A:All	Desert Wash	DWA-U:SAP	AG-Invasion	0.0050	1.0000				No		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-A:All	Flash-Flood	0.0075	1.0000	5	19		Yes		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-A:All	ReplacementFire	0.0010	1.0000	5	19		Yes		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-B:Closed	Cattle+Sheep-Grazing	0.0200	0.9990	5	19	1	No		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-B:Closed	Weed-Inventory+Treat	0.0100	1.0000	5	19		No	3	
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001	5	19		Yes		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:Early-Shrub	Cattle+Sheep-Grazing	0.0200	0.0010	5	19		No		
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0050	1.0000	5	19		Yes	5	
Desert Wash	DWA-B:Closed	Desert Wash	DWA-U:SAP	AG-Invasion	0.0050	1.0000	5	19		No		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-A:All	Flash-Flood	0.0075	1.0000	20			Yes		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-A:All	ReplacementFire	0.0001	1.0000	20			Yes		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-C:Closed	Cattle+Sheep-Grazing	0.0200	0.9990	20		1	No		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-C:Closed	Weed-Inventory+Treat	0.0100	1.0000	20			No	3	
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:Bare Ground	OHV	1.0000	0.0001	20			Yes		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:Early-Shrub	Cattle+Sheep-Grazing	0.0200	0.0010	20			No		
Desert Wash	DWA-C:Closed	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0050	1.0000	20			Yes	5	

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-U:SAP	AG-Invasion	0.0050	1.0000	20			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	0.0100	1.0000				No	3	
Desert Wash	DWA-U:Bare Ground	Desert Wash	DWA-U:Early-Shrub	Alternate-Succession	0.1000	1.0000	20			Yes		
Desert Wash	DWA-U:Bare Ground	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0050	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	0.0100	1.0000				No	3	
Desert Wash	DWA-U:Early-Shrub	Desert Wash	DWA-U:EFT	Exotic-Invasion	0.0050	1.0000				Yes	5	
Desert Wash	DWA-U:EFT	Desert Wash	DWA-A:All	Exotic-Control	0.0100	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	0.0100	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	0.0100	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	0.0100	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	0.0050	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	0.0100	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+	Drought	0.0056	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	0.0050	1.0000				Yes	5	
Desert Wash	DWA-U:SA+	Desert Wash	DWA-U:SA+	Drought	0.0056	0.9000			-1	No		
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+	Weed-Inventory+Treat	0.0100	1.0000				No	3	
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	0.0050	1.0000				Yes	5	
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SA	Cattle+Sheep-Grazing	0.0200	0.0010	3			No		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SAP	Cattle+Sheep-Grazing	0.0200	0.9990	3		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	ReplacementFire	0.0010	1.0000				Yes		
Desert Wash	DWA-U:SAP	Desert Wash	DWA-U:SAP	Weed-Inventory+Treat	0.0100	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:SAP	FineFuelDecomp	0.3300	1.0000				No	2	
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP+	Drought	0.0056	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:Bare Ground	OHV	1.0000	0.0001				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:EFT	Exotic-Invasion	0.0050	1.0000				Yes	5	
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SA+	Cattle+Sheep-Grazing	0.0200	0.0010	3		5	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	0.0200	0.9990	3		1	No		
Desert Wash	DWA-U:SAP+	Desert Wash	DWA-U:SAP+	Drought	0.0056	0.9000			-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+	Weed-Inventory+Treat	0.0100	1.0000				No	3	
Four-Wing Saltbush	FWS-A:Open	Four-Wing Saltbush	FWS-A:Open	Cattle+Sheep-Grazing	0.0100	0.9900	3	5	1	No		
Four-Wing Saltbush	FWS-A:Open	Four-Wing Saltbush	FWS-A:Open	Very-Wet-Year	0.0181	1.0000		5		Yes		
Four-Wing Saltbush	FWS-A:Open	Four-Wing Saltbush	FWS-U:Annual Grass	AG-Invasion	0.0050	1.0000		5		No		
Four-Wing Saltbush	FWS-A:Open	Four-Wing Saltbush	FWS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0100	3	5		Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-A:Open	ReplacementFire	0.0001	1.0000	6	19		Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-B:Open	Cattle+Sheep-Grazing	0.0100	0.9990	6	19	1	No		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-B:Open	Very-Wet-Year	0.0181	1.0000	6	19		Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0010	6	19		Yes		
Four-Wing Saltbush	FWS-B:Open	Four-Wing Saltbush	FWS-U:SAP	AG-Invasion	0.0050	1.0000	6	19		No		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-A:Open	ReplacementFire	0.0010	1.0000	20			Yes		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-A:Open	Very-Wet-Year	0.0181	1.0000	20			Yes		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-C:Closed	Cattle+Sheep-Grazing	0.0100	0.9990	20		1	No		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-U:Depleted	Cattle+Sheep-Grazing	0.0100	0.0010	20			No		
Four-Wing Saltbush	FWS-C:Closed	Four-Wing Saltbush	FWS-U:SAP	AG-Invasion	0.0050	1.0000	20			No		
Four-Wing Saltbush	FWS-U:Annual Grass	Four-Wing Saltbush	FWS-U:Annual Grass	Chaining+Native-Seed	0.0100	0.6000		3		Yes		
Four-Wing Saltbush	FWS-U:Annual Grass	Four-Wing Saltbush	FWS-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.2500		3		Yes		
Four-Wing Saltbush	FWS-U:Annual Grass	Four-Wing Saltbush	FWS-U:Annual Grass	Herbicide-Plateau+Seed	0.0100	0.2500		3		Yes		
Four-Wing Saltbush	FWS-U:Annual Grass	Four-Wing Saltbush	FWS-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Four-Wing Saltbush	FWS-U:Annual Grass	Four-Wing Saltbush	FWS-U:SAP	Alternate-Succession	0.3330	1.0000	9			No	9	
Four-Wing Saltbush	FWS-U:Annual Grass	Four-Wing Saltbush	FWS-U:SDI	Chaining+Plateau+Seed	0.0100	0.5000		3		Yes		
Four-Wing Saltbush	FWS-U:Annual Grass	Four-Wing Saltbush	FWS-U:SDI	Herbicide-Plateau+Seed	0.0100	0.2500		3		Yes		
Four-Wing Saltbush	FWS-U:Annual Grass	Four-Wing Saltbush	FWS-U:SDI+AG	Chaining+Plateau+Seed	0.0100	0.2500		3		Yes		
Four-Wing Saltbush	FWS-U:Annual Grass	Four-Wing Saltbush	FWS-U:Seeded Native	Chaining+Native-Seed	0.0100	0.4000		3		Yes		
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:Depleted	Thin+Native-Seed	0.0100	0.4000	6			Yes		
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:Early-Shrub	Very-Wet-Year	0.0181	1.0000	6			Yes		
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:SAP	AG-Invasion	0.0050	1.0000	6			No		
Four-Wing Saltbush	FWS-U:Depleted	Four-Wing Saltbush	FWS-U:Seeded Native	Thin+Native-Seed	0.0100	0.6000	6			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:SAP	Four-Wing Saltbush	FWS-U:Annual Grass	Cattle+Sheep-Grazing	0.0100	0.0010	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:Annual Grass	ReplacementFire	0.0100	1.0000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:Annual Grass	Thin+Herbicide+Seed	0.0100	0.2000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:Annual Grass	Very-Wet-Year	0.0181	1.0000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:SAP	Cattle+Sheep-Grazing	0.0100	0.9990	6		1	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:SDI	Thin+Herbicide+Seed	0.0100	0.6000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP	Four-Wing Saltbush	FWS-U:SDI+AG	Thin+Herbicide+Seed	0.0100	0.2000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:Annual Grass	Cattle+Sheep-Grazing	0.0100	0.0010	6			Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:Annual Grass	ReplacementFire	0.0150	1.0000	6			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SAP+	Four-Wing Saltbush	FWS-U:Annual Grass	Thin+Herbicide+Seed	0.0100	0.2500	6			Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:Annual Grass	Very-Wet-Year	0.0181	1.0000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:SAP	FineFuelDecomp	0.3300	1.0000	6			No	2	
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:SAP+	Cattle+Sheep-Grazing	0.0100	0.9990	6		1	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:SDI	Thin+Herbicide+Seed	0.0100	0.5000	6			Yes		
Four-Wing Saltbush	FWS-U:SAP+	Four-Wing Saltbush	FWS-U:SDI+AG	Thin+Herbicide+Seed	0.0100	0.2500	6			Yes		
Four-Wing Saltbush	FWS-U:SDI	Four-Wing Saltbush	FWS-B:Open	Natural-Recovery	0.0010	1.0000	6	19		No	10	
Four-Wing Saltbush	FWS-U:SDI	Four-Wing Saltbush	FWS-C:Closed	Natural-Recovery	0.0100	1.0000	20			No	10	
Four-Wing Saltbush	FWS-U:SDI	Four-Wing Saltbush	FWS-U:Depleted	Wild-Horse-Grazing	0.0100		20			No		
Four-Wing Saltbush	FWS-U:SDI	Four-Wing Saltbush	FWS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0010	3			Yes		
Four-Wing Saltbush	FWS-U:SDI	Four-Wing Saltbush	FWS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010		19		No		
Four-Wing Saltbush	FWS-U:SDI	Four-Wing Saltbush	FWS-U:SDI	Cattle+Sheep-Grazing	0.0100	0.9990	3		1	No		
Four-Wing Saltbush	FWS-U:SDI	Four-Wing Saltbush	FWS-U:SDI	Very-Wet-Year	0.0181	1.0000				Yes		
Four-Wing Saltbush	FWS-U:SDI	Four-Wing Saltbush	FWS-U:SDI	Wild-Horse-Grazing	0.0100	0.9990		19	1	No		
Four-Wing Saltbush	FWS-U:SDI	Four-Wing Saltbush	FWS-U:SDI+AG	AG-Invasion	0.0050	1.0000				No		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:Annual Grass	Cattle+Sheep-Grazing	0.0100	0.0010	3			Yes		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0010		19		No		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010	20			No		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:SDI	Competition	0.2000	1.0000	6			Yes	3	
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:SDI	Competition	0.3300	1.0000		5		No	3	
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:SDI	Herbicide-Plateau+Seed	0.0100	0.9500				No		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:SDI+AG	Cattle+Sheep-Grazing	0.0100	0.9990	3		1	No		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:SDI+AG	Herbicide-Plateau+Seed	0.0100	0.0500				No		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:SDI+AG	ReplacementFire	0.0050	1.0000				Yes		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:SDI+AG	Very-Wet-Year	0.0181	1.0000				Yes		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:SDI+AG	Very-Wet-Year	0.1000	1.0000				No		
Four-Wing Saltbush	FWS-U:SDI+AG	Four-Wing Saltbush	FWS-U:SDI+AG	Wild-Horse-Grazing	0.0100	0.9990			1	No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-A:Open	Natural-Recovery	0.3300	1.0000	3	5		No	5	
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:Depleted	Wild-Horse-Grazing	0.0100	0.0010	20			No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0010	3			Yes		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Early-Shrub	Wild-Horse-Grazing	0.0100			5		No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010	6	19		No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:SAP	AG-Invasion	0.0050	1.0000				No		
Four-Wing Saltbush	FWS-U:Seeded Native	Four-Wing Saltbush	FWS-U:Seeded Native	Cattle+Sheep-Grazing	0.0100	0.9990	3		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	0.0100	0.9990	6		1	No		
Gambel Oak-Mountain Shrub	GOMS-A:All	Gambel Oak-Mountain Shrub	GOMS-A:All	Cattle+Sheep-Grazing	0.0300	0.0100	3	4	3	No		
Gambel Oak-Mountain Shrub	GOMS-A:All	Gambel Oak-Mountain Shrub	GOMS-A:All	Cattle+Sheep-Grazing	0.0300	0.9900	3	4	1	No		
Gambel Oak-Mountain Shrub	GOMS-A:All	Gambel Oak-Mountain Shrub	GOMS-A:All	Freeze	0.0067	0.2000		4		Yes		
Gambel Oak-Mountain Shrub	GOMS-A:All	Gambel Oak-Mountain Shrub	GOMS-A:All	Freeze	0.0067	0.8000		4		No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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
Gambel Oak-Mountain Shrub	GOMS-A:All	Gambel Oak-Mountain Shrub	GOMS-U:SAP	AG-Invasion	0.0050	0.8000		4		No		
Gambel Oak-Mountain Shrub	GOMS-B:Closed	Gambel Oak-Mountain Shrub	GOMS-A:All	ReplacementFire	0.0200	1.0000	5	19		Yes		
Gambel Oak-Mountain Shrub	GOMS-B:Closed	Gambel Oak-Mountain Shrub	GOMS-A:All	Freeze	0.0067	0.2000	5	19		Yes		
Gambel Oak-Mountain Shrub	GOMS-B:Closed	Gambel Oak-Mountain Shrub	GOMS-B:Closed	Cattle+Sheep-Grazing	0.0300	0.0010	5	19	3	No		
Gambel Oak-Mountain Shrub	GOMS-B:Closed	Gambel Oak-Mountain Shrub	GOMS-B:Closed	Cattle+Sheep-Grazing	0.0300	0.9990	5	19	1	No		
Gambel Oak-Mountain Shrub	GOMS-B:Closed	Gambel Oak-Mountain Shrub	GOMS-B:Closed	Freeze	0.0067	0.8000	5	19		No		
Gambel Oak-Mountain Shrub	GOMS-B:Closed	Gambel Oak-Mountain Shrub	GOMS-U:SAP	AG-Invasion	0.0050	0.8000	5	19		No		
Gambel Oak-Mountain Shrub	GOMS-C:Closed	Gambel Oak-Mountain Shrub	GOMS-A:All	Freeze	0.0067	0.2000	20			Yes		
Gambel Oak-Mountain Shrub	GOMS-C:Closed	Gambel Oak-Mountain Shrub	GOMS-A:All	ReplacementFire	0.0200	1.0000	20			Yes		
Gambel Oak-Mountain Shrub	GOMS-C:Closed	Gambel Oak-Mountain Shrub	GOMS-C:Closed	Cattle+Sheep-Grazing	0.0300	0.0010	20		3	No		
Gambel Oak-Mountain Shrub	GOMS-C:Closed	Gambel Oak-Mountain Shrub	GOMS-C:Closed	Cattle+Sheep-Grazing	0.0300	0.9990	20		1	No		
Gambel Oak-Mountain Shrub	GOMS-C:Closed	Gambel Oak-Mountain Shrub	GOMS-C:Closed	Freeze	0.0067	0.8000	20			No		
Gambel Oak-Mountain Shrub	GOMS-C:Closed	Gambel Oak-Mountain Shrub	GOMS-U:SAP	AG-Invasion	0.0050	0.8000	20			No		
Gambel Oak-Mountain Shrub	GOMS-U:SAP	Gambel Oak-Mountain Shrub	GOMS-U:SAP	ReplacementFire	0.0200	0.2000	5			Yes		
Gambel Oak-Mountain Shrub	GOMS-U:SAP	Gambel Oak-Mountain Shrub	GOMS-U:SAP	Cattle+Sheep-Grazing	0.0300	0.0010	3		3	No		
Gambel Oak-Mountain Shrub	GOMS-U:SAP	Gambel Oak-Mountain Shrub	GOMS-U:SAP	Cattle+Sheep-Grazing	0.0300	0.9990	3		1	No		
Gambel Oak-Mountain Shrub	GOMS-U:SAP	Gambel Oak-Mountain Shrub	GOMS-U:SAP	Freeze	0.0067	0.2000				Yes		
Gambel Oak-Mountain Shrub	GOMS-U:SAP	Gambel Oak-Mountain Shrub	GOMS-U:SAP	Freeze	0.0067	0.8000				No		
Gambel Oak-Mountain Shrub	GOMS-U:SAP	Gambel Oak-Mountain Shrub	GOMS-U:SAP	ReplacementFire	0.0400	0.8000				Yes		
Gambel Oak-Mountain Shrub	GOMS-U:SAP	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Wet-Year	0.1000	1.0000				No		
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP	FineFuelDecomp	0.3300	1.0000				No	2	
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Drought	0.0056	0.1000				Yes		
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	ReplacementFire	0.0500	0.8000				Yes		
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Wet-Year	0.1000	1.0000				No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Cattle+Sheep-Grazing	0.0300	0.0010	3		3	No		
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Cattle+Sheep-Grazing	0.0300	0.9990	3		1	No		
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Drought	0.0056	0.9000			-1	No		
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Freeze	0.0067	0.2000				Yes		
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Freeze	0.0067	0.8000				No		
Gambel Oak-Mountain Shrub	GOMS-U:SAP+	Gambel Oak-Mountain Shrub	GOMS-U:SAP+	ReplacementFire	0.0200	0.2000	5			Yes		
Greasewood-Basin Big Sagebrush	GW-A:All	Greasewood-Basin Big Sagebrush	GW-A:All	Cattle+Sheep-Grazing	0.0100		3	4	2	No		
Greasewood-Basin Big Sagebrush	GW-A:All	Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	AG-Invasion	0.0050	1.0000		4		No		
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	0.0100		5		1	No		
Greasewood-Basin Big Sagebrush	GW-B:Closed	Greasewood-Basin Big Sagebrush	GW-U:SAP	AG-Invasion	0.0050	1.0000	5			No		
Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Cattle+Sheep-Grazing	0.0100		3		1	No		
Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.2500		3		Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Greasewood-Basin Big Sagebrush	GW-U:SDI	Chaining+Plateau+Seed	0.0100	0.5000		3		Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	Chaining+Plateau+Seed	0.0100	0.2500		3		Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Herbicide-Plateau+Seed	0.0100	0.5000		3		Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Greasewood-Basin Big Sagebrush	GW-U:SDI	Herbicide-Plateau+Seed	0.0100	0.5000		3		Yes		
Greasewood-Basin Big Sagebrush	GW-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	ReplacementFire	0.0010	1.0000	5			Yes		
Greasewood-Basin Big Sagebrush	GW-U:SAP	Greasewood-Basin Big Sagebrush	GW-U:SAP	Cattle+Sheep-Grazing	0.0100		5	19	1	No		
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:SAP+	Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	Cattle+Sheep-Grazing	0.0100	0.0010	5			Yes		
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	0.0100	0.9990	5		1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SAP+	Greasewood-Basin Big Sagebrush	GW-U:Annual Grass	ReplacementFire	0.0100	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:SDI	Greasewood-Basin Big Sagebrush	GW-U:SDI	Wild-Horse-Grazing	0.0100				1	No		
Greasewood-Basin Big Sagebrush	GW-U:SDI	Greasewood-Basin Big Sagebrush	GW-B:Closed	Natural-Recovery	0.0010	1.0000	5			No	10	
Greasewood-Basin Big Sagebrush	GW-U:SDI	Greasewood-Basin Big Sagebrush	GW-U:SDI	Cattle+Sheep-Grazing	0.0100		3		1	No		
Greasewood-Basin Big Sagebrush	GW-U:SDI	Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	AG-Invasion	0.0010	1.0000	5			No		
Greasewood-Basin Big Sagebrush	GW-U:SDI	Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	AG-Invasion	0.0050	1.0000		4		No		
Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	Greasewood-Basin Big Sagebrush	GW-U:SDI	Competition	0.2000	1.0000	5			No	3	
Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	Greasewood-Basin Big Sagebrush	GW-U:SDI	Competition	0.3300	1.0000		4		No	3	
Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	Cattle+Sheep-Grazing	0.0100		3		1	No		
Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	ReplacementFire	0.0100	1.0000				Yes		
Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	Greasewood-Basin Big Sagebrush	GW-U:SDI+AG	Wet-Year	0.1000	1.0000				No		
Juniper Savanna	JUN-A:All	Juniper Savanna	JUN-A:All	Cattle+Sheep-Grazing	0.0300	0.9990	3		1	No		
Juniper Savanna	JUN-A:All	Juniper Savanna	JUN-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010	3		3	No		
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 Grass	AG-Invasion	0.0001	1.0000				No		
Juniper Savanna	JUN-B:Open	Juniper Savanna	JUN-B:Open	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Juniper Savanna	JUN-B:Open	Juniper Savanna	JUN-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010				No		
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	0.0050	1.0000				No		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-C:Open	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-U:TA	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-A:All	ReplacementFire	0.0050	1.0000				Yes		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-B:Open	Drought	0.0056	0.1000				Yes		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-C:Open	Drought	0.0056	0.9000				Yes		
Juniper Savanna	JUN-C:Open	Juniper Savanna	JUN-U:TA	AG-Invasion	0.0010	1.0000				No		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-D:Open	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-U:TA	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-A:All	ReplacementFire	0.0020	1.0000				Yes		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-B:Open	Insect/Disease	0.0167	0.0300				Yes		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-C:Open	Insect/Disease	0.0167	0.0700				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	1.0000				No		
Juniper Savanna	JUN-D:Open	Juniper Savanna	JUN-U:TA	AG-Invasion	0.0010	1.0000				No		
Juniper Savanna	JUN-U:Annual Grass	Juniper Savanna	JUN-A:All	Herbicide-Plateau+Native-Seed	0.0100	0.8000		3		Yes		
Juniper Savanna	JUN-U:Annual Grass	Juniper Savanna	JUN-U:Annual Grass	Cattle+Sheep-Grazing	0.0300				1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-U:Annual Grass	Juniper Savanna	JUN-U:Annual Grass	Herbicide-Plateau+Native-Seed	0.0100	0.2000		3		Yes		
Juniper Savanna	JUN-U:Annual Grass	Juniper Savanna	JUN-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Juniper Savanna	JUN-U:Early-Shrub	Juniper Savanna	JUN-U:Early-Shrub	ReplacementFire	0.0050							
Juniper Savanna	JUN-U:SAP	Juniper Savanna	JUN-U:Annual Grass	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Juniper Savanna	JUN-U:SAP	Juniper Savanna	JUN-U:SAP	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Juniper Savanna	JUN-U:SAP	Juniper Savanna	JUN-U:Annual Grass	ReplacementFire	0.0100	1.0000				Yes		
Juniper Savanna	JUN-U:TA	Juniper Savanna	JUN-U:TA	Cattle+Sheep-Grazing	0.0300				1	No		
Juniper Savanna	JUN-U:TA	Juniper Savanna	JUN-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Juniper Savanna	JUN-U:TA	Juniper Savanna	JUN-U:Annual Grass	ReplacementFire	0.0050	1.0000				Yes		
Juniper Savanna	JUN-U:TA	Juniper Savanna	JUN-U:TA	Drought	0.0056	0.9000				Yes		
Limber-Bristlecone Pine	LB-A:All	Limber-Bristlecone Pine	LB-A:All	Drought	0.0056	1.0000		99	-5	No		
Limber-Bristlecone Pine	LB-A:All	Limber-Bristlecone Pine	LB-A:All	ReplacementFire	0.0010	1.0000		99		Yes		
Limber-Bristlecone Pine	LB-A:All	Limber-Bristlecone Pine	LB-A:All	SurfaceFire	0.0010	1.0000		99		No		
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		
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		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-A:All	Cattle+Sheep-Grazing	0.0300	0.9900	3	24	1	No		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-A:All	Drought	0.0056	1.0000		24	-1	No		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-A:All	ReplacementFire	0.0040	1.0000		24		Yes		
Low Sagebrush	LS-A:All	Low Sagebrush	LS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0100	3	24		No		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-A:All	Drought	0.0056	0.1000	25	119		Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-A:All	ReplacementFire	0.0040	1.0000	25	119		Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-B:Open	Cattle+Sheep-Grazing	0.0300	0.9990	25	119	1	No		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-B:Open	Drought	0.0056	0.9000	25	119		Yes		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010	25	119		No		
Low Sagebrush	LS-B:Open	Low Sagebrush	LS-U:SAP	AG-Invasion	0.0010	1.0000	25	119		No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-A:All	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0000					Yes		
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	0.0100	0.6000				Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-A:All	Thin	0.0100			200		Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-B:Open	Drought	0.0056	0.1000				Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-C:Closed	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-C:Closed	Drought	0.0056	0.9000				Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-C:Closed	RxFire	0.0100	0.4000				No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-C:Closed	Small-Tree-Lopping	0.0100		150			Yes		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:Depleted	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:SAP	AG-Invasion	0.0050					No		
Low Sagebrush	LS-C:Closed	Low Sagebrush	LS-U:TE	Tree-Encroachment	0.0200		250			No		
Low Sagebrush	LS-U:Annual Grass	Low Sagebrush	LS-U:Annual Grass	Chaining+Native-Seed	0.0100	0.4000		3		Yes		
Low Sagebrush	LS-U:Annual Grass	Low Sagebrush	LS-U:Annual Grass	ReplacementFire	0.0500					Yes		
Low Sagebrush	LS-U:Annual Grass	Low Sagebrush	LS-U:Seeded Native	Chaining+Native-Seed	0.0100	0.6000		3		Yes		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:Depleted	Drought	0.0056	0.9000				Yes		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:Depleted	Small-Tree-Lopping	0.0100		150			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Depleted	Low Sagebrush	LS-U:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.3000				Yes		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:Early-Shrub	Drought	0.0056	0.1000				Yes		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:Early-Shrub	ReplacementFire	0.0020					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:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Low Sagebrush	LS-U:Depleted	Low Sagebrush	LS-U:TE	Tree-Invasion	0.0050		200			Yes		
Low Sagebrush	LS-U:Early-Shrub	Low Sagebrush	LS-B:Open	Natural-Recovery	0.0010	1.0000	25	119		No		
Low Sagebrush	LS-U:Early-Shrub	Low Sagebrush	LS-C:Closed	Natural-Recovery	0.0010	1.0000	120			No		
Low Sagebrush	LS-U:Early-Shrub	Low Sagebrush	LS-U:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.3000				Yes		
Low Sagebrush	LS-U:Early-Shrub	Low Sagebrush	LS-U:Early-Shrub	ReplacementFire	0.0100	1.0000				Yes		
Low Sagebrush	LS-U:Early-Shrub	Low Sagebrush	LS-U:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:Annual Grass	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:Annual Grass	ReplacementFire	0.0100					Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:SA	Cattle+Sheep-Grazing	0.0300				1	No		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:SA	Drought	0.0056	0.9000				Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:SA	Small-Tree-Lopping	0.0100		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:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Low Sagebrush	LS-U:SA	Low Sagebrush	LS-U:TA	Tree-Invasion	0.0050		200			Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:Annual Grass	ReplacementFire	0.0200					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+	Drought	0.0056	0.9000				Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:SA+	Herbicide-Plateau+Native-Seed	0.0100	0.2000				No		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:SA+	Small-Tree-Lopping	0.0100		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:SAP	Herbicide-Plateau+Native-Seed	0.0100	0.2000				No		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.4000				Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:Seeded Native	Herbicide-Plateau+Native-Seed	0.0100	0.6000				Yes		
Low Sagebrush	LS-U:SA+	Low Sagebrush	LS-U:TA	Tree-Invasion	0.0050		200			Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-A:All	Drought	0.0056	0.0100	25			Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-A:All	ReplacementFire	0.0100	0.0500	25			Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-B:Open	Natural-Recovery	0.0010	1.0000	25	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 Grass	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:Annual Grass	Drought	0.0056	0.0900	25			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Annual Grass	ReplacementFire	0.0100	0.9500	25			Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SA	Cattle+Sheep-Grazing	0.0300	0.0010	25			No		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP	Cattle+Sheep-Grazing	0.0300	0.9990	25		1	No		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP	Drought	0.0056	0.9000	25			Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP	Small-Tree-Lopping	0.0100		150			Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:SAP+	Wet-Year	0.1000	1.0000	25			No		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Low Sagebrush	LS-U:SAP	Low Sagebrush	LS-U:TA	Tree-Invasion	0.0050	1.0000	200			Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-B:Open	Spot-Herbicide+Native-Seed	0.0100	0.7000	25			Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:Annual Grass	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:Annual Grass	Drought	0.0056	0.1000	25			Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:Annual Grass	ReplacementFire	0.0200	1.0000	25			Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SA+	Cattle+Sheep-Grazing	0.0300	0.0010	25			No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP	FineFuelDecomp	0.3300	1.0000	25			No	2	
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Cattle+Sheep-Grazing	0.0300	0.9990	25		1	No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Drought	0.0056	0.9000	25			Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Small-Tree-Lopping	0.0100		150			Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Spot-Herbicide+Native-Seed	0.0100	0.3000	25			No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:SAP+	Wet-Year	0.1000	1.0000	25			No		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.4000				Yes		
Low Sagebrush	LS-U:SAP+	Low Sagebrush	LS-U:TA	Tree-Invasion	0.0050	1.0000	200			Yes		
Low Sagebrush	LS-U:SDI-A	Low Sagebrush	LS-A:All	Natural-Recovery	0.0001		5			No	10	
Low Sagebrush	LS-U:SDI-A	Low Sagebrush	LS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010				No		
Low Sagebrush	LS-U:SDI-A	Low Sagebrush	LS-U:SDI-A	Cattle+Sheep-Grazing	0.0300	0.0500	3			Yes		
Low Sagebrush	LS-U:SDI-A	Low Sagebrush	LS-U:SDI-A	Cattle+Sheep-Grazing	0.0300	0.9500	3		1	No		
Low Sagebrush	LS-U:SDI-A	Low Sagebrush	LS-U:SDI-A	Drought	0.0056				-1	No		
Low Sagebrush	LS-U:SDI-A	Low Sagebrush	LS-U:SDI-A	ReplacementFire	0.0010					Yes		
Low Sagebrush	LS-U:SDI-A	Low Sagebrush	LS-U:SDI-A	Wild-Horse-Grazing	0.0100	0.9990			1	No		
Low Sagebrush	LS-U:SDI-A	Low Sagebrush	LS-U:SI-A+AG	AG-Invasion	0.0010					No		
Low Sagebrush	LS-U:SDI-B	Low Sagebrush	LS-A:All	ReplacementFire	0.0010					Yes		
Low Sagebrush	LS-U:SDI-B	Low Sagebrush	LS-B:Open	Natural-Recovery	0.0010					No	10	
Low Sagebrush	LS-U:SDI-B	Low Sagebrush	LS-U:SDI-B	Cattle+Sheep-Grazing	0.0300				1	No		
Low Sagebrush	LS-U:SDI-B	Low Sagebrush	LS-U:SDI-B	Drought	0.0056				-1	No		
Low Sagebrush	LS-U:SDI-B	Low Sagebrush	LS-U:SDI-B	Wild-Horse-Grazing	0.0100				1	No		
Low Sagebrush	LS-U:SDI-B	Low Sagebrush	LS-U:SI-B+AG	AG-Invasion	0.0010					No		
Low Sagebrush	LS-U:SDI-C	Low Sagebrush	LS-A:All	ReplacementFire	0.0010					Yes		
Low Sagebrush	LS-U:SDI-C	Low Sagebrush	LS-C:Closed	Natural-Recovery	0.0100					No	10	
Low Sagebrush	LS-U:SDI-C	Low Sagebrush	LS-U:SDI-C	Cattle+Sheep-Grazing	0.0300				1	No		
Low Sagebrush	LS-U:SDI-C	Low Sagebrush	LS-U:SDI-C	Drought	0.0056				-1	No		
Low Sagebrush	LS-U:SDI-C	Low Sagebrush	LS-U:SDI-C	Wild-Horse-Grazing	0.0100				1	No		
Low Sagebrush	LS-U:SDI-C	Low Sagebrush	LS-U:SI-C+AG	AG-Invasion	0.0010					No		
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. Output Obtained from ST-Sim 2.4.7 Database.

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:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010	3			No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Early-Shrub	Drought	0.0056	0.1000				Yes		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Early-Shrub	Wild-Horse-Grazing	0.0100			5		No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010	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	0.0300	0.9990	3		1	No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Seeded Native	Drought	0.0056	0.9000		24	-1	No		
Low Sagebrush	LS-U:Seeded Native	Low Sagebrush	LS-U:Seeded Native	Drought	0.0056	0.9000	25		25	Yes		
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	Wild-Horse-Grazing	0.0100	0.9990	6	24	1	No		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0010				No		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SDI-A	Competition	1.0000					No	3	
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	Cattle+Sheep-Grazing	0.0300	0.0500	3			Yes		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	Cattle+Sheep-Grazing	0.0300	0.9500	3		1	No		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	Drought	0.0056				-1	No		
Low Sagebrush	LS-U:SI-A+AG	Low Sagebrush	LS-U:SI-A+AG	ReplacementFire	0.0050					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	0.0100	0.9990			1	No		
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SDI-B	Competition	1.0000					No	3	
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-A+AG	ReplacementFire	0.0050					Yes		
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-B+AG	Cattle+Sheep-Grazing	0.0300				1	No		
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-B+AG	Drought	0.0056				-1	No		
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-B+AG	Wet-Year	0.1000					No		
Low Sagebrush	LS-U:SI-B+AG	Low Sagebrush	LS-U:SI-B+AG	Wild-Horse-Grazing	0.0100				1	No		
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SDI-C	Competition	1.0000					No	3	
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SI-A+AG	ReplacementFire	0.0050					Yes		
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SI-C+AG	Cattle+Sheep-Grazing	0.0300				1	No		
Low Sagebrush	LS-U:SI-C+AG	Low Sagebrush	LS-U:SI-C+AG	Drought	0.0056				-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	0.0100				1	No		
Low Sagebrush	LS-U:TA	Low Sagebrush	LS-U:Annual Grass	Drought	0.0056	0.0500	200			Yes		
Low Sagebrush	LS-U:TA	Low Sagebrush	LS-U:Annual Grass	ReplacementFire	0.0050	1.0000	200			Yes		
Low Sagebrush	LS-U:TA	Low Sagebrush	LS-U:SA	Small-Tree-Lopping	0.0100	0.5000	200		25	Yes		
Low Sagebrush	LS-U:TA	Low Sagebrush	LS-U:SAP	Drought	0.0056	0.0500	200			Yes		
Low Sagebrush	LS-U:TA	Low Sagebrush	LS-U:SAP	Small-Tree-Lopping	0.0100	0.5000	200		25	Yes		
Low Sagebrush	LS-U:TA	Low Sagebrush	LS-U:TA	Drought	0.0056	0.9000	200			Yes		
Low Sagebrush	LS-U:TE	Low Sagebrush	LS-B:Open	Drought	0.0056	0.0500	200			Yes		
Low Sagebrush	LS-U:TE	Low Sagebrush	LS-B:Open	Small-Tree-Lopping	0.0100	1.0000	200			Yes		
Low Sagebrush	LS-U:TE	Low Sagebrush	LS-U:Early-Shrub	Drought	0.0056	0.0500	200			Yes		
Low Sagebrush	LS-U:TE	Low Sagebrush	LS-U:Early-Shrub	ReplacementFire	0.0040	1.0000	200			Yes		
Low Sagebrush	LS-U:TE	Low Sagebrush	LS-U:TA	AG-Invasion	0.0050	1.0000	200			No		
Low Sagebrush	LS-U:TE	Low Sagebrush	LS-U:TE	Drought	0.0056	0.9000	200			Yes		
Mixed Conifer	MC-A:All	Mixed Conifer	MC-A:All	Drought	0.0056	1.0000		29		Yes		
Mixed Conifer	MC-A:All	Mixed Conifer	MC-A:All	ReplacementFire	0.0080	1.0000		29		Yes		
Mixed Conifer	MC-B:Closed	Mixed Conifer	MC-A:All	ReplacementFire	0.0100	1.0000	30	99		Yes		
Mixed Conifer	MC-B:Closed	Mixed Conifer	MC-C:Open	Insect/Disease	0.0100	1.0000	30	99		No		
Mixed Conifer	MC-B:Closed	Mixed Conifer	MC-C:Open	MixedFire	0.0160	1.0000	30	99		No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-B:Closed	Mixed Conifer	MC-U:TA	AG-Invasion	0.0001	1.0000	30	99		No		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-A:All	ReplacementFire	0.0003	1.0000	30	69		Yes		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-A:All	ReplacementFire	0.0050	1.0000	70	99		Yes		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-B:Closed	Fuel-Build-Up	1.0000	0.3300	30	99		No	35	
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-C:Open	Insect/Disease	0.0100	1.0000	30	99		Yes		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-C:Open	SurfaceFire	0.0003	1.0000	30	69		Yes		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-C:Open	SurfaceFire	0.0017	1.0000	70	99		No		
Mixed Conifer	MC-C:Open	Mixed Conifer	MC-U:TA	AG-Invasion	0.0001	1.0000	30	99		No		
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-C:Open	Chainsaw-Thinning	0.0100	1.0000	100	149		Yes		
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-D:Open	Chainsaw-Thinning	0.0100	1.0000	150			Yes		
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-A:All	ReplacementFire	0.0007	1.0000	150			Yes		
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-A:All	ReplacementFire	0.0050	1.0000	100	149		Yes		
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-C:Open	Insect/Disease	0.0010	1.0000	100	149		Yes		
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-C:Open	Insect/Disease	0.0050	1.0000	150			Yes		
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-D:Open	SurfaceFire	0.0017	1.0000	100	149		No		
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-D:Open	SurfaceFire	0.0063	1.0000	150			No		
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-E:Closed	Fuel-Build-Up	1.0000	0.3300	100			No	70	
Mixed Conifer	MC-D:Open	Mixed Conifer	MC-U:TA	AG-Invasion	0.0001	1.0000	100			No		
Mixed Conifer	MC-E:Closed	Mixed Conifer	MC-D:Open	Chainsaw-Thinning	0.0100	1.0000	100	129		No		
Mixed Conifer	MC-E:Closed	Mixed Conifer	MC-D:Open	Chainsaw-Thinning	0.0100	1.0000	130			Yes		
Mixed Conifer	MC-E:Closed	Mixed Conifer	MC-A:All	ReplacementFire	0.0100	1.0000	100			Yes		
Mixed Conifer	MC-E:Closed	Mixed Conifer	MC-D:Open	Insect/Disease	0.0056	1.0000	100			Yes		
Mixed Conifer	MC-E:Closed	Mixed Conifer	MC-D:Open	MixedFire	0.0017	1.0000	100			Yes		
Mixed Conifer	MC-E:Closed	Mixed Conifer	MC-U:TA	AG-Invasion	0.0001	1.0000	100			No		
Mixed Conifer	MC-U:Annual Grass	Mixed Conifer	MC-U:Annual Grass	ReplacementFire	0.1000	1.0000		29		Yes		
Mixed Conifer	MC-U:TA	Mixed Conifer	MC-U:TA	Chainsaw-Thinning	0.0100	1.0000	100	149		No		
Mixed Conifer	MC-U:TA	Mixed Conifer	MC-U:TA	Chainsaw-Thinning	0.0100	1.0000	150			Yes		
Mixed Conifer	MC-U:TA	Mixed Conifer	MC-B:Closed	Natural-Recovery	0.0100	1.0000	30	99		Yes	10	
Mixed Conifer	MC-U:TA	Mixed Conifer	MC-E:Closed	Natural-Recovery	0.0100	1.0000	100			No	10	
Mixed Conifer	MC-U:TA	Mixed Conifer	MC-U:Annual Grass	MixedFire	0.0151	0.7500	30			Yes		
Mixed Conifer	MC-U:TA	Mixed Conifer	MC-U:Annual Grass	ReplacementFire	0.0056	1.0000	30			Yes		
Mixed Conifer	MC-U:TA	Mixed Conifer	MC-U:TA	Insect/Disease	0.0056	1.0000	30			Yes		
Mixed Conifer	MC-U:TA	Mixed Conifer	MC-U:TA	MixedFire	0.0152	0.2500	30			Yes		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-A:All	Cattle+Sheep-Grazing	0.0100	0.9900	3	5	1	No		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-A:All	Very-Wet-Year	0.0181	1.0000		5		Yes		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-U:Annual Grass	AG-Invasion	0.0050	1.0000		5		No		
Mixed Salt Desert	MSD-A:All	Mixed Salt Desert	MSD-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0100	3	5		Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-A:All	Thin	0.0100					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	0.0100	0.9990			1	No		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-C:Open	Drought	0.0056					Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0010				Yes		
Mixed Salt Desert	MSD-B:Open	Mixed Salt Desert	MSD-U:SAP	AG-Invasion	0.0100					No		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-A:All	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-A:All	Thin	0.0100					Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-A:All	Very-Wet-Year	0.0181	0.0000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-C:Open	Mixed Salt Desert	MSD-C:Open	Cattle+Sheep-Grazing	0.0100	0.9990			1	No		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-C:Open	Drought	0.0180	1.0000				Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0010				Yes		
Mixed Salt Desert	MSD-C:Open	Mixed Salt Desert	MSD-U:SAP	AG-Invasion	0.0050	1.0000				No		
Mixed Salt Desert	MSD-U:Annual Grass	Mixed Salt Desert	MSD-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.2500		3		Yes		
Mixed Salt Desert	MSD-U:Annual Grass	Mixed Salt Desert	MSD-U:Annual Grass	Herbicide-Plateau+Seed	0.0100	0.2500		3		Yes		
Mixed Salt Desert	MSD-U:Annual Grass	Mixed Salt Desert	MSD-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Mixed Salt Desert	MSD-U:Annual Grass	Mixed Salt Desert	MSD-U:SDI	Chaining+Plateau+Seed	0.0100	0.5000		3		Yes		
Mixed Salt Desert	MSD-U:Annual Grass	Mixed Salt Desert	MSD-U:SDI	Herbicide-Plateau+Seed	0.0100	0.5000		3		Yes		
Mixed Salt Desert	MSD-U:Annual Grass	Mixed Salt Desert	MSD-U:SDI+AG	Chaining+Plateau+Seed	0.0100	0.2500		3		Yes		
Mixed Salt Desert	MSD-U:Annual Grass	Mixed Salt Desert	MSD-U:SDI+AG	Herbicide-Plateau+Seed	0.0100	0.2500		3		Yes		
Mixed Salt Desert	MSD-U:Early-Shrub	Mixed Salt Desert	MSD-U:Early-Shrub	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.5000				Yes		
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:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2500				Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:Annual Grass	ReplacementFire	0.0100					Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:Annual Grass	Very-Wet-Year	0.0181					Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0010				Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:SAP	Cattle+Sheep-Grazing	0.0100	0.9990			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:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Mixed Salt Desert	MSD-U:SAP	Mixed Salt Desert	MSD-U:SDI+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2500				Yes		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.3000				Yes		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:Annual Grass	ReplacementFire	0.0150					Yes		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:Annual Grass	Very-Wet-Year	0.0181					Yes		
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	0.0100				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:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.4000				Yes		
Mixed Salt Desert	MSD-U:SAP+	Mixed Salt Desert	MSD-U:SDI+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.3000				Yes		
Mixed Salt Desert	MSD-U:SDI	Mixed Salt Desert	MSD-A:All	Natural-Recovery	0.0001	1.0000		5		No	10	
Mixed Salt Desert	MSD-U:SDI	Mixed Salt Desert	MSD-B:Open	Natural-Recovery	0.0010	1.0000	6			No	10	
Mixed Salt Desert	MSD-U:SDI	Mixed Salt Desert	MSD-U:Early-Shrub	Cattle+Sheep-Grazing	0.0100	0.0100	3			Yes		
Mixed Salt Desert	MSD-U:SDI	Mixed Salt Desert	MSD-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010		5		No		
Mixed Salt Desert	MSD-U:SDI	Mixed Salt Desert	MSD-U:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100					Yes		
Mixed Salt Desert	MSD-U:SDI	Mixed Salt Desert	MSD-U:SDI	Cattle+Sheep-Grazing	0.0100	0.9900	3		1	No		
Mixed Salt Desert	MSD-U:SDI	Mixed Salt Desert	MSD-U:SDI	Thin	0.0100					Yes		
Mixed Salt Desert	MSD-U:SDI	Mixed Salt Desert	MSD-U:SDI	Wild-Horse-Grazing	0.0100	0.0010	6		1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SDI	Mixed Salt Desert	MSD-U:SDI	Wild-Horse-Grazing	0.0100	0.9990			1	No		
Mixed Salt Desert	MSD-U:SDI	Mixed Salt Desert	MSD-U:SDI+AG	AG-Invasion	0.0010	1.0000				No		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:Annual Grass	Cattle+Sheep-Grazing	0.0100	0.0100	3	5		No		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0010		5		No		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000				Yes		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI	Competition	0.2000	1.0000	6			No	3	
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI	Competition	0.3300	1.0000		5		No	3	
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI	Herbicide-Plateau	0.0100	0.8000				No		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI+AG	Cattle+Sheep-Grazing	0.0100	0.0100	6		1	No		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI+AG	Cattle+Sheep-Grazing	0.0100	0.9900	3		1	No		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI+AG	Herbicide-Plateau	0.0100	0.2000				No		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI+AG	ReplacementFire	0.0050	1.0000				Yes		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI+AG	Thin	0.0100					Yes		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI+AG	Very-Wet-Year	0.0181	1.0000				Yes		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI+AG	Wild-Horse-Grazing	0.0100	0.0010	6		1	No		
Mixed Salt Desert	MSD-U:SDI+AG	Mixed Salt Desert	MSD-U:SDI+AG	Wild-Horse-Grazing	0.0100	0.9990			1	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	0.0100	0.0010	3			No		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Early-Shrub	Wild-Horse-Grazing	0.0100			5		No		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010	6			No		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:SAP	AG-Invasion	0.0050	1.0000				No		
Mixed Salt Desert	MSD-U:Seeded Native	Mixed Salt Desert	MSD-U:Seeded Native	Cattle+Sheep-Grazing	0.0100	0.9990	3		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	0.0100	0.9990	6		1	No		
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Fence	0.0100	1.0000		4		No	50	
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Wild-Horse-Grazing	0.0100	0.9900		4		No	20	
Montane Riparian	MR-A:All	Montane Riparian	MR-U:Desertified	Weed-Inventory+Treat	0.0020	0.0010		4		No	3	
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Cattle+Sheep-Grazing	0.0500	0.9900	3	4		Yes	20	
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Flooding-7yr	0.1400	1.0000		4		Yes		
Montane Riparian	MR-A:All	Montane Riparian	MR-A:All	Weed-Inventory+Treat	0.0100	1.0000		4		No	3	
Montane Riparian	MR-A:All	Montane Riparian	MR-U:Desertified	RoadLateralFlow	0.0400	0.3300		4		No	20	
Montane Riparian	MR-A:All	Montane Riparian	MR-U:SFE	Cattle+Sheep-Grazing	0.0500	0.0100	3	4		No	20	
Montane Riparian	MR-B:Open	Montane Riparian	MR-B:Open	Fence	0.0100	1.0000	5	19		No	50	
Montane Riparian	MR-B:Open	Montane Riparian	MR-B:Open	Wild-Horse-Grazing	0.0100	0.9900	5	19	1	No	20	
Montane Riparian	MR-B:Open	Montane Riparian	MR-U:Desertified	Wild-Horse-Grazing	0.0100	0.0100	5	19		No	20	
Montane Riparian	MR-B:Open	Montane Riparian	MR-A:All	Flooding-20yr	0.0500	1.0000	5	19		Yes		
Montane Riparian	MR-B:Open	Montane Riparian	MR-A:All	ReplacementFire	0.0067	1.0000	5	19		Yes		
Montane Riparian	MR-B:Open	Montane Riparian	MR-B:Open	Cattle+Sheep-Grazing	0.0500	0.9950	5	19	1	No	20	
Montane Riparian	MR-B:Open	Montane Riparian	MR-B:Open	Weed-Inventory+Treat	0.0100	1.0000	5	19		No	3	
Montane Riparian	MR-B:Open	Montane Riparian	MR-U:Desertified	RoadLateralFlow	0.0400	0.3300	5	19		No	20	
Montane Riparian	MR-B:Open	Montane Riparian	MR-U:EFT	Exotic-Invasion	0.0100	1.0000	5	19		Yes	5	
Montane Riparian	MR-B:Open	Montane Riparian	MR-U:SFE	Cattle+Sheep-Grazing	0.0500	0.0100	5	19		No	20	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-B:Open	Chainsaw-Thinning	0.0100		50			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-C:Closed	Montane Riparian	MR-C:Closed	Fence	0.0100					No	50	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-C:Closed	Wild-Horse-Grazing	0.0100	0.9900			1	No	20	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-U:Desertified	Wild-Horse-Grazing	0.0100	0.0100				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	Cattle+Sheep-Grazing	0.0500	0.9950			1	No	20	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-C:Closed	Weed-Inventory+Treat	0.0100					No	3	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-U:Desertified	RoadLateralFlow	0.0400	0.3300				No	20	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-U:EFT	Exotic-Invasion	0.0100					Yes	5	
Montane Riparian	MR-C:Closed	Montane Riparian	MR-U:SFE	Cattle+Sheep-Grazing	0.0500	0.0050				No	20	
Montane Riparian	MR-U:Annual Grass	Montane Riparian	MR-U:Annual Grass	Cattle+Sheep-Grazing	0.0500		3		1	No	20	
Montane Riparian	MR-U:Annual Grass	Montane Riparian	MR-U:Annual Grass	Fence	0.0100	1.0000				Yes	50	
Montane Riparian	MR-U:Annual Grass	Montane Riparian	MR-U:Annual Grass	Wild-Horse-Grazing	0.0100				1	No	20	
Montane Riparian	MR-U:Annual Grass	Montane Riparian	MR-A:All	Flooding-100yr	0.0100	0.0100				Yes		
Montane Riparian	MR-U:Annual Grass	Montane Riparian	MR-A:All	Floodplain-Restoration	0.0100	0.9000				Yes		
Montane Riparian	MR-U:Annual Grass	Montane Riparian	MR-A:All	Small-Rock-Dam	0.0100	1.0000				Yes		
Montane Riparian	MR-U:Annual Grass	Montane Riparian	MR-U:Annual Grass	Flooding-100yr	0.0100	0.9900				Yes		
Montane Riparian	MR-U:Annual Grass	Montane Riparian	MR-U:Annual Grass	Floodplain-Restoration	0.0100	0.1000				Yes		
Montane Riparian	MR-U:Annual Grass	Montane Riparian	MR-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	Fence	0.0100	1.0000				No	50	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	Wild-Horse-Grazing	0.0100	0.9900			1	No	20	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:SAP	Wild-Horse-Grazing	0.0100	0.0100			5	No	20	
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	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-A:All	Floodplain-Restoration	0.0100	0.9000				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:Desertified	Cattle+Sheep-Grazing	0.0500	0.9950			1	No	20	
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	0.0100	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	1.0000				No		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:SAP	Cattle+Sheep-Grazing	0.0500	0.0050			5	No	20	
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:SFE	Small-Rock-Dam	0.0100	1.0000				Yes		
Montane Riparian	MR-U:Desertified	Montane Riparian	MR-U:TE	Tree-Invasion	0.0080	1.0000	50			Yes		
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Cattle+Sheep-Grazing	0.0500	0.0050	3			Yes	20	
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Cattle+Sheep-Grazing	0.0500	0.9950	3		1	No	20	
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Fence	0.0100	1.0000				No	50	
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Wild-Horse-Grazing	0.0100	0.0100				Yes	20	
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Wild-Horse-Grazing	0.0100	0.9900			1	No	20	
Montane Riparian	MR-U:EFT	Montane Riparian	MR-A:All	Exotic-Control	0.0100	0.7000		4		No		20
Montane Riparian	MR-U:EFT	Montane Riparian	MR-B:Open	Exotic-Control	0.0100	0.7000	5	19		No		20
Montane Riparian	MR-U:EFT	Montane Riparian	MR-C:Closed	Exotic-Control	0.0100	0.7000	20			No		20
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	Exotic-Control	0.0100	0.3000				Yes		20
Montane Riparian	MR-U:EFT	Montane Riparian	MR-U:EFT	ReplacementFire	0.0067	1.0000				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-C:Closed	Cattle+Sheep-Grazing	0.0500	0.0050			5	No	20	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0100			5	No	20	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SAP	Cattle+Sheep-Grazing	0.0500	0.9950			1	No	20	
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SAP	Fence	0.0100	1.0000				No	50	

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SAP	Montane Riparian	MR-U:SAP	Wild-Horse-Grazing	0.0100	0.9900			1	No	20	
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	0.0100	0.9000				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:Annual Grass	Flooding-100yr	0.0100	0.4950				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:Annual Grass	ReplacementFire	0.0400	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	0.0100	0.1000				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SAP	ReplacementFire	0.0400	0.1000				Yes		
Montane Riparian	MR-U:SAP	Montane Riparian	MR-U:SFE	Small-Rock-Dam	0.0100	1.0000				Yes		
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:Annual Grass	Wild-Horse-Grazing	0.0100					Yes	20	
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:SDA	Fence	0.0100	1.0000				No	50	
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:SDA	Wild-Horse-Grazing	0.0100				1	No	20	
Montane Riparian	MR-U:SDA	Montane Riparian	MR-A:All	Flooding-100yr	0.0100	0.0100				Yes		
Montane Riparian	MR-U:SDA	Montane Riparian	MR-A:All	Floodplain-Restoration	0.0100	0.9000				Yes		
Montane Riparian	MR-U:SDA	Montane Riparian	MR-A:All	Small-Rock-Dam	0.0100	1.0000				Yes		
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:Annual Grass	Cattle+Sheep-Grazing	0.0500	0.0050	3			Yes	20	
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:Annual Grass	Flooding-100yr	0.0100	0.1000				Yes		
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:Annual Grass	ReplacementFire	0.0400	0.1000				Yes		
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:SDA	Cattle+Sheep-Grazing	0.0500	0.9950			1	No	20	
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:SDA	Flooding-100yr	0.0100	0.8900				Yes		
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:SDA	Floodplain-Restoration	0.0100	0.1000				Yes		
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:SDA	ReplacementFire	0.0400	0.8000				Yes		
Montane Riparian	MR-U:SDA	Montane Riparian	MR-U:Seeded Native	ReplacementFire	0.0400	0.1000				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Fence	0.0100	1.0000				No	50	
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Wild-Horse-Grazing	0.0100	0.0100				Yes	20	
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Wild-Horse-Grazing	0.0100	0.9900			1	No	20	
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	1.0000				Yes	10	
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-A:All	Floodplain-Restoration	0.0100	0.9000				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-A:All	Small-Rock-Dam	0.0100	1.0000				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:SDA	AG-Invasion	0.0010	1.0000				No		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Cattle+Sheep-Grazing	0.0500	0.0050	3			Yes	20	
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	Cattle+Sheep-Grazing	0.0500	0.9950	3		1	No	20	
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	0.0100	0.1000				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:Seeded Native	ReplacementFire	0.0050	1.0000				Yes		
Montane Riparian	MR-U:Seeded Native	Montane Riparian	MR-U:TE	Tree-Invasion	0.0080	1.0000	50			Yes		
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:Desertified	Wild-Horse-Grazing	0.0100	0.0100				Yes	20	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Chainsaw-Thinning	0.0100		50		5	Yes		
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Fence	0.0100	1.0000				No	50	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Wild-Horse-Grazing	0.0100	0.9900			1	No	20	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:Desertified	Cattle+Sheep-Grazing	0.0500	0.0050	3			No	20	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:Desertified	RoadLateralFlow	0.0400	0.3300				No	20	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:EFT	Exotic-Invasion	0.0100	1.0000				Yes	5	
Montane Riparian	MR-U:SFE	Montane Riparian	MR-U:SFE	Cattle+Sheep-Grazing	0.0500	0.9950	3		1	No	20	
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		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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: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	0.0100	1.0000				No	3	
Montane Riparian	MR-U:TE	Montane Riparian	MR-U:Desertified	Chainsaw-Thinning	0.0100	1.0000	50		1	Yes		
Montane Riparian	MR-U:TE	Montane Riparian	MR-U:TE	Fence	0.0100	1.0000	50			No	50	
Montane Riparian	MR-U:TE	Montane Riparian	MR-A:All	Floodplain-Restoration	0.0100	0.9000	50			Yes		
Montane Riparian	MR-U:TE	Montane Riparian	MR-U:Annual Grass	ReplacementFire	0.0068	0.5000	50			Yes		
Montane Riparian	MR-U:TE	Montane Riparian	MR-U:Desertified	Floodplain-Restoration	0.0100	0.1000	50			Yes		
Montane Riparian	MR-U:TE	Montane Riparian	MR-U:Desertified	ReplacementFire	0.0068	0.5000	50			Yes		
Montane Riparian	MR-U:TE	Montane Riparian	MR-U:SAP	Small-Rock-Dam	0.0100	1.0000	50			Yes		
Montane Sagebrush Steppe	MSS-A:All	Montane Sagebrush Steppe	MSS-A:All	Cattle+Sheep-Grazing	0.0500	0.9900	3	11	1	No		
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:Annual Grass	AG-Invasion	0.0010	1.0000		11		No		
Montane Sagebrush Steppe	MSS-A:All	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0500	0.0100	3	11		No		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-A:All	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					Yes		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-A:All	Thin	0.0100					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-B:Open	Cattle+Sheep-Grazing	0.0500	0.9990			1	No		
Montane Sagebrush Steppe	MSS-B:Open	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0500	0.0010				No		
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	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					Yes		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-A:All	Thin	0.0100					Yes		
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	Drought	0.0056	0.1000				Yes		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-C:Closed	Cattle+Sheep-Grazing	0.0500	0.9990			1	No		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-C:Closed	Drought	0.0056	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:Depleted	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Montane Sagebrush Steppe	MSS-C:Closed	Montane Sagebrush Steppe	MSS-U:SAP	AG-Invasion	0.0050					No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-A:All	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					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	0.0100	0.7000				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-B:Open	Drought	0.0056	0.0300				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-C:Closed	Drought	0.0056	0.0700				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-C:Closed	Mastication	0.0100		100			Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-C:Closed	Small-Tree-Lopping	0.0100			99		Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-D:Open	Cattle+Sheep-Grazing	0.0500	0.9990			1	No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-D:Open	Drought	0.0056	0.9000				Yes		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-D:Open	RxFire	0.0100	0.3000				No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-U:Depleted	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-U:SAP	AG-Invasion	0.0050			99		No		
Montane Sagebrush Steppe	MSS-D:Open	Montane Sagebrush Steppe	MSS-U:TEA	AG-Invasion	0.0050		100		8	Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-B:Open	Chaining+Native-Seed	0.0100	0.8000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Chaining+Native-Seed	0.0100	0.2000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Masticate+Native-Seed	0.0100	0.1000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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	Tree-Encroachment	0.0200	1.0000	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	0.0100	0.7000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-B:Open	Drought	0.0056	0.1000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-B:Open	Masticate+Native-Seed	0.0100	0.9000				Yes		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-E:Closed	Drought	0.0056	0.9000			5	No		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-E:Closed	RxFire	0.0100	0.3000				No		
Montane Sagebrush Steppe	MSS-E:Closed	Montane Sagebrush Steppe	MSS-U:TEA	AG-Invasion	0.0050	1.0000				No		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:Annual Grass	Cattle+Sheep-Grazing	0.0500		3		1	No		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:Annual Grass	Chaining+Native-Seed	0.0100	0.2000			3	Yes		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.0500			3	Yes		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:SDI-A	Chaining+Plateau+Seed	0.0100	0.9000			3	Yes		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:Seeded Native	Chaining+Native-Seed	0.0100	0.8000			3	Yes		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Chaining+Plateau+Seed	0.0100	0.0500			3	Yes		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:Annual Grass	Herbicide-Plateau+Seed	0.0100	0.1000			3	Yes		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.8000			3	Yes		
Montane Sagebrush Steppe	MSS-U:Annual Grass	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Herbicide-Plateau+Seed	0.0100	0.1000			3	Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Depleted	Chaining+Native-Seed	0.0100	0.2000				No		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.2000						
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:SDI-A	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.8000				Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Seeded Native	2xChaining+Native-Seed	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Seeded Native	Chaining+Native-Seed	0.0100	0.8000				Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Seeded Native	Spyke+Native-Seed	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Seeded Native	Thin+Native-Seed	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Depleted	Drought	0.0056	0.9000				Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Depleted	Small-Tree-Lopping	0.0100		100	149		Yes		
Montane Sagebrush Steppe	MSS-U:Depleted	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Drought	0.0056	0.1000				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: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:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Montane Sagebrush Steppe	MSS-U:Early-Shrub	Montane Sagebrush Steppe	MSS-U:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.8000				Yes		
Montane Sagebrush Steppe	MSS-U:Early-Shrub	Montane Sagebrush Steppe	MSS-U:Early-Shrub	ReplacementFire	0.0200	1.0000				Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:SA	Small-Tree-Lopping	0.0100		100	150		Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.8000				Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SA	Montane Sagebrush Steppe	MSS-U:Annual Grass	ReplacementFire	0.0400					Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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	Drought	0.0056	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 Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
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	0.0100		100		38	Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:SA+	Small-Tree-Lopping	0.0100		100	150		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:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:Annual Grass	ReplacementFire	0.0500					Yes		
Montane Sagebrush Steppe	MSS-U:SA+	Montane Sagebrush Steppe	MSS-U:SA+	Drought	0.0056	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 Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Hypo-Hatchet-Spyke	0.0100	0.1000	100			No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Hypo-Hatchet-Spyke	0.0100	0.9000	100		39	Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.8000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:Annual Grass	ReplacementFire	0.0400					Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SA	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Cattle+Sheep-Grazing	0.0500	0.9990			1	No		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Drought	0.0056	0.9000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Masticate+Native-Seed	0.0100		150		39	Yes		
Montane Sagebrush Steppe	MSS-U:SAP	Montane Sagebrush Steppe	MSS-U:SAP	Small-Tree-Lopping	0.0100		100	149		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 Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
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+	Masticate+Herbicide+Seed	0.0100	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:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.7000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1500				Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Masticate+Herbicide+Seed	0.0100	0.2000	150			Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:Annual Grass	ReplacementFire	0.0500					Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SA+	Cattle+Sheep-Grazing	0.0500	0.0010				No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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+	Montane Sagebrush Steppe	MSS-U:SAP+	Cattle+Sheep-Grazing	0.0500	0.9990			1	No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Drought	0.0056	0.9000			-1	No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Hypo-Hatchet-Spyke	0.0100	0.1000	100			No		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Hypo-Hatchet-Spyke	0.0100	0.9000	100		38	Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SAP+	Small-Tree-Lopping	0.0100		100	149	38	Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:SDI-C	Masticate+Herbicide+Seed	0.0100	0.7000	150			Yes		
Montane Sagebrush Steppe	MSS-U:SAP+	Montane Sagebrush Steppe	MSS-U:TEA	Tree-Invasion	0.0080		80			Yes		
Montane Sagebrush Steppe	MSS-U:SDI-A	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050				No		
Montane Sagebrush Steppe	MSS-U:SDI-A	Montane Sagebrush Steppe	MSS-U:SDI-A	Forb+Grass-Native-Seeding	0.0100					No	5	
Montane Sagebrush Steppe	MSS-U:SDI-A	Montane Sagebrush Steppe	MSS-U:SDI-A	Wild-Horse-Grazing	0.0100	0.9950			1	No		
Montane Sagebrush Steppe	MSS-U:SDI-A	Montane Sagebrush Steppe	MSS-A:All	Natural-Recovery	0.0001	1.0000	5			No	10	
Montane Sagebrush Steppe	MSS-U:SDI-A	Montane Sagebrush Steppe	MSS-U:SDI-A	Cattle+Sheep-Grazing	0.0500	0.0500	3			Yes		
Montane Sagebrush Steppe	MSS-U:SDI-A	Montane Sagebrush Steppe	MSS-U:SDI-A	Cattle+Sheep-Grazing	0.0500	0.9500	3		1	No		
Montane Sagebrush Steppe	MSS-U:SDI-A	Montane Sagebrush Steppe	MSS-U:SDI-A	ReplacementFire	0.0050	1.0000				Yes		
Montane Sagebrush Steppe	MSS-U:SDI-A	Montane Sagebrush Steppe	MSS-U:SI-A+AG	AG-Invasion	0.0050	1.0000				No		
Montane Sagebrush Steppe	MSS-U:SDI-B	Montane Sagebrush Steppe	MSS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-B	Montane Sagebrush Steppe	MSS-U:SDI-A	Thin	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-B	Montane Sagebrush Steppe	MSS-U:SDI-B	Forb+Grass-Native-Seeding	0.0100					No	5	
Montane Sagebrush Steppe	MSS-U:SDI-B	Montane Sagebrush Steppe	MSS-U:SDI-B	Wild-Horse-Grazing	0.0100				1	No		
Montane Sagebrush Steppe	MSS-U:SDI-B	Montane Sagebrush Steppe	MSS-B:Open	Natural-Recovery	0.0010					No	10	
Montane Sagebrush Steppe	MSS-U:SDI-B	Montane Sagebrush Steppe	MSS-U:SDI-A	ReplacementFire	0.0050					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-B	Montane Sagebrush Steppe	MSS-U:SDI-B	Cattle+Sheep-Grazing	0.0500				1	No		
Montane Sagebrush Steppe	MSS-U:SDI-B	Montane Sagebrush Steppe	MSS-U:SI-B+AG	AG-Invasion	0.0050					No		
Montane Sagebrush Steppe	MSS-U:SDI-C	Montane Sagebrush Steppe	MSS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-C	Montane Sagebrush Steppe	MSS-U:SDI-A	Thin	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-C	Montane Sagebrush Steppe	MSS-U:SDI-C	Forb+Grass-Native-Seeding	0.0100					No	5	
Montane Sagebrush Steppe	MSS-U:SDI-C	Montane Sagebrush Steppe	MSS-U:SDI-C	Wild-Horse-Grazing	0.0100					No		
Montane Sagebrush Steppe	MSS-U:SDI-C	Montane Sagebrush Steppe	MSS-C:Closed	Natural-Recovery	0.0100					No	10	
Montane Sagebrush Steppe	MSS-U:SDI-C	Montane Sagebrush Steppe	MSS-U:SDI-A	ReplacementFire	0.0050					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-C	Montane Sagebrush Steppe	MSS-U:SDI-C	Cattle+Sheep-Grazing	0.0500				1	No		
Montane Sagebrush Steppe	MSS-U:SDI-C	Montane Sagebrush Steppe	MSS-U:SDI-D	Tree-Invasion	0.0080		80			Yes		
Montane Sagebrush Steppe	MSS-U:SDI-C	Montane Sagebrush Steppe	MSS-U:SI-C+AG	AG-Invasion	0.0010					No		
Montane Sagebrush Steppe	MSS-U:SDI-D	Montane Sagebrush Steppe	MSS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-D	Montane Sagebrush Steppe	MSS-U:SDI-B	Chaining+Seed	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-D	Montane Sagebrush Steppe	MSS-U:SDI-C	Small-Tree-Lopping	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-D	Montane Sagebrush Steppe	MSS-U:SDI-D	Wild-Horse-Grazing	0.0100				1	No		
Montane Sagebrush Steppe	MSS-U:SDI-D	Montane Sagebrush Steppe	MSS-D:Open	Natural-Recovery	0.1000					No	10	
Montane Sagebrush Steppe	MSS-U:SDI-D	Montane Sagebrush Steppe	MSS-U:SDI-A	ReplacementFire	0.0050					Yes		
Montane Sagebrush Steppe	MSS-U:SDI-D	Montane Sagebrush Steppe	MSS-U:SDI-D	Cattle+Sheep-Grazing	0.0500				1	No		
Montane Sagebrush Steppe	MSS-U:SDI-D	Montane Sagebrush Steppe	MSS-U:SI-D+AG	AG-Invasion	0.0050					No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Depleted	Wild-Horse-Grazing	0.0100	0.0050	39			No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Wild-Horse-Grazing	0.0100			5		No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050	6	38		No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Seeded Native	Wild-Horse-Grazing	0.0100	0.9950	6		1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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: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:Annual Grass	AG-Invasion	0.0050	1.0000		11		No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Early-Shrub	Cattle+Sheep-Grazing	0.0500		3	5		No		
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:Seeded Native	Cattle+Sheep-Grazing	0.0500	0.0010	6		3	No		
Montane Sagebrush Steppe	MSS-U:Seeded Native	Montane Sagebrush Steppe	MSS-U:Seeded Native	Cattle+Sheep-Grazing	0.0500	0.9990	6		1	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:SI-A+AG	Montane Sagebrush Steppe	MSS-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0050		11		No		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Wild-Horse-Grazing	0.0100	0.9950		11	1	No		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SDI-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	Cattle+Sheep-Grazing	0.0500	0.0500	3	11		Yes		
Montane Sagebrush Steppe	MSS-U:SI-A+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Cattle+Sheep-Grazing	0.0500	0.9500	3	11	1	No		
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-B+AG	Montane Sagebrush Steppe	MSS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000				Yes		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Thin	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-B+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-B+AG	Wild-Horse-Grazing	0.0100				1	No		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SDI-B	Competition	0.3300					No	3	
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SDI-B	Herbicide-Plateau+Seed	0.0100	0.7000				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+AG	Cattle+Sheep-Grazing	0.0500				1	No		
Montane Sagebrush Steppe	MSS-U:SI-B+AG	Montane Sagebrush Steppe	MSS-U:SI-B+AG	Herbicide-Plateau+Seed	0.0100	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+AG	Montane Sagebrush Steppe	MSS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000				Yes		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Thin	0.0100					Yes		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Wild-Horse-Grazing	0.0100				1	No		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SDI-C	Competition	0.2000					No	3	
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SDI-C	Herbicide-Plateau+Seed	0.0100	0.7000				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+AG	Cattle+Sheep-Grazing	0.0500				1	No		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Herbicide-Plateau+Seed	0.0100	0.3000				No		
Montane Sagebrush Steppe	MSS-U:SI-C+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Wet-Year	0.1000					No		
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+AG	Montane Sagebrush Steppe	MSS-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-D+AG	Montane Sagebrush Steppe	MSS-U:SDI-C	Masticate+Herbicide+Seed	0.0100	0.8000	100			Yes		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Hypo-Hatchet-Spyke	0.0100	0.0500				No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Hypo-Hatchet-Spyke	0.0100	0.9500				Yes		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-D+AG	Masticate+Herbicide+Seed	0.0100	0.2000	100			No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-D+AG	Wild-Horse-Grazing	0.0100	0.9950			1	No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SDI-D	Competition	0.1000					No	3	
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	0.0100		100			No		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-C+AG	Small-Tree-Lopping	0.0100			99		Yes		
Montane Sagebrush Steppe	MSS-U:SI-D+AG	Montane Sagebrush Steppe	MSS-U:SI-D+AG	Cattle+Sheep-Grazing	0.0500				1	No		
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 Grass	RxFire+Seed+Chain	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SDI-A	RxFire+Seed+Chain	0.0100	0.5000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SI-A+AG	RxFire+Seed+Chain	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:TEA	RxFire+Seed+Chain	0.0100	0.3000				No		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:Annual Grass	Masticate+Herbicide+Seed	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:Annual Grass	ReplacementFire	0.0085	0.5000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SDI-A	Masticate+Herbicide+Seed	0.0100	0.8000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:SI-A+AG	Masticate+Herbicide+Seed	0.0100	0.1000				Yes		
Montane Sagebrush Steppe	MSS-U:TEA	Montane Sagebrush Steppe	MSS-U:TEA	Drought	0.0056	0.9000				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	Pinyon-Juniper	PJ-A:All	ReplacementFire	0.0050	1.0000		9		Yes		
Pinyon-Juniper	PJ-A:All	Pinyon-Juniper	PJ-U:Annual Grass	AG-Invasion	0.0001	1.0000		9		No		
Pinyon-Juniper	PJ-B:Open	Pinyon-Juniper	PJ-A:All	ReplacementFire	0.0050	1.0000				Yes		
Pinyon-Juniper	PJ-B:Open	Pinyon-Juniper	PJ-U:SAP	AG-Invasion	0.0050	1.0000				No		
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-C:Open	Chainsaw-Thinning	0.0100					No	100	
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-C:Open	Masticate+Seed	0.0100					No	100	
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-A:All	ReplacementFire	0.0050	1.0000				Yes	30	
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-B:Open	Drought	0.0056	0.1000				Yes		
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-C:Open	Drought	0.0056	0.9000				Yes		
Pinyon-Juniper	PJ-C:Open	Pinyon-Juniper	PJ-U:TA	AG-Invasion	0.0010	1.0000				No		
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-D:Open	Chainsaw-Thinning	0.0100					No	100	
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-D:Open	Masticate+Seed	0.0100					No	100	
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	0.0300				Yes	30	
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-C:Open	Insect/Disease	0.0167	0.0700				Yes	30	
Pinyon-Juniper	PJ-D:Open	Pinyon-Juniper	PJ-D:Open	Insect/Disease	0.0167	0.9000				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:TA	AG-Invasion	0.0010					No		
Pinyon-Juniper	PJ-U:Annual Grass	Pinyon-Juniper	PJ-U:Annual Grass	Aerial-Seed	0.0100	0.1000		3				
Pinyon-Juniper	PJ-U:Annual Grass	Pinyon-Juniper	PJ-U:Exotic Forb	Exotic-Invasion	0.0001	1.0000				No		
Pinyon-Juniper	PJ-U:Annual Grass	Pinyon-Juniper	PJ-U:SDI	Aerial-Seed	0.0100	0.5000			3			
Pinyon-Juniper	PJ-U:Annual Grass	Pinyon-Juniper	PJ-U:SDI+AG	Aerial-Seed	0.0100	0.4000			3			
Pinyon-Juniper	PJ-U:Annual Grass	Pinyon-Juniper	PJ-U:SDI+AG	Chaining+Seed	0.0100	0.1500			3			

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Annual Grass	Pinyon-Juniper	PJ-U:Annual Grass	Chaining+Seed	0.0100	0.1500		3		Yes		
Pinyon-Juniper	PJ-U:Annual Grass	Pinyon-Juniper	PJ-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Pinyon-Juniper	PJ-U:Annual Grass	Pinyon-Juniper	PJ-U:SDI	Chaining+Seed	0.0100	0.7000		3		Yes		
Pinyon-Juniper	PJ-U:Exotic Forb	Pinyon-Juniper	PJ-A:All	Exotic-Control	0.0100	0.6000				Yes		
Pinyon-Juniper	PJ-U:Exotic Forb	Pinyon-Juniper	PJ-U:Exotic Forb	Exotic-Control	0.0100	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:SAP	Pinyon-Juniper	PJ-U:Annual Grass	ReplacementFire	0.0100	1.0000				Yes		
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-U:SAP	Wild-Horse-Grazing	0.0100	0.0010		29		No		
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-U:SDI	Wild-Horse-Grazing	0.0100	0.9990			1	No		
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-U:TA	Wild-Horse-Grazing	0.0100	0.0010	30			No		
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-B:Open	Natural-Recovery	0.0001	1.0000	5	29		No	10	
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-C:Open	Natural-Recovery	0.0010	1.0000	30	99		No	10	
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-D:Open	Natural-Recovery	0.0100	1.0000	100			No	10	
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-U:SDI	Drought	0.0056	0.1000				Yes		
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-U:SDI	Drought	0.0056	0.9000			-1	No		
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-U:SDI	ReplacementFire	0.0010	1.0000				Yes		
Pinyon-Juniper	PJ-U:SDI	Pinyon-Juniper	PJ-U:SDI+AG	AG-Invasion	0.0010	1.0000				No		
Pinyon-Juniper	PJ-U:SDI+AG	Pinyon-Juniper	PJ-U:SAP	Wild-Horse-Grazing	0.0100	0.0010		29		No		
Pinyon-Juniper	PJ-U:SDI+AG	Pinyon-Juniper	PJ-U:SDI+AG	Wild-Horse-Grazing	0.0100	0.9990			1	No		
Pinyon-Juniper	PJ-U:SDI+AG	Pinyon-Juniper	PJ-U:TA	Wild-Horse-Grazing	0.0100	0.0010	30			No		
Pinyon-Juniper	PJ-U:SDI+AG	Pinyon-Juniper	PJ-U:SDI	Competition	0.3300	1.0000				No	3	
Pinyon-Juniper	PJ-U:SDI+AG	Pinyon-Juniper	PJ-U:SDI+AG	Drought	0.0056	0.1000				Yes		
Pinyon-Juniper	PJ-U:SDI+AG	Pinyon-Juniper	PJ-U:SDI+AG	Drought	0.0056	0.9000			-1	No		
Pinyon-Juniper	PJ-U:SDI+AG	Pinyon-Juniper	PJ-U:SDI+AG	ReplacementFire	0.0050	1.0000				Yes		
Pinyon-Juniper	PJ-U:SDI+AG	Pinyon-Juniper	PJ-U:SDI+AG	Wet-Year	0.1000	1.0000				No		
Pinyon-Juniper	PJ-U:TA	Pinyon-Juniper	PJ-U:TA	Masticate+Seed	0.0100					No	100	
Pinyon-Juniper	PJ-U:TA	Pinyon-Juniper	PJ-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Pinyon-Juniper	PJ-U:TA	Pinyon-Juniper	PJ-U:Annual Grass	ReplacementFire	0.0050	1.0000				Yes	30	
Pinyon-Juniper	PJ-U:TA	Pinyon-Juniper	PJ-U:TA	Drought	0.0056	0.9000				Yes		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-A:All	Cattle+Sheep-Grazing	0.0300	0.0100	3	39	5	No		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-A:All	Cattle+Sheep-Grazing	0.0300	0.9900	3	39	1	No		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-A:All	ReplacementFire	0.0100	1.0000		39		Yes		
Ponderosa Pine	PP-A:All	Ponderosa Pine	PP-B:Closed	Fuel-Build-Up	0.3300	1.0000		39		Yes	38	
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-A:All	ReplacementFire	0.0067	1.0000	40	159		Yes		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-B:Closed	RxFire	0.0100	0.3000				No		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-C:Open	Chainsaw-Thinning	0.0100	1.0000	40	159		No		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-C:Open	Insect/Disease	0.0050	1.0000	40	159		Yes		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-C:Open	MixedFire	0.0400	1.0000	40	159		No		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-C:Open	RxFire	0.0100	0.7000	40	159		No		
Ponderosa Pine	PP-B:Closed	Ponderosa Pine	PP-U:TA	AG-Invasion	0.0010	1.0000	40	159		No		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-A:All	ReplacementFire	0.0003	1.0000	40	159		Yes		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-B:Closed	Cattle+Sheep-Grazing	0.0300	0.0010	40	159	1	No		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-B:Closed	Fuel-Build-Up	0.3300	1.0000	40	159		No	30	
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-C:Open	Cattle+Sheep-Grazing	0.0300	0.9990	40	159	1	No		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-C:Open	SurfaceFire	0.0550	1.0000	40	159		No		
Ponderosa Pine	PP-C:Open	Ponderosa Pine	PP-U:TA	AG-Invasion	0.0010	1.0000	40	159		No		
Ponderosa Pine	PP-D:Open	Ponderosa Pine	PP-A:All	ReplacementFire	0.0025	1.0000	160			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-D:Open	Ponderosa Pine	PP-C:Open	Senescence	0.0100	1.0000	400			Yes		
Ponderosa Pine	PP-D:Open	Ponderosa Pine	PP-D:Open	Cattle+Sheep-Grazing	0.0300	0.9990	160		1	No		
Ponderosa Pine	PP-D:Open	Ponderosa Pine	PP-D:Open	SurfaceFire	0.0550	1.0000	160			No		
Ponderosa Pine	PP-D:Open	Ponderosa Pine	PP-E:Closed	Cattle+Sheep-Grazing	0.0300	0.0010	160		1	No		
Ponderosa Pine	PP-D:Open	Ponderosa Pine	PP-E:Closed	Fuel-Build-Up	0.3300	1.0000	160			No	50	
Ponderosa Pine	PP-D:Open	Ponderosa Pine	PP-U:TA	AG-Invasion	0.0010	1.0000	160			No		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-D:Open	Chainsaw-Thinning	0.0100	1.0000	160	199		No		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-A:All	ReplacementFire	0.0050	1.0000	210			Yes		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-A:All	ReplacementFire	0.0067	1.0000	160	209		Yes		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-B:Closed	Senescence	0.0100	1.0000	400			Yes		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-D:Open	Chainsaw-Thinning	0.0100	1.0000	200			Yes		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-D:Open	Insect/Disease	0.0050	1.0000	160	209		Yes		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-D:Open	Insect/Disease	0.0100	1.0000	210			Yes		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-D:Open	MixedFire	0.0500	1.0000	160			No		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-D:Open	RxFire	0.0100	0.7000	160			No		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-E:Closed	RxFire	0.0100	0.3000	160			No		
Ponderosa Pine	PP-E:Closed	Ponderosa Pine	PP-U:TA	AG-Invasion	0.0010	1.0000	160			No		
Ponderosa Pine	PP-U:Annual Grass	Ponderosa Pine	PP-U:Annual Grass	ReplacementFire	0.1000	1.0000		39	-999	Yes		
Ponderosa Pine	PP-U:TA	Ponderosa Pine	PP-B:Closed	Natural-Recovery	0.0100	1.0000	40	159		No	3	
Ponderosa Pine	PP-U:TA	Ponderosa Pine	PP-E:Closed	Natural-Recovery	0.0100	1.0000	160			No	30	
Ponderosa Pine	PP-U:TA	Ponderosa Pine	PP-U:Annual Grass	Insect/Disease	0.0050	0.1000	40			Yes		
Ponderosa Pine	PP-U:TA	Ponderosa Pine	PP-U:Annual Grass	MixedFire	0.0400	0.2500	40			Yes		
Ponderosa Pine	PP-U:TA	Ponderosa Pine	PP-U:Annual Grass	ReplacementFire	0.0067	1.0000	40			Yes		
Ponderosa Pine	PP-U:TA	Ponderosa Pine	PP-U:TA	Cattle+Sheep-Grazing	0.0300	0.0010	40		5	No		
Ponderosa Pine	PP-U:TA	Ponderosa Pine	PP-U:TA	Cattle+Sheep-Grazing	0.0300	0.9990	40		1	No		
Ponderosa Pine	PP-U:TA	Ponderosa Pine	PP-U:TA	Insect/Disease	0.0050	0.9000	40			Yes		
Ponderosa Pine	PP-U:TA	Ponderosa Pine	PP-U:TA	MixedFire	0.0400	0.7500	40			No		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-A:Open	AG-Invasion	0.0010	1.0000		19		No		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-A:Open	Cattle+Sheep-Grazing	0.0300	0.9900	3	19	2	No		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-A:Open	NativeGrazing	0.0100	1.0000		19	-1	No		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-A:Open	ReplacementFire	0.0083	1.0000		19		Yes		
Semi-Desert Grassland	SDG-A:Open	Semi-Desert Grassland	SDG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0100	3	19		No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-A:Open	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-A:Open	Drought	0.0056	0.1000				Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-A:Open	ReplacementFire	0.0100	1.0000				Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-A:Open	Thin	0.0100					Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-B:Closed	Cattle+Sheep-Grazing	0.0300	0.9990			2	No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-B:Closed	Drought	0.0056	0.9000				Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-B:Closed	NativeGrazing	0.0100	1.0000				Yes		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:Depleted	Cattle+Sheep-Grazing	0.0300	0.0010	60			No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010		59		No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:SAP	AG-Invasion	0.0050	1.0000				No		
Semi-Desert Grassland	SDG-B:Closed	Semi-Desert Grassland	SDG-U:TEA	Tree-Encroachment	0.0080	1.0000	150			Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Depleted	Cattle+Sheep-Grazing	0.0300	0.9990	3		1	No		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Depleted	Drought	0.0056	0.9000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010	3			No		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Early-Shrub	Drought	0.0056	0.1000				Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:Early-Shrub	ReplacementFire	0.0100					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:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Semi-Desert Grassland	SDG-U:Depleted	Semi-Desert Grassland	SDG-U:TEA	Tree-Encroachment	0.0080		150			No		
Semi-Desert Grassland	SDG-U:Early-Shrub	Semi-Desert Grassland	SDG-U:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.5000				Yes		
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:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010	3			No		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Cattle+Sheep-Grazing	0.0300	0.9990	3		1	No		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Chaining+Native-Seed	0.0100	0.5000		3		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Chaining+Plateau+Seed	0.0100	0.2000		3		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Drought	0.0056	0.1000				Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Drought	0.0056	0.9000			2	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	Thin+Herbicide+Native-Seed	0.0100	0.2500	20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SAP	Thin+Herbicide+Seed	0.0100	0.2000	20			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:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SDI	Chaining+Plateau+Seed	0.0100	0.6000		3		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SDI	Thin+Herbicide+Seed	0.0100	0.6000	20			No		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SDI+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SDI+AG	Chaining+Plateau+Seed	0.0100	0.2000		3		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SDI+AG	Thin+Herbicide+Native-Seed	0.0100	0.2500	20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:SDI+AG	Thin+Herbicide+Seed	0.0100	0.2000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:Seeded Native	Chaining+Native-Seed	0.0100	0.5000		3		Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:Seeded Native	Thin+Herbicide+Native-Seed	0.0100	0.5000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP	Semi-Desert Grassland	SDG-U:TEA	Tree-Encroachment	0.0080		150			Yes		
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	0.0100	0.2500				Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2500				Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Cattle+Sheep-Grazing	0.0300	0.0010	3		5	No		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Cattle+Sheep-Grazing	0.0300	0.9990	3		1	No		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	Drought	0.0056	0.1000	20			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SAP+	Drought	0.0056	0.9000	20		2	Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	ReplacementFire	0.0200	1.0000	20			Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SAP+	ReplacementFire	0.1000	1.0000		19		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:SDI	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.5000				Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SDI	Thin+Herbicide+Seed	0.0100	0.5000				No		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SDI+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2500				Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:SDI+AG	Thin+Herbicide+Seed	0.0100	0.2500				Yes		
Semi-Desert Grassland	SDG-U:SAP+	Semi-Desert Grassland	SDG-U:TEA	Tree-Encroachment	0.0080	1.0000	150			No		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-A:Open	Natural-Recovery	0.0001		5	19		No	10	
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-B:Closed	Natural-Recovery	0.0010		20			No	10	
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0050	3			No		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050				No		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:SDI	Cattle+Sheep-Grazing	0.0300	0.9950	3		1	No		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:SDI	Drought	0.0056	0.1000	20			Yes		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:SDI	Drought	0.0056	0.9000	20		2	Yes		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:SDI	Forb+Grass-Native-Seeding	0.0100					No		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:SDI	ReplacementFire	0.0010			19		Yes		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:SDI	ReplacementFire	0.0050		20			Yes		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:SDI	Wild-Horse-Grazing	0.0100	0.9950			1	No		
Semi-Desert Grassland	SDG-U:SDI	Semi-Desert Grassland	SDG-U:SDI+AG	AG-Invasion	0.0010	1.0000				No		
Semi-Desert Grassland	SDG-U:SDI+AG	Semi-Desert Grassland	SDG-U:SAP	Cattle+Sheep-Grazing	0.0300	0.0050	3			Yes		
Semi-Desert Grassland	SDG-U:SDI+AG	Semi-Desert Grassland	SDG-U:SAP	Wild-Horse-Grazing	0.0100	0.0050				Yes		
Semi-Desert Grassland	SDG-U:SDI+AG	Semi-Desert Grassland	SDG-U:SDI	Competition	0.3330	1.0000				No	3	
Semi-Desert Grassland	SDG-U:SDI+AG	Semi-Desert Grassland	SDG-U:SDI+AG	Cattle+Sheep-Grazing	0.0300	0.9950	3		1	No		
Semi-Desert Grassland	SDG-U:SDI+AG	Semi-Desert Grassland	SDG-U:SDI+AG	Forb+Grass-Native-Seeding	0.0100					No		
Semi-Desert Grassland	SDG-U:SDI+AG	Semi-Desert Grassland	SDG-U:SDI+AG	ReplacementFire	0.0100	1.0000				Yes		
Semi-Desert Grassland	SDG-U:SDI+AG	Semi-Desert Grassland	SDG-U:SDI+AG	Wet-Year	0.1000	1.0000				No		
Semi-Desert Grassland	SDG-U:SDI+AG	Semi-Desert Grassland	SDG-U:SDI+AG	Wild-Horse-Grazing	0.0100	0.9950			1	No		
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:Early-Shrub	Cattle+Sheep-Grazing	0.0300		3	5		No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010	6			No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Early-Shrub	Wild-Horse-Grazing	0.0100					No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050	6			No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:SAP	AG-Invasion	0.0050	1.0000				No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Seeded Native	Cattle+Sheep-Grazing	0.0300	0.9990	6		1	No		
Semi-Desert Grassland	SDG-U:Seeded Native	Semi-Desert Grassland	SDG-U:Seeded Native	Drought	0.0056	1.0000			-1	Yes		
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	Wild-Horse-Grazing	0.0100	0.9950	6		1	No		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:Early-Shrub	Drought	0.0056	0.0500	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:Early-Shrub	ReplacementFire	0.0067	0.5000	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:SAP+	Drought	0.0056	0.0500	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:SAP+	Masticate+Herbicide+Seed	0.0100	0.2000	150			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:TEA	Semi-Desert Grassland	SDG-U:SAP+	ReplacementFire	0.0067	0.5000	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:SDI	Masticate+Herbicide+Seed	0.0100	0.6000	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:SDI+AG	Masticate+Herbicide+Seed	0.0100	0.2000	150			Yes		
Semi-Desert Grassland	SDG-U:TEA	Semi-Desert Grassland	SDG-U:TEA	Drought	0.0056	0.9000	150			Yes		
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	Cattle+Sheep-Grazing	0.0300	0.9900	3		1	No		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	NativeGrazing	0.0010	1.0000		4		Yes		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	NativeGrazing	0.0010	1.0000	5		-1	No		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-A:All	ReplacementFire	0.0020	1.0000				Yes		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-U:Annual Grass	AG-Invasion	0.0050	1.0000				No		
Stansbury Cliffrose	SC-A:All	Stansbury Cliffrose	SC-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0100	3			No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-A:All	Drought	0.0056	0.0100				Yes		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-A:All	ReplacementFire	0.0100	1.0000				Yes		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-B:Closed	Cattle+Sheep-Grazing	0.0300	0.9990				No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-B:Closed	Drought	0.0056	0.9900				No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-B:Closed	NativeGrazing	0.0010	1.0000			-1	No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Stansbury Cliffrose	SC-B:Closed	Stansbury Cliffrose	SC-U:SAP	AG-Invasion	0.0050	1.0000				No		
Stansbury Cliffrose	SC-C:Closed	Stansbury Cliffrose	SC-A:All	Drought	0.0056	0.0100	80			Yes		
Stansbury Cliffrose	SC-C:Closed	Stansbury Cliffrose	SC-A:All	ReplacementFire	0.0067	1.0000	80			Yes		
Stansbury Cliffrose	SC-C:Closed	Stansbury Cliffrose	SC-B:Closed	Drought	0.0056	0.0900	80			Yes		
Stansbury Cliffrose	SC-C:Closed	Stansbury Cliffrose	SC-C:Closed	Cattle+Sheep-Grazing	0.0300	0.9990	80			No		
Stansbury Cliffrose	SC-C:Closed	Stansbury Cliffrose	SC-C:Closed	Drought	0.0056	0.9000	80			Yes		
Stansbury Cliffrose	SC-C:Closed	Stansbury Cliffrose	SC-U:Depleted	Cattle+Sheep-Grazing	0.0300	0.0010	80	149		No		
Stansbury Cliffrose	SC-C:Closed	Stansbury Cliffrose	SC-U:TEA	AG-Invasion	0.0050	1.0000	80			No		
Stansbury Cliffrose	SC-C:Closed	Stansbury Cliffrose	SC-U:TEA	Cattle+Sheep-Grazing	0.0300	0.0010	150			No		
Stansbury Cliffrose	SC-C:Closed	Stansbury Cliffrose	SC-U:TEA	Tree-Encroachment	0.0200	1.0000	250			No		
Stansbury Cliffrose	SC-U:Annual Grass	Stansbury Cliffrose	SC-U:Annual Grass	Chaining+Native-Seed	0.0100	0.2000		3		Yes		
Stansbury Cliffrose	SC-U:Annual Grass	Stansbury Cliffrose	SC-U:Annual Grass	Wet-Year	0.1000	1.0000		2		Yes		
Stansbury Cliffrose	SC-U:Annual Grass	Stansbury Cliffrose	SC-U:Seeded Native	Chaining+Native-Seed	0.0100	0.8000		3		Yes		
Stansbury Cliffrose	SC-U:Annual Grass	Stansbury Cliffrose	SC-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Stansbury Cliffrose	SC-U:Annual Grass	Stansbury Cliffrose	SC-U:Annual Grass	Spot-Herbicide+Native-Seed	0.0100	0.3000		3		Yes		
Stansbury Cliffrose	SC-U:Annual Grass	Stansbury Cliffrose	SC-U:SAP	Alternate-Succession	1.0000	1.0000	12			Yes	3	
Stansbury Cliffrose	SC-U:Annual Grass	Stansbury Cliffrose	SC-U:Seeded Native	Spot-Herbicide+Native-Seed	0.0100	0.7000		3		Yes		
Stansbury Cliffrose	SC-U:Depleted	Stansbury Cliffrose	SC-U:Depleted	Small-Tree-Lopping	0.0100		80	99		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	Drought	0.0056	0.9900				No		
Stansbury Cliffrose	SC-U:Depleted	Stansbury Cliffrose	SC-U:Early-Shrub	Drought	0.0056	0.0100				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:SAP	AG-Invasion	0.0050	1.0000				No		
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 Grass	Drought	0.0056	0.0100				Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:Annual Grass	ReplacementFire	0.0150					Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Cattle+Sheep-Grazing	0.0300	0.0010			1	No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Cattle+Sheep-Grazing	0.0300	0.9990				No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Drought	0.0056	0.9900				No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Masticate+Herbicide+Native-Seed	0.0100	0.3000	100		13	Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SAP	NativeGrazing	0.0010				-1	No		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Small-Tree-Lopping	0.0100		80	99		Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:SAP	Spyke+Plateau+Native-Seed	0.0100	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	0.0100	0.7000	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP	Stansbury Cliffrose	SC-U:Seeded Native	Spyke+Plateau+Native-Seed	0.0100	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: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:Annual Grass	Drought	0.0056	0.0100	13			Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:Annual Grass	ReplacementFire	0.0200	1.0000	13			Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP	Masticate+Herbicide+Native-Seed	0.0100	0.1500	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP	Spyke+Plateau+Native-Seed	0.0100	0.1500	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Cattle+Sheep-Grazing	0.0300	0.0010	13		1	No		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Cattle+Sheep-Grazing	0.0300	0.9990	13			No		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Drought	0.0056	0.9900	13			No		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Masticate+Herbicide+Native-Seed	0.0100	0.1500	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Small-Tree-Lopping	0.0100	1.0000	80	99	13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:SAP+	Spyke+Plateau+Native-Seed	0.0100	0.1500	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:Seeded Native	Masticate+Herbicide+Native-Seed	0.0100	0.7000	100		13	Yes		
Stansbury Cliffrose	SC-U:SAP+	Stansbury Cliffrose	SC-U:Seeded Native	Spyke+Plateau+Native-Seed	0.0100	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:SDI-A	Stansbury Cliffrose	SC-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010		12		No		
Stansbury Cliffrose	SC-U:SDI-A	Stansbury Cliffrose	SC-U:SDI-A	Wild-Horse-Grazing	0.0100	0.9990		12	1	No		
Stansbury Cliffrose	SC-U:SDI-A	Stansbury Cliffrose	SC-A:All	Natural-Recovery	0.0001	1.0000	5	12		No	10	
Stansbury Cliffrose	SC-U:SDI-A	Stansbury Cliffrose	SC-U:SDI-A	Cattle+Sheep-Grazing	0.0300	0.0500	3	12		Yes		
Stansbury Cliffrose	SC-U:SDI-A	Stansbury Cliffrose	SC-U:SDI-A	Cattle+Sheep-Grazing	0.0300	0.9500	3	12	1	No		
Stansbury Cliffrose	SC-U:SDI-A	Stansbury Cliffrose	SC-U:SDI-A	NativeGrazing	0.0010	1.0000		4		Yes		
Stansbury Cliffrose	SC-U:SDI-A	Stansbury Cliffrose	SC-U:SDI-A	NativeGrazing	0.0010	1.0000	5	12	-1	No		
Stansbury Cliffrose	SC-U:SDI-A	Stansbury Cliffrose	SC-U:SDI-A	ReplacementFire	0.0050	1.0000		12		Yes		
Stansbury Cliffrose	SC-U:SDI-A	Stansbury Cliffrose	SC-U:SI-A+AG	AG-Invasion	0.0010	1.0000		12		No		
Stansbury Cliffrose	SC-U:SDI-B	Stansbury Cliffrose	SC-U:SDI-B	Wild-Horse-Grazing	0.0100		13	79	1	No		
Stansbury Cliffrose	SC-U:SDI-B	Stansbury Cliffrose	SC-B:Closed	Natural-Recovery	0.0010	1.0000	13	79		No	10	
Stansbury Cliffrose	SC-U:SDI-B	Stansbury Cliffrose	SC-U:SDI-A	Drought	0.0056	0.0100	13	79		Yes		
Stansbury Cliffrose	SC-U:SDI-B	Stansbury Cliffrose	SC-U:SDI-A	ReplacementFire	0.0050	1.0000	13	79		Yes		
Stansbury Cliffrose	SC-U:SDI-B	Stansbury Cliffrose	SC-U:SDI-B	Cattle+Sheep-Grazing	0.0300		13	79	1	No		
Stansbury Cliffrose	SC-U:SDI-B	Stansbury Cliffrose	SC-U:SDI-B	Drought	0.0056	0.9900	13	79		No		
Stansbury Cliffrose	SC-U:SDI-B	Stansbury Cliffrose	SC-U:SDI-B	NativeGrazing	0.0010	1.0000	13	79	-1	No		
Stansbury Cliffrose	SC-U:SDI-B	Stansbury Cliffrose	SC-U:SI-B+AG	AG-Invasion	0.0010	1.0000	13	79		No		
Stansbury Cliffrose	SC-U:SDI-C	Stansbury Cliffrose	SC-U:SDI-C	Cattle+Sheep-Grazing	0.0300				1	No		
Stansbury Cliffrose	SC-U:SDI-C	Stansbury Cliffrose	SC-U:SDI-C	Wild-Horse-Grazing	0.0100				1	No		
Stansbury Cliffrose	SC-U:SDI-C	Stansbury Cliffrose	SC-C:Closed	Natural-Recovery	0.0100	1.0000	80			No	10	
Stansbury Cliffrose	SC-U:SDI-C	Stansbury Cliffrose	SC-U:SDI-A	Drought	0.0056	0.0100	80			Yes		
Stansbury Cliffrose	SC-U:SDI-C	Stansbury Cliffrose	SC-U:SDI-B	Drought	0.0056	0.0900	80			Yes		
Stansbury Cliffrose	SC-U:SDI-C	Stansbury Cliffrose	SC-U:SDI-C	Drought	0.0056	0.9000	80			No		
Stansbury Cliffrose	SC-U:SDI-C	Stansbury Cliffrose	SC-U:SDI-C	ReplacementFire	0.0050	1.0000	80			Yes		
Stansbury Cliffrose	SC-U:SDI-C	Stansbury Cliffrose	SC-U:SI-C+AG	AG-Invasion	0.0010	1.0000	80			No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SDI-C	Stansbury Cliffrose	SC-U:TEA	Tree-Encroachment	0.0200	1.0000	250			No		
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:Closed	Natural-Recovery	0.3330	1.0000	80			No	5	
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Annual Grass	AG-Invasion	0.0050	1.0000		12		No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300		3	5		No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010	6			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:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0010	6			No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:SAP	AG-Invasion	0.0050	1.0000	13			No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	Cattle+Sheep-Grazing	0.0300	0.9990	6		1	No		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	Drought	0.0056	0.0100	13			Yes		
Stansbury Cliffrose	SC-U:Seeded Native	Stansbury Cliffrose	SC-U:Seeded Native	Drought	0.0056	0.9900	13			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	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		1	No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0010				No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Wild-Horse-Grazing	0.0100	0.9990			1	No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SDI-A	Competition	0.3300	1.0000		12		No	3	
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SDI-A	Herbicide-Plateau	0.0100	0.7000		12		No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Cattle+Sheep-Grazing	0.0300	0.0500	3			Yes		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Cattle+Sheep-Grazing	0.0300	0.9500	3		1	No		
Stansbury Cliffrose	SC-U:SI-A+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Herbicide-Plateau	0.0100	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	0.0100	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+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Wild-Horse-Grazing	0.0100				1	No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SDI-B	Competition	0.3300	1.0000	13	79		No	3	
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SDI-B	Herbicide-Plateau	0.0100	0.7000	13	79		No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Drought	0.0056	0.0100	13	79		Yes		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-A+AG	ReplacementFire	0.0100	1.0000	13	79		Yes		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Cattle+Sheep-Grazing	0.0300				1	No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Drought	0.0056	0.9900	13	79		Yes		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Herbicide-Plateau	0.0100	0.3000	13	79		No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	NativeGrazing	0.0010	1.0000	13	79	-1	No		
Stansbury Cliffrose	SC-U:SI-B+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Wet-Year	0.1000	1.0000	13	79		No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C+AG	Wild-Horse-Grazing	0.0100				1	No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SDI-B	Spyke+Plateau+Native-Seed	0.0100	0.7000	100			Yes		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SDI-C	Competition	0.2000	1.0000	80			No	3	
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SDI-C	Herbicide-Plateau	0.0100	0.7000	80	99		No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-A+AG	Drought	0.0056	0.0100	80			Yes		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-A+AG	ReplacementFire	0.0100	1.0000	80			Yes		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Drought	0.0056	0.0900	80			Yes		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-B+AG	Spyke+Plateau+Native-Seed	0.0100	0.3000	100			Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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+AG	Stansbury Cliffrose	SC-U:SI-C+AG	Cattle+Sheep-Grazing	0.0300				1	No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C+AG	Drought	0.0056	0.9000	80			No		
Stansbury Cliffrose	SC-U:SI-C+AG	Stansbury Cliffrose	SC-U:SI-C+AG	Herbicide-Plateau	0.0100	0.3000	80	99		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	0.0200	1.0000	250			No		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Annual Grass	Masticate+Herbicide+Native-Seed	0.0100	0.2000	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Annual Grass	Drought	0.0056	0.0100	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Annual Grass	ReplacementFire	0.0067	1.0000	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Annual Grass	Spyke+Plateau+Native-Seed	0.0100	0.2000	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Early-Shrub	Drought	0.0056	0.0450	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:SAP	Drought	0.0056	0.0450	80			Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:SAP	Masticate+Herbicide+Native-Seed	0.0100	0.2000	80		13	Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:SAP	Spyke+Plateau+Native-Seed	0.0100	0.2000	80		13	Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Seeded Native	Masticate+Herbicide+Native-Seed	0.0100	0.6000	80		13	Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:Seeded Native	Spyke+Plateau+Native-Seed	0.0100	0.6000	80		13	Yes		
Stansbury Cliffrose	SC-U:TEA	Stansbury Cliffrose	SC-U:TEA	Drought	0.0056	0.9000	80			Yes		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-A:All	Cattle+Sheep-Grazing	0.0500	0.9900	2	4	1	No		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-A:All	Drought	0.0056	1.0000		4		Yes		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-A:All	ReplacementFire	0.0125	1.0000		4		Yes		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-U:Annual Grass	AG-Invasion	0.0001	1.0000		4		No		
Utah Serviceberry	US-A:All	Utah Serviceberry	US-U:Early-Shrub	Cattle+Sheep-Grazing	0.0500	0.0100	2	4		No		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-A:All	Drought	0.0056	0.1000	5	19		Yes		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-A:All	ReplacementFire	0.0200	1.0000	5	19		Yes		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-B:Closed	Cattle+Sheep-Grazing	0.0500	0.9990	5	19	1	No		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-B:Closed	Drought	0.0056	0.9000	5	19		Yes		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-U:Early-Shrub	Cattle+Sheep-Grazing	0.0500	0.0010	5	19		No		
Utah Serviceberry	US-B:Closed	Utah Serviceberry	US-U:SAP	AG-Invasion	0.0050	1.0000	5	19		No		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-A:All	ReplacementFire	0.0250	1.0000				Yes		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-B:Closed	Drought	0.0056	0.1000				Yes		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-C:Closed	Cattle+Sheep-Grazing	0.0500	0.9990			1	No		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-C:Closed	Drought	0.0056	0.9000				Yes		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-U:Depleted	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Utah Serviceberry	US-C:Closed	Utah Serviceberry	US-U:SAP	AG-Invasion	0.0050	1.0000				No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-A:All	RxFire	0.0100	0.7000				Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-B:Closed	Chainsaw-Thinning	0.0100	0.6000				Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-C:Closed	Chainsaw-Thinning	0.0100	0.4000				Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-C:Closed	Small-Tree-Lopping	0.0100					Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-D:Open	RxFire	0.0100	0.3000				No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-A:All	ReplacementFire	0.0200	1.0000				Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-C:Closed	Drought	0.0056	0.1000				Yes		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-D:Open	Cattle+Sheep-Grazing	0.0500	0.9990			2	No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-D:Open	Drought	0.0056	0.9000				No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-U:TA	AG-Invasion	0.0050	1.0000				No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-U:TE	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Utah Serviceberry	US-D:Open	Utah Serviceberry	US-U:TE	Tree-Encroachment	0.0200	1.0000	200			No		
Utah Serviceberry	US-U:Annual Grass	Utah Serviceberry	US-A:All	Herbicide-Plateau+Native-Seed	0.0100	0.6000		3		Yes		
Utah Serviceberry	US-U:Annual Grass	Utah Serviceberry	US-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.1000		3		Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Annual Grass	Utah Serviceberry	US-U:Annual Grass	Herbicide-Plateau+Native-Seed	0.0100	0.4000		3		Yes		
Utah Serviceberry	US-U:Annual Grass	Utah Serviceberry	US-U:SDI-A	Chaining+Plateau+Seed	0.0100	0.8000		3		Yes		
Utah Serviceberry	US-U:Annual Grass	Utah Serviceberry	US-U:SI-A+AG	Chaining+Plateau+Seed	0.0100	0.1000		3		Yes		
Utah Serviceberry	US-U:Annual Grass	Utah Serviceberry	US-U:Annual Grass	Herbicide-Plateau+Seed	0.0100	0.2500		3		Yes		
Utah Serviceberry	US-U:Annual Grass	Utah Serviceberry	US-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Utah Serviceberry	US-U:Annual Grass	Utah Serviceberry	US-U:SAP	Alternate-Succession	0.1000	1.0000	5			No	6	
Utah Serviceberry	US-U:Annual Grass	Utah Serviceberry	US-U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.7500		3		Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:Depleted	Chaining+Seed	0.0100	0.2000			4	Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:Depleted	Small-Tree-Lopping	0.0100		80			Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:SDI-A	Chaining+Seed	0.0100	0.8000				Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:Depleted	Drought	0.0056	0.9000				Yes		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:Early-Shrub	Drought	0.0056	0.1000				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:SAP	AG-Invasion	0.0050					No		
Utah Serviceberry	US-U:Depleted	Utah Serviceberry	US-U:TE	Tree-Invasion	0.0080		80			Yes		
Utah Serviceberry	US-U:Early-Shrub	Utah Serviceberry	US-U:Early-Shrub	ReplacementFire	0.0200	1.0000				Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-B:Closed	Chaining+Plateau+Native-Seed	0.0100	0.4000	80			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-C:Closed	Chaining+Plateau+Native-Seed	0.0100	0.4000	80			No		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Chaining+Plateau+Native-Seed	0.0100	0.1000	80			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Chaining+Plateau+Native-Seed	0.0100	0.1000	80		15	Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-A:All	Thin+Herbicide+Native-Seed	0.0100	0.7000	5	19		Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-B:Closed	Thin+Herbicide+Native-Seed	0.0100	0.7000	20	79		Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:Annual Grass	Drought	0.0056	0.1000	5			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:Annual Grass	ReplacementFire	0.0250	1.0000	5			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Cattle+Sheep-Grazing	0.0500	0.0010	5		5	No		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Cattle+Sheep-Grazing	0.0500	0.9990	5		1	No		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Drought	0.0056	0.9000	5			Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Small-Tree-Lopping	0.0100	1.0000	80	149	14	Yes		
Utah Serviceberry	US-U:SAP	Utah Serviceberry	US-U:SAP	Thin+Herbicide+Native-Seed	0.0100	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:TA	Tree-Invasion	0.0080	1.0000	80			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+	Chaining+Plateau+Seed	0.0100	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:SDI-B	Chaining+Plateau+Seed	0.0100	0.3500	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SDI-C	Chaining+Plateau+Seed	0.0100	0.3500	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-B+AG	Chaining+Plateau+Seed	0.0100	0.1000	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-B+AG	Thin+Herbicide+Seed	0.0100	0.3000	20	79				
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SI-C+AG	Chaining+Plateau+Seed	0.0100	0.1000	80			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:Annual Grass	Drought	0.0056	0.1000	5			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:Annual Grass	ReplacementFire	0.0500	1.0000	5			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP	Drought	0.0056	0.9000	5			Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP+	Cattle+Sheep-Grazing	0.0500	0.0500	5		5	No		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP+	Cattle+Sheep-Grazing	0.0500	0.9500	5		1	No		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SAP+	Small-Tree-Lopping	0.0100	1.0000	80	149	14	Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SDI-A	Thin+Herbicide+Seed	0.0100	0.7000	5	19		Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:SDI-B	Thin+Herbicide+Seed	0.0100	0.7000	20	79		Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SI-A+AG	Thin+Herbicide+Seed	0.0100	0.3000	5	19		Yes		
Utah Serviceberry	US-U:SAP+	Utah Serviceberry	US-U:TA	Tree-Invasion	0.0080	1.0000	80			Yes		
Utah Serviceberry	US-U:SDI-A	Utah Serviceberry	US-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050		4		No		
Utah Serviceberry	US-U:SDI-A	Utah Serviceberry	US-U:SDI-A	Forb+Grass-Native-Seeding	0.0100					No	5	
Utah Serviceberry	US-U:SDI-A	Utah Serviceberry	US-U:SDI-A	Wild-Horse-Grazing	0.0100	0.9950		4	1	No		
Utah Serviceberry	US-U:SDI-A	Utah Serviceberry	US-U:SDI-A	Cattle+Sheep-Grazing	0.0500	0.0500	3	4		Yes		
Utah Serviceberry	US-U:SDI-A	Utah Serviceberry	US-U:SDI-A	Cattle+Sheep-Grazing	0.0500	0.9500	3	4	1	No		
Utah Serviceberry	US-U:SDI-A	Utah Serviceberry	US-U:SDI-A	ReplacementFire	0.0050	1.0000		4		Yes		
Utah Serviceberry	US-U:SDI-A	Utah Serviceberry	US-U:SI-A+AG	AG-Invasion	0.0010	1.0000		4		No		
Utah Serviceberry	US-U:SDI-B	Utah Serviceberry	US-U:SDI-B	Forb+Grass-Native-Seeding	0.0100					No	5	
Utah Serviceberry	US-U:SDI-B	Utah Serviceberry	US-U:SDI-B	Wild-Horse-Grazing	0.0100		5	19	1	No		
Utah Serviceberry	US-U:SDI-B	Utah Serviceberry	US-B:Closed	Natural-Recovery	0.0010	1.0000	5	19		No	10	
Utah Serviceberry	US-U:SDI-B	Utah Serviceberry	US-U:SDI-A	ReplacementFire	0.0050	1.0000	5	19		Yes		
Utah Serviceberry	US-U:SDI-B	Utah Serviceberry	US-U:SDI-B	Cattle+Sheep-Grazing	0.0500		5	19	1	No		
Utah Serviceberry	US-U:SDI-B	Utah Serviceberry	US-U:SI-B+AG	AG-Invasion	0.0050	1.0000	5	19		No		
Utah Serviceberry	US-U:SDI-C	Utah Serviceberry	US-U:SDI-C	Forb+Grass-Native-Seeding	0.0100					No	5	
Utah Serviceberry	US-U:SDI-C	Utah Serviceberry	US-U:SDI-C	Wild-Horse-Grazing	0.0100		20	79	1	No		
Utah Serviceberry	US-U:SDI-C	Utah Serviceberry	US-C:Closed	Natural-Recovery	0.0100	1.0000	20	79		No	10	
Utah Serviceberry	US-U:SDI-C	Utah Serviceberry	US-U:SDI-A	ReplacementFire	0.0050	1.0000	20	79		Yes		
Utah Serviceberry	US-U:SDI-C	Utah Serviceberry	US-U:SDI-C	Cattle+Sheep-Grazing	0.0500		20	79	1	No		
Utah Serviceberry	US-U:SDI-C	Utah Serviceberry	US-U:SI-C+AG	AG-Invasion	0.0010	1.0000	20	79		No		
Utah Serviceberry	US-U:SDI-D	Utah Serviceberry	US-U:SDI-D	Wild-Horse-Grazing	0.0100		80		1	No		
Utah Serviceberry	US-U:SDI-D	Utah Serviceberry	US-D:Open	Natural-Recovery	0.1000	1.0000	80			No	10	
Utah Serviceberry	US-U:SDI-D	Utah Serviceberry	US-U:SDI-A	ReplacementFire	0.0050	1.0000	80			Yes		
Utah Serviceberry	US-U:SDI-D	Utah Serviceberry	US-U:SDI-C	Small-Tree-Lopping	0.0100	1.0000	80			Yes		
Utah Serviceberry	US-U:SDI-D	Utah Serviceberry	US-U:SDI-D	Cattle+Sheep-Grazing	0.0500		80		1	No		
Utah Serviceberry	US-U:SDI-D	Utah Serviceberry	US-U:SI-D+AG	AG-Invasion	0.0010	1.0000	80			No		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0050		4		No		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Wild-Horse-Grazing	0.0100	0.9950		4	1	No		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SDI-A	Competition	0.3300	1.0000		4		No	3	
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.8000		4		Yes		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Cattle+Sheep-Grazing	0.0500	0.0500	3	4		Yes		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Cattle+Sheep-Grazing	0.0500	0.9500	3	4	1	No		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	Herbicide-Plateau+Seed	0.0100	0.2000		4		Yes		
Utah Serviceberry	US-U:SI-A+AG	Utah Serviceberry	US-U:SI-A+AG	ReplacementFire	0.0100	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-B+AG	Utah Serviceberry	US-U:SI-B+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B+AG	Wild-Horse-Grazing	0.0100				1	No		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SDI-B	Competition	0.3300	1.0000	5	19		No	3	
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SDI-B	Herbicide-Plateau+Seed	0.0100	0.8000	5	19		No		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-A+AG	ReplacementFire	0.0100	1.0000	5	19		Yes		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B+AG	Cattle+Sheep-Grazing	0.0500				1	No		
Utah Serviceberry	US-U:SI-B+AG	Utah Serviceberry	US-U:SI-B+AG	Herbicide-Plateau+Seed	0.0100	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+AG	Utah Serviceberry	US-U:SI-C+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C+AG	Wild-Horse-Grazing	0.0100				1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-C+AG	Utah Serviceberry	US-U:SDI-C	Competition	0.2000	1.0000	20	79		No	3	
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SDI-C	Herbicide-Plateau+Seed	0.0100	0.8000	20	79		No		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-A+AG	ReplacementFire	0.0100	1.0000	20	79		Yes		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C+AG	Cattle+Sheep-Grazing	0.0500				1	No		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C+AG	Herbicide-Plateau+Seed	0.0100	0.2000	20	79		No		
Utah Serviceberry	US-U:SI-C+AG	Utah Serviceberry	US-U:SI-C+AG	Wet-Year	0.1000	1.0000	20	79		No		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-D+AG	Wild-Horse-Grazing	0.0100				1	No		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SDI-C	Masticate+Herbicide+Seed	0.0100	0.8000	100			Yes		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SDI-D	Competition	0.1000	1.0000	80			No	3	
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-A+AG	ReplacementFire	0.0100	1.0000	80			Yes		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-D+AG	Cattle+Sheep-Grazing	0.0500				1	No		
Utah Serviceberry	US-U:SI-D+AG	Utah Serviceberry	US-U:SI-D+AG	Masticate+Herbicide+Seed	0.0100	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:TA	Utah Serviceberry	US-A:All	Masticate+Native-Seed	0.0100	0.7000				Yes		
Utah Serviceberry	US-U:TA	Utah Serviceberry	US-U:Annual Grass	Masticate+Native-Seed	0.0100	0.3000				Yes		
Utah Serviceberry	US-U:TA	Utah Serviceberry	US-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Utah Serviceberry	US-U:TA	Utah Serviceberry	US-U:Annual Grass	ReplacementFire	0.0200	1.0000				Yes		
Utah Serviceberry	US-U:TA	Utah Serviceberry	US-U:SAP	Masticate+Seed	0.0100	0.1500			2	Yes		
Utah Serviceberry	US-U:TA	Utah Serviceberry	US-U:SAP	Masticate+Seed	0.0100	0.1500			5	Yes		
Utah Serviceberry	US-U:TA	Utah Serviceberry	US-U:SDI-B	Masticate+Seed	0.0100	0.3500				Yes		
Utah Serviceberry	US-U:TA	Utah Serviceberry	US-U:SDI-C	Masticate+Seed	0.0100	0.3500				Yes		
Utah Serviceberry	US-U:TA	Utah Serviceberry	US-U:TA	Drought	0.0056	0.9000				Yes		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-A:All	Masticate+Native-Seed	0.0100	0.7000				Yes		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-U:Depleted	Masticate+Seed	0.0100	0.1500			2	Yes		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-U:Early-Shrub	Masticate+Native-Seed	0.0100	0.3000				Yes		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-U:Early-Shrub	Masticate+Seed	0.0100	0.1500			2	Yes		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-U:SDI-B	Masticate+Seed	0.0100	0.3500				Yes		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-U:SDI-C	Masticate+Seed	0.0100	0.3500				Yes		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-U:Early-Shrub	Drought	0.0056	0.1000				Yes		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-U:Early-Shrub	ReplacementFire	0.0067	1.0000				Yes		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-U:TA	AG-Invasion	0.0050	1.0000				No		
Utah Serviceberry	US-U:TE	Utah Serviceberry	US-U:TE	Drought	0.0056	0.9000				Yes		
Wet Meadow-Alkali Sacaton	WMas-A:Open	Wet Meadow-Alkali Sacaton	WMas-A:Open	Drought	0.0056	1.0000		2		Yes		
Wet Meadow-Alkali Sacaton	WMas-A:Open	Wet Meadow-Alkali Sacaton	WMas-A:Open	Weed-Inventory+Treat	0.0100	1.0000		2		No	3	
Wet Meadow-Alkali Sacaton	WMas-A:Open	Wet Meadow-Alkali Sacaton	WMas-A:Open	Wet-Year	0.1000	1.0000		2	1	Yes		
Wet Meadow-Alkali Sacaton	WMas-A:Open	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	AG-Invasion	0.0010	1.0000		2		No		
Wet Meadow-Alkali Sacaton	WMas-A:Open	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Exotic-Invasion	0.0010	1.0000		2		Yes	5	
Wet Meadow-Alkali Sacaton	WMas-B:Closed	Wet Meadow-Alkali Sacaton	WMas-B:Closed	Cattle+Sheep-Grazing	0.0400	0.9990	3	22	1	No		
Wet Meadow-Alkali Sacaton	WMas-B:Closed	Wet Meadow-Alkali Sacaton	WMas-B:Closed	Drought	0.0056	1.0000	3	22	2	No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-Alkali Sacaton	WMas-B:Closed	Wet Meadow-Alkali Sacaton	WMas-B:Closed	Weed-Inventory+Treat	0.0100	1.0000	3	22		No	3	
Wet Meadow-Alkali Sacaton	WMas-B:Closed	Wet Meadow-Alkali Sacaton	WMas-B:Closed	Wet-Year	0.1000	1.0000	3	22		Yes		
Wet Meadow-Alkali Sacaton	WMas-B:Closed	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	AG-Invasion	0.0010	0.0010	3	22		No		
Wet Meadow-Alkali Sacaton	WMas-B:Closed	Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Cattle+Sheep-Grazing	0.0400	0.0010	3	22		No		
Wet Meadow-Alkali Sacaton	WMas-B:Closed	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Exotic-Invasion	0.0050	1.0000	3	22		Yes	5	
Wet Meadow-Alkali Sacaton	WMas-C:Open	Wet Meadow-Alkali Sacaton	WMas-A:Open	Wet-Year	0.1000	0.1000				Yes		
Wet Meadow-Alkali Sacaton	WMas-C:Open	Wet Meadow-Alkali Sacaton	WMas-B:Closed	Thin	0.0100					Yes		
Wet Meadow-Alkali Sacaton	WMas-C:Open	Wet Meadow-Alkali Sacaton	WMas-B:Closed	Wet-Year	0.1000	0.9000				Yes		
Wet Meadow-Alkali Sacaton	WMas-C:Open	Wet Meadow-Alkali Sacaton	WMas-C:Open	Cattle+Sheep-Grazing	0.0400	0.9990			1	No		
Wet Meadow-Alkali Sacaton	WMas-C:Open	Wet Meadow-Alkali Sacaton	WMas-C:Open	Drought	0.0056				2	No		
Wet Meadow-Alkali Sacaton	WMas-C:Open	Wet Meadow-Alkali Sacaton	WMas-C:Open	Weed-Inventory+Treat	0.0100					No	3	
Wet Meadow-Alkali Sacaton	WMas-C:Open	Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Cattle+Sheep-Grazing	0.0400	0.0010				No		
Wet Meadow-Alkali Sacaton	WMas-C:Open	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Exotic-Invasion	0.0050					Yes	5	
Wet Meadow-Alkali Sacaton	WMas-C:Open	Wet Meadow-Alkali Sacaton	WMas-U:SAP	AG-Invasion	0.0050					No		
Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Cattle+Sheep-Grazing	0.0400	0.9990	3		1	No		
Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Drought	0.0056	1.0000		2		Yes		
Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Drought	0.0056	1.0000	3		2	No		
Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	ReplacementFire	0.0100	1.0000	3			Yes	2	
Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Weed-Inventory+Treat	0.0100	1.0000				No	3	
Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet-Year	0.1000	1.0000				Yes		
Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Cattle+Sheep-Grazing	0.0400	0.0010	3			No		
Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Exotic-Invasion	0.0010	1.0000		2		Yes	5	
Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Exotic-Invasion	0.0050	1.0000	3			Yes	5	
Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Wet Meadow-Alkali Sacaton	WMas-A:Open	Herbicide-Plateau+Native-Seed	0.0100	0.8000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-Alkali Sacaton	WMas-U:Annual Grass	Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Cattle+Sheep-Grazing	0.0400		3		1	No		
Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Herbicide-Plateau+Native-Seed	0.0100	0.2000			5	Yes		
Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes	2	
Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Weed-Inventory+Treat	0.0100	1.0000				No	3	
Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Exotic-Invasion	0.0050	1.0000				Yes	5	
Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet Meadow-Alkali Sacaton	WMas-A:Open	Thin	0.0100					Yes		
Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet Meadow-Alkali Sacaton	WMas-A:Open	Thin+Native-Seed	0.0100	0.7000				Yes		
Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet Meadow-Alkali Sacaton	WMas-C:Open	Thin+Native-Seed	0.0100	0.3000				Yes		
Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Cattle+Sheep-Grazing	0.0400		3			No		
Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Drought	0.0056	1.0000			2	No		
Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Weed-Inventory+Treat	0.0100	1.0000				No	3	
Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet-Year	0.1000	1.0000				Yes		
Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Exotic-Invasion	0.0050	1.0000				Yes	5	
Wet Meadow-Alkali Sacaton	WMas-U:Depleted	Wet Meadow-Alkali Sacaton	WMas-U:SAP	AG-Invasion	0.0050	1.0000				No		
Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Wet Meadow-Alkali Sacaton	WMas-A:Open	Exotic-Control	0.0100	0.6000		2		No		20
Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Wet Meadow-Alkali Sacaton	WMas-B:Closed	Exotic-Control	0.0100	0.6000	3	22		No		20
Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Wet Meadow-Alkali Sacaton	WMas-C:Open	Exotic-Control	0.0100	0.6000	23			No		20
Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Cattle+Sheep-Grazing	0.0400		3		1	No		
Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Exotic-Control	0.0100	0.4000				Yes		20
Wet Meadow-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-A:Open	Thin+Herbicide+Native-Seed	0.0100	0.9000				Yes		
Wet Meadow-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Thin+Herbicide+Native-Seed	0.0100	0.1000				Yes		
Wet Meadow-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-U:AGPG	Utilities	0.1000					Yes		
Wet Meadow-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Cattle+Sheep-Grazing	0.0400	0.0010	3			Yes		
Wet Meadow-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	Drought	0.0056	0.1000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-U:Annual Grass	ReplacementFire	0.0100					Yes	2	
Wet Meadow-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-U:Exotic Forb	Exotic-Invasion	0.0100					Yes	5	
Wet Meadow-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-U:SAP	Cattle+Sheep-Grazing	0.0400	0.9990			1	No		
Wet Meadow-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-U:SAP	Drought	0.0056	0.9000			1	No		
Wet Meadow-Alkali Sacaton	WMas-U:SAP	Wet Meadow-Alkali Sacaton	WMas-U:SAP	Weed-Inventory+Treat	0.0100					No	3	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Fence	0.0100	1.0000		2		No	20	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Wild-Horse-Grazing	0.0100	0.9900		2		Yes	20	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-U:Hummocked	Wild-Horse-Grazing	0.0100	0.0100		2		Yes	20	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Drought	0.0056	1.0000		2		Yes		
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Weed-Inventory+Treat	0.0100	1.0000		2		No	3	
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-A:Open	Wet-Year	0.1000	1.0000		2	1	No		
Wet Meadow-Montane	WM-A:Open	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0050	1.0000		2		Yes	5	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Fence	0.0100	1.0000	3	22		No	20	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Wild-Horse-Grazing	0.0100	0.9900	3	22		Yes	20	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-U:Hummocked	Wild-Horse-Grazing	0.0100	0.0100	3	22		Yes	20	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-A:Open	ReplacementFire	0.0250	1.0000	3	22		Yes	5	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Cattle+Sheep-Grazing	0.0500	0.9950	3	22	1	No	20	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Drought	0.0056	1.0000	3	22	2	No		
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Weed-Inventory+Treat	0.2500	1.0000	3	22		No	3	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-B:Closed	Wet-Year	0.1000	1.0000	3	22		Yes		
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0050	1.0000	3	22		Yes	5	
Wet Meadow-Montane	WM-B:Closed	Wet Meadow-Montane	WM-U:Hummocked	Cattle+Sheep-Grazing	0.0500	0.0050	3	22		No	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-A:Open	Thin	0.0100					Yes		
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-C:Open	Fence	0.0100					No	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-C:Open	Wild-Horse-Grazing	0.0100	0.9900				Yes	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-U:Hummocked	Wild-Horse-Grazing	0.0100	0.0100				Yes	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	Cattle+Sheep-Grazing	0.0500	0.9950			1	No	20	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-C:Open	Drought	0.0056				2	No		
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-C:Open	Weed-Inventory+Treat	0.0100					No	3	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0050					Yes	5	
Wet Meadow-Montane	WM-C:Open	Wet Meadow-Montane	WM-U:SFE	Cattle+Sheep-Grazing	0.0500	0.0050				No	20	
Wet Meadow-Montane	WM-U:Annual Grass	Wet Meadow-Montane	WM-U:Annual Grass	Cattle+Sheep-Grazing	0.0500		3		1	No	20	
Wet Meadow-Montane	WM-U:Annual Grass	Wet Meadow-Montane	WM-U:Annual Grass	Fence	0.0100	1.0000				No	20	
Wet Meadow-Montane	WM-U:Annual Grass	Wet Meadow-Montane	WM-U:Annual Grass	Wild-Horse-Grazing	0.0100				1	No	20	
Wet Meadow-Montane	WM-U:Annual Grass	Wet Meadow-Montane	WM-A:Open	Floodplain-Restoration	0.0100	0.9000				Yes		
Wet Meadow-Montane	WM-U:Annual Grass	Wet Meadow-Montane	WM-A:Open	Small-Rock-Dam	0.0100	0.7000				Yes		
Wet Meadow-Montane	WM-U:Annual Grass	Wet Meadow-Montane	WM-U:Annual Grass	Floodplain-Restoration	0.0100	0.1000				Yes		
Wet Meadow-Montane	WM-U:Annual Grass	Wet Meadow-Montane	WM-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Wet Meadow-Montane	WM-U:Annual Grass	Wet Meadow-Montane	WM-U:Annual Grass	Small-Rock-Dam	0.0100	0.3000				No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Desertified	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Fence	0.0100					No	20	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Thin	0.0100					Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Wild-Horse-Grazing	0.0100	0.9900			1	No	20	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:SA	Wild-Horse-Grazing	0.0100	0.0100			5	No	20	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-A:Open	Floodplain-Restoration	0.0100	0.9000				Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-A:Open	Small-Rock-Dam	0.0100	0.7000				Yes		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Annual Grass	AG-Invasion	0.0050			22		No		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Cattle+Sheep-Grazing	0.0500	0.9950	3		1	No	20	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Drought	0.0056				-1	No		
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:Desertified	Floodplain-Restoration	0.0100	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	Small-Rock-Dam	0.0100	0.3000				No		
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:SA	Cattle+Sheep-Grazing	0.0500	0.0050	3		5	No	20	
Wet Meadow-Montane	WM-U:Desertified	Wet Meadow-Montane	WM-U:TEA	Tree-Invasion	0.0080		50			Yes		
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Fence	0.0100	1.0000				No	20	
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Wild-Horse-Grazing	0.0100					Yes	20	
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-A:Open	Exotic-Control	0.0100	0.9000		2		No		20
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-B:Closed	Exotic-Control	0.0100	0.9000	3	22		No		20
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-C:Open	Exotic-Control	0.0100	0.9000	23			No		20
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Cattle+Sheep-Grazing	0.0500		3		1	No	20	
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Control	0.0100	0.1000				No		20
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	ReplacementFire	0.0250	1.0000				Yes	5	
Wet Meadow-Montane	WM-U:Exotic Forb	Wet Meadow-Montane	WM-U:Exotic Forb	Wet-Year	0.1000	1.0000				Yes		
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-A:Open	Natural-Recovery	0.3300	1.0000		2		No	5	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-B:Closed	Natural-Recovery	0.3300	1.0000	3	22		No	5	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-C:Open	Natural-Recovery	0.3300	1.0000	23			No	5	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0050	1.0000				No	5	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Cattle+Sheep-Grazing	0.0500		3			Yes	20	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Drought	0.0056	1.0000		2		Yes		
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Drought	0.0056	1.0000	3		2	No		
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Fence	0.0100	1.0000				No	20	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	ReplacementFire	0.0250	1.0000	2			Yes	5	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Weed-Inventory+Treat	0.0100	1.0000				No	3	
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Wet-Year	0.1000	1.0000		22	1	No		
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Wet-Year	0.1000	1.0000	23			Yes		
Wet Meadow-Montane	WM-U:Hummocked	Wet Meadow-Montane	WM-U:Hummocked	Wild-Horse-Grazing	0.0100					Yes	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Annual Grass	Thin	0.0100					Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0100				Yes	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Fence	0.0100					No	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Wild-Horse-Grazing	0.0100	0.9900			1	No	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-A:Open	Floodplain-Restoration	0.0100	0.9000				Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-A:Open	Small-Rock-Dam	0.0100	0.7000				Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Annual Grass	Cattle+Sheep-Grazing	0.0500	0.0050				Yes	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:Annual Grass	Drought	0.0056	0.1000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SA	Wet Meadow-Montane	WM-U:Annual Grass	ReplacementFire	0.0250					Yes	5	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Cattle+Sheep-Grazing	0.0500	0.9950			1	No	20	
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Drought	0.0056	0.9000				Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Floodplain-Restoration	0.0100	0.1000				Yes		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:SA	Small-Rock-Dam	0.0100	0.3000				No		
Wet Meadow-Montane	WM-U:SA	Wet Meadow-Montane	WM-U:TEA	Tree-Invasion	0.0080		50			Yes		
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-A:Open	Thin+Herbicide+Native-Seed	0.0100	1.0000				Yes		
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0100				Yes	20	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Fence	0.0100	1.0000				No	20	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Wild-Horse-Grazing	0.0100	0.9900			1	No	20	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-A:Open	Wet-Year	0.1000	0.1000				Yes		
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:Desertified	Cattle+Sheep-Grazing	0.0500	0.0050	3			No	20	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:Exotic Forb	Exotic-Invasion	0.0050	1.0000				Yes	5	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Cattle+Sheep-Grazing	0.0500	0.9950	3		1	No	20	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	ReplacementFire	0.0250	1.0000				Yes	5	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Weed-Inventory+Treat	0.2500	1.0000				No	3	
Wet Meadow-Montane	WM-U:SFE	Wet Meadow-Montane	WM-U:SFE	Wet-Year	0.1000	0.9000				Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Desertified	Small-Tree-Lopping	0.0100	1.0000	50		1	Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-A:Open	Floodplain-Restoration	0.0100	0.9000	50			Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Annual Grass	Drought	0.0056	0.0500	50			Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Annual Grass	Floodplain-Restoration	0.0100	0.1000	50			Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Annual Grass	ReplacementFire	0.0100	0.5000	50			Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Desertified	Drought	0.0056	0.0500	50			Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:Desertified	ReplacementFire	0.0100	0.5000	50			Yes		
Wet Meadow-Montane	WM-U:TEA	Wet Meadow-Montane	WM-U:TEA	Drought	0.0056	0.9000	50			Yes		
Winterfat	WF-A:All	Winterfat	WF-A:All	Cattle+Sheep-Grazing	0.0500	0.9900	3		1	No		
Winterfat	WF-A:All	Winterfat	WF-A:All	Wild-Horse-Grazing	0.0100	0.9900			1	No		
Winterfat	WF-A:All	Winterfat	WF-U:Annual Grass	AG-Invasion	0.0010	1.0000				No		
Winterfat	WF-A:All	Winterfat	WF-U:Depleted	Cattle+Sheep-Grazing	0.0500	0.0100	3			No		
Winterfat	WF-A:All	Winterfat	WF-U:Depleted	Wild-Horse-Grazing	0.0100	0.0100				No		
Winterfat	WF-B:Open	Winterfat	WF-A:All	ReplacementFire	0.0010	1.0000				Yes		
Winterfat	WF-B:Open	Winterfat	WF-A:All	Very-Wet-Year	0.0180	0.1000				Yes		
Winterfat	WF-B:Open	Winterfat	WF-B:Open	Cattle+Sheep-Grazing	0.0500	0.9990			1	No		
Winterfat	WF-B:Open	Winterfat	WF-B:Open	Very-Wet-Year	0.0180	0.9000				Yes		
Winterfat	WF-B:Open	Winterfat	WF-B:Open	Wild-Horse-Grazing	0.0100	0.9900			1	No		
Winterfat	WF-B:Open	Winterfat	WF-U:Depleted	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Winterfat	WF-B:Open	Winterfat	WF-U:Depleted	Wild-Horse-Grazing	0.0100	0.0100				No		
Winterfat	WF-B:Open	Winterfat	WF-U:SAP	AG-Invasion	0.0050	1.0000				Yes		
Winterfat	WF-C:Open	Winterfat	WF-A:All	ReplacementFire	0.0010	1.0000				Yes		
Winterfat	WF-C:Open	Winterfat	WF-A:All	Very-Wet-Year	0.0180	0.0500				Yes		
Winterfat	WF-C:Open	Winterfat	WF-B:Open	Very-Wet-Year	0.0180	0.1500				Yes		
Winterfat	WF-C:Open	Winterfat	WF-C:Open	Cattle+Sheep-Grazing	0.0500	0.9990				Yes		
Winterfat	WF-C:Open	Winterfat	WF-C:Open	Very-Wet-Year	0.0180	0.8000				Yes		
Winterfat	WF-C:Open	Winterfat	WF-C:Open	Wild-Horse-Grazing	0.0100	0.9900			1	No		
Winterfat	WF-C:Open	Winterfat	WF-U:Depleted	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Winterfat	WF-C:Open	Winterfat	WF-U:Depleted	Wild-Horse-Grazing	0.0100	0.0100				No		
Winterfat	WF-C:Open	Winterfat	WF-U:SAP	AG-Invasion	0.0050	1.0000				No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Annual Grass	Winterfat	WF-U:Annual Grass	Cattle+Sheep-Grazing	0.0500		3		1	No		
Winterfat	WF-U:Annual Grass	Winterfat	WF-U:Annual Grass	Herbicide-Plateau+Native-Seed	0.0100	0.5000				Yes		
Winterfat	WF-U:Annual Grass	Winterfat	WF-U:Annual Grass	Herbicide-Plateau+Planting	0.0100	0.4000				No		
Winterfat	WF-U:Annual Grass	Winterfat	WF-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		
Winterfat	WF-U:Annual Grass	Winterfat	WF-U:Annual Grass	Wild-Horse-Grazing	0.0100				1	No		
Winterfat	WF-U:Annual Grass	Winterfat	WF-U:Annual Grass	Wild-Horse-Grazing	0.0100				1	No		
Winterfat	WF-U:Annual Grass	Winterfat	WF-U:Seeded Native	Herbicide-Plateau+Native-Seed	0.0100	0.5000				Yes		
Winterfat	WF-U:Annual Grass	Winterfat	WF-U:Seeded Native	Herbicide-Plateau+Planting	0.0100	0.6000				Yes		
Winterfat	WF-U:Depleted	Winterfat	WF-A:All	Shrub+Grass-Seeding	0.0100	0.6000		49		No		
Winterfat	WF-U:Depleted	Winterfat	WF-B:Open	Grass-Seeding	0.0100	0.7000	50	149		No		
Winterfat	WF-U:Depleted	Winterfat	WF-C:Open	Grass-Seeding	0.0100	0.7000	150			No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Depleted	Cattle+Sheep-Grazing	0.0500		3		-1	No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Depleted	Grass-Seeding	0.0100	0.3000	50			No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Depleted	Shrub+Grass-Seeding	0.0100	0.4000		49		No		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Depleted	Very-Wet-Year	0.0180					Yes		
Winterfat	WF-U:Depleted	Winterfat	WF-U:Depleted	Wild-Horse-Grazing	0.0100				-1	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	0.0100	0.6000		149		No		
Winterfat	WF-U:SA	Winterfat	WF-C:Open	Herbicide-Plateau+Native-Seed	0.0100	0.6000	150			No		
Winterfat	WF-U:SA	Winterfat	WF-U:Annual Grass	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Winterfat	WF-U:SA	Winterfat	WF-U:Annual Grass	ReplacementFire	0.0100	1.0000				Yes		
Winterfat	WF-U:SA	Winterfat	WF-U:Annual Grass	Very-Wet-Year	0.0180	0.1000				Yes		
Winterfat	WF-U:SA	Winterfat	WF-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0100				No		
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	0.0500	0.9990			1	No		
Winterfat	WF-U:SA	Winterfat	WF-U:SA	Herbicide-Plateau+Native-Seed	0.0100	0.4000						
Winterfat	WF-U:SA	Winterfat	WF-U:SA	Wild-Horse-Grazing	0.0100	0.9900			1	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	0.0100	0.5000		149		No		
Winterfat	WF-U:SA+	Winterfat	WF-C:Open	Herbicide-Plateau+Native-Seed	0.0100	0.5000	150			No		
Winterfat	WF-U:SA+	Winterfat	WF-U:Annual Grass	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Winterfat	WF-U:SA+	Winterfat	WF-U:Annual Grass	ReplacementFire	0.0150	1.0000				Yes		
Winterfat	WF-U:SA+	Winterfat	WF-U:Annual Grass	Very-Wet-Year	0.0181	1.0000				Yes		
Winterfat	WF-U:SA+	Winterfat	WF-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0100				No		
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	0.0100	0.5000				No		
Winterfat	WF-U:SA+	Winterfat	WF-U:SA+	Cattle+Sheep-Grazing	0.0500	0.9990			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	0.0100	0.9900			1	No		
Winterfat	WF-U:SAP	Winterfat	WF-B:Open	Herbicide-Plateau+Native-Seed	0.0100	0.7000		149		No		
Winterfat	WF-U:SAP	Winterfat	WF-C:Open	Herbicide-Plateau+Native-Seed	0.0100	0.7000	150			No		
Winterfat	WF-U:SAP	Winterfat	WF-U:Annual Grass	ReplacementFire	0.0100	1.0000				Yes		
Winterfat	WF-U:SAP	Winterfat	WF-U:Annual Grass	Very-Wet-Year	0.0180	0.1000				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	Cattle+Sheep-Grazing	0.0500	0.0010				No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-U:SA	Wild-Horse-Grazing	0.0100	0.0100			1	No		
Winterfat	WF-U:SAP	Winterfat	WF-U:SAP	Cattle+Sheep-Grazing	0.0500	0.9990			1	No		
Winterfat	WF-U:SAP	Winterfat	WF-U:SAP	Herbicide-Plateau+Native-Seed	0.0100	0.3000				No		
Winterfat	WF-U:SAP	Winterfat	WF-U:SAP	Wild-Horse-Grazing	0.0100	0.9900			1	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	0.0100	0.6000		149		No		
Winterfat	WF-U:SAP+	Winterfat	WF-C:Open	Herbicide-Plateau+Native-Seed	0.0100	0.6000	150			No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:Annual Grass	ReplacementFire	0.0150	1.0000				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+	Cattle+Sheep-Grazing	0.0500	0.0010				No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:SA+	Wild-Horse-Grazing	0.0100	0.0100				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	0.0100	0.4000				No		
Winterfat	WF-U:SAP+	Winterfat	WF-U:SAP+	Cattle+Sheep-Grazing	0.0500	0.9990			1	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	0.0100	0.9900			1	No		
Winterfat	WF-U:SDI	Winterfat	WF-A:All	Natural-Recovery	0.0001			5		No	10	
Winterfat	WF-U:SDI	Winterfat	WF-B:Open	Natural-Recovery	0.0001		6					
Winterfat	WF-U:SDI	Winterfat	WF-U:Depleted	Cattle+Sheep-Grazing	0.0100	0.0100	3					
Winterfat	WF-U:SDI	Winterfat	WF-U:Depleted	Wild-Horse-Grazing	0.0100	0.0010		5		No		
Winterfat	WF-U:SDI	Winterfat	WF-U:SDI	Cattle+Sheep-Grazing	0.0100	0.9900	3		1	No		
Winterfat	WF-U:SDI	Winterfat	WF-U:SDI	Very-Wet-Year	0.0181		50			Yes		
Winterfat	WF-U:SDI	Winterfat	WF-U:SDI	Wild-Horse-Grazing	0.0100	0.0010	6		1	No		
Winterfat	WF-U:SDI	Winterfat	WF-U:SDI	Wild-Horse-Grazing	0.0100	0.9990			1	No		
Winterfat	WF-U:SDI	Winterfat	WF-U:SDI+AG	AG-Invasion	0.0010					No		
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:Annual Grass	Cattle+Sheep-Grazing	0.0100	0.0100	3	5		No		
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0010		5		No		
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:SDI	Competition	1.0000					No	3	
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:SDI+AG	Cattle+Sheep-Grazing	0.0100	0.0100	6		1	No		
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:SDI+AG	Cattle+Sheep-Grazing	0.0100	0.9900	3		1	No		
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:SDI+AG	ReplacementFire	0.0050					Yes		
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:SDI+AG	Very-Wet-Year	0.0018		50			Yes		
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:SDI+AG	Wet-Year	0.1000					No		
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:SDI+AG	Wild-Horse-Grazing	0.0100	0.0010	6		1	No		
Winterfat	WF-U:SDI+AG	Winterfat	WF-U:SDI+AG	Wild-Horse-Grazing	0.0100	0.9990			1	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:Open	Natural-Recovery	0.3300	1.0000	150			No	5	
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Depleted	Cattle+Sheep-Grazing	0.0500	0.0010	3			No		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Depleted	Wild-Horse-Grazing	0.0100			5		No		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Depleted	Wild-Horse-Grazing	0.0100	0.0100	6			No		
Winterfat	WF-U:Seeded Native	Winterfat	WF-U:Exotic Forb	Exotic-Invasion	0.0010	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	0.0500	0.9990	3	19	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	0.0100	0.9900	6		1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-A:All	Wyoming Big Sagebrush upland	WSup-A:All	Cattle+Sheep-Grazing	0.0300	0.9900	3	19	1	No		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0020	1.0000		19		Yes		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	AG-Invasion	0.0010	1.0000		19		No		
Wyoming Big Sagebrush upland	WSup-A:All	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0100	3	19		No		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-A:All	Thin	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0100	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-B:Open	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Wyoming Big Sagebrush upland	WSup-B:Open	Wyoming Big Sagebrush upland	WSup-U:SAP	AG-Invasion	0.0050					No		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	Spyke	0.0000	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	Thin	0.0000	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	Thin+Herbicide+Native-Seed	0.0000	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	Thin+Native-Seed	0.0000	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0100	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-B:Open	Drought	0.0056	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-C:Closed	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-C:Closed	Drought	0.0056	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-D:Open	Tree-Invasion	0.0080	1.0000	100			Yes		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-U:Depleted	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Wyoming Big Sagebrush upland	WSup-C:Closed	Wyoming Big Sagebrush upland	WSup-U:SAP	AG-Invasion	0.0050	1.0000				No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-A:All	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-C:Closed	Mastication	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-C:Closed	Small-Tree-Lopping	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0100					Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-C:Closed	Drought	0.0056	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-D:Open	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-D:Open	Drought	0.0056	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-U:Depleted	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-U:SAP	AG-Invasion	0.0050			124		No		
Wyoming Big Sagebrush upland	WSup-D:Open	Wyoming Big Sagebrush upland	WSup-U:TEA	AG-Invasion	0.0050		125			No		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-B:Open	Chaining+Native-Seed	0.0100	0.7000	150			Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-B:Open	Masticate+Native-Seed	0.0100	0.7500	150			Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Chaining+Native-Seed	0.0100	0.3000	150			Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Masticate+Native-Seed	0.0100	0.2500	150			Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-U:TEA	Tree-Encroachment	0.0200	1.0000	200			No		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-A:All	ReplacementFire	0.0080	1.0000	150			Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-B:Open	Drought	0.0056	0.1000	150			Yes		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-E:Closed	Drought	0.0056	0.9000	150		5	No		
Wyoming Big Sagebrush upland	WSup-E:Closed	Wyoming Big Sagebrush upland	WSup-U:TEA	AG-Invasion	0.0050	1.0000	150			No		
Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Chaining+Native-Seed	0.0000	0.5000			3	Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Chaining+Plateau+Seed	0.0100	0.1000			3	Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Chaining+Plateau+Seed	0.0100	0.8000			3	Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Chaining+Native-Seed	0.0000	0.5000			3	Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Chaining+Plateau+Seed	0.0100	0.1000			3	Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Herbicide-Plateau+Seed	0.0100	0.1500			3	Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Cattle+Sheep-Grazing	0.0300		3		1	No		
Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Herbicide-Plateau+Seed	0.0100	0.1500			3	Yes		
Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	ReplacementFire	0.1000	1.0000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Annual Grass	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.7000		3		Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Depleted	Chaining+Native-Seed	0.0100	0.3000				No		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Depleted	Small-Tree-Lopping	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Depleted	Small-Tree-Lopping	0.0100		100			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.4000				Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	2xChaining+Native-Seed	0.0100		60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Chaining+Native-Seed	0.0100	0.7000				No		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Spyke+Native-Seed	0.0100		60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Thin+Native-Seed	0.0100		60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Depleted	Drought	0.0056	0.9000	60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Drought	0.0056	0.1000	60			Yes		
Wyoming Big Sagebrush upland	WSup-U:Depleted	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	ReplacementFire	0.0080		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:Early-Shrub	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.4000				Yes		
Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	0.0100	0.6000				Yes		
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:SA	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA	Chaining+Seed	0.0100	0.1500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA	Small-Tree-Lopping	0.0100		100	150		Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Chaining+Seed	0.0100	0.7000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SA	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Chaining+Seed	0.0100	0.1500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	ReplacementFire	0.0150					Yes		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA	Cattle+Sheep-Grazing	0.0300				1	No		
Wyoming Big Sagebrush upland	WSup-U:SA	Wyoming Big Sagebrush upland	WSup-U:SA	Drought	0.0056	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 Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
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	0.0100		100		39	Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Small-Tree-Lopping	0.0100		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:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	ReplacementFire	0.0200					Yes		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Cattle+Sheep-Grazing	0.0300	0.0010			5	No		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-U:SA+	Wyoming Big Sagebrush upland	WSup-U:SA+	Drought	0.0056	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 Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Drought	0.0056	0.1000				Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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 Grass	ReplacementFire	0.0150					Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SA	Alternate-Succession	0.0100		50			No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SA	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Drought	0.0056	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Hypo-Hatchet-Spyke	0.0100	0.1000	100			No		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Hypo-Hatchet-Spyke	0.0100	0.9000	100		39	Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Masticate+Native-Seed	0.0100		100		39	Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP	Wyoming Big Sagebrush upland	WSup-U:SAP	Small-Tree-Lopping	0.0100		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 Grass	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
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	0.0100	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:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.6000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.2000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	ReplacementFire	0.0200					Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SA+	Cattle+Sheep-Grazing	0.0300	0.0010				No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Cattle+Sheep-Grazing	0.0300	0.9990			1	No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Drought	0.0056	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Hypo-Hatchet-Spyke	0.0100	0.1000	100			No		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SAP+	Hypo-Hatchet-Spyke	0.0100	0.9000	100		37	Yes		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SAP+	Small-Tree-Lopping	0.0100		100	149	37	Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SDI-C	Masticate+Herbicide+Seed	0.0100	0.7000	150			Yes		
Wyoming Big Sagebrush upland	WSup-U:SAP+	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Masticate+Herbicide+Seed	0.0100	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:SDI-A	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050		19		No		
Wyoming Big Sagebrush upland	WSup-U:SDI-A	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Forb+Grass-Native-Seeding	0.0100					No	5	
Wyoming Big Sagebrush upland	WSup-U:SDI-A	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Wild-Horse-Grazing	0.0100	0.9950		19	1	No		
Wyoming Big Sagebrush upland	WSup-U:SDI-A	Wyoming Big Sagebrush upland	WSup-A:All	Natural-Recovery	0.0001	1.0000	5	19		No	10	
Wyoming Big Sagebrush upland	WSup-U:SDI-A	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Cattle+Sheep-Grazing	0.0300	0.0500	3	19		Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-A	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Cattle+Sheep-Grazing	0.0300	0.9500	3	19	1	No		
Wyoming Big Sagebrush upland	WSup-U:SDI-A	Wyoming Big Sagebrush upland	WSup-U:SDI-A	ReplacementFire	0.0020	1.0000		19		Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-A	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	AG-Invasion	0.0010	1.0000		19		No		
Wyoming Big Sagebrush upland	WSup-U:SDI-B	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-B	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Forb+Grass-Native-Seeding	0.0100					No	5	
Wyoming Big Sagebrush upland	WSup-U:SDI-B	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Thin	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-B	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Wild-Horse-Grazing	0.0100				1	No		
Wyoming Big Sagebrush upland	WSup-U:SDI-B	Wyoming Big Sagebrush upland	WSup-B:Open	Natural-Recovery	0.0010					No	10	
Wyoming Big Sagebrush upland	WSup-U:SDI-B	Wyoming Big Sagebrush upland	WSup-U:SDI-A	ReplacementFire	0.0020					Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-B	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Cattle+Sheep-Grazing	0.0300				1	No		
Wyoming Big Sagebrush upland	WSup-U:SDI-B	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	AG-Invasion	0.0010					No		
Wyoming Big Sagebrush upland	WSup-U:SDI-C	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-C	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Thin	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-C	Wyoming Big Sagebrush upland	WSup-U:SDI-C	Forb+Grass-Native-Seeding	0.0100					No	5	
Wyoming Big Sagebrush upland	WSup-U:SDI-C	Wyoming Big Sagebrush upland	WSup-U:SDI-C	Wild-Horse-Grazing	0.0100				1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:SDI-C	Wyoming Big Sagebrush upland	WSup-U:SDI-A	ReplacementFire	0.0020	1.0000	60			Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-C	Wyoming Big Sagebrush upland	WSup-U:SDI-C	Cattle+Sheep-Grazing	0.0300				1	No		
Wyoming Big Sagebrush upland	WSup-U:SDI-C	Wyoming Big Sagebrush upland	WSup-U:SDI-C	Natural-Recovery	0.0100	1.0000	60			No	10	
Wyoming Big Sagebrush upland	WSup-U:SDI-C	Wyoming Big Sagebrush upland	WSup-U:SDI-D	Tree-Invasion	0.0080	1.0000	100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-C	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	AG-Invasion	0.0010	1.0000	60			No		
Wyoming Big Sagebrush upland	WSup-U:SDI-D	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-D	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Chaining+Seed	0.0100	1.0000	100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-D	Wyoming Big Sagebrush upland	WSup-U:SDI-D	Wild-Horse-Grazing	0.0100				1	No		
Wyoming Big Sagebrush upland	WSup-U:SDI-D	Wyoming Big Sagebrush upland	WSup-D:Open	Natural-Recovery	0.1000	1.0000	100			No	10	
Wyoming Big Sagebrush upland	WSup-U:SDI-D	Wyoming Big Sagebrush upland	WSup-U:SDI-A	ReplacementFire	0.0020	1.0000	100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-D	Wyoming Big Sagebrush upland	WSup-U:SDI-C	Small-Tree-Lopping	0.0100	1.0000	100			Yes		
Wyoming Big Sagebrush upland	WSup-U:SDI-D	Wyoming Big Sagebrush upland	WSup-U:SDI-D	Cattle+Sheep-Grazing	0.0300				1	No		
Wyoming Big Sagebrush upland	WSup-U:SDI-D	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	AG-Invasion	0.0010	1.0000	100			No		
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	
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	AG-Invasion	0.0050	1.0000		19		No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Depleted	Wild-Horse-Grazing	0.0100	0.0050	60			No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300		3	5	1	No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Cattle+Sheep-Grazing	0.0300	0.0010	6			No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wild-Horse-Grazing	0.0100			5		No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Early-Shrub	Wild-Horse-Grazing	0.0100	0.0050	6	59		No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:SAP	AG-Invasion	0.0050	1.0000	20			No		
Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Wyoming Big Sagebrush upland	WSup-U:Seeded Native	Cattle+Sheep-Grazing	0.0300	0.9990	6		1	No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:Seeded Native	Drought	0.0056	1.0000			-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	Wild-Horse-Grazing	0.0100	0.9950	6	59	1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Wild-Horse-Grazing	0.0100	0.0050		19		No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wild-Horse-Grazing	0.0100	0.9950		19	1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Competition	0.3300	1.0000		19		No	3	
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.8000		19		No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Cattle+Sheep-Grazing	0.0300	0.0500	3	19		Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Cattle+Sheep-Grazing	0.0300	0.9500	3	19	1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Herbicide-Plateau+Seed	0.0100	0.2000		19		No		
Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	ReplacementFire	0.0050	1.0000		19		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		19		No		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Wild-Horse-Grazing	0.0100				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Competition	0.3300					No	3	
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Herbicide-Plateau+Seed	0.0100	0.8000				No		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	ReplacementFire	0.0050					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Cattle+Sheep-Grazing	0.0300				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Herbicide-Plateau+Seed	0.0100	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		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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-C+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Forb+Grass-Native-Seeding	0.0100					No	5	
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wild-Horse-Grazing	0.0100				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-B	Thin+Herbicide+Native-Seed	0.0100	0.8000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-C	Competition	0.2000					No	3	
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	ReplacementFire	0.0050					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-B+AG	Thin+Herbicide+Native-Seed	0.0100	0.2000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Cattle+Sheep-Grazing	0.0300				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+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.9000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Aerial-Spyke+Aerial-Seed+Chain-Harrow	0.0100	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wild-Horse-Grazing	0.0100				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-C	Masticate+Herbicide+Seed	0.0100	0.8000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SDI-D	Competition	0.1000					No	3	
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	ReplacementFire	0.0050					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Hypo-Hatchet-Spyke	0.0100	0.9500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Masticate+Herbicide+Seed	0.0100	0.2000				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Mastication	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-C+AG	Small-Tree-Lopping	0.0100					Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Cattle+Sheep-Grazing	0.0300				1	No		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Hypo-Hatchet-Spyke	0.0100	0.0500				Yes		
Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wyoming Big Sagebrush upland	WSup-U:SI-D+AG	Wet-Year	0.1000					No		

Appendix 2. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.7 Database.

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:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Chaining+Seed	0.0100	0.1500				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	RxFire+Seed+Chain	0.0100	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Chaining+Seed	0.0100	0.7000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SDI-A	RxFire+Seed+Chain	0.0100	0.5000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Chaining+Seed	0.0100	0.1500				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	RxFire+Seed+Chain	0.0100	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:TEA	RxFire+Seed+Chain	0.0100	0.3000				No		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Drought	0.0056	0.1000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	Masticate+Herbicide+Seed	0.0100	0.2500	150			Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:Annual Grass	ReplacementFire	0.0080	1.0000				Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SDI-A	Masticate+Herbicide+Seed	0.0100	0.7000	150			Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:SI-A+AG	Masticate+Herbicide+Seed	0.0100	0.0500	150			Yes		
Wyoming Big Sagebrush upland	WSup-U:TEA	Wyoming Big Sagebrush upland	WSup-U:TEA	Drought	0.0056	0.9000				Yes		

Appendix 3. Spatial Frequency Distributions for Natural and Management Disturbances.

Transition Group	Maximum Area (Acres)	Relative Amount
2xChaining+Native-Seed	200	0
2xChaining+Native-Seed	1,500	100
2xChaining+Plateau+Seed	200	0
2xChaining+Plateau+Seed	3,000	100
2xChaining+Seed	200	0
2xChaining+Seed	3,000	100
Aerial-Seed	200	0
Aerial-Seed	10,000	100
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	50	0
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	400	100
Aerial-Spyke+Aerial-Seed+Chain-Harrow	50	0
Aerial-Spyke+Aerial-Seed+Chain-Harrow	400	100
AG-Invasion	1	99
AG-Invasion	10	1
AllFire	10	7.5
AllFire	100	12.5
AllFire	1,000	36.25
AllFire	5,000	43.75
Avalanches	100	100
Chaining+Native-Seed	200	0
Chaining+Native-Seed	3,000	100
Chaining+Plateau+Native-Seed	200	0
Chaining+Plateau+Native-Seed	3,000	100
Chaining+Plateau+Seed	200	0
Chaining+Plateau+Seed	3,000	100
Chaining+Seed	200	0
Chaining+Seed	3,000	100
Chainsaw+Lop-Scatter+Herbicide+Seed	200	0
Chainsaw+Lop-Scatter+Herbicide+Seed	3,000	100
Chainsaw-Thinning	200	0
Chainsaw-Thinning	3,000	100
Competition	1	100
Drought	100,000	100
Entrenchment	10	100
Exotic-Control	100	100
Exotic-Control+Native-Seed	100	100
Exotic-Invasion	1	90
Exotic-Invasion	10	10
Fence	1	0
Fence	50	100
FineFuelDecomp	100,000	100
Flash-Flood	100	100
Flooding	500	100

Appendix 3. Spatial Frequency Distributions for Natural and Management Disturbances.

Transition Group	Maximum Area (Acres)	Relative Amount
Floodplain-Recovery	1	100
Floodplain-Restoration	10	100
Forb+Grass-Native-Seeding	200	0
Forb+Grass-Native-Seeding	100,000	100
Freeze	100,000	100
Fuel-Build-Up	10	100
Grass-Seeding	1	0
Grass-Seeding	100	100
Herbicide-Plateau	200	0
Herbicide-Plateau	3,000	100
Herbicide-Plateau+Native-Seed	200	0
Herbicide-Plateau+Native-Seed	3,000	100
Herbicide-Plateau+Planting	1	0
Herbicide-Plateau+Planting	100	100
Herbicide-Plateau+Seed	200	0
Herbicide-Plateau+Seed	3,000	100
Hypo-Hatchet-Spyke	200	0
Hypo-Hatchet-Spyke	3,000	100
Insect/Disease	1	90
Insect/Disease	10	10
Livestock-Grazing	30,000	100
LosingClone	1	90
LosingClone	10	10
Masticate+Herbicide+Native-Seed	200	0
Masticate+Herbicide+Native-Seed	1,500	100
Masticate+Herbicide+Seed	200	0
Masticate+Herbicide+Seed	1,500	100
Masticate+Native-Seed	200	0
Masticate+Native-Seed	1,500	100
Masticate+Seed	200	0
Masticate+Seed	1,500	100
Masticate+Spot-Herbicide+Seed	200	0
Masticate+Spot-Herbicide+Seed	1,500	100
Mastication	200	0
Mastication	1,500	100
NativeGrazing	1	90
NativeGrazing	10	10
Natural-Recovery	1	90
Natural-Recovery	10	10
ReplacementFire	5,000	33
RoadLateralFlow	100	100
RxFire	200	0
RxFire	10,000	100

Appendix 3. Spatial Frequency Distributions for Natural and Management Disturbances.

Transition Group	Maximum Area (Acres)	Relative Amount
RxFire+Seed+Chain	200	0
RxFire+Seed+Chain	3,000	100
Senescence	1	100
Sheep-Grazing	30,000	100
Shrub+Grass-Seeding	1	0
Shrub+Grass-Seeding	100	100
Small-Rock-Dam	100	100
Small-Tree-Lopping	200	0
Small-Tree-Lopping	3,000	100
Spot-Herbicide+Native-Seed	3,000	100
Spyke	200	0
Spyke	1,500	100
Spyke+Native-Seed	200	0
Spyke+Native-Seed	1,500	100
Spyke+Plateau+Native-Seed	200	0
Spyke+Plateau+Native-Seed	1,500	100
Spyke+Seed	200	0
Spyke+Seed	1,500	100
Tamarisk-Beetle	1	90
Tamarisk-Beetle	10	10
Thin	200	0
Thin	1,500	100
Thin+Herbicide+Native-Seed	200	0
Thin+Herbicide+Native-Seed	1,500	100
Thin+Herbicide+Seed	200	0
Thin+Herbicide+Seed	1,500	100
Thin+Seed	200	0
Thin+Seed	1,500	100
Tree-Encroachment	1	100
Tree-Invasion	1	90
Tree-Invasion	10	10
Very-Wet-Year	1,000	100
Weed-Inventory+Treat	100	100
Wet-Year	100,000	100
Wild-Horse-Grazing	103,000	100

Appendix 4

Overview of Ecological Departure and Unified Ecological Departure

Conventional conservation planning procedures often lack rigorous, consistent, and quantitative means for assessing: (1) current ecological conditions at a landscape scale; (2) likely future conditions under continuation of existing management actions; (3) the effectiveness of alternative management actions; and (4) the benefits and costs of alternative management actions.

TNC's Landscape Conservation ForecastingTM process uses ecological system condition and wildlife habitat suitability metrics that address the shortcomings associated with other procedures. LCFTM uses "unified ecological departure" as the core metric to assess the condition of ecological systems.

An "**ecological system**" is similar to what the Natural Resources Conservation Service (NRCS) terms an "**ecological site**," although multiple ecological sites with the same dominant indicator species can be grouped into one ecological system. 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."¹ For example, a site with loamy soil between 8 and 10 inches of precipitation and another site with gravelly loam between 8 and 10 inches of precipitation would both be grouped by TNC as a Wyoming big sagebrush ecological system, because both sites are characterized by Wyoming big sagebrush. Ecological system is also synonymous with biophysical setting.

The ecological departure metric, described in greater detail below, was originally developed by the USDA Forest Service (USFS) and then formalized under the auspices of the national USFS-Department of the Interior-TNC program known as LANDFIRE.² Ecological departure is a broad-scale measure of ecological system "health" – an integrated, landscape-level estimate of the ecological condition of terrestrial and riparian ecological systems. For each ecological system, ecological departure considers vegetation species composition, vegetation structure, and ecological disturbance regimes (e.g., fire, insect outbreaks, drought-induced mortality, and others) to estimate an ecological system's departure from its reference, or historic, pre-European settlement condition (modeled reference conditions of natural disturbance regimes developed in the LANDFIRE program).

The "**reference**" condition, or "**natural range of variability (NRV)**," for a given ecological system is characterized by a modeled equilibrium distribution, or proportions, of all historic, or pre-European settlement vegetation classes with that system. "**Vegetation classes**" partly represent natural succession (i.e., differences in age), from early to mid to late succession, as well as open and closed canopy (i.e., differences in structure). As discussed further below,

¹ *National Forestry Manual*, www.nrcs.usda.gov/technical/ECS/forest/2002_nfm_complete.pdf.

² LANDFIRE originally referred to the metric, somewhat confusingly, as "Fire Regime Condition"; www.landfire.gov. The term has since been changed.

Appendix 4

Overview of Ecological Departure and Unified Ecological Departure

within a state-and-transition model, succession classes for reference vegetation conditions are typically labeled as A, B, C, D, and E classes. Non-reference classes, introduced as a result of post-settlement human causes, are known as “**uncharacteristic**” vegetation classes (typically termed “U classes”). Uncharacteristic vegetation or site conditions include, for example, invasive annual grasses and noxious weeds. Under reference conditions such uncharacteristic vegetation classes are absent. The presence of uncharacteristic vegetation indicates that an ecological system has departed from its reference condition (NRV), and is less than perfectly healthy.

“**Ecological departure**” calculates the difference between the estimated NRV of an ecological system, and existing or current proportions of vegetation classes for that ecological system (or predicted future proportions). Ecological departure is scored on a scale of 0% to 100% departure from NRV: zero percent represents the NRV, and 100% represents total departure.³

“**Unified ecological departure**” is a more generalized form of the traditional ecological departure metric, to which TNC recently added additional management elements that allow users to assign (a) special values to some very undesirable class of vegetation (for example, noxious weeds) and (b) thresholds to some desirable human-made vegetation classes that are created by restoration activities (for example, defining that at most 10% of the landscape seeded with introduced species, such as crested wheatgrass, will not result in ecological “penalties”).

Whereas ecological departure considers all uncharacteristic classes as equally “bad,” unified ecological departure allows for differential weighting of uncharacteristic vegetation classes, as some may be worse than others, and some may even be desirable (e.g., non-native species that are intentionally introduced after a fire to prevent the spread of cheatgrass).

Example calculations of both ecological departure and unified ecological departure, for a simplified shrubland ecological system, are shown in the following table (equations are presented in footnotes). In the table, there are two reference classes (“younger” and “older”) and two uncharacteristic classes (“exotic species” and “introduced species seeding”) expressed by their current percentages in the landscape. Their respective NRVs are also shown. The first uncharacteristic class is undesirable and is expected to be expensive to restore. Therefore, the class has been assigned a “badness” level of 1, which converts to a high-risk function value of -0.5 multiplying the observed percentage of the class to yield the effective observed percentage (see footnotes for formula). The other uncharacteristic vegetation class is an introduced species seeding that managers consider acceptable for wildlife management and for keeping cheatgrass to low levels. Managers in this hypothetical example decided that no penalty will be

³ A score of 33% or lower is typically considered to be low departure (i.e., close to reference status), moderate departure is found in the range from 34% to 66%, and high departure is a score of 67% or higher.

Appendix 4 Overview of Ecological Departure and Unified Ecological Departure

incurred for an introduced species seeding if it does not exceed a 25% management threshold in the landscape. In this example, ecological departure and unified ecological departure are calculated, respectively, in the observed percentage and effective observed percentage columns. In the table, the presence of the introduced species seeding lowers unified ecological departure (i.e., better condition) compared to the traditional ecological departure. The “bad” uncharacteristic class increases unified ecological departure (i.e., worse condition, closer to 100% departure) beyond what is observed for ecological departure.

Simplified Shrubland Ecological System With Two Reference and Two Uncharacteristic Classes					
Vegetation Class	“Badness” level (B = 0 to 2) ^{&}	Mgmt Threshold %	Reference or NRV %	Observed in Class %	Effective Observed %
<i>Reference: Young</i>	na	na	20	1	1
<i>Reference: Older</i>	na	na	80	59	59
<i>Uncharacteristic: Exotic species</i>	1	0	0	16	HRF × 16 = -0.5 × 16 = -8
<i>Uncharacteristic: Introduced Species Seeding</i>	0	25 (no penalty if ≤25%)	0	24	Min[25, 24] = 24
Ecological Departure (%) [#]				100 - 1 - 59 = 40	
Unified Ecological Departure (%) [@]					100 - 1 - 59 - (-8) - 24 = 24

[&] 0= not a high risk vegetation class; 1 = undesirable vegetation class and/or expensive to restore; 2 = extremely undesirable vegetation class and expensive to restore.

$$\text{# Ecological Departure (ED)} = 100\% - \sum_{i=1}^R \min\{\text{Observed}\%_i, \text{NRV}\%_i\}$$

$$\text{Min}(100, \text{Max}[0, \text{ED} - \sum_{i=R+1}^{U_{\text{No-Thresh}}} \min\{\text{HRF}_i \times \text{Observed}\%_i, 0\}]) -$$

[@] Unified Ecological Departure (UED) =

$$\sum_{j=U_{\text{No-Thresh}}+1}^N \min\{\text{Threshold}\%_j, \text{Observed}\%_j\}$$

where R , $U_{\text{no-Thresh}}$, and N are, respectively, the order number of reference, undesirable without threshold value, and total vegetation classes, Threshold_j is a user-supplied management threshold for class j (here, assumed 25% for simplicity), and HRF is the high-risk function of class j for different levels of “badness” (see below).

[^] Uncharacteristic vegetation class with a badness level >0 are assigned a high risk value based on the arbitrary function HRF selected based on desirable curve fitting properties. We chose a negative sigmoid function for HRF :

$$\text{HRF}_j = -e^{c(B-1)} / (1 + e^{c(B-1)})$$

where c is an arbitrary fitted coefficient (here 10) and B is the badness level from the table. $\text{HRF} = 0, -0.5, \text{ and } -1$ for, respectively, values of $B = 0, 1, \text{ and } 2$.

Appendix 5. Equations and Figures of Resource Selection Functions and Habitat Suitability.

Resource Selection Functions for Greater sage-grouse

For sage-grouse, resource selection functions were divided into three seasonal sets: nesting (nest site selection and nest success, also called breeding), summer (brood-rearing), and winter. The resource selection functions described below were the result of a sage-grouse expert workshop held on March 13, 2014 at TNC's office in Salt Lake City.

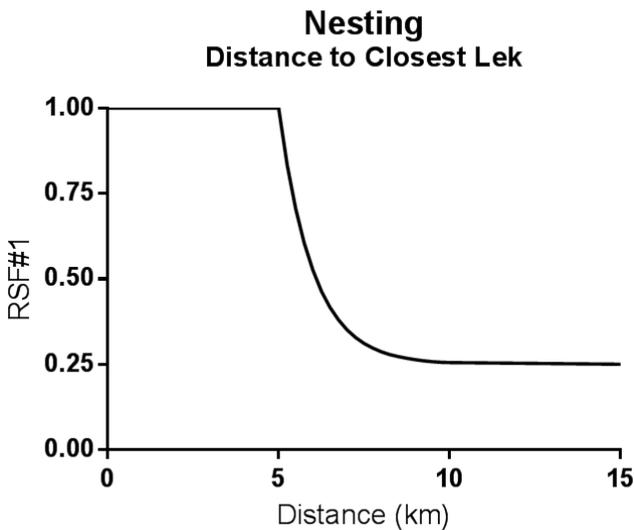
We developed heuristic resource selection functions because there is only very limited movement data from collared sage-grouse from the distinct Hamlin Valley and Black Mountains populations. Without sufficient data, it was not possible to build statistical logistic regression equations representing different resource selection functions. Using sage-grouse demographic and movement data from the entire State of Utah, experts assisted with defining the shape of resource selection functions that had the strongest effect on sage-grouse habitat suitability. Each resource selection function was bound between 0 (not suitable) and 1 (very suitable).

Nesting

Five resource selection functions (RSF) were selected to characterize the nesting (i.e., breeding) habitat ($RSF_{N,i}$, $i = 1, 2, \dots, 5$).

The first RSF for nesting ($RSF_{N,1}$) was based on the distance of each pixel to the closest lek (a nest site):

If the distance to a lek < 5 km, then $RSF_{N,1} = 1$;
 If distance to lek ≥ 5 km, then $RSF_{N,1} = 0.25 + 0.75 * e^{-1 * (\text{distance to closest lek} - 5)}$.



The second RSF ($RSF_{N,2}$) was based on the distance of each pixel to the closest trees, which hens avoid:

$$RSF_{N,2} = e^{5 \times (\text{Distance to closest trees} - 1.2)} / (1 + e^{5 \times (\text{Distance to closest trees} - 1.2)})$$

where 1.2 is the inflection point and 5 determines the curvature. This equation was simply used for curve fitting (figure below) and has no inherent ecological components. Trees farther than 2 km are not expected to affect nesting. Certain Ecological System – Vegetation Class combinations were defined as “trees” for this analysis; Table A5-1 contains a list of these System-x-Class combinations.

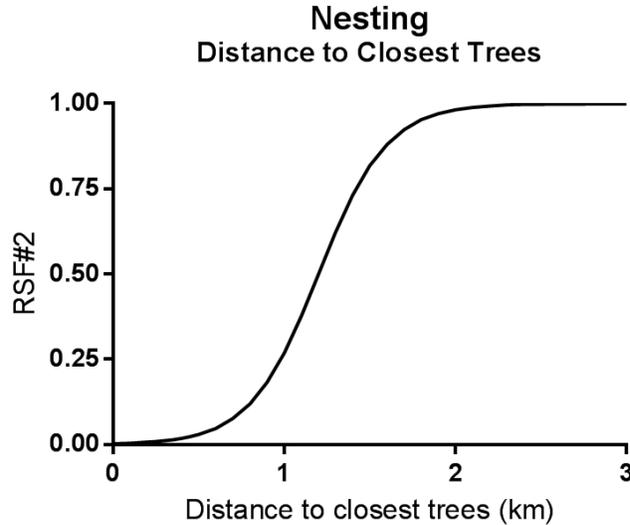


Table A5-1. Ecological System – Vegetation Class combinations defined as “trees.”

Ecological System	Vegetation Class	Ecological System	Vegetation Class
Aspen Woodland	ASP-A:Closed	Mixed Conifer	MC-B:Closed
	ASP-B:Closed		MC-C:Open
	ASP-C:Closed		MC-D:Open
	ASP-D:Open		MC-E:Closed
	ASP-U:Depleted		
Aspen-Mixed Conifer	2-Mid:Closed	Montane Riparian	MR-C:Closed
	4-Late:Closed		MR-U:EFT
	5-Late:Open	Montane Sagebrush Steppe	MSS-E:Closed
	6-Late:Closed		MSS-U:TEA
Basin Wildrye	BW-U:TEA	Pinyon-Juniper	PJ-A:All
Black Sagebrush	BS-D:Open		PJ-B:Open
	BS-U:TEA		PJ-C:Open
Curl-leaf Mountain Mahogany	CMM-A:All		PJ-D:Open
	CMM-B:Open		PJ-U:Annual Grass
	CMM-D:Open	PJ-U:SDI+AG	
	CMM-E:Closed	PJ-U:TA	
	CMM-U:Annual Grass		
Gambel Oak-Mountain Shrub	GOMS-A:All	Ponderosa Pine	PP-A:All
	GOMS-B:Closed		PP-B:Closed
	GOMS-C:Closed		PP-C:Open
	GOMS-U:SAP		PP-D:Open
Limber-Bristlecone Pine	LB-B:Open	Stansbury Cliffrose	SC-C:Closed
	LB-C:Open		SC-U:TEA
Low Sagebrush	LS-U:TA	Utah Serviceberry	US-D:Open
	LS-U:TE		US-U:TA
			US-U:TE
		Wyoming Big Sagebrush upland	WSup-E:Closed
			WSup-U:TEA

The third RSF (RSF_{N,3}) for nesting characterized the nesting habitat a hen would traverse arriving from the lek. The RSF was based on the proportion of pixels with adequate shrub cover between each pixel and the closest lek (P; figure below). In ARC GIS, the value of P was estimated from an ellipse spanning the distance between the lek and the focal pixel. The number of pixels with a normalized nesting value ≥ 0.3 (see Table A5-3 at end of this Appendix) divided by the total number of pixels in the ellipse was P:

$RSF_{N,3} = e^{-10 \times (P - 0.5)} / (1 + e^{-10 \times (P - 0.5)})$, where 0.5 is the inflection point. Certain Ecological System – Vegetation Class combinations were defined as “shrubs” for this analysis; Table A5-2 contains a list of these System-x-Class combinations.

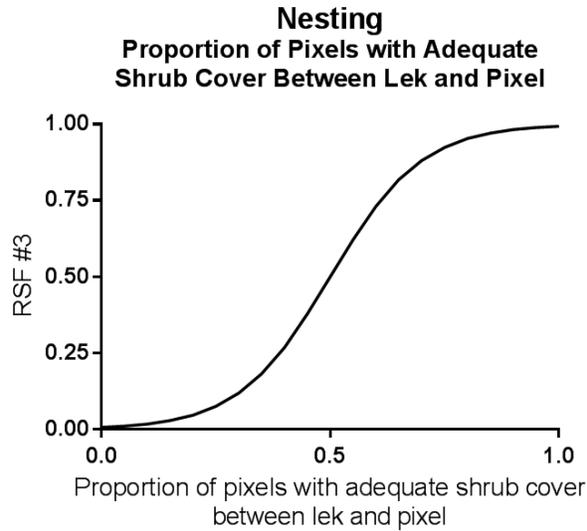


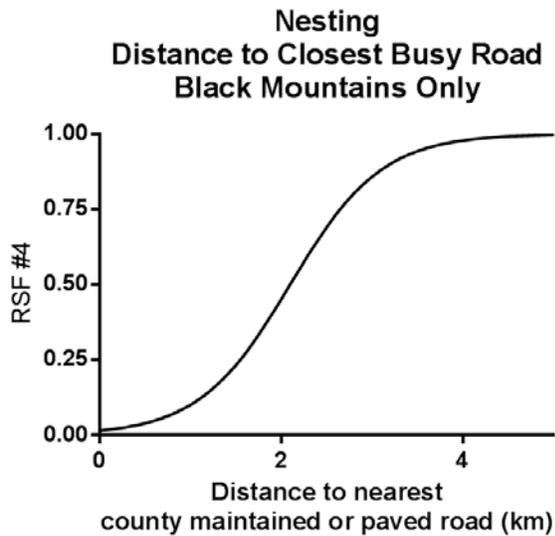
Table A5-2. Ecological System – Vegetation Class combinations defined as “shrubs.”

Ecological System	Vegetation Class	Ecological System	Vegetation Class
Basin Wildrye	BW-U:Depleted	Montane Sagebrush Steppe	MSS-A:All
	BW-U:SAP		MSS-B:Open
Black Sagebrush	BS-A:All		MSS-C:Closed
	BS-B:Open		MSS-D:Open
	BS-C:Closed		MSS-U:SAP
	BS-U:Depleted		MSS-U:SDI-A
	BS-U:SA		MSS-U:SDI-B
	BS-U:SAP		MSS-U:SDI-C
	BS-U:SAP+		MSS-U:SI-A+AG
	BS-U:SDI-A		MSS-U:SI-B+AG
	BS-U:SDI-B	MSS-U:SI-C+AG	
	BS-U:SDI-C	Utah Serviceberry	US-A:All
	BS-U:SI-A+AG		US-B:Closed
	BS-U:SI-B+AG		US-C:Closed
Low Sagebrush	LS-A:All		US-D:Open
	LS-B:Open		US-U:SAP
	LS-C:Closed	US-U:SDI-B	
	LS-U:Depleted	Wyoming Big Sagebrush upland	WSup-B:Open
	LS-U:SAP		WSup-C:Closed
	LS-U:SDI-A		WSup-U:SA
	LS-U:SDI-B		WSup-U:SAP
	LS-U:SDI-C		WSup-U:SDI-B
LS-U:SI-B+AG	WSup-U:SDI-C		
	WSup-U:SI-B+AG		
	WSup-U:SI-C+AG		

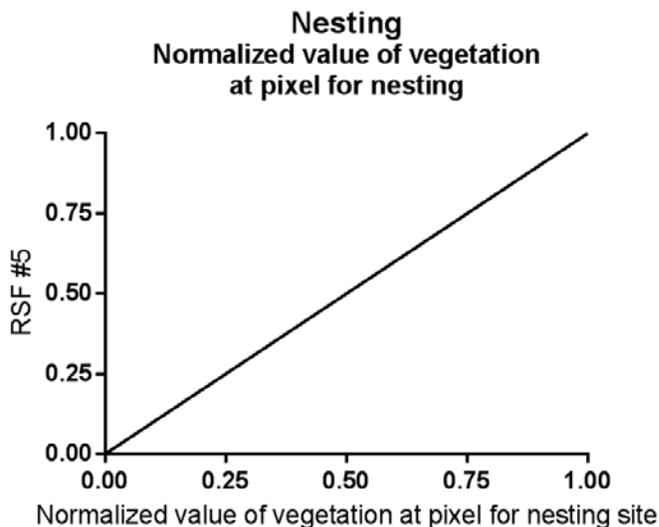
The fourth RSF ($RSF_{N,4}$) only applied to the Black Mountains where roads were considered sufficiently busy (i.e., noisy) to affect sage-grouse. These roads were the paved highway between Cedar City and Minersville and several large county maintained roads. The independent variable was the distance (km) between each pixel and the closest busy road (D).

$$RSF_{N,4} = e^{2 \times (D - 2.1)} / (1 + e^{2 \times (D - 2.1)}),$$

where 2.1 is the inflection point. Notice that the effect of roads is similar to the effect of trees. The road effect, however, was considered more pronounced than the tree effects because trees lose their effect at about 2 km, whereas roads only lose their effect at about 4 km.



The fifth RSF ($RSF_{N,5}$) was equal to the expert-defined normalized nesting value of the vegetation class (see Table A5-3 at end of this Appendix) to breeding habitat for each pixel (nest site).



The overall habitat suitability of the nesting season was:

$$RSF_N = \text{average}\{RSF_{N,1}, RSF_{N,2}, RSF_{N,3}, RSF_{N,4}, RSF_{N,5}\} = \sum_{i=1}^5 RSF_{N,i} / 5.$$

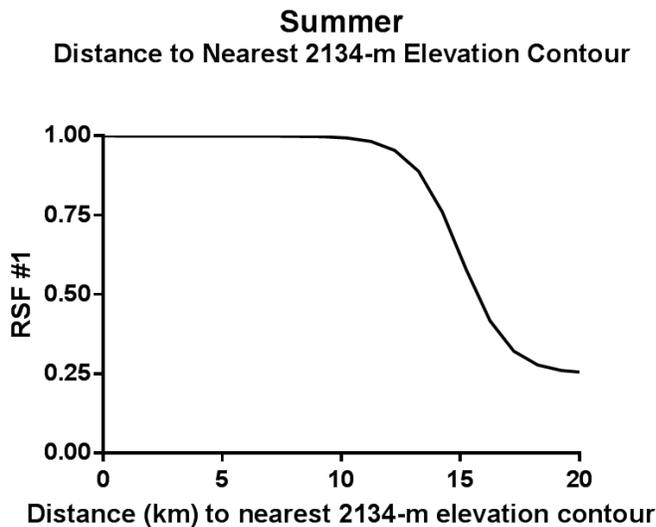
Summer

Five resource selection functions characterized the summer (i.e., brood-rearing) season ($RSF_{S,j}$, $j = 1, 2, \dots, 5$):

The first summer RSF ($RSF_{S,1}$) accounted for the ability of hens and chicks to walk to moist upland vegetation supporting insects at higher elevations, perhaps during the early-brood rearing period. Chicks were considered successful if they could walk to moist vegetation within 10 km; however, their ability to survive dropped very rapidly for longer distances. The independent variable was the distance of each pixel to the closest 2,134 m (7,000 ft) elevation contour, the approximate level of mountain big sagebrush (D).

$$RSF_{S,1} = 1 - 0.75 \times e^{1 \times (D - 15)} / (1 + e^{1 \times (D - 15)}),$$

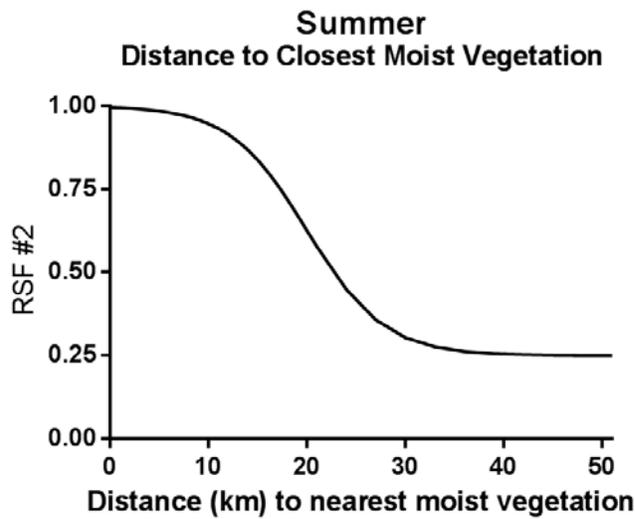
where 15 km is the inflection point.



The second RSF ($RSF_{S,2}$) was also based on access to moist vegetation but more directly to wet meadows and riparian vegetation (i.e., Wet Meadow during late-brood rearing, Montane Riparian during late-brood rearing, Montane Sagebrush Steppe during early-brood rearing, and Mountain Shrub during early-brood rearing). The independent variable was the distance of each pixel to the closest moist vegetation (D).

$$RSF_{S,2} = 1 - 0.75 \times e^{0.256 \times (D - 20)} / (1 + e^{0.256 \times (D - 20)}),$$

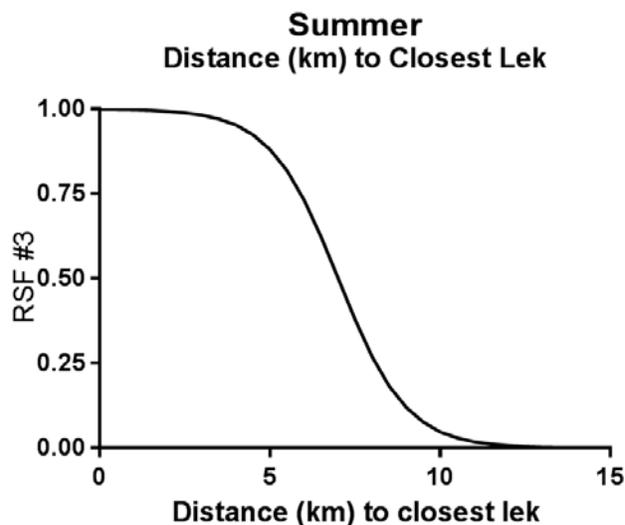
where 20 km is the inflection point. Again with this relationship, the chicks achieve higher success if they can reach moist vegetation within 10 km. Thereafter, survival was assumed to drop rapidly.



The third RSF ($RSF_{S,3}$), based on the proximity to leks, was less intuitive and may represent an indirect effect of distance to moist vegetation. For instance, if a hen and chicks are far away from a lek, it is also very likely they had to walk a long distance to critical moist vegetation, which is not desirable. The independent variable is the distance of a pixel to the closest lek (D).

$$RSF_{S,3} = 1 - e^{1 \times (D - 7)} / (1 + e^{1 \times (D - 7)}),$$

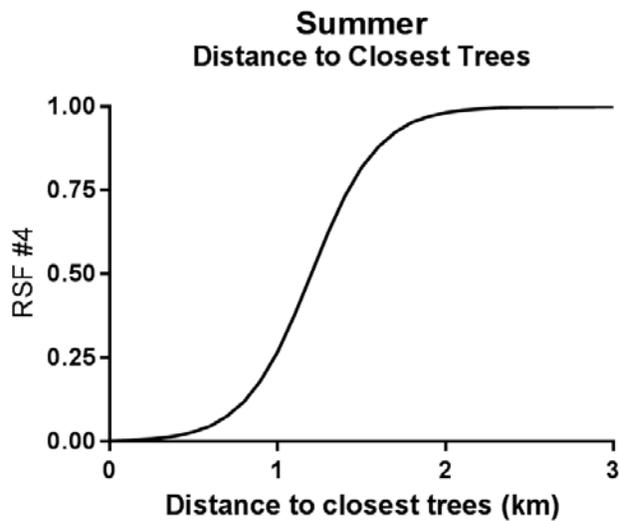
where 7 km is the inflection point.



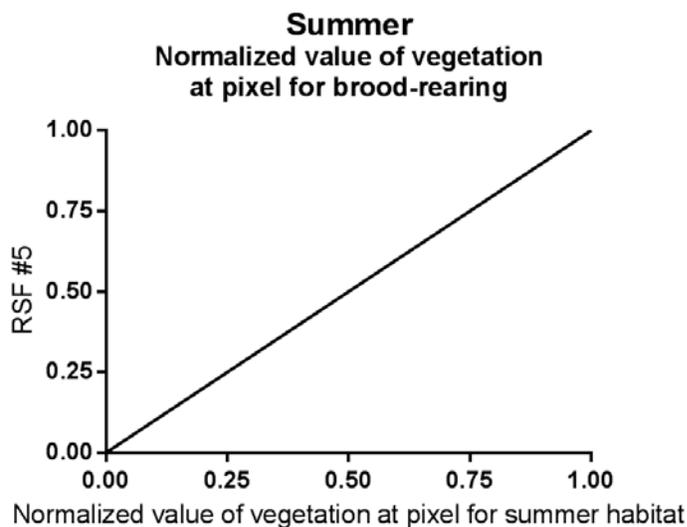
The fourth RSF ($RSF_{S,4}$) is identical to the one shown for the nesting RSF as a function of distance to the closest trees (D).

$$RSF_{S,4} = e^{5 \times (\text{Distance to closest trees} - 1.2)} / (1 + e^{5 \times (\text{Distance to closest trees} - 1.2)}),$$

where the inflection point is 1.2.



The fifth and last summer RSF ($RSF_{S,5}$) was equal to the expert-defined normalized summer value of the vegetation class (see Table A5-4 at end of this Appendix) for a pixel.



The overall habitat suitability of the summer season was:

$$RSF_S = \text{average}\{RSF_{S,1}, RSF_{S,2}, RSF_{S,3}, RSF_{S,4}, RSF_{S,5}\} = \sum_{i=1}^5 RSF_{S,i} / 5.$$

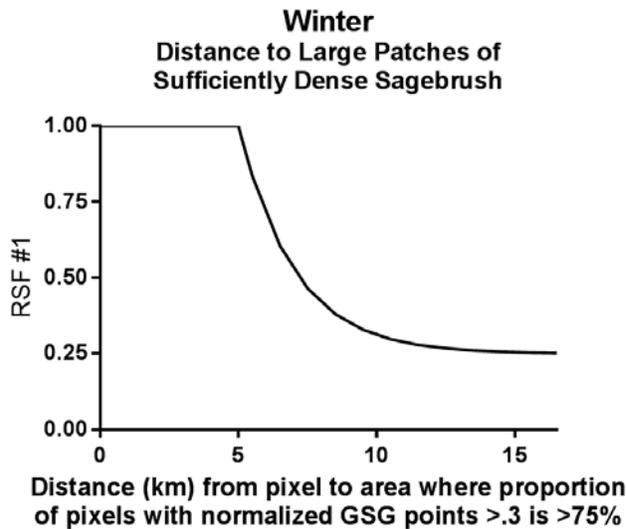
Winter

Three resource selection functions characterized the winter season ($RSF_{W,i}$, $i = 1,2,3$).

The first RSF for winter ($RSF_{W,1}$) was based on sage-grouse finding large patches of continuous sagebrush cover that provide shelter, protection from predators, and food. The independent variable was the distance of a pixel to an area of large size where >75% of pixels have an acceptable cover of sagebrush

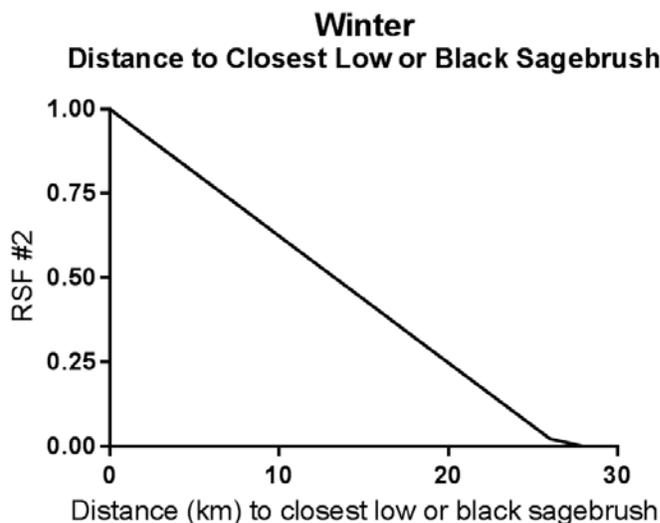
(D). Acceptable cover consisted of vegetation classes whose winter normalized values were greater than 0.3 (see Table A5-5 at end of this Appendix). We ran a focal statistics calculation to find acceptable vegetation cover within a 200 acre (5 km) window. Scored cells were those whose 5 km neighborhood comprised of at least 75% of identified acceptable vegetation. If the neighborhood contained less than 75% of acceptable cover it received a score of 0 and did not contribute to the Winter RSF score.

If $D < 5$ km, then $RSF_{W,1} = 1$,
 If $D \geq 5$ km, then $RSF_{W,1} = 0.25 + 0.75 \times e^{-0.5 \times (D - 5)}$

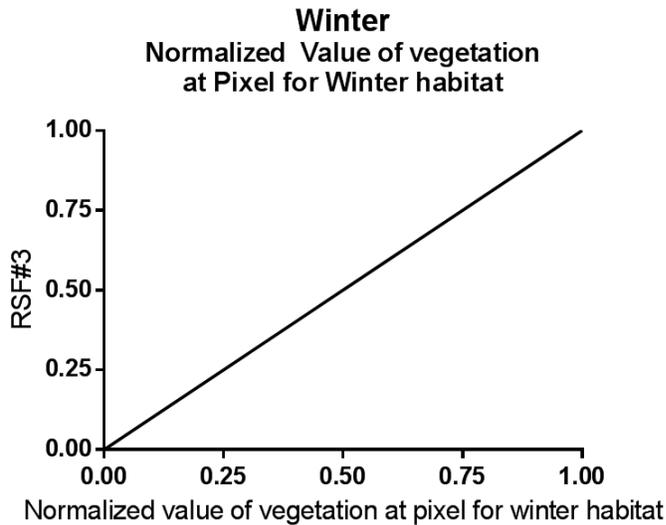


The second RSF ($RSF_{W,2}$) reflected a foraging preference of sage-grouse for the more nutritional low or black sagebrush. These sagebrush species are more highly selected for food than big sagebrush species by sage-grouse during the winter. Experts determined that the relationship to distance was linear. The independent variable was the distance of each pixel to the closest low or black sagebrush pixel (D).

If $D \leq 26.6$ km, then $RSF_{W,2} = -0.037593985 \times D + 1$,
 If $D > 26.6$ km, then $RSF_{W,2} = 0$.



The third RSF ($RSF_{W,3}$) was equal to the expert-defined winter normalized value of the vegetation class for the pixel (see Table A5-5 at end of this Appendix).



The overall habitat suitability of the winter season was the average of the three winter RSF:

$$RSF_W = \text{average}\{RSF_{W,1}, RSF_{W,2}, RSF_{W,3}\} = \sum_{i=1}^3 RSF_{W,i}/3.$$

Overall Habitat Suitability

The average habitat suitability across all seasons was the average of RSF_N , RSF_S , and RSF_W multiplied by an evenness factor. Evenness gives an idea of the distribution of RSF_N , RSF_S , and RSF_W scores. We used Simpson's evenness index, found on page 169 of

<http://www.umass.edu/landeco/research/fragstats/documents/fragstats.help.4.2.pdf>.

$$HS = \text{average}\{RSF_N, RSF_S, RSF_W\} \times \text{Simpson's Index of Evenness}$$

$$= (\sum_{i=N,S,W} RSF_i/N) \times (1 - \sum_{i=N,S,W} p_i^2)/(1 - 1/N)$$

where p_i is the relative value of the seasonal RSF_i : $p_i = RSF_i / \sum_{j=N,S,W} RSF_j$ and $N = 3$ seasonal habitats.

This value per pixel was between 0 (not suitable) and 1 (very suitable). Statistical habitat suitability models are not constructed as such, especially not using an evenness index. However, in the absence of a more formal approach, the above calculations allowed us to account for both the contribution of seasonal habitat suitability (poor to excellent), and whether some seasonal habitats were deficient and, as a result, lowered the overall habitat.

Resource Selection Functions for Utah Prairie Dog

Among the two landscapes of this project, the Utah prairie dog is only found in the Black Mountains. Unlike for sage-grouse, calculation of habitat suitability of Utah prairie dog is not seasonal and far simpler. The resource selection functions described below also were the result of a Utah prairie dog expert workshop held on March 13, 2014 at TNC's office in Salt Lake City.

Two resource selection functions were calculated based on vegetation classes and distance to prairie dog towns:

The first RSF for Utah prairie dog (RSF_1) was based on the amount of taller vegetation surrounding a pixel. Utah prairie dogs do not tolerate shrub cover greater than 15%. A function with values of 0 or 1 defined the habitat around a pixel such that each pixel received a score of 1 if all pixels within a 200-acre neighborhood around the pixel had a shrub cover of $\leq 15\%$, and contained no trees. Shrub cover was defined as primarily the reference and uncharacteristic early-succession vegetation classes (see Table A5-6 at end of this Appendix).

The second RSF for Utah prairie dog (RSF_2) was based on the ability of prairie dog to reach other colonies. The function was the distance of each pixel to the closest prairie dog town (D). Scoring decreased linearly after reaching 3km. After 5 km no score was given to the pixel.

0-3 km = 1.0
3-3.5 km = 0.8
3.5-4 km = 0.6
4-4.5 km = 0.4
4.5-5 km = 0.2
>5 km = 0.0

Overall habitat suitability was the weighted average of the two functions, where RSF_1 (shrub cover) was weighted at 40% and (RSF_2) (the distance to existing prairie dog town) was weighted at 60%. The final score was bounded between 0 and 1.

Table A5-3. Vegetation-class “points” for sage-grouse NESTING (BREEDING) habitat in Hamlin Valley and the Black Mountains.

Veg Class	Black Sagebrush	Sagr Pts	Low Sagebrush	Sagr Pts	Basin Big Sagebrush	Sagr Pts
A	A	1.0	A	1.0	A	0.1
B	B	1.0	B	1.0	B	0.8
C	C	0.5	C	0.5	C	1.0
D	D	0.1				
E						
U-AG	U-AG	0.1	U-AG	0.1	U-AG	0.1
U-DP	U-DP	0.3	U-DP	0.3	U-DP	0.1
U-EF						
U-ES	U-ES	0.1	U-ES	0.1	U-ES	0.1
U-SA	U-SA	0.3	U-SA	0.3	U-SA	0.5
U-SA+	U-SA+	0.3	U-SA+	0.3	U-SA+	0.5
U-SAP	U-SAP	0.5	U-SAP	0.5	U-SAP	1.0
U-SAP+	U-SAP+	0.5	U-SAP+	0.5	U-SAP+	1.0
U-TA			U-TA	0.1		
U-TE			U-TE	0.1		
U-TEA	U-TEA	0.1			U-TEA	0.1
U-SD	U-SD	0.5	U-SD	0.5	U-SD	0.5
U-SD+AG						
U-SDA						
U-SDI						
U-SDI+AG						
U-SDI-A	U-SDI-A	1.0	U-SDI-A	1.0	U-SDI-A	0.1
U-SDI-B	U-SDI-B	1.0	U-SDI-B	1.0	U-SDI-B	0.8
U-SDI-C	U-SDI-C	0.5	U-SDI-C	0.5	U-SDI-C	1.0
U-SDI-D						
U-SI-A+AG	U-SI-A+AG	1.0	U-SI-A+AG	1.0	U-SI-A+AG	0.1
U-SI-B+AG	U-SI-B+AG	1.0	U-SI-B+AG	1.0	U-SI-B+AG	0.8
U-SI-C+AG	U-SI-C+AG	0.5	U-SI-C+AG	0.5	U-SI-C+AG	1.0
U-SI-D+AG						
U-DE						
U-DW						
U-EFD						
U-EFT						
U-PD						
U-SFE						

Table A5-3 (Continued). Vegetation-class “points” for sage-grouse NESTING (BREEDING) habitat in Hamlin Valley and the Black Mountains.

Veg Class	Wyoming Big Sagebrush	Sagr Pts	Montane Sagebr Steppe	Sagr Pts	Utah Serviceberry	Sagr Pts
A	A	0.1	A	0.5	A	0.5
B	B	0.5	B	1.0	B	1.0
C	C	1.0	C	0.5	C	0.5
D	D	0.2	D	0.3	D	0.3
E	E	0.1	E	0.1		
U-AG	U-AG	0.1	U-AG	0.1	U-AG	0.1
U-DP	U-DP	0.1	U-DP	0.1	U-DP	0.1
U-EF						
U-ES	U-ES	0.1	U-ES	0.1	U-ES	0.1
U-SA	U-SA	0.5	U-SA	0.2		
U-SA+	U-SA+	0.5	U-SA+	0.2		
U-SAP	U-SAP	1.0	U-SAP	0.5	U-SAP	0.5
U-SAP+	U-SAP+	1.0	U-SAP+	0.5	U-SAP+	0.5
U-TA					U-TA	0.1
U-TE					U-TE	0.1
U-TEA	U-TEA	0.1	U-TEA	0.1		
U-SD			U-SD	0.5		
U-SD+AG						
U-SDA						
U-SDI						
U-SDI+AG						
U-SDI-A	U-SDI-A	0.1	U-SDI-A	0.5	U-SDI-A	0.5
U-SDI-B	U-SDI-B	0.5	U-SDI-B	1.0	U-SDI-B	1.0
U-SDI-C	U-SDI-C	1.0	U-SDI-C	0.5	U-SDI-C	0.5
U-SDI-D	U-SDI-D	0.2	U-SDI-D	0.2	U-SDI-D	0.2
U-SI-A+AG	U-SI-A+AG	0.1	U-SI-A+AG	0.5	U-SI-A+AG	0.5
U-SI-B+AG	U-SI-B+AG	0.5	U-SI-B+AG	1.0	U-SI-B+AG	1.0
U-SI-C+AG	U-SI-C+AG	1.0	U-SI-C+AG	0.5	U-SI-C+AG	0.5
U-SI-D+AG	U-SI-D+AG	0.2	U-SI-D+AG	0.2	U-SI-D+AG	0.2
U-DE						
U-DW						
U-EFD						
U-EFT						
U-PD						
U-SFE						

Table A5-4. Vegetation-class “points” for sage-grouse SUMMER habitat in Hamlin Valley and the Black Mountains.

Veg Class	Black Sagebrush	Sagr Pts	Low Sagebrush	Sagr Pts	Wyoming Big Sagebrush	Sagr Pts	Montane Sagebr Steppe	Sagr Pts
A	A	0.5	A	0.7	A	1.0	A	1.0
B	B	0.5	B	0.7	B	1.0	B	1.0
C	C	0.1	C	0.3	C	0.5	C	0.5
D	D	0.1			D	0.1	D	0.1
E					E	0.1	E	0.1
U-AG	U-AG	0.1	U-AG	0.1	U-AG	0.1	U-AG	0.1
U-DP	U-DP	0.3	U-DP	0.3	U-DP	0.3	U-DP	0.3
U-EF								
U-ES	U-ES	0.1	U-ES	0.1	U-ES	0.1	U-ES	0.1
U-SA	U-SA	0.1	U-SA	0.1	U-SA	0.3	U-SA	0.3
U-SA+	U-SA+	0.1	U-SA+	0.1	U-SA+	0.3	U-SA+	0.3
U-SAP	U-SAP	0.2	U-SAP	0.3	U-SAP	0.5	U-SAP	0.5
U-SAP+	U-SAP+	0.2	U-SAP+	0.3	U-SAP+	0.5	U-SAP+	0.5
U-TA			U-TA	0.1				
U-TE			U-TE	0.1				
U-TEA	U-TEA	0.1			U-TEA	0.1	U-TEA	0.1
U-SD	U-SD	0.2	U-SD	0.3			U-SD	0.3
U-SD+AG								
U-SDA								
U-SDI								
U-SDI+AG								
U-SDI-A	U-SDI-A	0.5	U-SDI-A	0.7	U-SDI-A	1.0	U-SDI-A	1.0
U-SDI-B	U-SDI-B	0.5	U-SDI-B	0.7	U-SDI-B	1.0	U-SDI-B	1.0
U-SDI-C	U-SDI-C	0.1	U-SDI-C	0.3	U-SDI-C	0.5	U-SDI-C	0.5
U-SDI-D					U-SDI-D	0.1	U-SDI-D	0.1
U-SI-A+AG	U-SI-A+AG	0.5	U-SI-A+AG	0.7	U-SI-A+AG	1.0	U-SI-A+AG	1.0
U-SI-B+AG	U-SI-B+AG	0.5	U-SI-B+AG	0.7	U-SI-B+AG	1.0	U-SI-B+AG	1.0
U-SI-C+AG	U-SI-C+AG	0.1	U-SI-C+AG	0.3	U-SI-C+AG	0.5	U-SI-C+AG	0.5
U-SI-D+AG					U-SI-D+AG	0.1	U-SI-D+AG	0.1
U-DE								
U-DW								
U-EFD								
U-EFT								
U-PD								
U-SFE								

Table A5-4 (Continued). Vegetation-class “points” for sage-grouse SUMMER habitat in Hamlin Valley and the Black Mountains.

Veg Class	Stansbury Cliffrose	Sagr Pts	Utah Serviceberry	Sagr Pts	Montane Riparian	Sagr Pts
A	A	1.0	A	1.0	A	1.0
B	B	1.0	B	1.0	B	1.0
C	C	0.5	C	0.5	C	0.3
D			D	0.1		
E						
U-AG	U-AG	0.1	U-AG	0.1	U-AG	0.1
U-DP	U-DP	0.3	U-DP	0.3		
U-EF						
U-ES	U-ES	0.1	U-ES	0.1		
U-SA						
U-SA+						
U-SAP	U-SAP	0.5	U-SAP	0.5	U-SAP	0.1
U-SAP+	U-SAP+	0.5	U-SAP+	0.5		
U-TA			U-TA	0.1		
U-TE			U-TE	0.1	U-TE	0.1
U-TEA	U-TEA	0.1				
U-SD					U-SD	0.3
U-SD+AG						
U-SDA					U-SDA	0.1
U-SDI						
U-SDI+AG						
U-SDI-A	U-SDI-A	1.0	U-SDI-A	1.0		
U-SDI-B	U-SDI-B	1.0	U-SDI-B	1.0		
U-SDI-C	U-SDI-C	0.5	U-SDI-C	0.5		
U-SDI-D			U-SDI-D	0.1		
U-SI-A+AG	U-SI-A+AG	1.0	U-SI-A+AG	1.0		
U-SI-B+AG	U-SI-B+AG	1.0	U-SI-B+AG	1.0		
U-SI-C+AG	U-SI-C+AG	0.5	U-SI-C+AG	0.5		
U-SI-D+AG			U-SI-D+AG	0.1		
U-DE					U-DE	0.1
U-DW					U-DW	0.1
U-EFD					U-EFD	0.1
U-EFT					U-EFT	0.1
U-PD					U-PD	0.1
U-SFE					U-SFE	0.3

Table A5-4 (Continued). Vegetation-class “points” for sage-grouse SUMMER habitat in Hamlin Valley and the Black Mountains.

Veg Class	Wet Meadow montane	Sagr Pts	Aspen Woodland	Sagr Pts	Aspen-Mixed Conifer	Sagr Pts
A	A	1.0	A	1.0	A	1.0
B	B	1.0	B	1.0	B	1.0
C	C	1.0	C	1.0	C	1.0
D			D	0.5	D	0.1
E					E	0.1
U-AG	U-AG	0.1				
U-DP			U-DP	0.3		
U-EF	U-EF	0.5				
U-ES						
U-SA	U-SA	0.1				
U-SA+						
U-SAP						
U-SAP+						
U-TA						
U-TE						
U-TEA	U-TEA	0.1				
U-SD						
U-SD+AG						
U-SDA						
U-SDI	U-SDI	0.1				
U-SDI+AG						
U-SDI-A						
U-SDI-B						
U-SDI-C						
U-SDI-D						
U-SI-A+AG						
U-SI-B+AG						
U-SI-C+AG						
U-SI-D+AG						
U-DE	U-DE	0.1				
U-DW						
U-EFD						
U-EFT						
U-PD						
U-SFE	U-SFE	0.5				

Table A5-5. Vegetation-class “points” for sage-grouse WINTER habitat in Hamlin Valley and the Black Mountains.

Veg Class	Black Sagebrush	Sagr Pts	Low Sagebrush	Sagr Pts	Basin Big Sagebrush	Sagr Pts
A	A	0.3	A	0.3	A	0.3
B	B	1.0	B	1.0	B	1.0
C	C	1.0	C	1.0	C	1.0
D	D	0.3				
E						
U-AG	U-AG	0.3	U-AG	0.1	U-AG	0.1
U-DP	U-DP	0.3	U-DP	1.0	U-DP	1.0
U-EF						
U-ES	U-ES	0.1	U-ES	0.1	U-ES	0.1
U-SA	U-SA	0.8	U-SA	0.8	U-SA	0.8
U-SA+	U-SA+	0.8	U-SA+	0.8	U-SA+	0.8
U-SAP	U-SAP	0.8	U-SAP	0.8	U-SAP	0.8
U-SAP+	U-SAP+	0.8	U-SAP+	0.8	U-SAP+	0.8
U-TA			U-TA	0.1		
U-TE			U-TE	0.1		
U-TEA	U-TEA	0.1			U-TEA	0.1
U-SD	U-SD	0.5	U-SD	0.5	U-SD	0.5
U-SD+AG						
U-SDA						
U-SDI						
U-SDI+AG						
U-SDI-A	U-SDI-A	0.3	U-SDI-A	0.3	U-SDI-A	0.3
U-SDI-B	U-SDI-B	1.0	U-SDI-B	0.3	U-SDI-B	1.0
U-SDI-C	U-SDI-C	1.0	U-SDI-C	0.3	U-SDI-C	1.0
U-SDI-D						
U-SI-A+AG	U-SI-A+AG	0.3	U-SI-A+AG	0.3	U-SI-A+AG	0.3
U-SI-B+AG	U-SI-B+AG	1.0	U-SI-B+AG	1.0	U-SI-B+AG	1.0
U-SI-C+AG	U-SI-C+AG	1.0	U-SI-C+AG	1.0	U-SI-C+AG	1.0
U-SI-D+AG						
U-DE						
U-DW						
U-EFD						
U-EFT						
U-PD						
U-SFE						

Table A5-5 (Continued). Vegetation-class “points” for sage-grouse WINTER habitat in Hamlin Valley and the Black Mountains.

Veg Class	Wyoming Big Sagebrush	Sagr Pts	Montane Sagebr Steppe	Sagr Pts	Semi-Desert Grassland	Sagr Pts
A	A	0.3	A	0.3	A	0.1
B	B	1.0	B	1.0	B	0.5
C	C	1.0	C	1.0		
D	D	0.3	D	0.3		
E	E	0.1	E	0.1		
U-AG	U-AG	0.1	U-AG	0.1		
U-DP	U-DP	1.0	U-DP	1.0	U-DP	1.0
U-EF						
U-ES	U-ES	0.1	U-ES	0.1	U-ES	0.1
U-SA	U-SA	0.8	U-SA	0.8		
U-SA+	U-SA+	0.8	U-SA+	0.8		
U-SAP	U-SAP	0.8	U-SAP	0.8	U-SAP	0.3
U-SAP+	U-SAP+	0.8	U-SAP+	0.8	U-SAP+	0.3
U-TA						
U-TE						
U-TEA	U-TEA	0.1	U-TEA	0.1	U-TEA	0.1
U-SD			U-SD	0.5		
U-SD+AG						
U-SDA						
U-SDI					U-SDI	0.1
U-SDI+AG					U-SDI+AG	0.1
U-SDI-A	U-SDI-A	0.3	U-SDI-A	0.3		
U-SDI-B	U-SDI-B	1.0	U-SDI-B	1.0		
U-SDI-C	U-SDI-C	1.0	U-SDI-C	1.0		
U-SDI-D	U-SDI-D	0.3	U-SDI-D	0.3		
U-SI-A+AG	U-SI-A+AG	0.3	U-SI-A+AG	0.3		
U-SI-B+AG	U-SI-B+AG	1.0	U-SI-B+AG	1.0		
U-SI-C+AG	U-SI-C+AG	1.0	U-SI-C+AG	1.0		
U-SI-D+AG	U-SI-D+AG	0.3	U-SI-D+AG	0.3		
U-DE						
U-DW						
U-EFD						
U-EFT						
U-PD						
U-SFE						

Table A5-6. Vegetation-class “points” for Utah prairie dog in the Black Mountains.

Veg Class	Basin Big Sage semi-desert	UPD Pts	Basin Wildrye - Basin Big Sage	UPD Pts	Black Sagebrush	UPD Pts	Greasewood-Basin Big Sage	UPD Pts
A	A	1.0	A	0.8	A	1.0	A	0.1
B	B	0.7	B	0.0	B	0.7	B	0.1
C	C	0.0	C	0.0	C	0.1		
D					D	0.0		
E								
U-AG	U-AG	0.5	U-AG	0.1	U-AG	0.5	U-AG	0.1
U-AGPG								
U-DP	U-DP	0.0	U-DP	0.0	U-DP	0.0		
U-EF			U-EF	0.1				
U-ES	U-ES	0.0	U-ES	0.0	U-ES	0.7		
U-SA	U-SA	0.1			U-SA	0.1	U-SA	0.1
U-SA+	U-SA+	0.1			U-SA+	0.1	U-SA+	0.1
U-SAP	U-SAP	0.1	U-SAP	0.1	U-SAP	0.1		
U-SAP+	U-SAP+	0.1	U-SAP+	0.1	U-SAP+	0.1		
U-TA								
U-TE								
U-TEA	U-TEA	0.0	U-TEA	0.0	U-TEA	0.0		
U-SD	U-SD	1.0			U-SD	1.0	U-SD	0.1
U-SD+AG								
U-SDA								
U-SDI			U-SDI	0.5			U-SDI	0.1
U-SDI+AG			U-SDI+AG	0.5			U-SDI+AG	0.1
U-SDI-A	U-SDI-A	1.0			U-SDI-A	1.0		
U-SDI-B	U-SDI-B	0.7			U-SDI-B	0.7		
U-SDI-C	U-SDI-C	0.0			U-SDI-C	0.1		
U-SDI-D								
U-SI-A+AG	U-SI-A+AG	1.0			U-SI-A+AG	1.0		
U-SI-B+AG	U-SI-B+AG	0.7			U-SI-B+AG	0.7		
U-SI-C+AG	U-SI-C+AG	0.0			U-SI-C+AG	0.1		
U-SI-D+AG								
U-DE								
U-DW								
U-EFD								
U-EFT								
U-PD								
U-SFE								

Table A5-6 (Continued). Vegetation-class “points” for Utah prairie dog in the Black Mountains.

Veg Class	Low Sagebrush	UPD Pts	Mixed Salt Desert	UPD Pts	Montane Sagebr Steppe	UPD Pts	Semi-Desert Grassland	UPD Pts
A	A	1.0	A	0.3	A	1.0	A	1.0
B	B	0.7	B	0.3	B	0.7	B	1.0
C	C	0.1	C	0.1	C	0.0		
D					D	0.0		
E					E	0.0		
U-AG	U-AG	0.5	U-AG	0.1	U-AG	0.5		
U-AGPG								
U-DP	U-DP	0.0			U-DP	0.0	U-DP	0.1
U-EF								
U-ES	U-ES	0.7			U-ES	0.0	U-ES	0.7
U-SA	U-SA	0.1	U-SA	0.1	U-SA	0.0		
U-SA+	U-SA+	0.1	U-SA+	0.1	U-SA+	0.0		
U-SAP	U-SAP	0.1			U-SAP	0.0	U-SAP	0.7
U-SAP+	U-SAP+	0.1			U-SAP+	0.0	U-SAP+	0.7
U-TA	U-TA	0.0						
U-TE	U-TE	0.0						
U-TEA					U-TEA	0.0	U-TEA	0.0
U-SD	U-SD	1.0	U-SD	0.3	U-SD	1.0		
U-SD+AG								
U-SDA								
U-SDI			U-SDI	0.3			U-SDI	1.0
U-SDI+AG			U-SDI+AG	0.3			U-SDI+AG	1.0
U-SDI-A	U-SDI-A	1.0			U-SDI-A	1.0		
U-SDI-B	U-SDI-B	0.7			U-SDI-B	0.7		
U-SDI-C	U-SDI-C	0.1			U-SDI-C	0.0		
U-SDI-D					U-SDI-D	0.0		
U-SI-A+AG	U-SI-A+AG	1.0			U-SI-A+AG	1.0		
U-SI-B+AG	U-SI-B+AG	0.7			U-SI-B+AG	0.7		
U-SI-C+AG	U-SI-C+AG	0.1			U-SI-C+AG	0.0		
U-SI-D+AG					U-SI-D+AG	0.0		
U-DE								
U-DW								
U-EFD								
U-EFT								
U-PD								
U-SFE								

Table A5-6 (Continued). Vegetation-class “points” for Utah prairie dog in the Black Mountains.

Veg Class	Wet Meadow- Alkali Sacaton	UPD Pts	Wet Mdw- montane	UPD Pts	Winterfat	UPD Pts	Wyoming Big Sagebrush	UPD Pts
A	A	0.3	A	0.5	A	0.5	A	1.0
B	B	0.3	B	0.5	B	0.5	B	0.7
C	C	0.1	C	0.1	C	0.3	C	0.0
D							D	0.0
E							E	0.0
U-AG	U-AG	0.1	U-AG	0.5	U-AG	0.3	U-AG	0.5
U-AGPG	U-AGPG	0.3						
U-DP					U-DP	0.3	U-DP	0.0
U-EF	U-EF	0.1	U-EF	0.1	U-EF	0.0		
U-ES							U-ES	0.0
U-SA			U-SA	0.1	U-SA	0.3	U-SA	0.0
U-SA+					U-SA+	0.3	U-SA+	0.0
U-SAP	U-SAP	0.1			U-SAP	0.3	U-SAP	0.0
U-SAP+					U-SAP+	0.3	U-SAP+	0.0
U-TA								
U-TE								
U-TEA			U-TEA	0.0			U-TEA	0.0
U-SD					U-SD	0.5		
U-SD+AG					U-SD+AG	0.5		
U-SDA								
U-SDI			U-SDI	0.1	U-SDI	0.5		
U-SDI+AG					U-SDI+AG	0.5		
U-SDI-A							U-SDI-A	1.0
U-SDI-B							U-SDI-B	0.7
U-SDI-C							U-SDI-C	0.0
U-SDI-D							U-SDI-D	0.0
U-SI-A+AG							U-SI-A+AG	1.0
U-SI-B+AG							U-SI-B+AG	0.7
U-SI-C+AG							U-SI-C+AG	0.0
U-SI-D+AG							U-SI-D+AG	0.0
U-DE			U-DE	0.1				
U-DW								
U-EFD								
U-EFT								
U-PD								
U-SFE	U-SFE	0.0	U-SFE	0.1				

Appendix 6 Temporal Multipliers

Fire Activity Variability

Federal data were available for fire activity between 1984 and 2011 for the two project areas. Data from the federal Monitoring Trends in Burn Severity (MTBS) were downloaded for the whole western U.S.A. and time series of fire size from 1984 to 2011 were extracted by “clipping” to each project areas (all ownerships) with ARC GIS 10 (Figure A6.1).

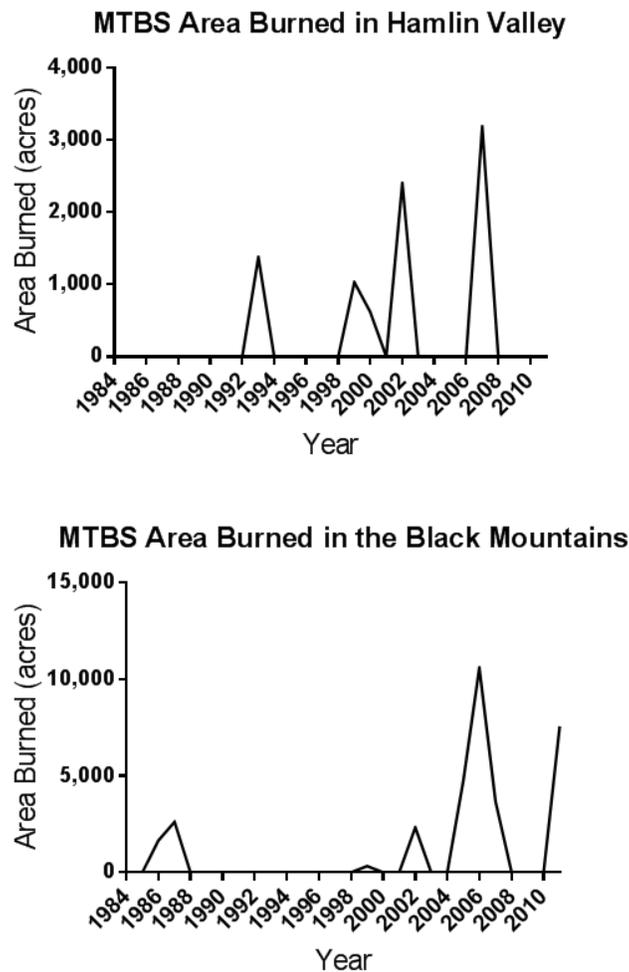


Figure A6.1. Area burned (acres) from 1984 to 2011 in Hamlin Valley and the Black Mountains (UT) based on downloaded geodata from MTBS.

To introduce future fire variability into simulations, we used properties of previous fires and past precipitation time series to calculate time series of future burn area. Five time series of fire activity were used as replicates for all scenarios. First, maximum fire size was obtained from past fire data in each project area. The maximum fire sizes were 3,188 acres for Hamlin Valley and 10,592 acres for the Black Mountains. Maximum fire size determined the upper

limit of future fires because the rest of the calculation of area burned was a non-dimensional function of fire variability between zero and one based on drought levels. To capture drought variability we used the Standard Precipitation Index (SPI), which was first published in 1993 as a drought index based only on precipitation (McKee, Doesken, and Kleist 1993). SPI is based on the probability of precipitation for any time scale. Different timescales reflect the fact that some ecological and physical processes operate at different time scales.

Second, five 25-year time series of SPI (1895-2013) ending in August for cumulative 8-month and 24-month periods for the climatic region containing the project areas were extracted by copying 25-year partial time series starting at five randomly selected years: 1904 for replicate #1, 1956 for replicate #2, 1922 for replicate #3, 1955 for replicate #4, and 1910 for replicate #5. These starts dates were used in other temporal multipliers shown next. The 8-month SPI measured fuels dryness/wetness during the current year, whereas the 24-month SPI measured the same characteristic cumulatively from the last two years. We assumed that fire activity in the current year was more likely if the 8-month SPI indicated a current dry year, whereas the 24-month SPI up to the previous year indicated wetter than average condition favoring fine fuel build up in shrublands. Taylor and Beaty (2005) showed that drought is highly negatively correlated to fire frequency and total area burned for forest types during pre-settlement in the northern Sierra Nevada: more fire was observed during increasingly drier years. The same relationship holds for average temperature (Westerling et al. 2008). This, however, does not apply to shrublands that must first experience consecutive wetter than average years to accumulate fine fuels that will more likely burn in a dry year immediately following the wet year sequence (Westerling and Bryant 2008; Westerling 2009). We used two versatile Gompertz equations to represent this differential effect of years:

$$\begin{aligned} \text{Yearly shrubland-woodland area burned variability} &= \\ &= \text{MaxFire} \times e^{-1.1 \times \exp[-2 \times 0.01 \times \text{SPI}\{24\text{-mo}, t-1\}]} \times (1 - e^{-2.5 \times \exp[-50 \times 0.01 \times \text{SPI}\{8\text{-mo}, t\}]}) \quad (\text{Eq. A6.1}) \end{aligned}$$

where MaxFire = maximum fire area. Equation A6.1 combines two Gompertz functions to accommodate negative and positive values of SPI. The first part of equation A6.1 after MaxFire, representing fine fuels production over two year ending in the previous year $t-1$, is a classic Gompertz function. Wetter years ($\text{SPI} > 0$) increase the value of this function (fine fuels accumulation) to a maximum of one. The first part of the equation is multiplied by the second function representing the current year, which is one minus another Gompertz function bound between zero and one. Increasingly drier soil moisture ($\text{SPI} < 0$) causes the second part of equation A6.1 to increase to a maximum of one (maximum ignition probability). Equation A6.1 is not the final temporal multiplier, however, because it is not divided by its average area burned over 25 years. Yearly values of Eq. A6.1 were divided by their temporal average over 25 years.

Although Eq. A6.1 attempted to capture fire variability, the amount of fire depends on fire management actions, which consists of fire suppression. The effect of fire suppression was obtained by multiplying each yearly value by 0.1 to represent 90% fire suppression. We determined that fire suppression was about 90% successful because that is the ratio of MTBS area burn and the predicted area burned under reference conditions as simulated with the

models. The five time series (i.e., 5 replicates) were uploaded into ST-Sim such that each yearly value in a replicate temporal multiplier multiplied the average wildfire rate in the models for a specific time step (Figure A6.2).

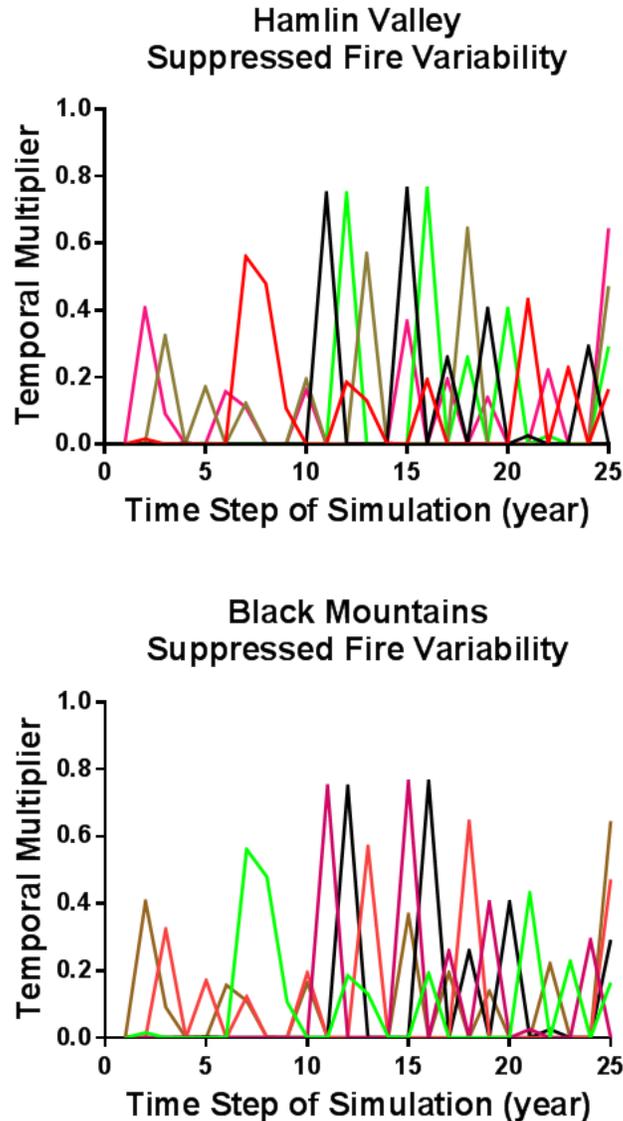


Figure A6.2. Five replicates of temporal probability multipliers for fire activity. Each replicate is color-coded and represented by a 25-year period. Fire variability is suppressed by 90%.

Upland Variability

Remaining upland temporal multipliers were climate related: annual grass invasion rate, drought-induced mortality, insect and disease mortality, freeze-induced mortality, tree invasion rate, and very-wet-year mortality. The SPI was used for many multipliers, except freezing mortality in Gambel oak.

We assumed that more severe droughts cause increased plant mortality, whereas wetter conditions suppress mortality. We also assumed that insect/disease mortality variability was also caused by severe drought. A severe drought is defined as at least five consecutive years of well below average precipitation (Biondi et al. 2008); therefore, we used the 5-year SPI of the current year to evaluate if the project area had experience a five-year drought. Because SPI can be negative, therefore incompatible with ST-Sim as a temporal multiplier, we chose a function with negative exponentials to create positive values that increased exponentially with smaller (more negative) SPI values:

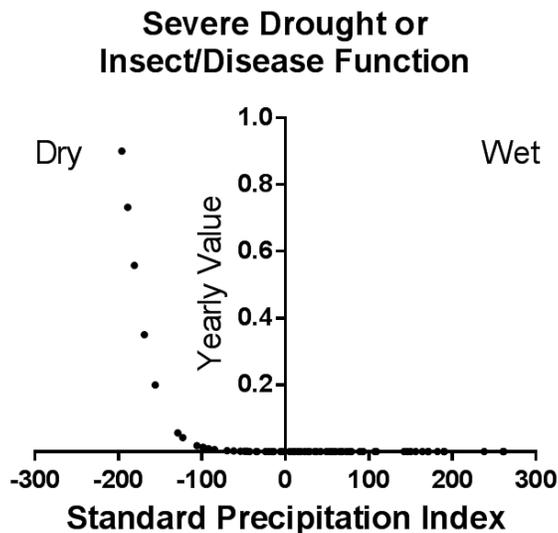
$$\begin{aligned} \text{Severe drought and insect-disease mortality} \\ = 2 \times e^{5 \times (D - D100)} / (1 + e^{5 \times (D - D100)}) \end{aligned} \quad (\text{Eq. A6.2; below})$$

where

$D = \text{Adjusted SPI Value} = \text{abs}[0.01 \times (\text{SPI} - \text{MaxWettestSPI})]$,

$\text{MaxWettestSPI} = \text{wettest SPI observed in 1941} = 261$,

$D100 = D \text{ value for SPI of } -100 = 4.61$.



Function parameters were chosen such that the time series were between zero and one and yearly values of the time series only increased above 0.01 when drought was severe, which was arbitrarily chosen to be SPI values ≤ -100 . The parameter “2” allowed the function to reach a maximum value of one; otherwise it would not exceed 0.5. The MaxWettestSPI of 261 was subtracted from the observed SPI to guarantee that the exponential function always had a negative exponent. The D100 parameter determined the value of SPI for which severe drought starts being felt, which is $\text{SPI} = -100$. To obtain the temporal multiplier time series, each value of equation A6.3 was divided by the time series’ average over 25 years. Figure A6.3 show the temporal multipliers.

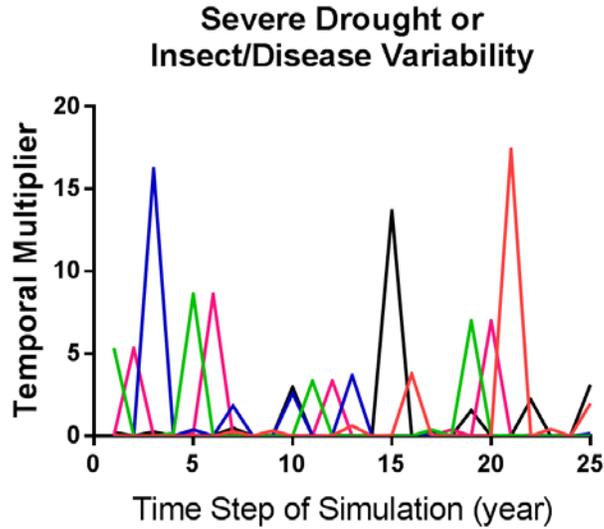
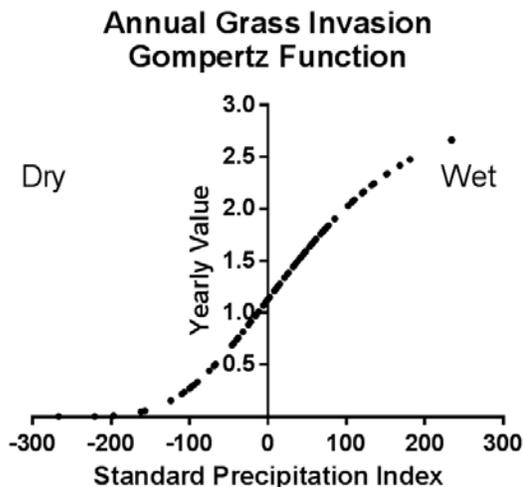


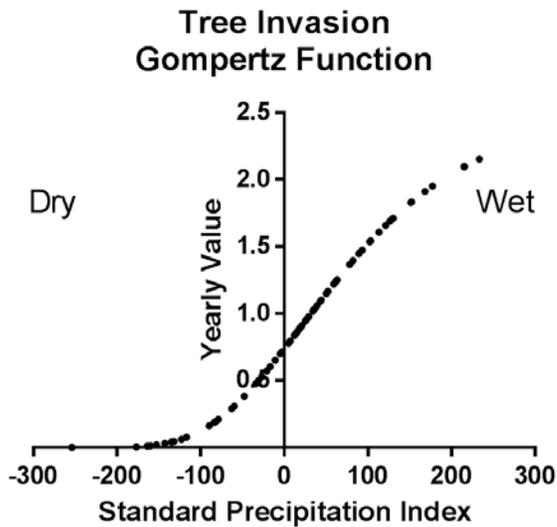
Figure A6.3. Five replicates of temporal probability multipliers for severe drought variability. Each replicate is color-coded and represented by a 25-year period.

Temporal variability for non-native annual grass and forb invasion and tree (mostly pinyon and juniper) invasion rates were dependent on drought levels: greater drought severity, therefore lower soil moisture, was detrimental to recruitment and growth and, conversely, greater soil moisture favored the spread of annual grasses and trees (Bradley 2009; Brown et al. 2004; Smith et al. 2000). We assumed that tree invasion was a much slower process than annual grass invasion. SPI values from the 4-month period finishing in June (end of annual grass germination) were chosen for annual grass invasion, whereas SPI time series of 6-month period finishing in September (end of primary period of tree growth) were used for tree invasion. We used a simple Gompertz function for each of annual grasses and tree invasions to represent the contribution of negative and positive SPI values expressed as positive values of invasion variability. This implies that SPI was directly related to the variability of these invasion rates:

$$\text{Annual grass invasion (below)} = 3 \times e^{-2.4 \times \exp[-0.9 \times (0.01 \times \text{SPI} + 1)]} \quad (\text{Eq. A6.3})$$



$$\text{Tree invasion (below)} = 2.5 \times e^{-3 \times \exp[-0.9 \times (0.01 \times \text{SPI} + 1)]}$$



Parameters values were chosen to reflect that both annual grass invasion and tree invasion happens even during moderately dry conditions and the rate is one (i.e., not different from neutral) during 5-year average precipitation levels for annual grasses. The yearly invasion values calculated with these Gompertz functions were transformed into temporal multipliers by dividing each year's value by the temporal average of the time series (Figs. A6.4 and A6.5).

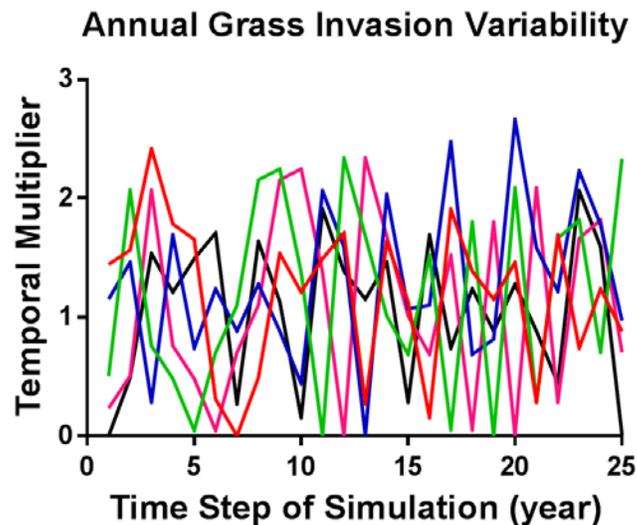


Figure A6.4. Five replicates of temporal probability multipliers for annual grass invasion variability. Each replicate is color-coded and represented by a 25-year period.

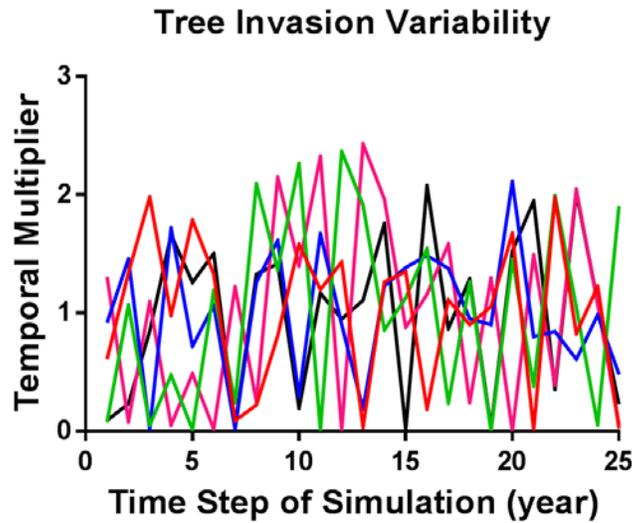


Figure A6.5. Five replicates of temporal probability multipliers for tree invasion variability. Each replicate is color-coded and represented by a 25-year period.

Tree encroachment is the process by which mature pinyon and juniper trees suppress and ultimately eliminate the shrub and herbaceous understory in shrublands invaded by trees for decades. Although tree invasion benefits from wetter conditions, tree encroachment is assumed more intense during 12-month droughts that would result in trees outcompeting shrubs and grasses for soil moisture. SPI time series of 12-month drought ending in October were chosen for tree encroachment. Because drought is critical to the process, the function for tree encroachment and severe drought are of the same type, albeit with different parameters (below).

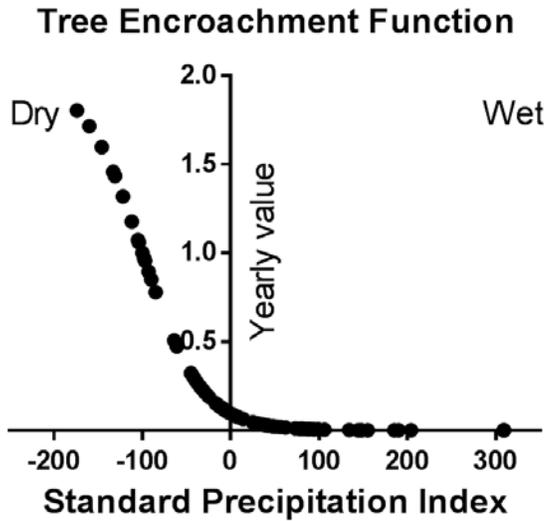
$$\begin{aligned} \text{Tree-encroachment} \\ = 2 \times e^{3 \times (T - T100)} / (1 + e^{3 \times (T - T100)}) \end{aligned} \quad (\text{Eq. A6.4; below})$$

where

$$T = \text{Adjusted SPI Value} = \text{abs}[0.01 \times (\text{SPI} - \text{MaxWettestSPI})],$$

$$\text{MaxWettestSPI} = \text{wettest SPI observed} = 380,$$

$$T100 = T \text{ value for SPI of } -100 = 4.8.$$



The explanations for this function is similar to that of severe drought, however the value of T100 is the value needed for tree encroachment to be equal to 1 as it is assumed that tree encroachment may still occur for wetter conditions. To obtain the yearly temporal multiplier values, each value was divided by the temporal average over 25 year of the replicate time series (Fig. A6.6).

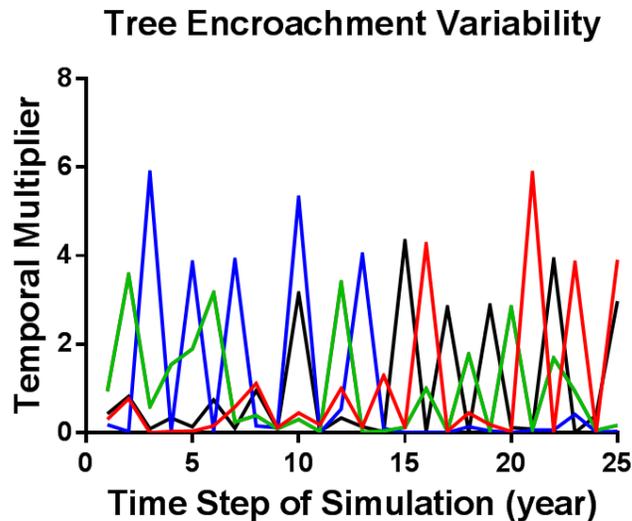


Figure A6.6. Five replicates of temporal probability multipliers for tree encroachment variability. Each replicate is color-coded and represented by a 25-year period.

The very-wet year temporal multiplier calculation used the same time series of SPI for 12-month ending in October (end of the hydrologic year), however the wet side of the SPI spectrum caused larger values. The very-wet year temporal multiplier introduced variability to

mortality caused by shrub root rot or attack of roots by rootworms in salt desert communities. The calculation of these temporal multipliers was very similar to that of tree encroachment, except that the relation to SPI was flipped:

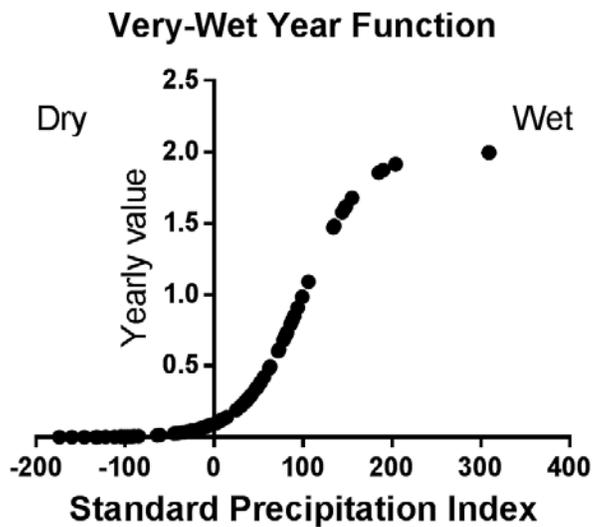
$$\text{Very-wet year} = 2 \times e^{3 \times (\text{VW} - \text{VW100})} / (1 + e^{3 \times (\text{VW} - \text{VW100})}) \quad (\text{Eq. A6.5; below})$$

where

VW = Adjusted SPI Value = $0.01 \times (\text{SPI} - \text{MaxDriestSPI})$,

MaxDriestSPI = driest SPI observed = -340,

VW100 = VW value for SPI of 100 = 4.4.



The VW100 parameter is the inflection point where the function equals one, the neutral value. The temporal multipliers were obtained by dividing each yearly value by the temporal average over 25 years (Fig. A6.7).

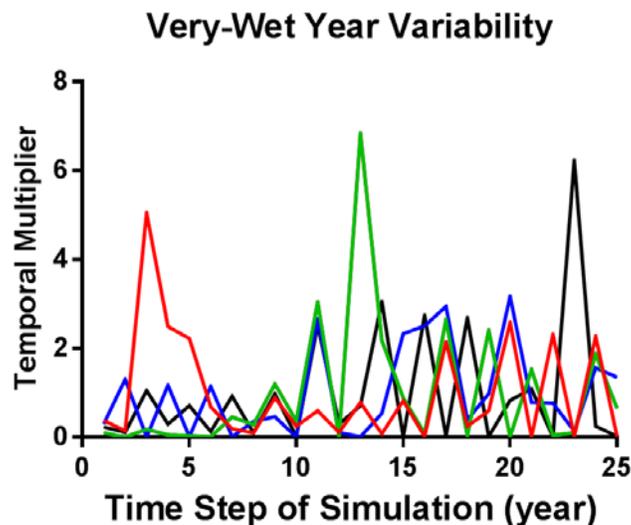


Figure A6.7. Temporal multipliers for very-wet years for the fourth climatic division of Nevada and Utah. Five replicates are color-coded and shown each per 25-year period.

The last temporal multipliers using SPI was for wet year variability. The SPI data were for the 12 previous months ending in May. The function for very-wet year and wet year were similar; however, parameters were slightly different.

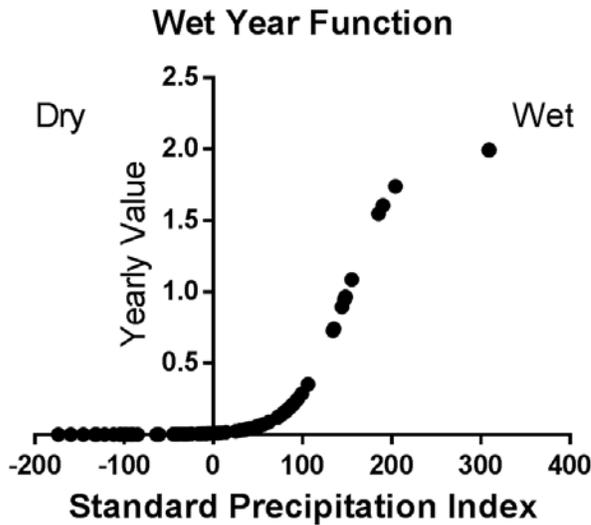
$$\text{Wet year variability} = 2 \times e^{3.5 \times (W - W_{100})} / (1 + e^{3.5 \times (W - W_{100})}) \quad (\text{Eq. A6.6; below})$$

where

$W = \text{Adjusted SPI Value} = 0.01 \times (\text{SPI} - \text{MaxDriestSPI})$,

$\text{MaxDriestSPI} = \text{driest SPI observed} = -213$,

$W_{100} = \text{VW value for SPI of 100} = 3.63$.



The temporal multipliers were obtained by dividing each yearly value by the temporal average over 25 years (Fig. A6.8).

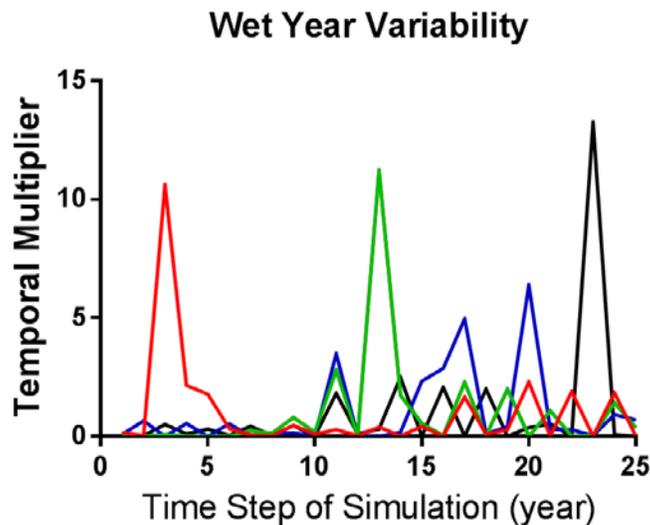


Figure A6.8. Temporal multipliers for wet years for the fourth climatic division of Nevada and Utah. Five replicates are color-coded and shown each per 25-year period.

Mortality caused by late freezing only applied to the Gambel oak system, although this phenomenon was observed in other high-elevation systems of the western Utah (Clarence 1921). The variability of this process was primarily determined by an early spring (March and April) thaw followed by a hard freeze in May. This process was captured through a binary step function and a continuous function:

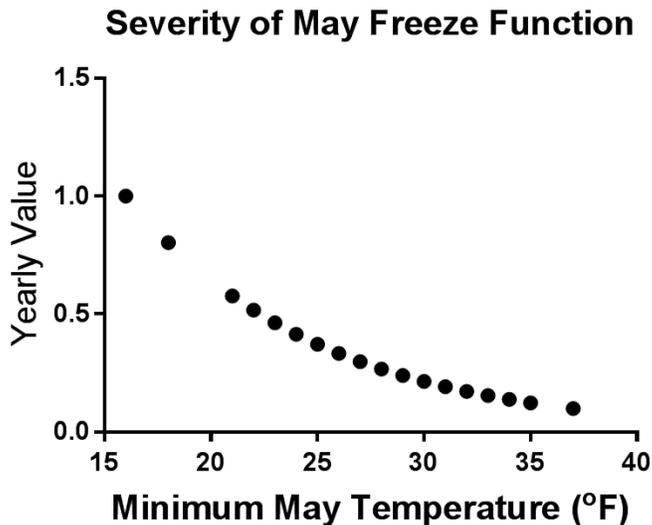
Late Spring Freeze Mortality =

$$(\text{March and April Thaw}) \times (\text{Severity of May Freeze}), \quad (\text{Eq. A6.7; below})$$

where

$$\begin{aligned} \text{March and April Thaw} = 0 &= \text{average March \underline{or} April temperature} \leq 32^{\circ}\text{F} \\ &= 1 = \text{average March \underline{and} April temperatures} > 32^{\circ}\text{F} \end{aligned}$$

$$\text{Severity of May Freeze} = e^{-0.11 \times (\text{MinMayTemp} - \text{HistoricMinMayTemp})}$$



where *MinMayTemp* is the lowest monthly temperature recorded in May of the current year at the Cedar City airport and *HistoricMinMayTemp* is the lowest monthly temperature recorded in May from 1948 to 2013 at the Cedar City airport. The temporal multiplier per year was obtained by dividing each yearly value by the temporal average over 25 years (Fig. A6.9). It is obvious that late-spring freeze events will occur only rarely in the Gambel oak simulations.

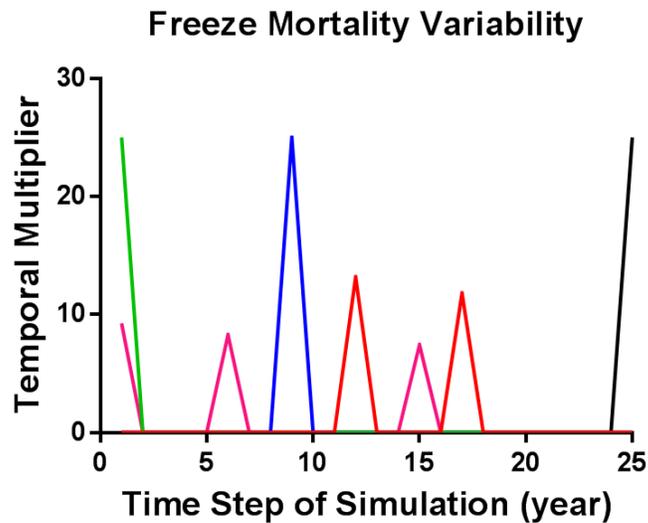


Figure A6.9. Temporal multipliers for mortality caused by freezing based on the minimum temperature recorded at the Cedar City (UT) airport’s weather station. The five replicates are color-coded and shown each per 50-year period.

Riparian Variability

Montane riparian and desert washes systems were strongly dependent on flood events and their discharge variation (Rood et al. 2003; McBride and Strahan 1984). For perennial reaches, we used flow data from the Beaver River near Beaver, Utah, measured between 1914 and 2013 (US Geological Survey: # USGS 10234500 BEAVER RIVER NEAR BEAVER, UT). We created five replicates of 25 years each by resampling the original time series using random start years before 1988 (= 2013 – 25 years) to start the time series (1933, 1956, 1922, 1955, and 1936).

Peak flow data from the Beaver River were used to calculate temporal variability for the 7-year, 20-year, and 100-year flood events, whereas annual flow data were used to derived exotic species invasion rates. Seven-year, 20-year, and 100-year flood events were all based on filtering for increasingly higher values of annual peak flow. The three levels of flooding corresponded to 7-year events that killed or removed only herbaceous vegetation; 20-year events that killed or removed shrubs and young trees; and 100-year events that top-killed larger trees (i.e., these are three distinct disturbances in the riparian models). We used a crude recurrence analysis to obtain flow thresholds for 7-, 20-, and 100-year flood events (Fig. A6.10).

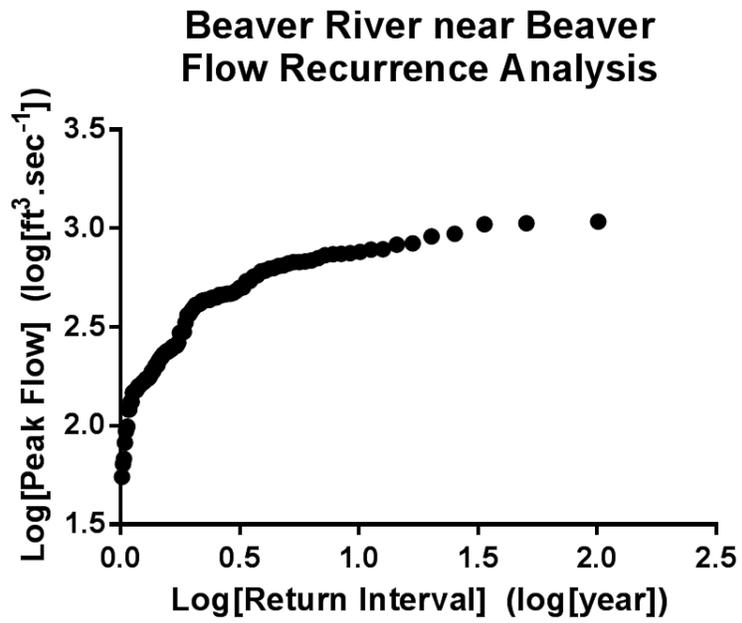


Figure A6.10. Recurrence analysis to obtain flow thresholds for 7-, 20-, and 100-year flood events

The 7-, 20-, and 100-year flood time series, respectively, encompassed yearly flood events greater than 707.9, 907.8, and 1071.5 cfs of peak flow for certain years; otherwise, flood events were zero. Each yearly value of each time series was divided by the temporal average to obtain the temporal multipliers (Figure A6.11).

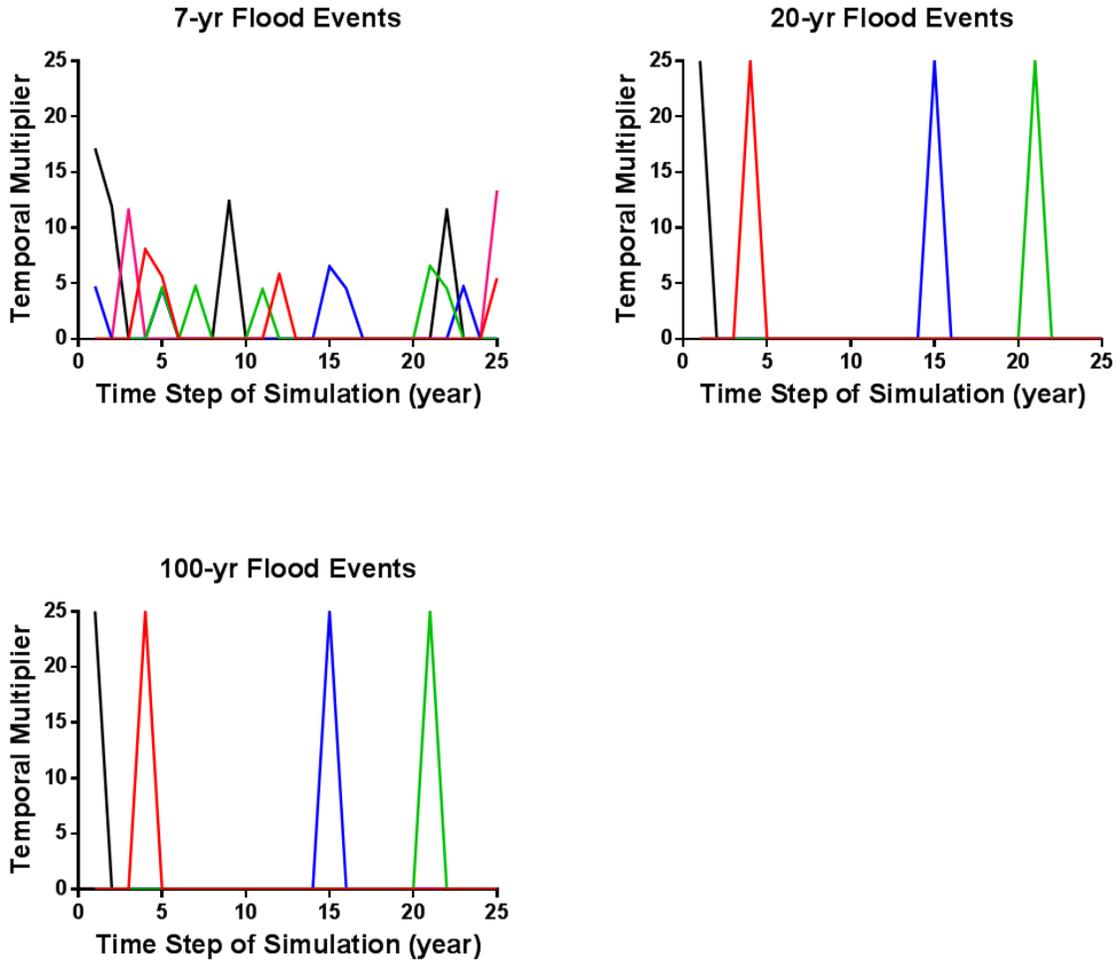


Figure A6.11. Temporal multipliers for 7-, 20-, and 100-year flood events based on peak flows from the Beaver River near Beaver (UT). The five replicates are color-coded and shown each per 50-year period.

Annual discharge from the Beaver River near Beaver was used to determine exotic forb and exotic tree invasion rates. We assumed that the variability of exotic species invasion was entirely dependent on average annual discharge (annual discharge is the average discharge among months, whereas peak discharge is the maximum discharge recorded). Years of greater than average annual discharge would favor the invasion of exotic forbs and trees. The rate of exotic forb invasion in ST-Sim models was, therefore, multiplied by the annual flow temporal multiplier. The temporal multipliers were obtained by using the annual flow time series without filtering and divided by the time series temporal average. Data are shown in Figure A6.12.

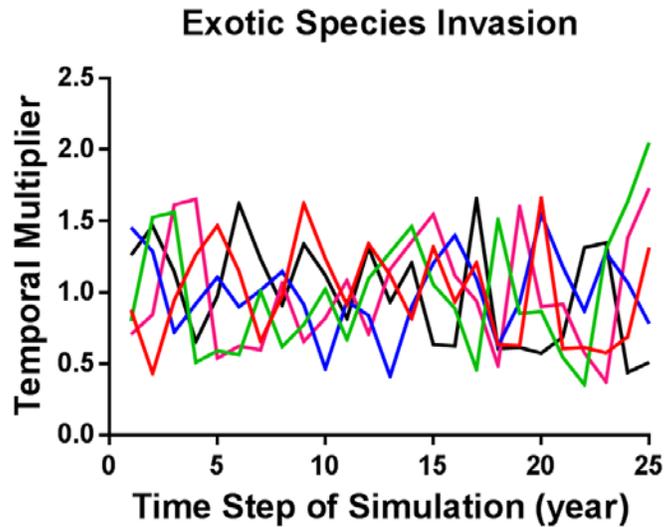


Figure A6.12. Riparian temporal multipliers for exotic species invasion calculated from annual discharge data from annual yearly flows recorded from the Beaver River near Beaver (UT). The five replicates are color-coded and shown each per 50-year period.

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Appendix 7. Management Actions/Treatments and Costs in Ecological Systems.

Ecological System →	Aspen Woodland	Aspen-Mixed Conifer	Basin Wildrye	Big Sagebrush semi-desert	Black Sagebrush	Desert Wash	Four-Wing Saltbush	Greasewood-Basin Big Sagebrush
Management Action/Treatment ↓								
2xChaining+Native-Seed				\$230	\$230			
2xChaining+Plateau+Seed				\$180	\$220			
2xChaining+Seed			\$190		\$190			
Aerial-Seed								
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow			\$350	\$350	\$350			
Aerial-Spyke+Aerial-Seed+Chain-Harrow			\$200	\$200	\$200			
Chaining+Native-Seed				\$230	\$175			
Chaining+Plateau+Native-Seed				\$260	\$200			
Chaining+Plateau+Seed				\$145	\$145		\$185	\$185
Chaining+Seed					\$120			
Chainsaw-Thinning	\$80	\$80			\$20			
Exotic-Control			\$250			\$320		
Exotic-Control+Native-Seed			\$360					
Fence	\$10,000	\$10,000						
Floodplain-Restoration								
Forb+Grass-Native-Seeding			\$175	\$175	\$175			
Grass-Seeding								
Herbicide-Plateau								
Herbicide-Plateau+Native-Seed								
Herbicide-Plateau+Planting								
Herbicide-Plateau+Seed			\$150	\$150	\$110		\$150	\$110
Hypo-Hatchet-Spyke					\$25			
Masticate+Herbicide+Native-Seed			\$625					
Masticate+Herbicide+Seed			\$550		\$310			
Masticate+Native-Seed			\$575		\$325			
Masticate+Seed					\$270			
Mastication					\$200			
RxFire	\$150	\$150	\$150					
RxFire+Seed+Chain					\$235			
Shrub+Grass-Seeding								
Small-Rock-Dam								
Small-Tree-Lopping	\$60		\$20		\$80			
Spot-Herbicide+Native-Seed								
Spyke				\$25				
Spyke+Native-Seed			\$175	\$175	\$240			
Spyke+Plateau+Native-Seed								
Thin			\$35	\$35	\$35			
Thin+Herbicide+Native-Seed			\$320	\$320				
Thin+Herbicide+Seed							\$240	
Thin+Native-Seed			\$275	\$275	\$250		\$275	
Weed-Inventory+Treat			\$360			\$360		

Appendix 7. Management Actions/Treatments and Costs in Ecological Systems.

Ecological System →	Low Sagebrush	Mixed Conifer	Mixed Salt Desert	Montane Riparian	Montane Sagebrush Steppe	Pinyon-Juniper	Ponderosa Pine
Management Action/Treatment ↓							
2xChaining+Native-Seed					\$230		
2xChaining+Plateau+Seed							
2xChaining+Seed							
Aerial-Seed						\$20	
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	\$350				\$350		
Aerial-Spyke+Aerial-Seed+Chain-Harrow	\$200		\$200		\$200		
Chaining+Native-Seed	\$175				\$175		
Chaining+Plateau+Native-Seed							
Chaining+Plateau+Seed			\$185		\$185		
Chaining+Seed					\$120	\$120	
Chainsaw-Thinning		\$80		\$80		\$80	\$20
Exotic-Control				\$360		\$430	
Exotic-Control+Native-Seed							
Fence				\$8,000			
Floodplain-Restoration				\$2,000			
Forb+Grass-Native-Seeding					\$175		
Grass-Seeding							
Herbicide-Plateau			\$10				
Herbicide-Plateau+Native-Seed	\$225						
Herbicide-Plateau+Planting							
Herbicide-Plateau+Seed			\$110		\$110		
Hypo-Hatchet-Spyke					\$25		
Masticate+Herbicide+Native-Seed							
Masticate+Herbicide+Seed					\$310		
Masticate+Native-Seed					\$325		
Masticate+Seed					\$270	\$500	
Mastication					\$200		
RxFire	\$150				\$100		\$150
RxFire+Seed+Chain					\$235		
Shrub+Grass-Seeding							
Small-Rock-Dam				\$500			
Small-Tree-Lopping	\$80			\$80	\$80		
Spot-Herbicide+Native-Seed	\$225						
Spyke							
Spyke+Native-Seed					\$240		
Spyke+Plateau+Native-Seed							
Thin	\$35		\$35		\$35		
Thin+Herbicide+Native-Seed							
Thin+Herbicide+Seed							
Thin+Native-Seed					\$250		
Weed-Inventory+Treat				\$360			

Appendix 7. Management Actions/Treatments and Costs in Ecological Systems.

Ecological System →	Semi-Desert Grassland	Stansbury Cliffrose	Utah Serviceberry	Wet Meadow-Alkali Sacaton	Wet Meadow-Montane	Winterfat	Wyoming Big Sagebrush upland
Management Action/Treatment ↓							
2xChaining+Native-Seed							\$230
2xChaining+Plateau+Seed							
2xChaining+Seed							
Aerial-Seed							
Aerial-Spyke+Aerial-Native-Seed+Chain-Harrow	\$350				\$350		\$350
Aerial-Spyke+Aerial-Seed+Chain-Harrow	\$200				\$200		\$200
Chaining+Native-Seed		\$230	\$230				\$175
Chaining+Plateau+Native-Seed			\$260				
Chaining+Plateau+Seed	\$185		\$185				\$185
Chaining+Seed			\$120				\$120
Chainsaw-Thinning			\$20				
Exotic-Control				\$360	\$360		
Exotic-Control+Native-Seed							
Fence					\$8,000		
Floodplain-Restoration					\$2,000		
Forb+Grass-Native-Seeding			\$175				\$175
Grass-Seeding						\$125	
Herbicide-Plateau		\$10					
Herbicide-Plateau+Native-Seed				\$225		\$225	
Herbicide-Plateau+Planting						\$225	
Herbicide-Plateau+Seed			\$150				\$110
Hypo-Hatchet-Spyke							\$25
Masticate+Herbicide+Native-Seed		\$625					
Masticate+Herbicide+Seed	\$550		\$550				\$310
Masticate+Native-Seed			\$325				\$325
Masticate+Seed			\$270				
Mastication							\$200
RxFire			\$100				
RxFire+Seed+Chain			\$235				\$235
Shrub+Grass-Seeding						\$175	
Small-Rock-Dam					\$500		
Small-Tree-Lopping		\$20	\$20		\$20		\$60
Spot-Herbicide+Native-Seed		\$225					
Spyke							\$25
Spyke+Native-Seed							\$240
Spyke+Plateau+Native-Seed		\$250					
Thin	\$35			\$125	\$125		\$35
Thin+Herbicide+Native-Seed	\$320		\$320	\$320	\$320		\$265
Thin+Herbicide+Seed	\$240		\$240				
Thin+Native-Seed				\$275			\$250
Weed-Inventory+Treat				\$320	\$320		

Appendix 8. Current (Initial) Acres of Ecological Systems and Vegetation Classes.

Ecological System	Vegetation Class	Hamlin Valley			Black Mountains					
	Yellow = High Risk	System Ac	Class Ac	Class %	System Ac	Class Ac	Class %			
Aspen Woodland	ASP-A:Closed	118.6	0.3	0.3%	4.8	0.0	0.0%			
	ASP-B:Closed		6.5	5.5%		0.0	0.0%			
	ASP-C:Closed		67.0	56.5%		0.0	0.0%			
	ASP-D:Open		11.0	9.2%		0.0	0.0%			
	ASP-U:Depleted		33.8	28.5%		4.8	100.0%			
Aspen-Mixed Conifer	1-Early:All	391.8	0.0	0.0%	0.0	0.0	0.0%			
	2-Mid:Closed		15.8	4.0%		0.0	0.0%			
	4-Late:Closed		30.6	7.8%		0.0	0.0%			
	5-Late:Open		148.4	37.9%		0.0	0.0%			
	6-Late:Closed		197.1	50.3%		0.0	0.0%			
	Basin Wildrye		BW-A:Open	1,402.3		0.0	0.0%	1,413.0	0.0	0.0%
BW-B:Closed		3.2	0.2%		0.0	0.0%				
BW-C:Open		0.0	0.0%		0.0	0.0%				
BW-U:Annual Grass		4.3	0.3%		36.3	2.6%				
BW-U:Depleted		387.2	27.6%		340.2	24.1%				
BW-U:Early-Shrub		771.6	55.0%		163.5	11.6%				
BW-U:Exotic Forb		1.9	0.1%		211.9	15.0%				
BW-U:SAP		192.6	13.7%		659.9	46.7%				
BW-U:SAP+		0.0	0.0%		0.0	0.0%				
BW-U:SDI		41.5	3.0%		0.0	0.0%				
BW-U:SDI+AG		0.0	0.0%		0.0	0.0%				
BW-U:Seeded Native		0.0	0.0%		0.0	0.0%				
BW-U:TEA		0.0	0.0%		1.2	0.1%				
Big Sagebrush semi-desert		BSsd-A:All	0.0		0.0	0.0%	12.1		0.0	0.0%
		BSsd-B:Closed			0.0	0.0%			0.0	0.0%
		BSsd-C:Open			0.0	0.0%			0.0	0.0%
	BSsd-U:Annual Grass	0.0		0.0%	0.0	0.0%				
	BSsd-U:Depleted	0.0		0.0%	0.0	0.0%				
	BSsd-U:Early-Shrub	0.0		0.0%	0.0	0.0%				
	BSsd-U:SA	0.0		0.0%	0.0	0.0%				
	BSsd-U:SA+	0.0		0.0%	0.0	0.0%				
	BSsd-U:SAP	0.0		0.0%	12.1	100.0%				
	BSsd-U:SAP+	0.0		0.0%	0.0	0.0%				
	BSsd-U:SDI-A	0.0		0.0%	0.0	0.0%				
	BSsd-U:SDI-B	0.0		0.0%	0.0	0.0%				
	BSsd-U:SDI-C	0.0		0.0%	0.0	0.0%				
	BSsd-U:Seeded Native	0.0		0.0%	0.0	0.0%				
	BSsd-U:SI-A+AG	0.0		0.0%	0.0	0.0%				
	BSsd-U:SI-B+AG	0.0		0.0%	0.0	0.0%				
	BSsd-U:SI-C+AG	0.0		0.0%	0.0	0.0%				
	BSsd-U:TEA	0.0		0.0%	0.0	0.0%				
	Black Sagebrush	BS-A:All		54,115.4	558.4	1.0%		62,371.4	2,016.0	3.2%
BS-B:Open		2,679.5	5.0%		5,281.5	8.5%				
BS-C:Closed		1,450.8	2.7%		6,032.2	9.7%				
BS-D:Open		22,885.5	42.3%		8,164.4	13.1%				
BS-U:Annual Grass		419.5	0.8%		1,237.4	2.0%				
BS-U:Depleted		380.1	0.7%		9,395.7	15.1%				
BS-U:Early-Shrub		7.6	0.0%		325.7	0.5%				
BS-U:SA		1,923.2	3.6%		4,574.4	7.3%				
BS-U:SA+		0.0	0.0%		0.0	0.0%				
BS-U:SAP		6,871.2	12.7%		17,581.9	28.2%				
BS-U:SAP+		0.0	0.0%		0.0	0.0%				
BS-U:SDI-A		0.0	0.0%		40.0	0.1%				
BS-U:SDI-B		46.8	0.1%		178.0	0.3%				
BS-U:SDI-C		0.0	0.0%		35.1	0.1%				
BS-U:Seeded Native		0.0	0.0%		0.0	0.0%				
BS-U:SI-A+AG		0.0	0.0%		194.9	0.3%				
BS-U:SI-B+AG		0.0	0.0%		416.5	0.7%				
BS-U:SI-C+AG		0.0	0.0%		9.7	0.0%				
BS-U:TEA		16,892.8	31.2%		6,888.2	11.0%				

Appendix 8. Current (Initial) Acres of Ecological Systems and Vegetation Classes.

Ecological System	Vegetation Class	Hamlin Valley			Black Mountains		
	Yellow = High Risk	System Ac	Class Ac	Class %	System Ac	Class Ac	Class %
Curl-leaf Mountain Mahogany	CMM-A:All	5,262.1	42.8	0.8%	1,178.1	98.1	8.3%
	CMM-B:Open		93.1	1.8%		4.8	0.4%
	CMM-C:Closed		0.0	0.0%		0.0	0.0%
	CMM-D:Open		2,370.3	45.0%		926.3	78.6%
	CMM-E:Closed		2,738.8	52.0%		148.9	12.6%
	CMM-U:Annual Grass		17.1	0.3%		0.0	0.0%
	CMM-U:TA		0.0	0.0%		0.0	0.0%
Desert Wash	DWA-A:All	32.4	16.1	49.6%	6.1	0.0	0.0%
	DWA-B:Closed		9.1	28.1%		2.4	39.7%
	DWA-C:Closed		0.0	0.0%		0.0	0.0%
	DWA-U:Bare Ground		0.0	0.0%		0.0	0.0%
	DWA-U:Early-Shrub		0.0	0.0%		2.4	39.7%
	DWA-U:EFT		0.0	0.0%		0.0	0.0%
	DWA-U:SA		0.0	0.0%		0.0	0.0%
	DWA-U:SA+		0.0	0.0%		0.0	0.0%
	DWA-U:SAP		7.3	22.4%		1.2	19.8%
	DWA-U:SAP+		0.0	0.0%		0.0	0.0%
	Four-Wing Saltbush		FWS-A:Open	0.0		0.0	0.0%
FWS-B:Open		0.0	0.0%		0.0	0.0%	
FWS-C:Closed		0.0	0.0%		0.0	0.0%	
FWS-U:Annual Grass		0.0	0.0%		0.0	0.0%	
FWS-U:Depleted		0.0	0.0%		0.0	0.0%	
FWS-U:Early-Shrub		0.0	0.0%		0.0	0.0%	
FWS-U:SAP		0.0	0.0%		0.0	0.0%	
FWS-U:SAP+		0.0	0.0%		0.0	0.0%	
FWS-U:SDI		0.0	0.0%		0.0	0.0%	
FWS-U:SDI+AG		0.0	0.0%		0.0	0.0%	
FWS-U:Seeded Native		0.0	0.0%		0.0	0.0%	
Gambel Oak-Mountain Shrub	GOMS-A:All	1.5	0.0	0.0%	360.8	67.8	18.8%
	GOMS-B:Closed		0.5	30.9%		289.4	80.2%
	GOMS-C:Closed		1.1	72.1%		2.4	0.7%
	GOMS-U:SAP		0.0	0.0%		1.2	0.3%
	GOMS-U:SAP+		0.0	0.0%		0.0	0.0%
Greasewood-Basin Big Sagebrush	GW-A:All	68.3	0.0	0.0%	6,123.0	406.8	6.6%
	GW-B:Closed		0.0	0.0%		560.6	9.2%
	GW-U:Annual Grass		0.0	0.0%		842.7	13.8%
	GW-U:SAP		68.3	99.9%		4,312.8	70.4%
	GW-U:SAP+		0.0	0.0%		0.0	0.0%
	GW-U:SDI		0.0	0.0%		0.0	0.0%
	GW-U:SDI+AG		0.0	0.0%		0.0	0.0%
	GW-U:Seeded Native		0.0	0.0%		0.0	0.0%
Juniper Savanna	JUN-A:All	0.0	0.0	0.0%	2,764.2	1,376.7	49.8%
	JUN-B:Open		0.0	0.0%		0.0	0.0%
	JUN-C:Open		0.0	0.0%		0.0	0.0%
	JUN-D:Open		0.0	0.0%		1,387.6	50.2%
	JUN-U:Annual Grass		0.0	0.0%		0.0	0.0%
	JUN-U:Early-Shrub		0.0	0.0%		0.0	0.0%
	JUN-U:SAP		0.0	0.0%		0.0	0.0%
JUN-U:TA	0.0	0.0%	0.0	0.0%			
Limber-Bristlecone Pine	LB-A:All	36.9	0.0	0.0%	0.0	0.0	0.0%
	LB-B:Open		7.4	20.1%		0.0	0.0%
	LB-C:Open		29.5	79.9%		0.0	0.0%
Low Sagebrush	LS-A:All	2,227.9	8.8	0.4%	799.1	18.2	2.3%
	LS-B:Open		595.5	26.7%		110.2	13.8%
	LS-C:Closed		1,443.8	64.8%		266.4	33.3%
	LS-U:Annual Grass		0.0	0.0%		0.0	0.0%
	LS-U:Depleted		0.3	0.0%		0.0	0.0%
	LS-U:Early-Shrub		9.6	0.4%		0.0	0.0%
	LS-U:SA		0.0	0.0%		0.0	0.0%
	LS-U:SA+		0.0	0.0%		0.0	0.0%
	LS-U:SAP		160.8	7.2%		194.9	24.4%

Appendix 8. Current (Initial) Acres of Ecological Systems and Vegetation Classes.

Ecological System	Vegetation Class	Hamlin Valley			Black Mountains		
	Yellow = High Risk	System Ac	Class Ac	Class %	System Ac	Class Ac	Class %
Low Sagebrush (Continued)	LS-U:SAP+		0.0	0.0%		0.0	0.0%
	LS-U:SDI-A		0.0	0.0%		158.6	19.8%
	LS-U:SDI-B		0.0	0.0%		17.0	2.1%
	LS-U:SDI-C		0.0	0.0%		26.6	3.3%
	LS-U:Seeded Native		0.0	0.0%		0.0	0.0%
	LS-U:SI-A+AG		0.0	0.0%		0.0	0.0%
	LS-U:SI-B+AG		0.0	0.0%		2.4	0.3%
	LS-U:SI-C+AG		0.0	0.0%		0.0	0.0%
	LS-U:TA		0.0	0.0%		4.8	0.6%
	LS-U:TE		9.1	0.4%		0.0	0.0%
	Mixed Conifer	MC-A:All	305.3	1.1	0.4%	10.9	0.0
MC-B:Closed		0.0		0.0%	2.4		22.2%
MC-C:Open		25.9		8.5%	0.0		0.0%
MC-D:Open		250.8		82.2%	7.3		66.6%
MC-E:Closed		27.5		9.0%	1.2		11.1%
MC-U:Annual Grass		0.0		0.0%	0.0		0.0%
MC-U:TA		0.0		0.0%	0.0		0.0%
Mixed Salt Desert	MSD-A:All	0.0	0.0	0.0%	541.2	17.0	3.1%
	MSD-B:Open		0.0	0.0%		0.0	0.0%
	MSD-C:Open		0.0	0.0%		0.0	0.0%
	MSD-U:Annual Grass		0.0	0.0%		4.8	0.9%
	MSD-U:Early-Shrub		0.0	0.0%		141.7	26.2%
	MSD-U:SAP		0.0	0.0%		377.8	69.8%
	MSD-U:SAP+		0.0	0.0%		0.0	0.0%
	MSD-U:SDI		0.0	0.0%		0.0	0.0%
	MSD-U:SDI+AG		0.0	0.0%		0.0	0.0%
	MSD-U:Seeded Native		0.0	0.0%		0.0	0.0%
Montane Riparian	MR-A:All	178.7	0.5	0.3%	124.7	1.2	1.0%
	MR-B:Open		98.5	55.1%		2.4	1.9%
	MR-C:Closed		0.9	0.5%		0.0	0.0%
	MR-U:Annual Grass		0.0	0.0%		0.0	0.0%
	MR-U:Desertified		0.0	0.0%		1.2	1.0%
	MR-U:EFT		0.0	0.0%		86.0	68.9%
	MR-U:SAP		0.0	0.0%		1.2	1.0%
	MR-U:SDA		0.0	0.0%		0.0	0.0%
	MR-U:Seeded Native		0.0	0.0%		0.0	0.0%
	MR-U:SFE		78.8	44.1%		32.7	26.2%
	MR-U:TE		0.0	0.0%		0.0	0.0%
Montane Sagebrush Steppe	MSS-A:All	98,208.7	2,941.0	3.0%	38,280.3	507.3	1.3%
	MSS-B:Open		1,369.1	1.4%		458.9	1.2%
	MSS-C:Closed		2,392.9	2.4%		3,659.0	9.6%
	MSS-D:Open		8,935.1	9.1%		1,021.9	2.7%
	MSS-E:Closed		4,681.5	4.8%		313.6	0.8%
	MSS-U:Annual Grass		5,720.5	5.8%		1,017.1	2.7%
	MSS-U:Depleted		367.3	0.4%		843.9	2.2%
	MSS-U:Early-Shrub		1,358.7	1.4%		136.8	0.4%
	MSS-U:SA		1,867.6	1.9%		1,345.2	3.5%
	MSS-U:SA+		0.0	0.0%		0.0	0.0%
	MSS-U:SAP		1,775.9	1.8%		5,448.6	14.2%
	MSS-U:SAP+		0.0	0.0%		0.0	0.0%
	MSS-U:SDI-A		5,015.5	5.1%		4,431.5	11.6%
	MSS-U:SDI-B		65.0	0.1%		127.1	0.3%
	MSS-U:SDI-C		87.3	0.1%		802.8	2.1%
	MSS-U:SDI-D		0.0	0.0%		7.3	0.0%
	MSS-U:Seeded Native		0.0	0.0%		0.0	0.0%
	MSS-U:SI-A+AG		0.0	0.0%		1,747.2	4.6%
	MSS-U:SI-B+AG		1.9	0.0%		220.4	0.6%
	MSS-U:SI-C+AG		0.0	0.0%		333.0	0.9%
	MSS-U:SI-D+AG		0.0	0.0%		8.5	0.0%
	MSS-U:TEA		61,629.5	62.8%		15,850.5	41.4%

Appendix 8. Current (Initial) Acres of Ecological Systems and Vegetation Classes.

Ecological System	Vegetation Class	Hamlin Valley			Black Mountains					
	Yellow = High Risk	System Ac	Class Ac	Class %	System Ac	Class Ac	Class %			
Pinyon-Juniper	PJ-A:All	46,891.4	298.8	0.6%	36,488.4	33.9	0.1%			
	PJ-B:Open		115.4	0.2%		2.4	0.0%			
	PJ-C:Open		0.0	0.0%		79.9	0.2%			
	PJ-D:Open		41,721.9	89.0%		27,992.3	76.7%			
	PJ-U:Annual Grass		651.9	1.4%		81.1	0.2%			
	PJ-U:Exotic Forb		0.0	0.0%		0.0	0.0%			
	PJ-U:SAP		0.0	0.0%		0.0	0.0%			
	PJ-U:SDI		0.0	0.0%		29.1	0.1%			
	PJ-U:SDI+AG		0.0	0.0%		0.0	0.0%			
	PJ-U:Seeded Native		0.0	0.0%		0.0	0.0%			
	PJ-U:TA		4,103.4	8.8%		8,269.7	22.7%			
Ponderosa Pine	PP-A:All	1,086.3	526.8	48.5%	0.0	0.0	0.0%			
	PP-B:Closed		6.3	0.6%		0.0	0.0%			
	PP-C:Open		323.4	29.8%		0.0	0.0%			
	PP-D:Open		229.8	21.2%		0.0	0.0%			
	PP-E:Closed		0.0	0.0%		0.0	0.0%			
	PP-U:Annual Grass		0.0	0.0%		0.0	0.0%			
	PP-U:TA		0.0	0.0%		0.0	0.0%			
	SDG-A:Open		0.0	0.0		0.0%	319.6	0.0	0.0%	
SDG-B:Closed	0.0	0.0%		0.0	0.0%					
SDG-U:Depleted	0.0	0.0%		13.3	4.2%					
SDG-U:Early-Shrub	0.0	0.0%		9.7	3.0%					
SDG-U:SAP	0.0	0.0%		296.6	92.8%					
SDG-U:SAP+	0.0	0.0%		0.0	0.0%					
SDG-U:SDI	0.0	0.0%		0.0	0.0%					
SDG-U:SDI+AG	0.0	0.0%		0.0	0.0%					
SDG-U:Seeded Native	0.0	0.0%		0.0	0.0%					
SDG-U:TEA	0.0	0.0%		0.0	0.0%					
Stansbury Cliffrose	SC-A:All	0.0		0.0	0.0%	2,070.5		81.1	3.9%	
	SC-B:Closed		0.0	0.0%	360.8		17.4%			
	SC-C:Closed		0.0	0.0%	374.1		18.1%			
	SC-U:Annual Grass		0.0	0.0%	486.7		23.5%			
	SC-U:Depleted		0.0	0.0%	0.0		0.0%			
	SC-U:Early-Shrub		0.0	0.0%	0.0		0.0%			
	SC-U:SAP		0.0	0.0%	622.3		30.1%			
	SC-U:SAP+		0.0	0.0%	0.0		0.0%			
	SC-U:SDI-A		0.0	0.0%	23.0		1.1%			
	SC-U:SDI-B		0.0	0.0%	36.3		1.8%			
	SC-U:SDI-C		0.0	0.0%	0.0		0.0%			
	SC-U:Seeded Native		0.0	0.0%	0.0		0.0%			
	SC-U:SI-A+AG		0.0	0.0%	31.5		1.5%			
	SC-U:SI-B+AG		0.0	0.0%	0.0		0.0%			
	SC-U:SI-C+AG		0.0	0.0%	0.0		0.0%			
	SC-U:TEA		0.0	0.0%	54.5		2.6%			
	Utah Serviceberry		US-A:All	8,947.6	82.5		0.9%	1,018.3	127.1	12.5%
			US-B:Closed		1,135.7		12.7%		147.7	14.5%
US-C:Closed		2,984.2	33.4%		291.8	28.7%				
US-D:Open		3,310.5	37.0%		199.8	19.6%				
US-U:Annual Grass		0.0	0.0%		0.0	0.0%				
US-U:Depleted		0.0	0.0%		0.0	0.0%				
US-U:Early-Shrub		0.0	0.0%		0.0	0.0%				
US-U:SAP		144.9	1.6%		211.9	20.8%				
US-U:SAP+		0.0	0.0%		0.0	0.0%				
US-U:SDI-A		0.0	0.0%		0.0	0.0%				
US-U:SDI-B		0.0	0.0%		2.4	0.2%				
US-U:SDI-C		0.0	0.0%		0.0	0.0%				
US-U:SDI-D		0.0	0.0%		0.0	0.0%				
US-U:SI-A+AG		0.0	0.0%		0.0	0.0%				
US-U:SI-B+AG		0.0	0.0%		0.0	0.0%				
US-U:SI-C+AG		0.0	0.0%		0.0	0.0%				
US-U:SI-D+AG		0.0	0.0%		0.0	0.0%				

Appendix 8. Current (Initial) Acres of Ecological Systems and Vegetation Classes.

Ecological System	Vegetation Class	Hamlin Valley			Black Mountains		
	Yellow = High Risk	System Ac	Class Ac	Class %	System Ac	Class Ac	Class %
Utah Serviceberry (Continued)	US-U:TA		480.9	5.4%		0.0	0.0%
	US-U:TE		808.9	9.0%		37.5	3.7%
Wet Meadow-Alkali Sacaton	WMas-A:Open	0.0	0.0	0.0%	320.9	158.6	49.4%
	WMas-B:Closed		0.0	0.0%		105.3	32.8%
	WMas-C:Open		0.0	0.0%		1.2	0.4%
	WMas-U:AGPG		0.0	0.0%		2.4	0.8%
	WMas-U:Annual Grass		0.0	0.0%		7.3	2.3%
	WMas-U:Depleted		0.0	0.0%		0.0	0.0%
	WMas-U:Exotic Forb		0.0	0.0%		1.2	0.4%
	WMas-U:SAP		0.0	0.0%		44.8	14.0%
	WMas-U:TEA						
Wet Meadow-Montane	WM-A:Open	143.8	3.4	2.4%	50.9	0.0	0.0%
	WM-B:Closed		112.9	78.5%		19.4	38.1%
	WM-C:Open		0.0	0.0%		0.0	0.0%
	WM-U:Annual Grass		0.0	0.0%		0.0	0.0%
	WM-U:Desertified		0.2	0.1%		0.0	0.0%
	WM-U:Exotic Forb		0.0	0.0%		3.6	7.1%
	WM-U:Hummocked		0.0	0.0%		0.0	0.0%
	WM-U:SA		0.0	0.0%		0.0	0.0%
	WM-U:SDI		0.0	0.0%		0.0	0.0%
	WM-U:SFE		27.3	19.0%		27.8	54.7%
	WM-U:TEA		0.0	0.0%		0.0	0.0%
Winterfat	WF-A:All	1,005.7	0.0	0.0%	3,979.9	4.8	0.1%
	WF-B:Open		42.3	4.2%		299.1	7.5%
	WF-C:Open		762.0	75.8%		351.1	8.8%
	WF-U:Annual Grass		62.5	6.2%		629.6	15.8%
	WF-U:Depleted		66.4	6.6%		31.5	0.8%
	WF-U:Exotic Forb		42.6	4.2%		937.2	23.5%
	WF-U:SA		0.0	0.0%		0.0	0.0%
	WF-U:SA+		0.0	0.0%		0.0	0.0%
	WF-U:SAP		29.8	3.0%		1,704.8	42.8%
	WF-U:SAP+		0.0	0.0%		0.0	0.0%
	WF-U:SDI		0.0	0.0%		0.0	0.0%
	WF-U:SDI+AG		0.0	0.0%		21.8	0.5%
	WF-U:Seeded Native		0.0	0.0%		0.0	0.0%
Wyoming Big Sagebrush upland	WSup-A:All	65,340.5	40.5	0.1%	197,690.5	8,228.5	4.2%
	WSup-B:Open		3,274.8	5.0%		2,292.0	1.2%
	WSup-C:Closed		9,219.9	14.1%		7,493.6	3.8%
	WSup-D:Open		961.1	1.5%		1,823.4	0.9%
	WSup-E:Closed		182.9	0.3%		339.0	0.2%
	WSup-U:Annual Grass		211.1	0.3%		21,405.6	10.8%
	WSup-U:Depleted		673.0	1.0%		2,637.1	1.3%
	WSup-U:Early-Shrub		207.9	0.3%		5,536.9	2.8%
	WSup-U:SA		3,424.2	5.2%		14,789.8	7.5%
	WSup-U:SA+		0.0	0.0%		0.0	0.0%
	WSup-U:SAP		11,752.5	18.0%		71,309.5	36.1%
	WSup-U:SAP+		0.0	0.0%		0.0	0.0%
	WSup-U:SDI-A		598.8	0.9%		13,872.0	7.0%
	WSup-U:SDI-B		21,079.9	32.3%		1,043.7	0.5%
	WSup-U:SDI-C		7,395.2	11.3%		787.0	0.4%
	WSup-U:SDI-D		0.0	0.0%		7.3	0.0%
	WSup-U:Seeded Native		0.0	0.0%		0.0	0.0%
	WSup-U:SI-A+AG		206.8	0.3%		10,449.1	5.3%
	WSup-U:SI-B+AG		0.0	0.0%		2,139.5	1.1%
	WSup-U:SI-C+AG		0.0	0.0%		834.2	0.4%
	WSup-U:SI-D+AG		0.0	0.0%		389.9	0.2%
WSup-U:TEA	6,111.9	9.4%	32,312.4	16.3%			

Ecological Systems selected for management analyses are shaded turquoise.

**Appendix 9. Vegetation Class Percentages in Ecological Systems Selected for Management Analyses,
at the Current Time and After 25 Years of MINIMUM MANAGEMENT.**

Ecological System	Vegetation Class	Ref %	Allowable Threshold		Hamlin Valley			Black Mountains				
			HV	BM	CURRENT			MIN MGMT Class %	CURRENT			MIN MGMT Class %
					System Ac	Class Ac	Class %		System Ac	Class Ac	Class %	
Aspen Woodland	ASP-A:Closed	7	—	—	118.6	0.3	0.3%	6.4%	4.8	0.0	0.0%	0.0%
	ASP-B:Closed	23	—	—		6.5	5.5%	15.0%		0.0	0.0%	80.0%
	ASP-C:Closed	43	—	—		67.0	56.5%	63.8%		0.0	0.0%	20.0%
	ASP-D:Open	27	—	—		11.0	9.2%	9.5%		0.0	0.0%	0.0%
	ASP-U:Depleted	0	0.00	0.00		33.8	28.5%	5.3%		4.8	100.0%	0.0%
Black Sagebrush	BS-A:All	15	—	—	54,115.4	558.4	1.0%	0.8%	62,371.4	2,016.0	3.2%	0.9%
	BS-B:Open	48	—	—		2,679.5	5.0%	2.6%		5,281.5	8.5%	10.3%
	BS-C:Closed	25	—	—		1,450.8	2.7%	4.3%		6,032.2	9.7%	7.3%
	BS-D:Open	12	—	—		22,885.5	42.3%	35.2%		8,164.4	13.1%	9.7%
	BS-U:Annual Grass	0	0.00	0.00		419.5	0.8%	2.9%		1,237.4	2.0%	4.1%
	BS-U:Depleted	0	0.00	0.00		380.1	0.7%	0.6%		9,395.7	15.1%	11.7%
	BS-U:Early-Shrub	0	0.00	0.00		7.6	0.0%	0.4%		325.7	0.5%	1.5%
	BS-U:SA	0	0.00	0.00		1,923.2	3.6%	5.2%		4,574.4	7.3%	13.2%
	BS-U:SA+	0	0.00	0.00		0.0	0.0%	3.7%		0.0	0.0%	7.8%
	BS-U:SAP	0	0.00	0.00		6,871.2	12.7%	5.6%		17,581.9	28.2%	11.8%
	BS-U:SAP+	0	0.00	0.00		0.0	0.0%	0.5%		0.0	0.0%	1.6%
	BS-U:SDI-A	0	9.00	5.25		0.0	0.0%	0.0%		40.0	0.1%	0.0%
	BS-U:SDI-B	0	28.80	16.80		46.8	0.1%	0.1%		178.0	0.3%	1.3%
	BS-U:SDI-C	0	15.00	8.75		0.0	0.0%	0.0%		35.1	0.1%	0.1%
	BS-U:Seeded Native	0	15.00	15.00		0.0	0.0%	0.0%		0.0	0.0%	0.0%
	BS-U:SI-A+AG	0	0.00	0.00		0.0	0.0%	0.0%		194.9	0.3%	0.0%
	BS-U:SI-B+AG	0	0.00	0.00		0.0	0.0%	0.0%		416.5	0.7%	0.0%
	BS-U:SI-C+AG	0	0.00	0.00		0.0	0.0%	0.0%		9.7	0.0%	0.0%
	BS-U:TEA	0	0.00	0.00		16,892.8	31.2%	38.0%		6,888.2	11.0%	18.8%
	Low Sagebrush	LS-A:All	10	—		—	2,227.9	8.8		0.4%	1.8%	799.1
LS-B:Open		37	—	—	595.5	26.7%		26.4%	110.2	13.8%	15.1%	
LS-C:Closed		53	—	—	1,443.8	64.8%		53.6%	266.4	33.3%	28.2%	
LS-U:Annual Grass		0	0.00	0.00	0.0	0.0%		0.7%	0.0	0.0%	2.0%	
LS-U:Depleted		0	0.00	0.00	0.3	0.0%		0.5%	0.0	0.0%	0.2%	
LS-U:Early-Shrub		0	0.00	0.00	9.6	0.4%		0.5%	0.0	0.0%	0.2%	
LS-U:SA		0	0.00	0.00	0.0	0.0%		0.2%	0.0	0.0%	0.2%	
LS-U:SA+		0	0.00	0.00	0.0	0.0%		0.0%	0.0	0.0%	0.0%	
LS-U:SAP		0	0.00	0.00	160.8	7.2%		15.6%	194.9	24.4%	19.4%	
LS-U:SAP+		0	0.00	0.00	0.0	0.0%		0.5%	0.0	0.0%	7.9%	
LS-U:SDI-A		0	6.00	3.50	0.0	0.0%		0.0%	158.6	19.8%	0.2%	

**Appendix 9. Vegetation Class Percentages in Ecological Systems Selected for Management Analyses,
at the Current Time and After 25 Years of MINIMUM MANAGEMENT.**

Ecological System	Vegetation Class	Ref %	Allowable Threshold		Hamlin Valley			Black Mountains					
			HV	BM	CURRENT		MIN MGMT Class %	CURRENT		MIN MGMT Class %			
					System Ac	Class Ac		Class %	System Ac		Class Ac	Class %	
Montane Sagebrush Steppe (Cont'd)	MSS-U:Seeded Native	0	22.00	22.00									
	MSS-U:SI-A+AG	0	0.00	0.00		0.0	0.0%		0.0	0.0%		0.0%	
	MSS-U:SI-B+AG	0	0.00	0.00		0.0	0.0%		1,747.2	4.6%		0.0%	
	MSS-U:SI-C+AG	0	0.00	0.00		1.9	0.0%		220.4	0.6%		1.0%	
	MSS-U:SI-D+AG	0	0.00	0.00		0.0	0.0%		333.0	0.9%		0.2%	
	MSS-U:TEA	0	0.00	0.00		0.0	0.0%		8.5	0.0%		0.1%	
						61,629.5	62.8%		15,850.5	41.4%		41.9%	
Pinyon-Juniper	PJ-A:All	3	—	—	46,891.4	298.8	0.6%		36,488.4	33.9	0.1%		0.2%
	PJ-B:Open	6	—	—		115.4	0.2%			2.4	0.0%		0.8%
	PJ-C:Open	25	—	—		0.0	0.0%			79.9	0.2%		2.2%
	PJ-D:Open	66	—	—		41,721.9	89.0%			27,992.3	76.7%		72.7%
	PJ-U:Annual Grass	0	0.00	0.00		651.9	1.4%			81.1	0.2%		1.1%
	PJ-U:Exotic Forb	0	0.00	0.00		0.0	0.0%			0.0	0.0%		0.0%
	PJ-U:SAP	0	0.00	0.00		0.0	0.0%			0.0	0.0%		0.0%
	PJ-U:SDI	0	60.00	35.00		0.0	0.0%			29.1	0.1%		0.1%
	PJ-U:SDI+AG	0	0.00	0.00		0.0	0.0%			0.0	0.0%		0.0%
	PJ-U:Seeded Native	0	0.00	3.00		0.0	0.0%			0.0	0.0%		0.0%
	PJ-U:TA	0	0.00	0.00		4,103.4	8.8%			8,269.7	22.7%		22.9%
Ponderosa Pine	PP-A:All	10	—	—	1,086.3	526.8	48.5%		[Absent]	—	—		—
	PP-B:Closed	9	—	—		6.3	0.6%			—	—		—
	PP-C:Open	25	—	—		323.4	29.8%			—	—		—
	PP-D:Open	52	—	—		229.8	21.2%			—	—		—
	PP-E:Closed	4	—	—		0.0	0.0%			—	—		—
	PP-U:Annual Grass	0	0.00	0.00		0.0	0.0%			—	—		—
	PP-U:TA	0	0.00	0.00		0.0	0.0%			—	—		—
Stansbury Cliffrose	SC-A:All	9	—	—	[Absent]	—	—		2,070.5	81.1	3.9%		0.3%
	SC-B:Closed	37	—	—		—	—			360.8	17.4%		19.9%
	SC-C:Closed	54	—	—		—	—			374.1	18.1%		15.9%
	SC-U:Annual Grass	0	0.00	0.00		—	—			486.7	23.5%		2.6%
	SC-U:Depleted	0	0.00	0.00		—	—			0.0	0.0%		0.1%
	SC-U:Early-Shrub	0	0.00	0.00		—	—			0.0	0.0%		0.2%
	SC-U:SAP	0	0.00	0.00		—	—			622.3	30.1%		31.0%
	SC-U:SAP+	0	0.00	0.00		—	—			0.0	0.0%		19.1%
	SC-U:SDI-A	0	5.40	3.15		—	—			23.0	1.1%		0.0%
	SC-U:SDI-B	0	22.20	12.95		—	—			36.3	1.8%		4.0%
	SC-U:SDI-C	0	32.40	18.90		—	—			0.0	0.0%		0.2%

**Appendix 9. Vegetation Class Percentages in Ecological Systems Selected for Management Analyses,
at the Current Time and After 25 Years of MINIMUM MANAGEMENT.**

Ecological System	Vegetation Class	Ref %	Allowable Threshold		Hamlin Valley			Black Mountains					
			HV	BM	CURRENT		MIN MGMT Class %	CURRENT		MIN MGMT Class %			
					System Ac	Class Ac		Class %	System Ac		Class Ac	Class %	
Stansbury Cliffrose (Cont'd)	SC-U:Seeded Native	0	9.00	9.00									
	SC-U:SI-A+AG	0	0.00	0.00									
	SC-U:SI-B+AG	0	0.00	0.00									
	SC-U:SI-C+AG	0	0.00	0.00									
	SC-U:TEA	0	0.00	0.00									
Utah Serviceberry	US-A:All	9	—	—	8,947.6	82.5	0.9%	0.3%	1,018.3	0.0	0.0%	0.0%	
	US-B:Closed	28	—	—		—	—	—		—	31.5	1.5%	0.0%
	US-C:Closed	49	—	—		—	—	—		—	0.0	0.0%	0.0%
	US-D:Open	14	—	—		—	—	—		—	0.0	0.0%	0.3%
	US-U:Annual Grass	0	0.00	0.00		0.0	0.0%	0.7%		54.5	2.6%	6.5%	
	US-U:Depleted	0	0.00	0.00		0.0	0.0%	0.2%		127.1	12.5%	0.5%	
	US-U:Early-Shrub	0	0.00	0.00		0.0	0.0%	0.3%		147.7	14.5%	2.1%	
	US-U:SAP	0	0.00	0.00		144.9	1.6%	4.4%		291.8	28.7%	25.1%	
	US-U:SAP+	0	0.00	0.00		0.0	0.0%	0.2%		199.8	19.6%	38.7%	
	US-U:SDI-A	0	5.40	3.15		0.0	0.0%	0.0%		0.0	0.0%	2.3%	
	US-U:SDI-B	0	16.80	9.80		0.0	0.0%	0.0%		0.0	0.0%	0.2%	
	US-U:SDI-C	0	29.40	17.15		0.0	0.0%	0.0%		0.0	0.0%	0.2%	
	US-U:SDI-D	0	8.40	4.90		0.0	0.0%	0.0%		0.0	0.0%	0.0%	
	US-U:SI-A+AG	0	0.00	0.00		0.0	0.0%	0.0%		0.0	0.0%	0.0%	
	US-U:SI-B+AG	0	0.00	0.00		0.0	0.0%	0.0%		0.0	0.0%	0.0%	
	US-U:SI-C+AG	0	0.00	0.00		0.0	0.0%	0.0%		0.0	0.0%	0.0%	
	US-U:SI-D+AG	0	0.00	0.00		0.0	0.0%	0.0%		0.0	0.0%	0.0%	
	US-U:TA	0	0.00	0.00		480.9	5.4%	14.2%		0.0	0.0%	8.1%	
	US-U:TE	0	0.00	0.00		808.9	9.0%	8.4%		37.5	3.7%	3.0%	
	Wet Meadow-Montane	WM-A:Open	3	—		—	143.8	3.4		2.4%	1.8%	50.9	0.0
WM-B:Closed		89	—	—	112.9	78.5%		30.9%	19.4	38.1%	49.1%		
WM-C:Open		8	—	—	0.0	0.0%		38.1%	0.0	0.0%	24.6%		
WM-U:Annual Grass		0	0.00	0.00	0.0	0.0%		1.8%	0.0	0.0%	0.0%		
WM-U:Desertified		0	0.00	0.00	0.2	0.1%		1.1%	0.0	0.0%	0.0%		
WM-U:Exotic Forb		0	0.00	0.00	0.0	0.0%		7.2%	3.6	7.1%	15.4%		
WM-U:Hummocked		0	0.00	0.00	0.0	0.0%		3.7%	0.0	0.0%	0.6%		
WM-U:SA		0	0.00	0.00	0.0	0.0%		0.0%	0.0	0.0%	0.0%		
WM-U:SDI		0	0.00	0.00	0.0	0.0%		0.0%	0.0	0.0%	0.0%		
WM-U:SFE		0	0.00	0.00	27.3	19.0%		15.6%	27.8	54.7%	10.3%		
WM-U:TEA		0	0.00	0.00	0.0	0.0%		0.0%	0.0	0.0%	0.0%		

**Appendix 9. Vegetation Class Percentages in Ecological Systems Selected for Management Analyses,
at the Current Time and After 25 Years of MINIMUM MANAGEMENT.**

Ecological System	Vegetation Class	Ref %	Allowable Threshold		Hamlin Valley			Black Mountains					
			HV	BM	CURRENT			MIN MGMT Class %	CURRENT			MIN MGMT Class %	
					System Ac	Class Ac	Class %		System Ac	Class Ac	Class %		
Wyoming Big Sagebrush upland	Yellow = High Risk												
	WSup-A:All	14	—	—	65,340.5	40.5	0.1%	0.6%	197,690.5	8,228.5	4.2%	0.4%	
	WSup-B:Open	29	—	—		3,274.8	5.0%	0.3%		2,292.0	1.2%	8.8%	
	WSup-C:Closed	42	—	—		9,219.9	14.1%	14.4%		7,493.6	3.8%	3.7%	
	WSup-D:Open	6	—	—		961.1	1.5%	1.3%		1,823.4	0.9%	0.6%	
	WSup-E:Closed	9	—	—		182.9	0.3%	1.2%		339.0	0.2%	0.9%	
	WSup-U:Annual Grass	0	0.00	0.00		211.1	0.3%	2.0%		21,405.6	10.8%	17.1%	
	WSup-U:Depleted	0	0.00	0.00		673.0	1.0%	1.1%		2,637.1	1.3%	1.3%	
	WSup-U:Early-Shrub	0	0.00	0.00		207.9	0.3%	0.4%		5,536.9	2.8%	3.3%	
	WSup-U:SA	0	0.00	0.00		3,424.2	5.2%	6.1%		14,789.8	7.5%	8.8%	
	WSup-U:SA+	0	0.00	0.00		0.0	0.0%	1.4%		0.0	0.0%	2.7%	
	WSup-U:SAP	0	0.00	0.00		11,752.5	18.0%	12.5%		71,309.5	36.1%	20.8%	
	WSup-U:SAP+	0	0.00	0.00		0.0	0.0%	3.0%		0.0	0.0%	7.4%	
	WSup-U:SDI-A	0	8.40	4.90		598.8	0.9%	0.1%		13,872.0	7.0%	0.1%	
	WSup-U:SDI-B	0	17.40	10.15		21,079.9	32.3%	0.5%		1,043.7	0.5%	3.5%	
	WSup-U:SDI-C	0	25.20	14.70		7,395.2	11.3%	41.5%		787.0	0.4%	1.6%	
	WSup-U:SDI-D	0	3.60	2.10		0.0	0.0%	1.5%		7.3	0.0%	0.0%	
	WSup-U:Seeded Native	0	14.00	14.00		0.0	0.0%	0.0%		0.0	0.0%	0.0%	
	WSup-U:SI-A+AG	0	0.00	0.00		206.8	0.3%	0.0%		10,449.1	5.3%	0.0%	
	WSup-U:SI-B+AG	0	0.00	0.00		0.0	0.0%	0.8%		2,139.5	1.1%	0.1%	
	WSup-U:SI-C+AG	0	0.00	0.00		0.0	0.0%	0.6%		834.2	0.4%	0.0%	
	WSup-U:SI-D+AG	0	0.00	0.00		0.0	0.0%	0.0%		389.9	0.2%	0.0%	
	WSup-U:TEA	0	0.00	0.00		6,111.9	9.4%	10.6%		32,312.4	16.3%	19.0%	