Landscape Conservation Forecasting™ for

Washington County's National Conservation Areas

Report to the St. George Field Office, Bureau of Land Management
September 2011

Photos: Red Cliffs (above) and Beaver Dam Wash (below) National Conservation Areas; L. Provencher, 2011.

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Executive Summary

Introduction

The Red Cliffs and Beaver Dam Wash National Conservation Areas (NCAs) are located in Washington County, in southwestern Utah. They were designated by Congress in 2009 in order "to conserve, protect, and enhance … the ecological, scenic, wildlife, recreational, cultural, historical, natural, and scientific resources" of their public lands, which are managed by the St. George Field Office of the Bureau of Land Management (BLM).

In 2011, the BLM entered into a Cooperative Agreement with The Nature Conservancy (TNC) to collaborate on key management issues for the two NCAs. In conjunction with the BLM and other stakeholders, TNC applied the process of Landscape Conservation Forecasting™ to fulfill a primary objective of the Agreement: *Guide the development of specific, cost-effective fire and vegetation management actions to maintain, enhance or restore vegetation conditions in the NCAs, and/or enhance the suitability of their desert tortoise habitat*.

Located in south-central Washington County, the 45,000-acre Red Cliffs NCA is a colorful mosaic of sandstone, sand dunes, lava flows and mesas at the base of the Pine Valley Mountains. Substantial areas of it are a wildland-urban interface, as its public lands abut urban and suburban developments. Located in the southwestern part of the County, the 63,500-acre Beaver Dam Wash NCA is a mostly unfragmented landscape formed by alluvial benches east and west of the Beaver Dam Wash, and alluvial fans on the limestone-dominated Beaver Dam Mountains.

Both NCAs support primarily Mojave Desert ecosystems. Major vegetation types include creosotebush-white bursage, blackbrush, sand sagebrush, warm season grassland, warm desert riparian, and desert washes. These diverse habitats support a variety of plant and animal species including the federally-listed desert tortoise (*Gopherus agassizii*), Gila monster (*Heloderma suspectum*), mule deer (*Odocoileus hemionus*), kit fox (*Vulpes macrotis*) and migratory birds.

Lower-elevation Mojave Desert ecosystems did not develop with fire, and are poorly adapted to it. Increased extent and abundance of non-native annual grasses and forbs have contributed to large increases in fire frequency and intensity in these ecosystems since the 1970s. Burned areas now support fire return intervals as short as 5-10 years in areas where fire was previously scarce or absent. Many native shrubs do not respond well to one or multiple burns, and non-native annuals compete successfully against native species by using soil moisture before natives are active. Control of non-native annuals is best achieved by multiple applications of herbicides. This practice faces major obstacles, however. Herbicide control is short lived in the Mojave Desert, because seedbank emergence and new invasion allow non-natives to re-establish within three years.

Restoration of lowland Mojave Desert shrublands, especially those that have burned, is notoriously unsuccessful. New restoration technologies for seedings and live-plantings are currently being investigated by universities and federal agencies to improve success rates. However, success may be contingent on temporary removal of livestock grazing from areas where new seedings or plantings have been done, at least during the time it would take for the new vegetation to become sufficiently established.

The "multiple use" mandate of FLPMA had been limited since 1999 in the lands that, a decade later, were designated as the Red Cliffs and Beaver Dam Wash NCAs. In 1999, the BLM St. George Field Office's management focus in these areas shifted toward the protection of critical habitat and listed species, through restrictions and closures to the major categories of multiple use that are typically associated with public lands. The two NCAs are now managed by BLM to assist the recovery and delisting of the threatened Mojave desert tortoise and other native species, through closures and restrictions on land uses and human activities that can impact native-species habitats and populations.

Given the recent changes in Mojave Desert disturbance regimes (fire and non-native species), the present management of the two NCAs provides opportunity to improve ecological resilience, conserve and restore quality of desert tortoise habitat, and reduce detrimental effects of wildfire to ecological systems with uncharacteristic fuel accumulations. The LCF project aims to build a good foundation for this to happen.

Process and Methods

The Landscape Conservation Forecasting™ process used for the NCAs consisted of six primary components or steps, as follows:

1. Develop maps of potential vegetation types, called ecological systems or synonymously biophysical settings, and current vegetation classes within ecological systems, by conducting remote sensing of satellite imagery.
2. Refine computerized predictive state-and-transition ecological models for the ecological systems by updating TNC's "library" of models.
3. Determine current condition of all ecological systems using two metrics:
    a. Ecological departure (a.k.a., Fire Regime Condition or FRC), a broad-scale measure of ecological-system "health."
    b. Desert tortoise habitat departure, a new metric pioneered by TNC that measures the "health" of ecological systems in terms of meeting habitat needs of the tortoise.
4. Use the computerized ecological models to forecast anticipated future conditions (both ecological and tortoise) of ecological systems under a minimum management scenario.
5. Use the computerized ecological models to forecast anticipated future conditions (both ecological and tortoise) of ecological systems under alternative management scenarios.
6. Use Return-on-Investment analysis to assess which strategies for which ecological systems yield the most advantageous results.

An initial workshop to define ecological systems and their vegetation classes was held in January 2011. TNC contracted with Spatial Solutions Inc. to produce maps of the systems and their current classes via remote sensing of satellite imagery, verified by road and hiking observations. The majority of this work was conducted during the winter and spring of 2011. Eleven ecological systems were mapped in the Red Cliffs NCA, and nine in the Beaver Dam Wash NCA. Short descriptions of these systems and their classes are presented in Appendix 1.

Existing state-and-transition models of the NCAs' ecological systems were refined and customized by TNC, to reflect the expression and functioning of the systems within those areas. These predictive ecological models contain three types of vegetation classes: *reference* classes (basically pre-settlement status); *uncharacteristic* classes (conditions appearing after Euro-American settlement); and *management* classes (resulting from specific treatments or projects). Models were constructed and run using the modeling software PATH/ VDDT, a product of ESSA Technologies. A complete description of the model dynamics is found in Appendix 2, and model parameter values are shown in Appendix 3.

To simulate strong yearly variability of processes and disturbances in the models (e.g., fire activity, non-native species invasion rates, flooding, etc.) TNC incorporated *temporal multipliers* in model runs. A temporal multiplier is a number in a yearly time series that multiplies a base disturbance rate in the models. Due to the extremely episodic nature of weather, fire, and flooding in the Mojave Desert, temporal multipliers have profound effects on model-run results. A more detailed explanation of temporal multipliers is presented in Appendix 4.

The current condition of ecological systems was derived using the metric of ecological departure. An ecological departure value is 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, 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. The latter, reference-baseline concept is referred to as Natural Range of Variability (NRV), and was calculated for each ecological system using the PATH/VDDT modeling software noted above. NRV and ecological departure values for the ecological systems of the two NCAs appear in Appendix 6.

This LCF project created an innovation to measure how well ecological conditions meet the habitat needs of a species, in this case the listed-Threatened desert tortoise. This metric, termed desert tortoise habitat departure, compares: (1) the "ideal," NRV-based quality of tortoise habitat conditions in an ecological system, with (2) the current quality of tortoise habitat conditions in that system. It uses the same fundamental NRV-versus-current approach as does the traditional ecological departure metric for coarse-scale ecological systems. In other words, desert tortoise habitat departure is a species-habitat-based "plug-in" module to the underlying coarse-vegetation-type architecture of LCF.

The desert tortoise habitat departure metric is only applicable in six ecological systems in the two NCAs (i.e., the systems that are used by desert tortoise). The tortoise habitat departure approach is a complement to, but is NOT a replacement for, modeling/measuring of all tortoise conservation "needs." One cannot rely solely on this project's tortoise habitat departure metric as a comprehensive and sensitive guide to tortoise management and conservation.

Using the computer-based models, TNC simulated the likely future condition of each ecological system under a regime of MINIMUM MANAGEMENT. MINIMUM MANAGEMENT essentially represents a status-quo level of BLM management with no proactive projects other than the continuation of current management practices, including fire suppression. However, the MINIMUM MANAGEMENT modeling simulations did explicitly incorporate potential sources of future ecosystem alteration, including increased invasion rates of non-native species, increased tree encroachment rates in shrublands, modified mean fire return intervals in shrublands, and illegal off-highway vehicle use. The two measures of future condition under MINIMUM MANAGEMENT were the same as the measures of current condition: (1) ecological departure, and (2) desert tortoise habitat departure, in each ecological system after 20 and 50 years. In the final analysis, the 50-year results were reported.

Eleven ecological systems in the Red Cliffs NCA, and seven ecological systems in the Beaver Dam Wash NCA, were selected for simulations of likely future conditions under various regimes of active management. **This was the heart of the LCF process**, as stated in a primary objective of the BLM-TNC Agreement for the two NCAs: *Guide the development of specific, cost-effective fire and vegetation management actions to maintain, enhance or restore the condition of ecological systems, and/or enhance the suitability of desert tortoise habitat*.

Project participants worked jointly on three interrelated tasks toward achieving this Agreement objective: (1) develop a set of specific guiding *management objectives*; (2) list a comprehensive set of *management strategies* that BLM and partners can implement; and (3) analyze the predicted results of various alternative *management scenarios*, i.e. combinations of management strategies that have a similar theme. These tasks were the focus of two multi-day planning workshops held at the St. George Field Office of BLM in July and August, 2011.

The key Management Objectives for the two NCAs are as follows:

- Meet NCA statutory objectives (conserve, protect, and enhance) and other statutory or administrative requirements.
- Improve or maintain ecological condition of all systems.
- For the six ecological systems that are vital tortoise habitat, reduce departure from desired future condition (tortoise habitat departure) from high to low.
- For the remaining ecological systems, reduce departure from desired future condition (NRV) from high to moderate or low, to the degree that strategies are feasible and affordable.
- Protect reference vegetation classes, unburned, and only once-burned shrubland classes.
- Decrease fuel loading and continuity to help reduce risk of loss from wildfire to natural and cultural resources in the NCAs.

- Consider other objects of importance in the enabling legislation (e.g. recreation, endangered species, scenic resources, etc.) – do no harm!
- Help make treatment projects competitive for funding resources.
- Keep multiple management options open within above context.

Management strategies are treatments or actions taken by land- or resource-managers in order to: (1) improve the condition of ecological systems that are currently in an undesirable (highly-departed) condition, and/or (2) abate the most serious future threats to ecological systems. Strategies were either specific to single ecological systems, or applicable (modeled) at a landscape level across multiple ecological systems. Each management strategy had a cost-per-acre figure and a yearly application rate determined for it. Some strategies also had a built-in "failure rate" to reflect only partial success of a treatment or action, while still incurring a cost of application. The list of management strategies appears in Appendix 5.

Management scenarios represent common "themes" for grouping individual management strategies, so that the effectiveness of sets-of-strategies can be better compared within and across ecological systems. 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 (described above) – a "control" scenario of continued status-quo BLM management with no proactive projects other than maintaining current management practices, including fire suppression.
2. MAXIMUM MANAGEMENT – a scenario in which unlimited funds are allocated to strategies with the goal of reducing ecological departure and/or desert tortoise habitat departure to the greatest extent possible, and assuming no constraints on strategy implementation.
3. STREAMLINED MANAGEMENT – a scenario of management strategies aimed at enhancing ecological or tortoise-habitat condition for reduced cost, based on funding that the NCAs realistically could receive; a set of strategies that produced the highest return on investment, or ratio of benefit (improvement in condition) to affordable cost.

Beyond these three standard scenarios, project participants also developed so-called "thematic" scenarios that focus in on specific management strategies singly or few-in-combination. These customized scenarios were developed to guide general decision making; examples of them include Fuel Breaks only, Planting & Herbicide only, and the Black Fingers of Death (BFOD) fungi with different success rates.

TNC then conducted PATH/VDDT computer runs of the state-and-transition models to test and refine each proposed management scenario (i.e. its constituent management strategies) for each of the selected ecological systems. The two measures of future condition under all active-management scenarios (MAXIMUM, STREAMLINED, and THEMATIC/CUSTOMIZED) were the same as the measures of current condition: (1) ecological departure, and (2) desert tortoise habitat departure, in each ecological system after 20 and 50 years. Once again, for the final analysis the 50-year results were reported. The 50-year horizon was chosen over a 20-year one because some experimental management strategies were predicted to become commercially viable only after 20 years.

The final step in the process was to calculate for each scenario the ratio of: (1) the predicted *benefit* of the scenario, as measured by magnitude of ecological improvement, to (2) the *cost* of the scenario's management strategies. TNC developed this ratio as a Return on Investment (ROI) metric to identify which scenario produced the greatest ecological benefit per dollar invested across multiple scenarios, both within each ecological system and across multiple systems.

The ROI 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. Of course, managers may also select final scenarios, strategies 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.

Context and Application

The 2011 application of LCF to the two NCAs in Washington County was a pioneering new reach for the process. It was the first use of LCF at the much lower elevations of the Mojave Desert, where habitats are hotter and more harsh than those of prior LCF applications. Major vegetation types "new" to LCF in this setting include thermic shrublands of blackbrush and creosotebush. Never before had the LCF process dealt with such complete and comprehensive ecological departure – most of the ecological systems in the two NCAs had departure values at the maximum of 100%, i.e. total dis-similarity from these systems' natural range of variability. Never before had LCF encountered such a nearly-intractable problem as the pervasive abundance of annual brome grasses that foster destructive wildfires of a size and intensity far greater than the fire regime with which Mojave Desert habitats developed over past millennia.

Under these conditions, the predominant habitats of the Mojave Desert are fertile subjects for rapidly-developing scientific study. Ideally, quantitative values given to parameters in the models – especially success/failure rates of promising new management actions such as the BFOD fungi – would be grounded in credible scientific studies. However, this science has not yet "matured" to the point of its conclusions gaining widespread acceptance. Therefore, the partners conducting this LCF process assigned some model parameter values according to educated, experimental best-conclusions that seemed plausible, in lieu of waiting for defensible values from the results of ongoing studies.

In a sense, the models in the two NCAs thus forecast the results of "experiments" – types, levels and combinations of management actions – that the partners believe to have some realistic chance of success for improving ecological conditions. The partners all acknowledge that the models are adaptive, and thus must be adapted in the future according to actual field results – degree of success – of management actions.

Key Conclusions

1. **At the current time, all ecological systems in each NCA are highly departed from their natural range of variability.**
2. **The primary cause of ecological departure across the landscape is due to the nearly complete presence of non-native grasses and forbs in burned and unburned areas.**
3. **Large areas of each NCA burned in 2005-06, and thereby converted from shrub to annual non-native grassland and forbland.**
4. **Desert tortoise habitat departure, a new metric developed by TNC and stakeholders, is slightly to moderately departed for relevant ecological systems in both NCAs.** Despite complete invasion by non-native annuals, sufficient vegetation remains available to provide most, though not necessarily all, *structural* habitat needs of the desert tortoise.
5. **Without active management, non-native grassland and forbland vegetation classes are projected to increase at the expense of shrublands that have been invaded by non-native grasses and forbs.**
6. **Without active management, exotic trees and forbs are predicted to increase in desert washes and riparian systems (montane and warm desert types).**
7. **A subset of ecological systems was selected for specific analyses of active management in the two NCAs.** Key ecological management issues by system include:
    a. ***Thermic and mesic blackbrush, and creosotebush-white bursage*** – burned areas are dominated by, and non-burned shrublands are invaded by, non-native annual species; burned areas are projected to increased with time.
    b. ***Mountain shrub and big sagebrush steppe*** – large proportions of burned areas are dominated by non-native annual grasses and forbs.
    c. ***Warm season grassland and desert sand sagebrush*** – these contain high percentages of late-succession classes with significant cover of non-native annual grasses and forbs.
    d. ***Riparian and desert washes*** – invasion by saltcedar and non-native annual grasses and forbs, and invasion by exotic forbs and trees.
8. **A variety of actions, some experimental with hypothetical success rates, were modeled for each ecological system selected for management. Multiple actions are required for most systems.**
    a. ***Thermic and mesic blackbrush, and creosotebush-white bursage*** management strategies include: a) herbicide application followed by planting containerized shrub and forbs (experimental); b) herbicide application followed by seeding of new and successful native plant species cultivars (experimental); c) exclusion of livestock for 10 years from planted areas; d) deployment of landscape-level fuel breaks; and e) application of the BFOD fungi with higher success rates of infection as a standalone "herbicide" and as a replacement for herbicide used in treatments (experimental).

b. ***Mountain shrub and big sagebrush steppe*** management strategies include: herbicide application followed by seeding of native herbaceous and shrub species.

c. ***Warm season grassland and desert sand sagebrush*** management strategies include: a) herbicide application to control non-native annuals; b) herbicide application followed by seeding native herbaceous species; and c) deployment of landscape-level fuel breaks.

d. ***Riparian and desert washes*** management strategies include: a) weed inventory; b) cutting of saltcedar followed by stump painting with herbicide; c) spraying exotic forbs with herbicide; and d) controlling non-native annuals in riparian understory with herbicide.

9. **Scenarios using a single action or actions in combination were simulated for ecological systems used by desert tortoise.**

   a. **Landscape-level fuel breaks** alone can cost-effectively slow the loss of remaining shrublands needed by desert tortoise and prevent a devastating second fire in already burned areas. Suggested implementation rates for fuel breaks are high. Strategic spatial analysis of fire risk from testing different positioning of fuel breaks is recommended.

   b. **Restoration of desert tortoise habitat** in the two NCAs is highly dependent on the commercial development of four experimental technologies: a) planting containerized Mojave shrubs and forbs; b) the BFOD fungi (mode of application and potency); c) highly-performing cultivars of Mojave Desert species; and d) methods of seed delivery that reduce granivory.

   c. **Making public lands in the Beaver Dam Wash NCA unavailable for livestock grazing** would benefit desert washes, which are preferred desert tortoise habitat. However, this simulated action had small negative return-on-investments for creosotebush-white bursage and thermic and mesic blackbrush.

   d. **Simulated "livestock closure only"** – which was used to reduce stocking rates temporarily in desert washes and to protect plantings and seedings in creosotebush-white bursage and thermic and mesic blackbrush – always had small (i.e., not statistically significant) beneficial effects on desert tortoise departure when used in combination with planting and seeding.

10. **Comparison of ROIs alone indicates a higher priority for management actions in desert washes, warm-season grassland, mountain shrub, and mesic blackbrush**. However, planning for the recovery of desert tortoise may dictate resources also to be delivered to creosotebush-white bursage and thermic blackbrush, especially because fuel breaks are most likely to be implemented in these systems.

11. **Workshop participants created two groups of actions with spatial consequences: landscape level (i.e. across ecological systems), and specific to vegetation classes.**

    a. The area of implementation for focused livestock management and law enforcement is potentially the whole Beaver Dam Wash NCA.

b. Mapping fuel breaks is a more strategic exercise that requires a narrowing of a whole NCA down to selective strips of lands that are most likely to stop fires.

c. All restoration actions that require seeding or planting are conducted in burned areas, whereas all actions that propose to control non-native annuals in the understory of shrublands with the BFOD fungi are conducted in unburned areas.

d. The area of montane riparian is only 40 acres and nearly the whole area needs to be treated. The problems in warm desert riparian are more localized and mapped.

Introduction

Project Background and Objectives

The Red Cliffs and Beaver Dam Wash National Conservation Areas (NCAs) are located in Washington County, in southwestern Utah. Both are comprised of public lands managed by the St. George Field Office of the Bureau of Land Management (BLM). The two NCAs were designated by Congress through the Omnibus Public Land Management Act of 2009 [P.L.111-11], and are **the first NCAs to be designated by Congress in Utah. They were d**esignated in order "to conserve, protect, and enhance … the ecological, scenic, wildlife, recreational, cultural, historical, natural, and scientific resources" of these public lands.

The BLM, The Nature Conservancy (TNC), U.S. Fish and Wildlife Service (USFWS), Utah Division of Wildlife Resources (UDWR), and other stakeholders mutually desire to conserve and restore these NCAs for the benefit of desert tortoise (*Gopherus agassizii*), other desert wildlife species, and ecological systems threatened by non-native plant species and uncharacteristic wildfires.

In 2011, the St. George Field Office of the BLM entered into a Cooperative Agreement with TNC to collaborate on fire, vegetation, and desert tortoise management issues for the two NCAs. TNC applied the process of Landscape Conservation Forecasting™ – including satellite imagery, remote sensing, predictive ecological models, and cost-benefit assessments (Provencher et al. 2008, 2009; Low et al. 2010) – to accomplish the Agreement's objectives. These Agreement objectives appear in the box below. T**his report is submitted to the BLM to inform the development of future management plans for the two NCAs.**

Objectives of the BLM-TNC Agreement for the two Washington County NCAs

- Map current vegetation and potential vegetation (the latter known as *ecological systems* or *biophysical settings*) of the two NCAs.
- Determine the condition of ecological systems expressed as ecological departure from reference conditions, or as departure from desirable habitat conditions for desert tortoise.
- Guide the development of specific, cost-effective fire and vegetation management actions to maintain, enhance or restore the condition of ecological systems, and/or enhance the suitability of desert tortoise habitat.

Project Area

Location and Features

The Red Cliffs and Beaver Dam Wash NCAs are located in Washington County, in southwestern Utah. They are separated by approximately 15 miles, and their locations are shown in Figure 1.

The Red Cliffs NCA is located in the south-central part of Washington County, generally north of the corridor of settlement that stretches from Ivins on the west through St. George to the vicinity of Hurricane on the east. It includes about 45,000 acres of public land, of which 19,900 acres are within two designated wilderness areas: Red Mountain Wilderness and Cottonwood Canyon Wilderness. The Beaver Dam Wash NCA is located in the southwestern corner of Washington County, along the Nevada and Arizona state lines. It is comprised of roughly 63,500 acres of BLM-managed public lands.

National Conservation Areas in Washington County, Utah

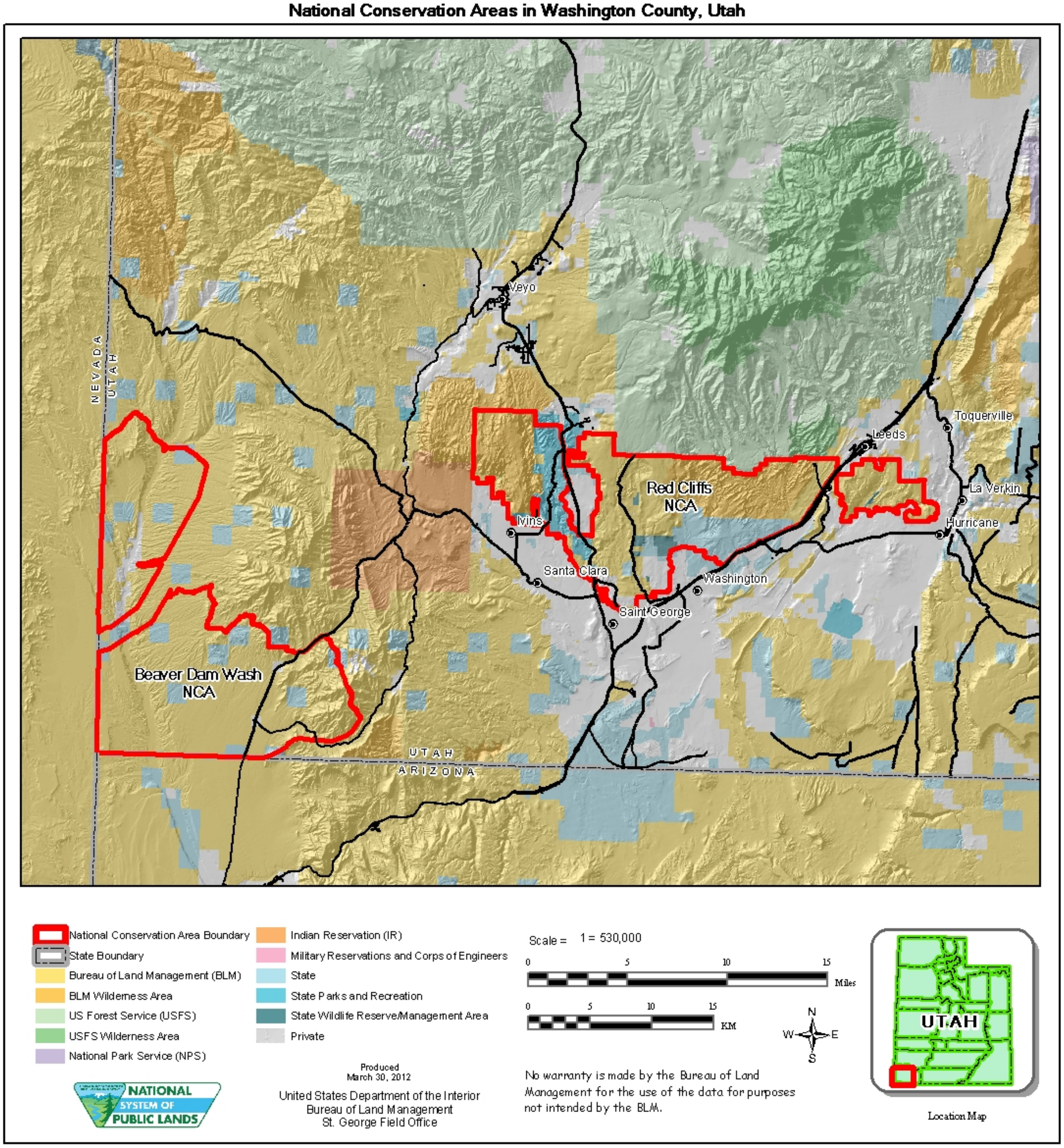


Figure 1. Red Cliffs and Beaver Dam Wash NCAs in Washington County, Utah.

The Red Cliffs NCA landscape is a colorful mosaic of sandstone, sand dunes, lava flows and mesas, at the base of the Pine Valley Mountains. Substantial areas of the Red Cliffs NCA are a wildland-urban interface, as the public lands abut municipal and private lands of the Cities of St. George, Ivins, Santa Clara, and Hurricane. Houses, buildings, utilities, and paved roads fragment the adjacent non-federal landscape.

The Beaver Dam Wash NCA is a mostly unfragmented landscape formed by alluvial benches east and west of the Beaver Dam Wash, and alluvial fans on the limestone-dominated Beaver Dam Mountains. U.S. Highway 91 is the only paved roadway through the NCA and development is limited to the private inholdings along the Beaver Dam Wash at Lytle Ranch.

<u>Ecological Setting</u>

The Mojave Desert, the Great Basin Desert and the Colorado Plateau merge in Washington County and result in ecological transition zones within the NCAs. Both NCAs support a diversity of ecosystems which provide habitat for a variety of plant and animal species including the federally-listed desert tortoise, Gila monster (*Heloderma suspectum*), mule deer (*Odocoileus hemionus*), kit fox (*Vulpes macrotis*) and migratory birds.

The two NCAs support primarily Mojave Desert ecological systems – creosotebush-white bursage, blackbrush, sand sagebrush, warm season grassland, warm desert riparian and washes, and pinyon-juniper woodland. Although both NCAs are considered part of the Mojave Desert ecoregion, the Red Cliffs NCA shares more characteristics with the Colorado Plateau than the Mojave Desert, such as thick sandstone layering, sand deposits, sand sagebrush, warm season grasslands, and increased monsoonal storm activity. The Beaver Dam Mountains appear to act as an effective climatic barrier between the two NCAs. TNC identified the Mormon Mesa-Pine Valley Mountains corridor (which includes the Beaver Dam Wash NCA) as a priority landscape in ecoregional assessments (The Nature Conservancy 2000; Nachlinger et al. 2001), due to the diversity of vegetation types and high occurrence of Mojave Desert wildlife species, such as desert tortoise and Gila monster.

Ecological systems of lower elevations of the Mojave Desert are not adapted to fire because they did not evolve with fire. The low productivity of the warm desert shrublands precluded the accumulation of fine fuels that would carry fire. It was only at the greater precipitation zones of higher elevations of the Mojave Desert that fire became a natural component of the disturbance regime.

However, increased areal extent and abundance of non-native annual grasses and forbs, particularly red brome (*Bromus rubens*) and cheatgrass (*Bromus tectorum*), have contributed to significant increases in fire frequency and intensity since the 1970s (Brooks and Esque, 2002). Red brome and cheatgrass occurred throughout what is now the Red Cliffs NCA prior to the mid 2000s (A. McLuckie, UDWR, personal communication). Further, BLM's fire history for the Beaver Dam Slope shows that wildland fires had been increasing in number, size, and frequency during the 1990s through the early-mid 2000s. Then, copious precipitation in early 2005 promoted massive growth of plants – natives and especially the non-native annual brome grasses – that dramatically increased the amount of fuels on the landscape. With this prodigious accumulation of non-native fine fuels in place, large areas of the eastern Mojave Desert in Nevada and Utah burned, including parts of the Red Cliffs and Beaver Dam Wash NCAs, in a series of catastrophic events in 2005-2006.

Thus, regional invasion by non-native annual grasses, mostly the two *Bromus* species, introduced atypical fire events to the Mojave Desert. Burned areas now support fire return intervals as short as 5-10 years in areas where fire was previously scarce or absent. Many native shrubs do not respond well to one burn, and especially to multiple burns (Callison et al. 1985; Abella et al. 2009a; Engel and Abella 2011). Moreover, non-native annual grasses and forbs compete successfully against native herbs and shrubs by extracting soil moisture before natives are active (Melgoza et al. 1990; Young et al. 1987). Control of non-native annual grasses and forbs, even for the purpose of restoring native species, may face obstacles because it is best achieved by multiple applications of herbicides. In the Mojave Desert, herbicide control is short lived (2-3 years) because seedbank emergence and new invasion allow non-natives to completely re-establish within 3 years.

Restoration of lowland Mojave Desert shrublands, especially burned areas, is notoriously unsuccessful (Abella and Newton 2009b). New restoration technologies for seedings and live-plantings are currently being investigated by universities (Abella et al. 2010; Abella et al. 2009a) and federal agencies (http://www.werc.usgs.gov/Project.aspx?ProjectID=94) to improve success rates. However, researchers and most land managers believe that success of such restoration practices will be hindered if livestock grazing continues to occur in areas where new seedings or plantings have been done, at least during the time it would take for the new vegetation to become sufficiently established.

Management Setting

The "multiple use" mandate of FLPMA has been limited in both NCAs since 1999, when BLM's management focus clearly shifted toward the protection of critical habitat and listed species, through restrictions and closures to the major categories of multiple use that are typically associated with public lands. More-specific features of the current management of each NCA appear in the following two paragraphs.

The Red Cliffs NCA is managed by BLM to assist the recovery and delisting of the threatened Mojave desert tortoise and other native species, through closures and restrictions on land uses and human activities that can impact habitats and species populations. In 1999, the St. George Field Office Resource Management Plan (RMP) restricted or closed the 45,000 acres to virtually all multiple uses except sustainable public recreation. Livestock grazing is not licensed there, and the lands of the NCA have not been managed as "public rangelands" for more than a decade, to assist desert tortoise recovery, through the protection of critical habitat. P.L.111-11 further defined the purposes of the NCA for conservation, rather than management as "public rangeland" under the Taylor Grazing Act or other earlier legislation. Further, the Red Cliffs NCA is closed to mining, oil and gas leasing/development, mineral material harvesting, and other surface disturbing-type developments. Non-motorized public recreation on designated roads and trails is an authorized use of the NCA and a majority of the boundary of the NCA is fenced to prevent unauthorized off-road vehicular travel. The two designated wilderness areas are managed to protect their wilderness character through restrictions on motorized and mechanized vehicle travel.

The Beaver Dam Wash NCA is managed by BLM to assist the recovery and delisting of the threatened Mojave desert tortoise and other native species, through closures and restrictions on land uses and human activities that can impact habitats and species populations. The public lands of what is now this NCA were in 1999 designated as the Beaver Dam Wash ACEC, and land uses were restricted to protect desert tortoises and designated critical habitat. At that time BLM elected to allow livestock grazing to continue in the ACEC, but limited to fall-winter, a decision that was not consistent with recommendation from the USFWS 1994 Recovery Plan for Mojave Desert tortoises. P.L.111-11 language likewise now focuses management of the Beaver Dam Wash NCA away from multiple uses toward conservation. The NCA is closed to mining, oil and gas leasing/development, mineral material harvesting and other surface disturbing-type developments. However, livestock grazing continues to be licensed for a fall-winter season of use in four allotments within the NCA. Other authorized land uses include hunting and non-motorized recreation. Three areas of this NCA were Congressionally-designated through P.L.111-11 in 2009 as “Designated Road Areas” where motorized vehicle travel is limited to those roads shown on the map that supported this legislation.

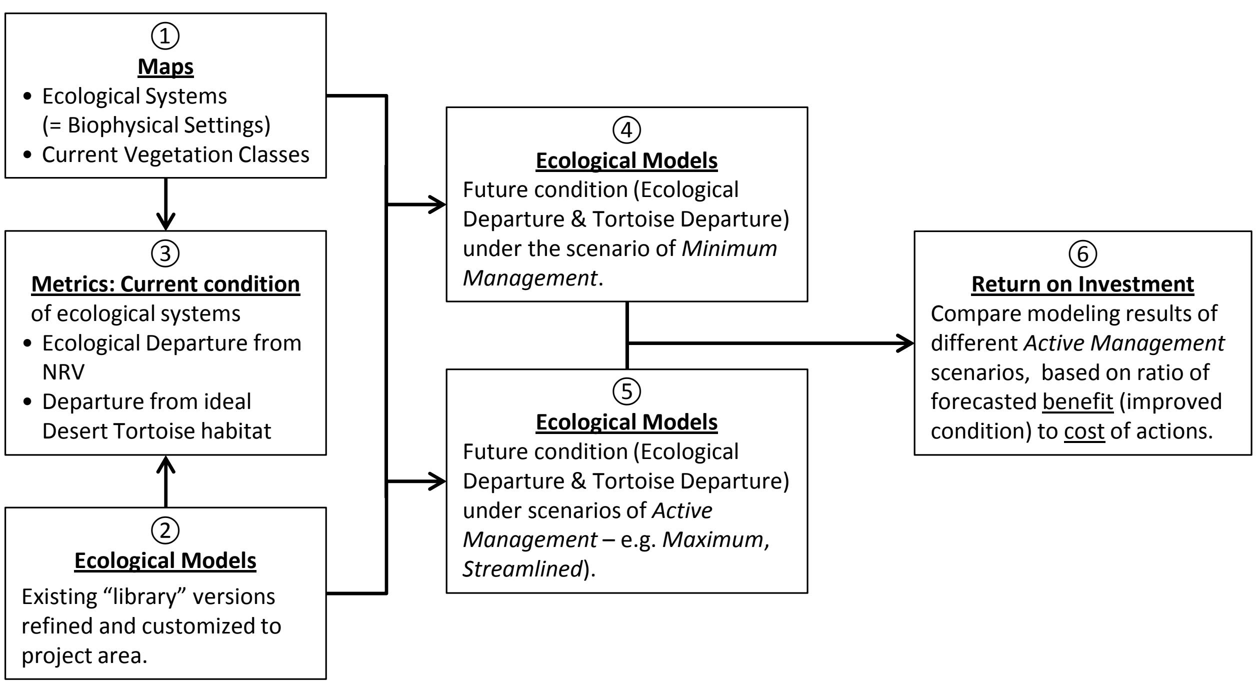
Given the recent changes in Mojave Desert disturbance regimes (fire and non-native species), the present management of the two NCAs provides opportunity to improve ecological resilience, conserve and restore quality of desert tortoise habitat, and reduce detrimental effects of wildfire to ecological systems with uncharacteristic fuel accumulations. The LCF project aims to build a good foundation for this to happen.

Process and Methods

The Landscape Conservation Forecasting™ process used for the NCAs consisted of six primary components or steps, as follows:

1. Develop maps of potential vegetation types, called ecological systems or synonymously biophysical settings, and current vegetation classes within ecological systems, by conducting remote sensing of satellite imagery.
2. Refine computerized predictive state-and-transition ecological models for the ecological systems by updating TNC's "library" of models.
3. Determine current condition of all ecological systems using two metrics:
   a. Ecological departure (a.k.a., Fire Regime Condition or FRC), a broad-scale measure of ecological-system "health."
   b. Desert tortoise habitat departure, a new metric pioneered by TNC that measures the "health" of ecological systems in terms of meeting habitat needs of the tortoise.
4. Use the computerized ecological models to forecast anticipated future conditions (both ecological and tortoise) of ecological systems under a minimum management scenario.
5. Use the computerized ecological models to forecast anticipated future conditions (both ecological and tortoise) of ecological systems under alternative management scenarios.
6. Use Return-on-Investment analysis to assess which strategies for which ecological systems yield the most advantageous results.

A simple schematic diagram that displays the relationship of these components to each other is presented below:



In terms of project chronology, an initial workshop to define vegetation classes prior to remote sensing was held in January 2011 at the UDWR office in Hurricane, Utah. The majority of the remote sensing was then conducted during the winter and spring of 2011. Separate remote sensing efforts were conducted for each NCA, starting with Beaver Dam Wash NCA. Planning started during July 2011. Two multi-day planning workshops were held at the St. George Field Office of BLM in St. George, Utah. In these workshops, BLM biologists, rangeland managers and fire ecologists joined TNC staff and resource professionals from USFWS, UDWR, and the Washington County HCP Administrator's Office to review and refine ecological models, review findings, and identify and explore potential vegetation management scenarios.

A rough timeline of the work done on the project's components is presented in Table 1. This chronology was much accelerated compared to other projects conducted by TNC.

Table 1. Project timeline.

	2011											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Initial Workshop: Pre-mapping vegetation description	■											
Remote sensing: mapping	■	■	■	■	■	■	■					
Remote sensing: field work			■	■	■							
Desert tortoise geo-data reinterpretation				■	■	■						
Predictive ecological models				■	■	■	■	■				
Current condition of ecological systems						■	■					
Workshop 1: Review maps and current condition, begin modeling							■					
Modeling: futures under minimum and maximum management							■					
Workshop 2: Modeling active management, Return on Investment							■					
Modeling: futures under active management scenarios							■	■	■			
Return-on-Investment analyses								■	■			
Accuracy Assessment										■	■	
Report preparation									■	■	■	■

Detailed 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 consist of:

1) the distribution of ecological systems – i.e., the dominant *potential* vegetation types expected in the physical environment under natural disturbance regimes; and
2) current vegetation succession classes of each ecological system.

Preferably, ecological systems are 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 on land in its ability to produce a distinctive kind and amount of vegetation." (*National Forestry Manual*, www.nrcs.usda.gov/technical/ECS/forest/2002_nfm_complete.pdf). Staff from NRCS, however, recommended against using Washington County's soil survey for this purpose because it is outdated.

Remote Sensing Analysis of Ecological Systems and Current Vegetation Classes

Therefore, Spatial Solutions, Inc. was contracted by TNC to conduct remote sensing analysis of the project area, which started in January 2011. TNC provided Spatial Solutions with a description of ecological systems and assisted in remote sensing field surveys. Spatial Solutions used the software Imagine® from Leica Geosystems to conduct the unsupervised classification of color-infrared NAIP imagery (pixels are 1m multispectral imagery) captured in 2009 during different dates, including early spring captures for Red Cliffs. The imagery was clipped to the boundary defined by BLM, which exceeded that of the NCAs and was buffered outward by ½ km. Additional remote sensing and field work were completed for areas missed by the first mapping.

The unsupervised classification of the satellite imagery is described in Provencher et al. (2008, 2009) and Low et al. (2010). To support interpretation of spectral classes (Lillesand and Kiefer 2000), TNC and Spatial Solutions conducted an initial field trip to establish training plots and rapid observations from March 12-28, 2011. Spatial Solutions collected formal training plots and 1,000+ geo-referenced rapid road and hiking observations. A large proportion of each project area was visited.

The field and geo-referenced road data were combined, when necessary, with the BLM's precipitation zone Geographic Information Systems layer to create draft maps of ecological systems and current vegetation classes. Vegetation classes could only be defined after the ecological system was assigned to a group of pixels. The short description of each vegetation class by ecological system used for remote sensing is presented in Appendix 1. A draft map of ecological systems and vegetation classes was verified and improved during a second field trip from May 17-20, 2011. At each pre-selected field location, TNC verified the mapped ecological system and current vegetation class. The same verification process was conducted for "road and hiking observations." This final field trip allowed Spatial Solutions to complete the ecological system map and the current vegetation class map. The last iteration in the final draft map of current vegetation classes was used to calculate draft ecological departure scores (defined farther below). The current vegetation class map and the ecological departure scores were reviewed at the first workshop and revised before the second August workshop.

The ecological systems that were finally mapped for the Red Cliffs and Beaver Dam Wash NCAs are shown in Table 2. They reflect the influence of geology, landforms, soils, elevation, and ecological processes such as fire, flooding, and insect outbreaks. Acre figures in Table 2 include only public lands managed by BLM, although a larger area was remotely sensed. Barren areas comprised primarily of rock outcrops accounted for ~10,000 acres in the Red Cliffs NCA.

Table 2. Ecological systems of the two NCAs in Washington County.

Ecological System	Red Cliffs NCA (acres)	Beaver Dam Wash NCA (acres)
Big Sagebrush Steppe-upland	3,060.6	14.4
Blackbrush-mesic	17,260.4	33,627.8
Blackbrush-thermic	5,005.4	3,652.5
Creosotebush-White Bursage	3,043.1	22,040.8
Desert Sand Sagebrush	1,585.7	—
Desert Washes	402.5	3,345.2
Littleleaf Mountain Mahogany	—	0.4
Montane Riparian	39.5	—
Mountain Shrub	4.2	142.5
Pinyon-Juniper	3,719.4	270.4
Warm Desert Riparian	159.9	114.3
Warm Season Grassland	118.2	—
Total	**34,398.9**	**63,208.3**

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

1. It was very difficult to separate thermic (lower elevation) and mesic (higher elevation) blackbrush at their ecotone. The difficulty increases in burned areas where shrub cover has been removed. The difference is important because desert tortoise greatly prefers thermic blackbrush. Also, juniper and pinyon can occupy mesic blackbrush, but not thermic blackbrush, in the oldest vegetation classes. Two rules were arbitrarily used: a) the presence of white bursage indicated thermic blackbrush, and b) blackbrush found above and inclusive of the 10 inch precipitation zone was considered mesic, whereas blackbrush below this limit was thermic (*Personal communication, Patti Nowak, NRCS of Nevada*).
2. Similarly to above, it was difficult to separate thermic blackbrush from creosotebush-white bursage at their ecotone, as they share the same species but in slightly different proportions. We rapidly discovered that the species creosotebush (*Larrea tridentata*) is a poor indicator because it is found even as high in elevation as big sagebrush steppe. To resolve this issue,

we arbitrarily labeled an ecological system as blackbrush-thermic if the species blackbrush was present, because it is more "ancient" than either creosotebush or white bursage. We tracked the ecotone very carefully to find an elevation break point, which was not well defined because slope, soil depth, and aspect played an important role. The separation of this ecotone consumed many field hours.

3. Separation of ecological systems in burned areas proved very challenging, especially in Red Cliffs. Burned areas usually contained no remaining evidence of blackbrush or creosotebush, unless fire intensity was low enough to allow resprouting of creosotebush. Further, creosotebush was observed resprouting in areas known to be formerly blackbrush. An ecological system was judged to be blackbrush if we could find stumps of blackbrush, which have distinctive split stems. This required walking large areas. If stumps were not found, the ecological system was determined to be creosotebush-white bursage. Further, Spatial Solutions Inc. used pre-fire Landsat imagery (30-m multi-spectral) from 2005 to help determine whether an ecological system was blackbrush or creosotebush-white bursage.
4. We found two types of the mountain shrub ecological system that we nonetheless lumped. At lower elevation and on shallower soil, Stansbury's cliffrose (*Purshia mexicana*) was present standing, albeit dead, after fires. At higher elevation on steep slopes and in deeper soils of the Beaver Dam Mountains, serviceberry (*Amelanchier* spp.) was found in burned and unburned areas with more abundant perennial grass cover than those areas with cliffrose. We may have under-estimated the area of mountain shrub, especially that with cliffrose, because we needed visual confirmation of standing stems and fire could have completely consumed some stems. Moreover, serviceberry is brighter than cliffrose in the infrared spectrum, therefore it was easier to detect.
5. We distinguished between the mountain riparian and warm desert riparian where perennial water was present. The great majority of the project area contained the warm desert riparian ecological system defined by species such as Goodding's willow (*Salix gooddingii*) and mesquite (*Prosopis* spp). We found one occurrence where these species were absent: Quail Creek upstream of Interstate 15, which was clearly above the 10 inch precipitation zone.
6. We initially mapped desert washes as deep and shallow (these were lumped after the first workshop but the remote sensing kept them separate) because we assumed these features were important to desert tortoise. Whether a wash is shallow or deep is entirely a matter of perspective, which was that of desert tortoise and necessitated a vertical barrier preventing exit. Moreover, the same wash can be deep or shallow in different reaches. The only method available to Spatial Solutions Inc. to map a deep wash was to detect the shadow of a wash wall on the wash floor (the satellite imagery is rarely taken exactly at noon, so shadows are common); therefore, if shadows were present, the wash was mapped as deep; otherwise it was shallow by default.
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 sign of old age (large diameter lateral branches and flat-topping). Unlike elsewhere, however, steep slopes were not often a factor for mapping true woodlands in the Red Cliffs because trees grow on mesas with thin soils.

Ecological Systems – Natural Range of Variability

In order to calculate current (or future) condition or "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 post-European settlement climate (Hann and Bunnell 2001; Provencher et al. 2007, 2008; Rollins 2009).

The NRV was calculated with the state-and-transition modeling software PATH/Vegetation Dynamics Development Tool (VDDT, ESSA Technologies; Barrett 2001; Beukema et al. 2003). To determine the NRV for each ecological system in the project area, we modified models from a TNC project completed with the Dixie National Forest (Tuhy et al. 2010). The NRV for each ecological system in each NCA is listed below in Table 3; the NCAs are shown separately because some ecological systems have different NRVs in the two areas.

Refinement of Predictive Ecological Models

The LCF 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. A threshold also implies the creation of uncharacteristic classes. Unlike thresholds, relatively reversible changes (e.g., fire, flooding, drought, insect outbreaks, and others) operate between phases within a state.

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

The classes of pre-settlement vegetation defined by the NRV were considered to be each ecological system's core *reference* condition. At their core, therefore, all models had the LANDFIRE reference condition represented by some variation around the A-B-C-D-E reference

Table 3. The Natural Range of Variability for ecological systems of Red Cliffs and Beaver Dam Wash NCAs. [Numbers in the cells are percentages, and the sum of each row is 100%]

Red Cliffs NCA		NRV[1]					
Ecological System ↓	**Class →**	**A**	**B**	**C**	**D**	**E**	**U**
Big Sagebrush Steppe-upland		30	47	20	1	2	0
Blackbrush-mesic		11	–	73	16	–	0
Blackbrush-thermic		5	–	95	–	–	0
Creosotebush-White Bursage		8	–	92	–	–	0
Desert Sand Sagebrush		2	98	–	–	–	0
Desert Washes (shallow & deep)		10	18	72	–	–	0
Montane Riparian		10	19	71	–	–	0
Mountain Shrub		7	15	63	14	–	0
Pinyon-Juniper		2	3	13	82	–	0
Warm Desert Riparian		10	19	8	40	23	0
Warm Season Grassland		4	96	–	–	–	0

Beaver Dam Wash NCA		NRV[1]					
Ecological System ↓	**Class →**	**A**	**B**	**C**	**D**	**E**	**U**
Big Sagebrush Steppe-upland		30	47	20	1	2	0
Blackbrush-mesic		10	39	35	8	8	0
Blackbrush-thermic		5	48	47	–	–	0
Creosotebush-White Bursage		9	36	38	17	–	0
Desert Washes (shallow & deep)		10	18	72	–	–	0
Littleleaf Mountain Mahogany		6	10	84	–	–	0
Mountain Shrub		7	15	63	14	–	0
Pinyon-Juniper		2	3	13	82	–	0
Warm Desert Riparian		10	19	8	40	23	0

1. Standard LANDFIRE coding 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).

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 reference condition does not describe vegetation caused by unintentional events (e.g., invasion of cheatgrass), or by post-settlement management actions. In addition to modeling reference conditions, therefore, the predictive models also include: (1) vegetation classes that are considered to be *uncharacteristic*, such as dominance of non-native annual grasses, in a "U" class with many specific descriptors; and (2) a *management* component of both vegetation classes and treatments that allows managers to simulate future conditions under alternative management strategies and scenarios (Low et al. 2010).

The vegetation classes of all ecological systems are briefly defined in Appendix 1. Class definitions found in Appendix 1 are essential to understanding the desert tortoise habitat departure metric described shortly. A complete description of the models (model dynamics) is found in Appendix 2, and model parameter values (probabilistic transitions) are shown in Appendix 3.

Assessment of Current Ecological Condition

Two metrics are used to track ecological condition within the two NCAs: (1) ecological departure, which is the traditional metric used by the LCF process for coarse-scale ecological systems; and (2) desert tortoise habitat departure, an innovation developed for the two NCAs. The NRV of ecological systems is used in the calculation of both of these measures of condition.

The Mojave Desert poses unusual management challenges. Restoration of Mojave Desert low-elevation scrub is generally unsuccessful, because existing methods cannot provide long term control of non-native annuals. As a result, the traditional ecological departure metric cannot be sensitive to management actions at lower elevations because this metric treats all uncharacteristic classes as equal. Therefore the second metric, desert tortoise habitat departure, was developed to meet the need of managers to track the effects of restoration actions on desert tortoise habitat suitability.

<u>Ecological Departure</u>

Ecological departure is a broad-scale measure of the condition or "health" of each ecological system, and was originally developed under the national LANDFIRE program. 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.

Ecological departure thus summarizes, in a single number, how out-of-balance each ecological system is in terms of dissimilarity between the <u>current</u> 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 post-European settlement climate (NRV).

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 (≤33%); Class 2 represents moderate departure (34 - 66%); and Class 3 represents high departure (≥67%) (Hann *et al*. 2004). An example of the calculation of ecological departure, and assignment to the corresponding ecological departure class, is shown in Table 4.

Table 4. Example of calculation of Ecological Departure and assignment to Ecological Departure Class.

	Vegetation Class[1]						
	A	B	C	D	E	U	Sum
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
Current % presence of classes	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	27.6
Ecological Departure (%)[2]							72.4
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% ≤ ED ≤ 33%; 2 for 34% ≤ ED ≤ 66%; 3 for 67% ≤ ED ≤ 100%.

Desert Tortoise Habitat Departure

The fundamental building blocks of the LCF process – the essential units that are mapped and used in model analyses – are *coarse-scale vegetation types* known as ecological systems and their constituent vegetation classes. As described above, the traditional measure of ecological condition used by LCF, known as ecological departure, is the dissimilarity between (1) the reference (NRV) mix of vegetation classes in an ecological system, and (2) the current mix of vegetation classes within that system.

This project created an innovation to the LCF process that uses the same fundamental building blocks to measure how well ecological conditions meet the habitat needs of a species, in this case the listed-Threatened desert tortoise. This metric, which we named desert tortoise habitat departure, compares (1) the "ideal," NRV-based quality of tortoise habitat conditions in an ecological system, with (2) the current quality of tortoise habitat conditions in that system. It uses the same basic NRV-versus-current approach as does the traditional ecological departure metric for coarse-scale ecological systems. In other words, desert tortoise habitat departure is a species-habitat-based "plug-in" module to the basic underlying coarse-vegetation-type architecture of LCF.

As a note of caution up-front, this tortoise habitat departure approach grounded in LCF is a complement to, but is NOT a replacement for, modeling/measuring of all tortoise conservation "needs." That is, one cannot rely solely on the LCF tortoise habitat departure metric as a comprehensive and sensitive guide to tortoise management and conservation. For the latter purpose, other factors need to be considered that the LCF tortoise departure metric, by its design, cannot handle or account for. Such factors include plant nutrition (for tortoises), quantity of forage consumed by other herbivores (chiefly domestic livestock), predation, disease, etc. – factors which perhaps can be accounted for in dedicated tortoise species models.

The desert tortoise habitat departure metric is only applicable in six ecological systems in the two NCAs, i.e. the ecological systems that are used by desert tortoise: Blackbrush-mesic, Blackbrush-thermic, Creosotebush-White Bursage, Desert Sand Sagebrush, Warm Desert Wash, and Warm Season Grassland.

The procedure to calculate a desert tortoise habitat departure value for an ecological system requires two pieces of information:

1. A score of *desert tortoise habitat suitability*, also referred to as "tortoise points," for each of the system's vegetation classes, and
2. The percentage of area that each vegetation class comprises in the total area of the ecological system. This percentage of area can apply to the expected or reference situation (NRV), to the current situation (from remote sensing interpretation), or to future situations (from model-run forecasts).

A scoring system for assigning tortoise points to vegetation classes was developed by desert tortoise specialists participating in this LCF project. An explanation of this scoring system, which is basically a set of rules, appears in the text box on the following page.

Once this scoring system was established, the tortoise specialists led a sub-group effort that assigned scores to all vegetation classes of the six ecological systems used by desert tortoise, as listed above. The resulting tortoise point scores for ecological systems and classes are presented in Table 5.

The tortoise point values in Table 5 are the first of two pieces of information needed to calculate desert tortoise habitat departure for relevant ecological systems. The second piece of information is the percentage of area that each vegetation class comprises in the total area of its ecological system. Sources of class percentage-of-area values are as follows:

- For the reference/NRV situation: calculated with the state-and-transition modeling software and shown in Table 3 and Appendix 6.
- For the current situation: determined from interpretation of remote sensing data and shown in Appendix 6.
- For future situations: output results from model runs of minimum management and active management scenarios (defined farther below).

Desert Tortoise Habitat Suitability Scores for Ecological Systems and Vegetation Classes (aka Tortoise Points)

A scoring system was developed to define the importance of different ecological systems and their constituent vegetation classes for desert tortoises. A 9-point scale (from 0 to 8) was used, with 0 being ecological systems/classes that the desert tortoise avoids, and 8 representing ecological systems/classes that provide the best possible forage, cover and substrate conditions for tortoises, with exotic species scarce or absent (< 5%). A score of 8 would have the highest densities of tortoise across all ecological systems. A score of 5 or above suggests that the tortoise can have a viable population in that vegetation class. A score of 4 or below suggests that the tortoise will not persist (e.g., reduced weight gain, low fecundity, high mortality) and that exotics dominate the landscape (> 5%).

The scoring scale is an absolute scale across all ecological systems. For example, the creosotebush-white bursage system can have conditions scored as high as 8, while the best conditions in mesic blackbrush score only a 6. The scale is based primarily on characteristics of tortoise forage and cover as well as tortoise relative densities.

The following are the criteria used to assign each score:

8 – Excellent conditions for tortoises: All tortoise needs are met; the best possible condition for tortoises with the highest possible relative densities; exotic species are scarce or absent (< 5%).

7 – Very Good conditions for tortoises: Very good forage and cover; high relative densities of tortoises; exotic species are present (< or > 5%) but not dominant.

6 – Good conditions for tortoises: Moderate amounts of forage and cover; medium relative densities of tortoises; exotic species are present (< or > 5%) but not dominant.

5 – Fair conditions for tortoises: Moderate levels of forage and/or cover; low relative densities of tortoises; exotic species are present (> 5%) but not dominant.

4 – Poor conditions for tortoises: Much reduced levels of forage and/or cover (i.e., 25-50% vegetation structure); low relative densities of tortoises; exotics dominant.

3 – Very Poor conditions for tortoises: Limited forage and/or cover (i.e., 25% or less vegetation structure); very low relative densities of tortoises, exotics dominant.

2 – Extremely Poor conditions for tortoises: Very limited forage and/or cover (i.e., very little vegetation structure); extremely low relative densities of tortoises, exotics dominant.

1 – Ecological system/class provides no needs for tortoises; tortoises usually absent but occasionally observed.

0 – Ecological system/class that tortoises avoid, tortoises are never found.

Table 5. Desert tortoise habitat suitability scores ("tortoise points") for vegetation classes in each of the six ecological systems used by desert tortoise.

Vegetation Class*	Class Code	ECOLOGICAL SYSTEM Blackbrush-mesic (BM)	Blackbrush-thermic (BT)	Creosote-Bursage (CB)	Desert Shallow Wash (SWA)	Desert Sand Sagebrush (DSS)	Warm Season Grassland (GRL)
Early-succession	A	**5**	**6**	**6**	**5**	**3**	**8**
Mid-succession + Joshua Tree	B	**6**	**8**	**8**			
Mid-succession - no Joshua Tree	B,C →	(C) **6**	(C) **8**	(C) **8**	(B) **8**		(B) **8**
Late-succession - no Joshua Tree	B,D →	(D) **3**				(B) **7**	
Late-succession + Joshua Tree	C,D,E →	(E) **4**		(D) **8**	(C) **8**		
Bare Ground	U:BG	**0**	**0**	**0**	**0**		
Depleted	U:DP					**2**	**3**
Early Shrub	U:ES	**3**	**3**	**3**	**3**		
Early Exotic Annual Grasses and Forbs	U:EEX						**1**
Exotic Annual Grasses and Forbs (once burned)	U:EX	**1**	**1**	**1**			**6**
Exotic Annual Grasses and Forbs (> twice burned)	U:EX2B	**1**	**1**	**1**			
Planted Mojave Vegetation	U:PL	**5**	**6**	**6**			
Native Species Seeding	U:SD	**3**	**3**	**3**			
Introduced and Native Species Seeding	U:SDI	**2**	**2**	**2**			
Shrubs with Exotic Annuals and Native Perennials	U:SEP	**6**	**7**	**7**	**7**	**6**	
Shrubs with Exotic Annuals and Native Perennials with Joshua Tree	U:SEPJ	**6**	**7**	**7**			
Shrubs with Exotic Annuals	U:SES				**3**		**7**
Tree with Exotic Annual Grasses	U:TEX	**1**					
Exotic Trees (tamarisk)	U:ET				**0**		

* Appendix 1 contains a description of each vegetation class.

Calculation of desert tortoise habitat departure values for an ecological system then follows a step-wise process that is described in the remainder of this sub-section, with multiple references to a visual example presented in Table 5a.

Within each multi-colored block of the two ecological systems in Table 5a:

– Constituent vegetation classes are listed in the first (farthest left) column.

– Tortoise points (TP) assigned to each class are in the second column (pale yellow). These match the values in Table 5.

– NRV % values for each class are in the third column (pale blue); only reference classes have values > 0. These match the class NRV values in Table 3 for Beaver Dam Wash NCA.

– The fourth column (pale blue) contains the product of the numbers in the preceding two columns, which is then summed at the bottom of this fourth column.

This sum (of tortoise points x NRV % class areas) integrates into one single number the conditions in which the tortoise survived and thrived for millennia prior to European human settlement – and thus this number represents a benchmark or standard of "ideal" tortoise conditions *from which a departure can be derived*.

The next two columns in each ecological system block (pale orange/tan) display the current %-of-area values for each vegetation class (values are in Appendix 6), again multiplied by the tortoise points for each class (yellow), and then summed at the bottom. This sum integrates into one single number the current "State Of The System" for the tortoise.

The sum of tortoise points x current class % values is then divided by the sum of tortoise points x NRV class % values, the result is subtracted from 1 to make it a dissimilarity or departure value, and this departure value is finally multiplied by 100 to convert it into a percent.

This single value, shown in the "Tortoise Departure (Current)" rows in Table 5a, represents a current-from-NRV departure score of tortoise habitat suitability for its ecological system. This tortoise habitat departure value is based not on class-by-class comparisons (the traditional method of ecological departure), but on comparison of the single integrated numbers (NRV & current) of tortoise habitat suitability. However, as with ecological departure, smaller values (lower numbers) of desert tortoise habitat departure indicate greater habitat suitability – "healthier" conditions – for desert tortoise.

The final two columns in each ecological system block (pink) display the future %-of-area values for each vegetation class derived from model runs of a "MINIMUM MANAGEMENT" scenario (defined later), again multiplied by the tortoise points for each class (yellow), and then summed at the bottom. This sum integrates into one single number the forecasted (modeled) future "State Of The System" for the tortoise under a scenario of MINIMUM MANAGEMENT.

The sum of tortoise points x future class % values is then divided by the sum of tortoise points x NRV class % values, the result is subtracted from 1 to make it a dissimilarity or departure value, and this departure value is finally multiplied by 100 to convert it into a percent.

Table 5a. Visual representation of the calculation of desert tortoise habitat departure values in two ecological systems.

Blackbrush thermic (BDW)	TP*	NRV %	TP x NRV %	Current %	TP x Current %	Min Mgt %	TP x Min Mgt %
BT-A:AL	6	5	30		0		0
BT-B:JT	8	48	384		0		0
BT-C:CL	8	47	376		0		0
BT-U:BG	0		0		0		0
BT-U:ES	3		0		0	4	12
BT-U:EX	1		0	33	33	3	3
BT-U:EX2B	1		0		0	24	24
BT-U:PL	6		0		0		0
BT-U:SD	3		0		0		0
BT-U:SDI	2		0		0		0
BT-U:SEP	7		0	31	217	34	238
BT-U:SEPJ	7		0	36	252	36	252
	SUM→		**790**		**502**		**529**
Tortoise Departure (Current) = 1 - [Σ(TPxCurrent)/Σ(TPxNRV)]				→	36		
Tortoise Departure (MinMgt) = 1 - [Σ(TPxMinMgt)/Σ(TPxNRV)]				→	→	→	33

Desert Wash (BDW)	TP*	NRV %	TP x NRV %	Current %	TP x Current %	Min Mgt %	TP x Min Mgt %
SWA-A:AL	5	10	50	79	395	6	30
SWA-B:CL	8	18	144		0	15	120
SWA-C:CL	8	72	576		0	39	312
SWA-U:BG	0		0		0		0
SWA-U:ES	3		0		0	2	6
SWA-U:ET	0		0		0		0
SWA-U:SEP	7		0		0	6	42
SWA-U:SES	3		0	21	63	32	96
	SUM→		**770**		**458**		**606**
Tortoise Departure (Current) = 1 - [Σ(TPxCurrent)/Σ(TPxNRV)]				→	41		
Tortoise Departure (MinMgt) = 1 - [Σ(TPxMinMgt)/Σ(TPxNRV)]				→	→	→	21

* TP = "Tortoise Points" defined by experts for each Vegetation Class.

This single value, shown in the "Tortoise Departure (MinMgt)" rows in Table 5a, represents a future-from-NRV departure score of tortoise habitat suitability for its ecological system under MINIMUM MANAGEMENT, based on comparison of the single integrated numbers (NRV & future) of tortoise habitat suitability.

Not shown in the two ecological system blocks of Table 5a, but readily added, would be additional pairs of columns displaying additional future %-of-area values for each vegetation class derived from model runs of various "Active Management" scenarios (defined later). Each additional pair of columns would have its own future-from-NRV departure score of tortoise habitat suitability calculated for each associated Active Management Scenario modeling result.

It is noteworthy that desert tortoise habitat departure values can be negative (less than zero) in active-management modeling scenarios where future predicted acres (future class % values) are concentrated in one or a few classes with high tortoise point scores. Further, good (low value) tortoise habitat departure scores can be reached via management actions in ecological systems that are used by tortoises but that are heavily invaded by non-native annual species.

Accounting for Variability in Disturbances and Climate

The basic PATH/VDDT 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. PATH/VDDT automatically supplies variability around these rates. However, in real-world conditions the disturbance rates are likely to vary appreciably over time and more than provided by PATH/VDDT's default variability. To simulate strong yearly variability for fire activity, drought-induced mortality, non-native species invasion rates, tree encroachment rate, loss of herbaceous understory, and flooding, TNC incorporated *temporal multipliers* in the model run replicates. Due to the extremely episodic nature of weather, fire, and flooding in the Mojave Desert, temporal multipliers have profound effects on reporting variables.

A temporal multiplier is a number in a yearly time series that multiplies a base disturbance rate in the PATH/VDDT models. For example, in a given year, a temporal multiplier of one implies no change in a disturbance rate, whereas a multiplier of zero is a complete suppression of the disturbance rate, and a multiplier of three triples the disturbance rate. 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 4.

Assessment of Future Ecological Condition – MINIMUM MANAGEMENT

Using the computer-based models, TNC simulated the likely future condition of each ecological system after 20 and 50 years, under a scenario of *MINIMUM MANAGEMENT*. MINIMUM MANAGEMENT essentially represents a custodial level of BLM management with no proactive projects other than the continuation of current management practices, including 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 estimate 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 bromes and exotic forbs), increased tree encroachment rates in shrublands, modified mean fire return intervals in shrublands, livestock grazing, and illegal off-highway vehicle use.

The two primary measures used for assessing future condition were the same as for current condition: (1) ecological departure, and (2) desert tortoise habitat departure, in each system after 20 and 50 years. In the final analysis, the 50-year results were reported.

Ecological departure values can be grouped into three categories that are termed Ecological Departure Classes: Class 1 represents low departure of ≤33%; Class 2 represents moderate departure of 34-66%; and Class 3 represents high departure of ≥67%) (see Table 4). Desert tortoise habitat departure values can also be grouped into these three classes although, as noted above, tortoise departure values can be negative (less than zero) in certain circumstances. In general, smaller values (lower numbers) of both ecological and tortoise habitat departure indicate "healthier" conditions.

Assessment of Future Ecological Condition – Alternative Active Management Strategies

Eleven ecological systems in the Red Cliffs NCA, and seven ecological systems in the Beaver Dam Wash NCA, were selected for analyses of future management (Table 6). Because current management differs slightly between the two NCAs, analyses of future management were done separately for them. The ecological systems in Table 6 were selected based upon their size, high departure from NRV, likelihood of high future departure, and importance to the desert tortoise and mule deer (mountain shrub). Further explanation of why each of these systems was chosen for management analyses is presented later in **Findings** under the section **Management Strategies and Scenarios**.

A primary objective of the BLM-TNC Agreement for the two NCAs is to guide the development of specific, cost-effective fire and vegetation management actions to maintain, enhance or restore the condition of ecological systems, and/or enhance the suitability of desert tortoise habitat. NCA management and staff, other stakeholders, and TNC worked jointly on three interrelated tasks toward achieving this primary Agreement objective: (1) develop a set of more-specific guiding *management objectives*; (2) list a comprehensive set of *management strategies* that the BLM and other partners can implement; and (3) analyze the results (per ecological departure and desert tortoise habitat departure) of various alternative *management scenarios*, i.e., combinations of management strategies that have a similar theme.

Table 6. Ecological systems of the two NCAs selected for management analyses. Acres include only public lands managed by BLM, though a larger area was remotely sensed.

	Red Cliffs NCA (acres)	Beaver Dam Wash NCA (acres)
Big Sagebrush Steppe-upland	3,060.6	—
Blackbrush-mesic	17,260.4	33,627.8
Blackbrush-thermic	5,005.4	3,652.5
Creosotebush-White Bursage	3,043.1	22,040.8
Desert Sand Sagebrush	1,585.7	—
Desert Washes (shallow & deep)	402.5	3,345.2
Montane Riparian	39.5	—
Mountain Shrub	4.2	142.5
Pinyon-Juniper	3,719.4	270.4
Warm Desert Riparian	159.9	114.3
Warm Season Grassland	118.2	—

Management Objectives

Participants at the July 2011 workshop developed a set of key **Management Objectives** for the two NCAs. These objectives are listed in the box below.

Management Objectives for the Red Cliffs and Beaver Dam Wash NCAs

- Meet NCA statutory objectives (conserve, protect, and enhance) and other statutory or administrative requirements.
- Improve or maintain ecological condition of all systems.
- For the six ecological systems that are vital tortoise habitat, reduce departure from desired future condition (tortoise habitat departure) from high to low.
- For the remaining ecological systems, reduce departure from desired future condition (NRV) from high to moderate or low, to the degree that strategies are feasible and affordable.
- Protect reference vegetation classes, unburned, and only once-burned shrubland classes.
- Decrease fuel loading and continuity to help reduce risk of loss from wildfire to natural and cultural resources in the NCAs.
- Consider other objects of importance in the enabling legislation (e.g. recreation, endangered species, scenic resources, etc.) – do no harm!
- Help make treatment projects competitive for funding resources.
- Keep multiple management options open within above context.

Management Strategies

Workshop participants identified various management strategies (also termed actions or treatments) toward achieving the management objectives for the two NCAs and their ecological systems. The effectiveness of strategies was tested using the predictive ecological models.

All management strategies were fundamentally designed to: (1) improve the condition of ecological systems that are currently in an undesirable condition, and/or (2) abate the most serious future threats to ecological systems or human settlements. Each management strategy had a cost-per-acre figure and a yearly application rate determined for it, using various published sources as well as the local experience of agency staff and stakeholders (Appendix 5). The array of general management strategies appears in the list below; details will be presented later in **Findings** under the section **Management Strategies and Scenarios**.

- Strategies across ecological systems (landscape level):
  - Fuel breaks;
  - Special livestock management (Beaver Dam Wash NCA only); and
  - Greater law enforcement.
- Strategies specific to ecological systems:
  - Creosotebush-White Bursage and Blackbrush — herbicide application to control non-native annuals, and native plant seeding or planting of containerized Mojave Desert shrubs and forbs;
  - Desert Washes — chainsaw cutting of tamarisk (saltcedar) followed by stump painting with herbicide, herbicide application to control non-native annuals;
  - Warm Season Grassland, Desert Sand Sagebrush, Mountain Shrub, and Pinyon-Juniper — herbicide application to control non-native annuals, and native plant seeding;
  - Montane Riparian — chainsaw cutting of tamarisk (saltcedar) followed by stump painting with herbicide, and spot application of herbicides to non-native forbs; and
  - Warm Desert Riparian — weed inventory, chainsaw cutting of tamarisk (saltcedar) followed by stump painting with herbicide, spot application of herbicides to non-native forbs, and hand spraying of herbicide to control non-native annuals in the understory of riparian woodlands.

Initial draft sets of management strategies were developed by stakeholders in the July 2011 workshop. TNC then conducted PATH/VDDT computer runs of the state-and-transition models to test and refine a suite of strategies for each of the selected ecological systems (Table 6) over a 50-year time horizon. A 50-year horizon was chosen over a 20-year one because some experimental management strategies were predicted to become commercially viable only after 20 years. These models also included a "failure rate" for many management strategies to reflect that some strategies only partially succeed at restoring a vegetation class, although cost is incurred for failure. Many different combinations of alternative management strategies and levels of treatment were tested to develop successful scenarios (see below). This trial-and-error process created a robust set of strategies that reduced ecological departure and/or desert tortoise habitat departure while minimizing cost.

<u>Management Scenarios</u>

Management scenarios represent common "themes" for grouping individual management strategies, so that the effectiveness of sets-of-strategies can be better compared within and across ecological systems. Scenarios are comparable to alternatives proposed in BLM Resource Management Plans or project-specific National Environmental Policy Act (NEPA) analyses.

Based on past experience in eastern California, Nevada, and southwestern 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 the top part of Table 7. At the request of the BLM, several single-strategy or thematic scenarios were also developed to guide general decision making; these thematic scenarios are described in the remainder of Table 7. Because scenarios are broad themes to guide modeling during workshops, they become more specific within each ecological system than what is shown in Table 7; such specific details will be presented later in **Findings** under the section **Management Strategies and Scenarios**.

Table 7. Descriptions of standard and thematic (single-strategy) management scenarios for Red Cliffs and Beaver Dam Wash NCAs.

STANDARD MANAGEMENT SCENARIOS
MINIMUM
This is a control scenario that included 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 reflected 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 a no-treatment control, but does not always represent current management.
MAXIMUM
This scenario allocated unlimited management funds to strategies with the goal of reducing ecological departure and/or desert tortoise habitat departure to the greatest extent possible. This scenario assumed no financial or other resource constraints on strategy implementation (i.e., annual agency budgets were typically exceeded).
STREAMLINED
This scenario was identified interactively by managers and stakeholders at and following the workshops. It aims to reduce ecological departure and/or desert tortoise habitat departure as much as possible within the constraints of anticipated (realistic) agency budgets, management funding availability, and regulatory requirements. Bascially, the STREAMLINED MANAGEMENT scenario sought a set of strategies that produced the highest return on investment, or ratio of benefit (improvement in condition) to affordable cost.
THEMATIC MANAGEMENT SCENARIOS
FUEL BREAK - ONLY
The FUEL BREAK - ONLY scenario included only 200-foot fuel breaks strategically applied along rights-of-way, roads, and boundaries throughout the landscape. The herbicide Plateau® was aerially applied during years of greater productivity (7-year El Niño cycle). Five ecological systems benefited from fuel breaks: Creosotebush-White Bursage, Blackbrush-mesic, Blackbrush-thermic, Desert Washes, and Warm Season Grassland. The number of acres treated was obtained from the STREAMLINED SCENARIO.

Table 7 (Continued). Descriptions of standard and thematic (single-strategy) management scenarios for Red Cliffs and Beaver Dam Wash NCAs.

PLANTING AND HERBICIDE - ONLY
The PLANTING AND HERBICIDE - ONLY scenario consisted of spraying Plateau® to control non-native annual grasslands and forblands followed by planting of containerized shrubs and forbs. Due to the experimental nature of this method, it was expected that the treatment would only be applied after five years of commercial development. Targeted ecological systems were Creosotebush-White Bursage, Blackbrush-mesic, and Blackbrush-thermic.
PLANTING AND HERBICIDE & LIVESTOCK CLOSURE - ONLY (BEAVER DAM WASH NCA ONLY)
The PLANTING AND HERBICIDE & LIVESTOCK CLOSURE - ONLY scenario consisted of spraying Plateau® to control non-native annual grasslands and forblands followed by planting of containerized shrubs and forbs. Moreover, plantings were protected from livestock grazing for 10 consecutive years, although reduction of stocking rates was also applied to Desert Washes, especially since these occur everywhere in the landscape. A secondary effect of temporary (10-year) livestock closures was the small increase of fuel loadings: the models assumed a small suppression of fire activity when livestock graze non-native annuals during the winter months. Due to the experimental nature of this method, it was expected that the treatment would only be applied after five years of commercial development. Targeted ecological systems were Creosotebush-White Bursage, Blackbrush-mesic, Blackbrush-thermic, and Desert Washes.
NO GRAZING - ONLY (BEAVER DAM WASH NCA ONLY)
The NO GRAZING - ONLY scenario assumed that public lands in the Beaver Dam Wash NCA would be made unavailable for livestock grazing. As above, removal of livestock grazing from the NCA allowed slightly greater fire activity through increase of fine fuel loadings.
LAW ENFORCEMENT - ONLY
The LAW ENFORCEMENT - ONLY scenario was designed to increase the visibility of law enforcement substantially, in order to reduce illegal OHV activity.
BLACK FINGERS OF DEATH - ONLY, WITH 75% SUCCESS RATE
The BLACK FINGERS OF DEATH - ONLY, WITH 75% SUCCESS RATE scenario involves an experimental application of the black fingers of death (BFOD) fungus – finger-shaped smut emerging from seeds – to non-native annual grasses that has a reduction effect similar to herbicide. Given that patents are pending, the stakeholder group allowed a 5-year period of commercial development of the BFOD fungus – i.e., the treatment only became available five years from the start of simulations. The BFOD was used alone as a biocide, and also combined with the planting and seeding treatments. Targeted ecological systems were Creosotebush-White Bursage, Blackbrush-mesic, Blackbrush-thermic, Desert Washes, Desert Sand Sagebrush, and Warm Season Grassland. Because current projections of success of BFOD are 75-80%, we first simulated a 75% success rate for this action (independent of the success rate of planting or seeding).
BLACK FINGERS OF DEATH - ONLY, WITH 50% SUCCESS RATE
The same as the BLACK FINGERS OF DEATH - ONLY scenario described above, but with a 50% success rate instead of 75%.
BLACK FINGERS OF DEATH - ONLY, WITH 25% SUCCESS RATE
The same as the BLACK FINGERS OF DEATH - ONLY scenario described above, but with a 25% success rate instead of 75%.

Each scenario required budgets for each ecological system, which included costs of all management strategies. Budgets were also expressed as area limits, which was the maximum area that could be treated per year for individual strategies. If computer simulations reached a given management strategy's annual area limit, that management strategy was subsequently discontinued in the simulation for that year. Cost information for each management strategy for each ecological system, under all scenarios, is listed in Appendix 5.

Computer Simulations and Reporting Variables

The scenarios from Table 7 were simulated for each ecological system for 50 years using PATH/VDDT 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. The two reporting variables for model simulations were the two primary measures of future ecological condition as noted above, namely: (1) ecological departure, and (2) desert tortoise habitat departure.

Return-On-Investment Analysis

The final step in the process was to calculate for each scenario the ratio of: (1) the predicted *benefit* of the scenario, as measured by magnitude of ecological improvement, to (2) the *cost* of the scenario's management strategies. TNC developed this ratio as a Return on Investment (ROI) metric to identify which scenario produced the greatest ecological benefit per dollar invested across multiple scenarios *within* each ecological system. For purposes of measuring the benefit, i.e. the magnitude of improvement in ecological departure (or tortoise habitat departure), the baseline used was the pertinent departure score of the MINIMUM MANAGEMENT scenario after 50 years; the baseline was not the departure score as it is now (current).

TNC also developed an ROI metric of greatest ecological benefit per dollar invested *across* multiple targeted ecological systems, also in relation to a baseline of MINIMUM MANAGEMENT. More specifically, this so-called ecological system-wide ROI is the change of ecological departure (or tortoise habitat departure) between the MINIMUM MANAGEMENT scenario and the MAXIMUM, STREAMLINED, OR ANY THEMATIC MANAGEMENT scenario in the last year of the simulation, multiplied by the total area of the ecological system, divided (respectively) by total cost of each scenario over the duration of the simulation – here 50 years. One uniform correction factor of 1,000 across all ecological systems was used to bring all measures to a common order of magnitude.

The ROI 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. Of course, managers may also select final scenarios, strategies 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

Eleven ecological systems were mapped in the Red Cliffs NCA, and nine were mapped in the Beaver Dam Wash NCA (Table 2; Figures 2 and 3). Mesic blackbrush was the most abundant ecological system in both NCAs. In the Red Cliffs NCA, other abundant ecological systems were (in decreasing order of area): thermic blackbrush, pinyon-juniper woodland, big sagebrush steppe upland, creosotebush-white bursage, desert sand sagebrush, and desert washes. In the Beaver Dam Wash NCA, other abundant ecological systems were (in decreasing order of area): creosotebush-white bursage, thermic blackbrush, and desert washes. The smallest ecological systems (<50 acres) were montane riparian and mountain shrub in the Red Cliffs NCA, and littleleaf mountain mahogany and big sagebrush steppe upland in the Beaver Dam Wash NCA.

Current Ecological Departure

All ecological systems in both NCAs were highly departed from their reference condition (Table 8), except for littleleaf mountain mahogany (small area) in the Beaver Dam Wash NCA. The primary cause of high ecological departure in most systems across both NCAs was the presence or dominance of non-native annual grasses (red brome and cheatgrass) and forbs (*Erodium* sp.). Many areas of southwestern Utah that burned in 2005 and 2006, as an extension of the southern Nevada fire complex (2005) or independently, were transformed into non-native annual grasslands and forblands with few shrubs remaining (Abella et al. 2009a). The shrublands and woodlands that did not burn were invaded by non-native annuals. Therefore, both NCAs were almost entirely in uncharacteristic vegetation classes (see Appendix 6 for current areas by classes). One exception to this widespread annual-invasion phenomenon is seen in the desert washes ecological system. Desert washes have high departure primarily because of a predominance of early-succession classes following the flash floods of December 2010. In other words, at the present time (2011) many desert washes are now dominated by the early-succession vegetation class following those recent flash floods, and thus are very highly departed by virtue of imbalance among reference classes A-C, not because of predominance of uncharacteristic (non-native annuals) classes.

Current Desert Tortoise Habitat Departure

Despite high levels of invasion by non-native annuals, current desert tortoise habitat departure was at worst in the moderate class (Table 8). Various species of desert shrubs were sufficiently abundant in the six relevant ecological systems to provide habitat value ("tortoise points" – see Table 5) to the tortoise. In the Red Cliffs NCA, four ecological systems had low levels of tortoise habitat departure: mesic blackbrush, thermic blackbrush, desert sand sagebrush, and warm-season grassland. In the Beaver Dam Wash NCA, only the creosotebush-white bursage system had a current low level of tortoise departure. Moderate levels of tortoise departure were observed in creosotebush-white bursage and desert washes in the Red Cliffs NCA, and in mesic blackbrush, thermic blackbrush, and desert washes in the Beaver Dam Wash NCA.

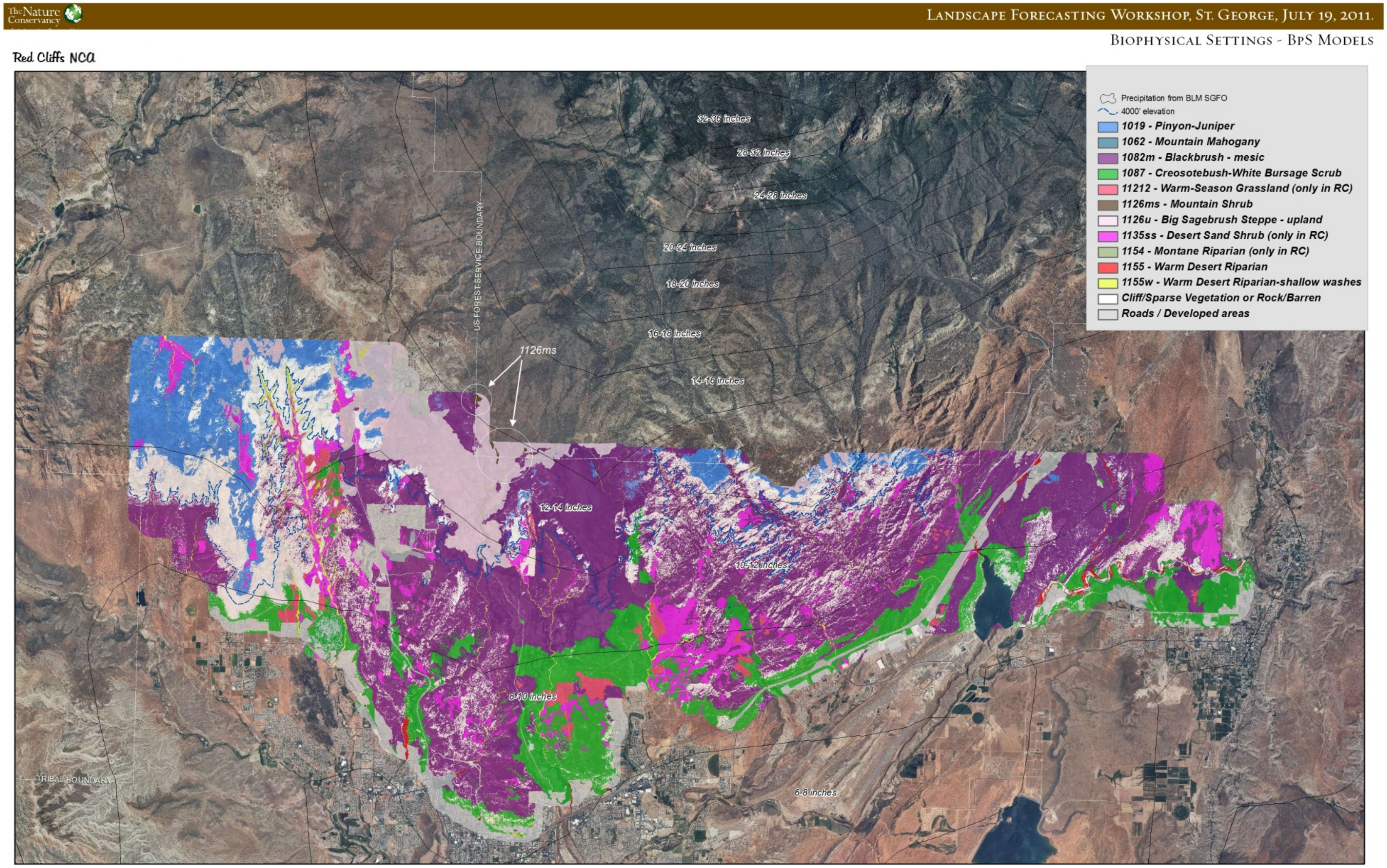


Figure 2. Ecological systems of the Red Cliffs NCA, Washington County, Utah.

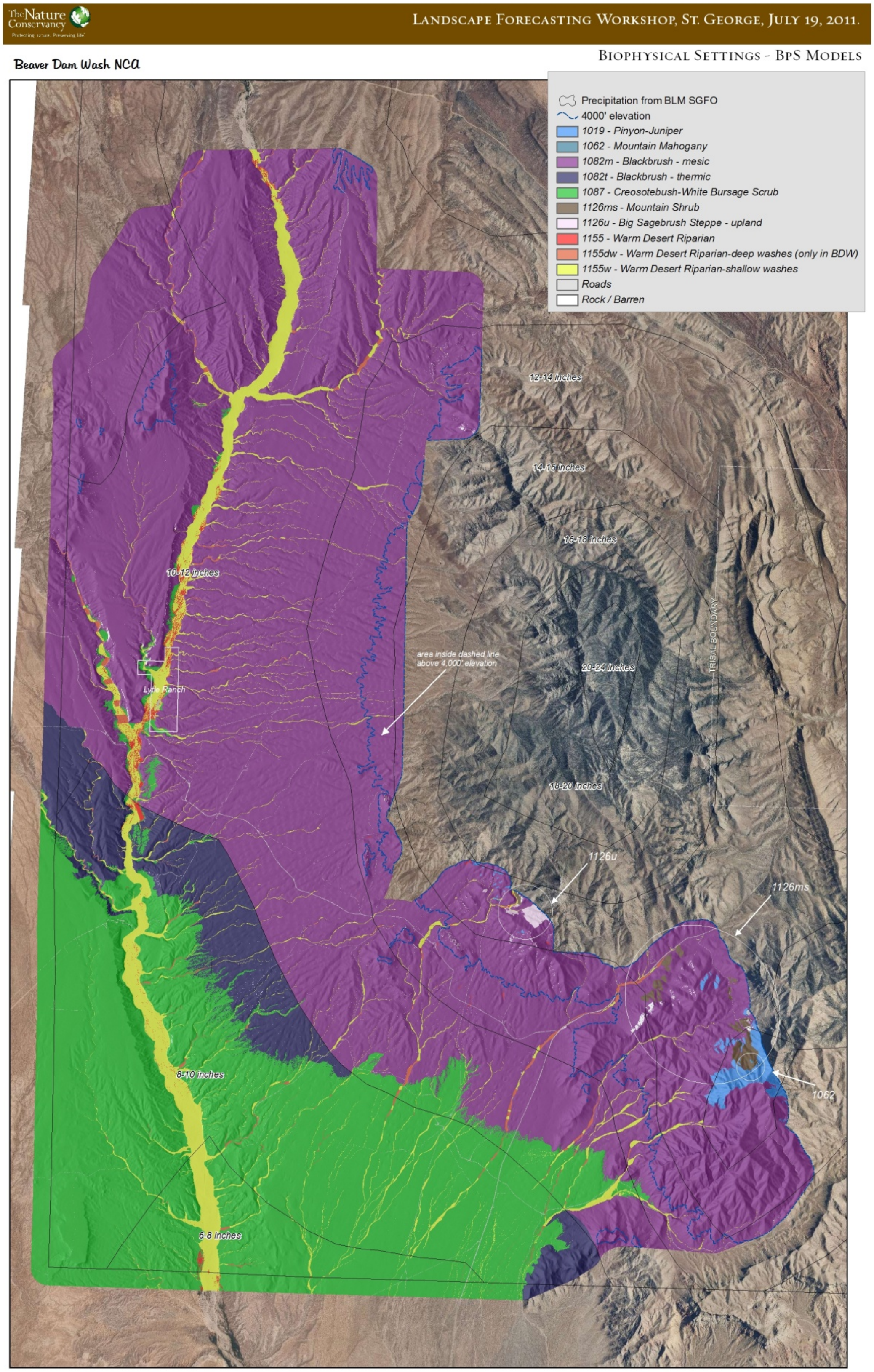


Figure 3. Ecological systems of the Beaver Dam Wash NCA, Washington County, Utah.

Table 8. Current ecological departure and desert tortoise habitat departure of ecological systems in the Red Cliffs and Beaver Dam Wash NCAs[1].

	Red Cliffs NCA (acres)	Ecological Departure (%)	Desert Tortoise Departure (%)[2]
Big Sagebrush Steppe	3,060.6	100	
Blackbrush-mesic	17,260.4	100	25
Blackbrush-thermic	5,005.4	100	20
Creosotebush-White Bursage	3,043.1	100	52
Desert Sand Sagebrush	1,585.7	100	13
Desert Washes (shallow & deep)	402.5	90	50
Montane Riparian	39.5	99	
Mountain Shrub	4.2	100	
Pinyon-Juniper	3,719.4	100	
Warm Desert Riparian	159.9	100	
Warm Season Grassland	118.2	100	15

	Beaver Dam Wash NCA (acres)	Ecological Departure (%)	Desert Tortoise Departure (%)[2]
Big Sagebrush Steppe	14.4	100	
Blackbrush-mesic	33,627.8	100	58
Blackbrush-thermic	3,652.5	100	37
Creosotebush-White Bursage	22,040.8	100	18
Desert Washes (shallow & deep)	3,345.2	90	40
Littleleaf Mountain Mahogany	0.4	14	
Mountain Shrub	142.5	100	
Pinyon-Juniper	270.4	94	
Warm Desert Riparian	114.3	100	

1. Cell color indicates Departure Class: Green (Class 1) = low departure, ≤33%; Yellow (Class 2) = moderate departure, 34-66%; Red (Class 3) = high departure, ≥67%.
2. Blank cells under desert tortoise departure (%) are ecological systems to which the metric does not apply.

Predicted Future Ecological Condition – MINIMUM MANAGEMENT

Ecological Departure

Ecological departure remained highly departed after 50 years under the scenario of MINIMUM MANAGEMENT in all ecological systems of the Red Cliffs NCA (Table 9). The same is true for the Beaver Dam Wash NCA except for desert washes, which showed moderate departure after 50 years due to rebalancing of succession classes after flash flooding. Although still high, ecological departure decreased after 50 years in the desert washes and montane riparian systems of the Red Cliffs NCA, again due to rebalancing of succession classes after flash flooding.

Desert Tortoise Habitat Departure

In the Red Cliffs NCA, desert tortoise habitat departure increased in the mesic and thermic blackbrush ecological systems after 50 years under the scenario of MINIMUM MANAGEMENT (Table 9). Tortoise departure decreased, an improvement, in creosotebush-white bursage (due to natural recovery of shrubs after fire), and in desert washes (due to rebalancing of succession classes after flash flooding). In the Beaver Dam Wash NCA, tortoise habitat departure increased in the creosotebush-white bursage system after 50 years under MINIMUM MANAGEMENT, but decreased (an improvement) in the desert washes and mesic and thermic blackbrush systems.

Table 9. Current ecological departure and desert tortoise habitat departure, and predicted ecological departure and desert tortoise habitat departure under MINIMUM MANAGEMENT after 50 years, of ecological systems in the Red Cliffs and Beaver Dam Wash NCAs[1].

	Ecological Departure (%)		Desert Tortoise Departure (%)[2]	
	Current condition	MINIMUM MGMT - 50 yrs	Current Condition	MINIMUM MGMT - 50 yrs
Red Cliffs NCA				
Big Sagebrush Steppe	100	98		
Blackbrush-mesic	100	100	25	51
Blackbrush-thermic	100	100	20	61
Creosotebush-White Bursage	100	100	52	40
Desert Sand Sagebrush	100	100	13	13
Desert Washes	90	69	50	36
Montane Riparian	99	100		
Mountain Shrub	100	100		
Pinyon-Juniper	100	100		
Warm Desert Riparian	100	71		
Warm Season Grassland	100	100	15	15
Beaver Dam Wash NCA				
Big Sagebrush Steppe	100			
Blackbrush-mesic	100	100	58	20
Blackbrush-thermic	100	100	37	21
Creosotebush-White Bursage	100	100	18	38
Desert Washes	90	45	40	21
Littleleaf Mountain Mahogany	14			
Mountain Shrub	100	100		
Pinyon-Juniper	94			
Warm Desert Riparian	100	89		

1. Cell color indicates Departure Class: Green (Class 1) = low departure, ≤33%; Yellow (Class 2) = moderate departure, 34-66%; Red (Class 3) = high departure, ≥67%.
2. Blank cells under desert tortoise departure (%) are ecological systems to which the metric does not apply.

Management Strategies and Scenarios

For the targeted ecological systems analyzed in greater detail, management strategies were developed under MAXIMUM MANAGEMENT, STREAMLINED MANAGEMENT, and THEMATIC MANAGEMENT SCENARIOS. All strategies were designed to improve the condition of ecological systems that are currently in an undesirable condition and/or to abate serious future threats to them. Different types of strategies and degrees of application were tested to achieve specific objectives of the scenarios. Total 50-year costs for strategy implementation were calculated for each ecological system under each scenario, as well as any one-time costs.

All scenarios for each ecological system were then tested via computer simulations using PATH/VDDT to determine whether or not they achieved the desired objectives. Outcomes were calculated for ecological departure and desert tortoise departure over 50 years. Area results by vegetation class and ecological system for each replicate are shown, respectively, for all management SCENARIOS IN APPENDICES 7 THROUGH 16.

Summary descriptions of active-management modeling results are presented for each targeted ecological system that was selected for such analyses for each NCA. Each system description includes text, a summary table, and a composite figure that together provide the following information:

1. Brief description of each ecological system's causes of departure for each NCA;

2. List of management objectives per scenario;

3. Table of description of management strategies, including acres treated and cost, for all scenarios;

4. Summary of outcomes (ecological departure, ROI based on ecological departure, desert tortoise departure, and ROI based on desert tortoise departure) expressed as box plots (mean, ± 1 standard error, and the 95% confidence interval). Overlapping confidence intervals from different boxes generally indicates that averages are not statistically different.

Following these individual descriptions of targeted ecological systems, a sub-section summarizes inter-system ROI results, and a final section discusses mapping of areas for implementation of actions.

Red Cliffs NCA: Blackbrush-mesic

Mesic blackbrush is the largest ecological system of the Red Cliffs NCA and is found from east to west in the NCA. At present, this system exhibits complete ecological departure at 100%; however, desert tortoise departure is relatively low at 25% because shrublands invaded by non-native annuals represent 61% of the landscape. These shrublands provide shade and food to desert tortoise. About 39% of the ecological system transitioned to non-native annual grasslands and forblands after burning in 2005.

After 50 years in a regime of minimum management, ecological departure did not change because acres were shuffled among uncharacteristic vegetation classes. With minimum management, wildfires converted more shrublands with non-native annuals into non-native annual grasslands and forblands. As a result, desert tortoise departure increased (i.e., became worse) from 25% to 51% reflecting the elimination of vegetation structure that provides shade and some food for desert tortoise.

BLM and stakeholders focused on a variety of treatment actions (strategies) used alone or in combination including herbicide application, native species seeding and planting, and fuel breaks.

50-Year Management Objectives

- Protect blackbrush shrublands from future fire.
- Increase native shrub and herbaceous cover in burned areas.
- Maintain desert tortoise departure below the current 25% score.

50-Year Management Strategies and Costs

Scenario	Action Description		Acres/ year		Cost/ acre	50-yr total cost
		1-4 yrs	5-19 yrs	20-50 yrs		
Maximum	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	308	422	$650	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	3,284	4,629	5,105	$11	
						$14,155,828
Streamlined	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	145	303	$650	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	1,318	9,312	10,770	$11	
						$9,166,756

Planting+ Herbicide-only	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	334	601	$650	
						$15,367,798
Fuel Break only	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	3,285	4,600	5,217	$11	
						$2,682,452
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	10% of 17,260	10% of 17,260	10% of 17,260	$1	
						$86,300
75% BFOD only	Application of BFOD fungi at 75% success rate in shrublands invaded by non-native annuals	0	400	512	$300	
	Application of BFOD fungi at 75% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	327	223	$650	
						$13,655,553
50% BFOD only	Application of BFOD fungi at 50% success rate in shrublands invaded by non-native annuals	0	394	710	$300	
	Application of BFOD fungi at 50% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	319	231	$650	
						$15,537,082
25% BFOD only	Application of BFOD fungi at 25% success rate in shrublands invaded by non-native annuals	0	401	792	$300	
	Application of BFOD fungi at 25% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	315	231	$650	
						$16,900,629

The average annual cost of these treatments among scenarios for the Red Cliffs NCA varied between $1,726 and $338,013 per year of implementation.

50-Year Outcomes

- Clear differences for ecological departure existed between scenarios with and without the BFOD fungi (Figure 4 top). Without the BFOD fungi, departure remained above 95%, although the MAXIMUM MANAGEMENT and PLANTING AND HERBICIDE-ONLY scenarios achieved the greatest reductions to ecological departure. Actions with the BFOD fungi reaching 75% and 50% success rates greatly reduced ecological departure from the >95% to <20% compared to the MINIMUM MANAGEMENT scenario. At a 25% success rate, ecological departure only reached an average of about 58%. For the Mojave Desert, this stunning outcome means that reference classes can be reclaimed from uncharacteristic shrublands.

- The ROI for ecological departure was close to zero and differences minimal among scenarios without the BFOD fungi (Figure 4 bottom). ROI increased dramatically with the BFOD fungi. The higher the success rate for the BFOD fungi, the greater the ROI. The difference in ROI between 75% and 50% success rates (Figure 4 bottom) were more noticeable than for ecological departure (Figure 4 top).

- Very different and more encouraging results were observed for desert tortoise departure (Figure 5 top). The lowest (best) average scores of desert tortoise departure (about -5%) were achieved in the MAXIMUM, STREAMLINED, and PLANTING AND HERBICIDE-ONLY MANAGEMENT scenarios (Figure 5 top). The next lowest score were observed for the 75% and 50% success rates of the BFOD ONLY scenarios. The FUEL-BREAK-ONLY and MINIMUM MANAGEMENT scenarios were about equal, whereas the 25% success rate BFOD-ONLY scenario achieved the highest departure at about 80%.

- The greatest ROI based on desert tortoise departure was achieved by the STREAMLINED MANAGEMENT scenario (~110), whereas the lowest ROI was realized by the BFOD-ONLY 25% SUCCESS RATE scenario (~-30) because the MINIMUM MANAGEMENT scenario did better (Figure 5 bottom). Other scenarios were about equal because of overlapping 95% confidence intervals, although a case could be made for the FUEL-BREAK-ONLY MANAGEMENT scenario as a distinct second best ROI.

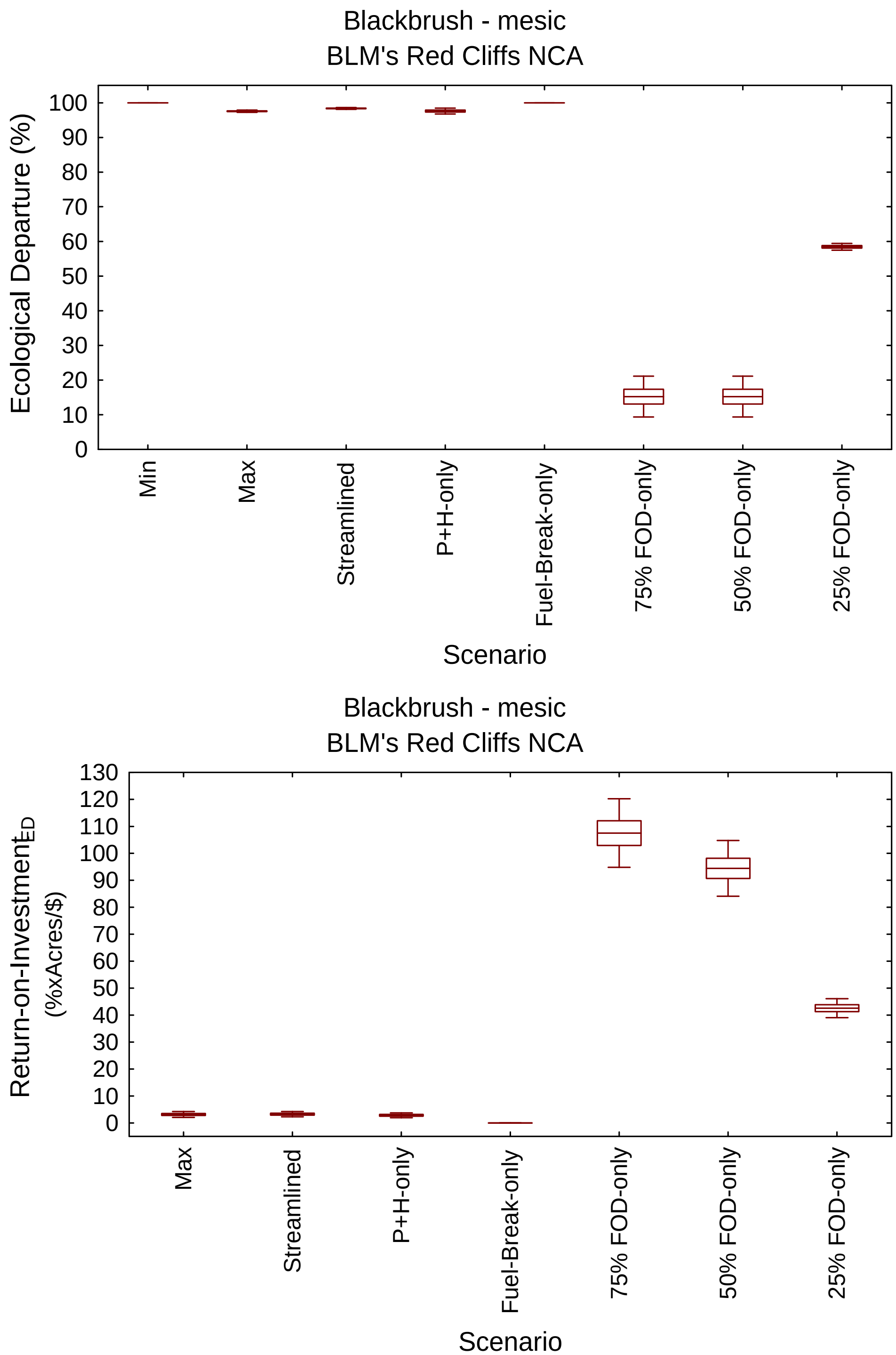


Figure 4. Ecological departure (%) and Return-on-Investment for ecological departure (subscript $_{ED}$) of blackbrush–mesic after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

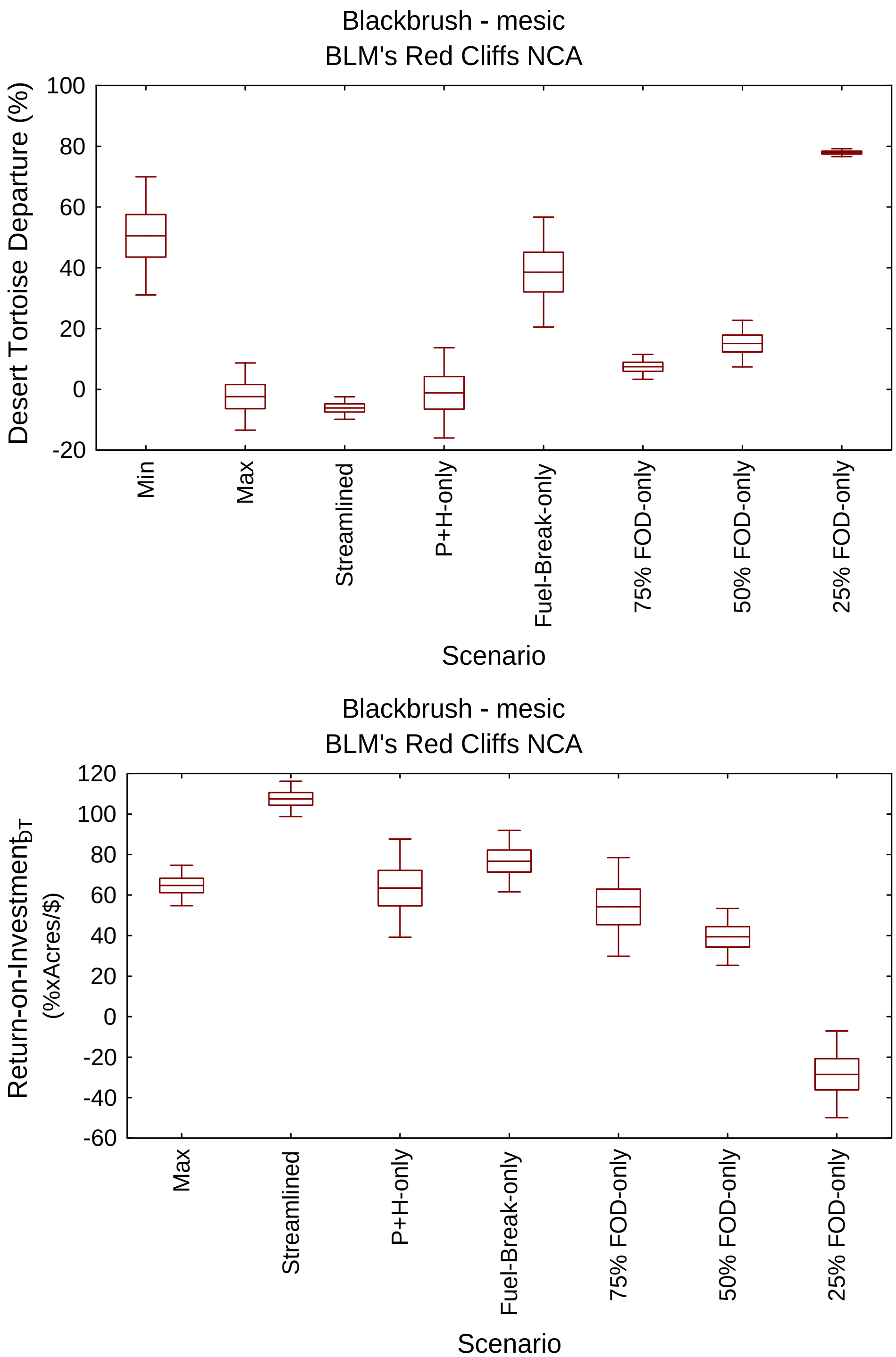


Figure 5. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of blackbrush–mesic after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

Red Cliffs NCA: Blackbrush-thermic

Thermic blackbrush is the second largest ecological system of the Red Cliffs NCA and is mostly located in the central southern part of the NCA. At present, this system exhibits complete ecological departure at 100%; however, desert tortoise departure is relatively low at 20% because shrublands invaded by non-native annuals represent 88% of the landscape. These shrublands provide shade and food to desert tortoise. The remaining 22% of the ecological system transitioned to non-native annual grasslands and forblands after burning in 2005.

After 50 years in a regime of minimum management, ecological departure did not change because acres were shuffled among uncharacteristic vegetation classes. With minimum management, wildfires converted more shrublands with non-native annuals into non-native annual grasslands and forblands. As a result, desert tortoise departure increased (i.e., became worse) from 20% to 61% reflecting the elimination of vegetation structure that provides shade and some food for desert tortoise.

BLM and stakeholders focused on a variety of treatment actions (strategies) used alone or in combination including herbicide application, native species seeding and planting, and fuel breaks.

50-Year Management Objectives

- Protect blackbrush shrublands from future fire.
- Increase native shrub and herbaceous cover in burned areas.
- Maintain desert tortoise departure below the current 20% score.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/year 1-4 yrs	Acres/year 5-19 yrs	Acres/year 20-50 yrs	Cost/acre	50-yr total cost
Maximum	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	43	223	$250	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	998	1,618	1,359	$11	
						$5,686,214
Streamlined	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	38	114	$650	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	392	3,238	3,183	$11	
						$4,305,934

Planting+ Herbicide-only	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	48	349	$650	
						$7,495,980
Fuel Break only	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	1,004	1,648	1,549	$11	
						$2,682,452
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	10% of 5,005	10% of 5,005	10% of 5,005	$1	
						$25,025
75% BFOD only	Application of BFOD fungi at 75% success rate in shrublands invaded by non-native annuals	0	74	216	$450	
	Application of BFOD fungi at 75% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	104	141	$650	
						$5,905,959
50% BFOD only	Application of BFOD fungi at 50% success rate in shrublands invaded by non-native annuals	0	350	57	$450	
	Application of BFOD fungi at 50% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	15	16	$650	
						$5,973,851
25% BFOD only	Application of BFOD fungi at 25% success rate in shrublands invaded by non-native annuals	0	74	636	$450	
	Application of BFOD fungi at 25% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	87	129	$650	
						$9,702,065

The average annual cost of these treatments among scenarios for the Red Cliffs NCA varied between $500 and $194,044 per year of implementation.

50-Year Outcomes

- Without the BFOD scenarios, ecological departure remained departed at about 100% (Figure 6 top). All three scenarios with the BFOD fungi greatly reduced ecological departure from 100% to ~10% compared to the MINIMUM MANAGEMENT scenario (Figure 6 top).

- The ROI for ecological departure was zero without the BFOD scenario (Figure 6 bottom). Given a fixed application rate of restoration actions with the BFOD fungi included, ROI increased dramatically. The ROI slightly increased with the success rate of the BFOD fungi, although the highest success rates for the fungi were associated with the highest variability.

- Compared to the MINIMUM MANAGEMENT scenario, desert tortoise departure exhibited three levels (Figure 7 top). The lowest (best) average scores of desert tortoise departure (about 0%) were achieved by the BFOD scenarios with 75% and 50% success rates. The MAXIMUM MANAGEMENT, STREAMLINED, and PLANTING AND HERBICIDE-ONLY belonged to the second lowest group at about 18%. The 25% success rate BFOD -ONLY and FUEL-BREAK-ONLY MANAGEMENT scenarios performed the least well and were only slightly better than the MINIMUM MANAGEMENT scenario.

- Due to its very low cost, the FUEL-BREAK-ONLY scenario showed the highest desert tortoise departure ROI (FIGURE 7 BOTTOM). This indicates a real benefit to fuel breaks in the absence of more aggressive restoration. The second best ROIs were about equal (although with very unequal variability) among the STREAMLINED MANAGEMENT and the BFOD WITH 75% AND 50% SUCCESS RATES scenarios (Figure 9 bottom).

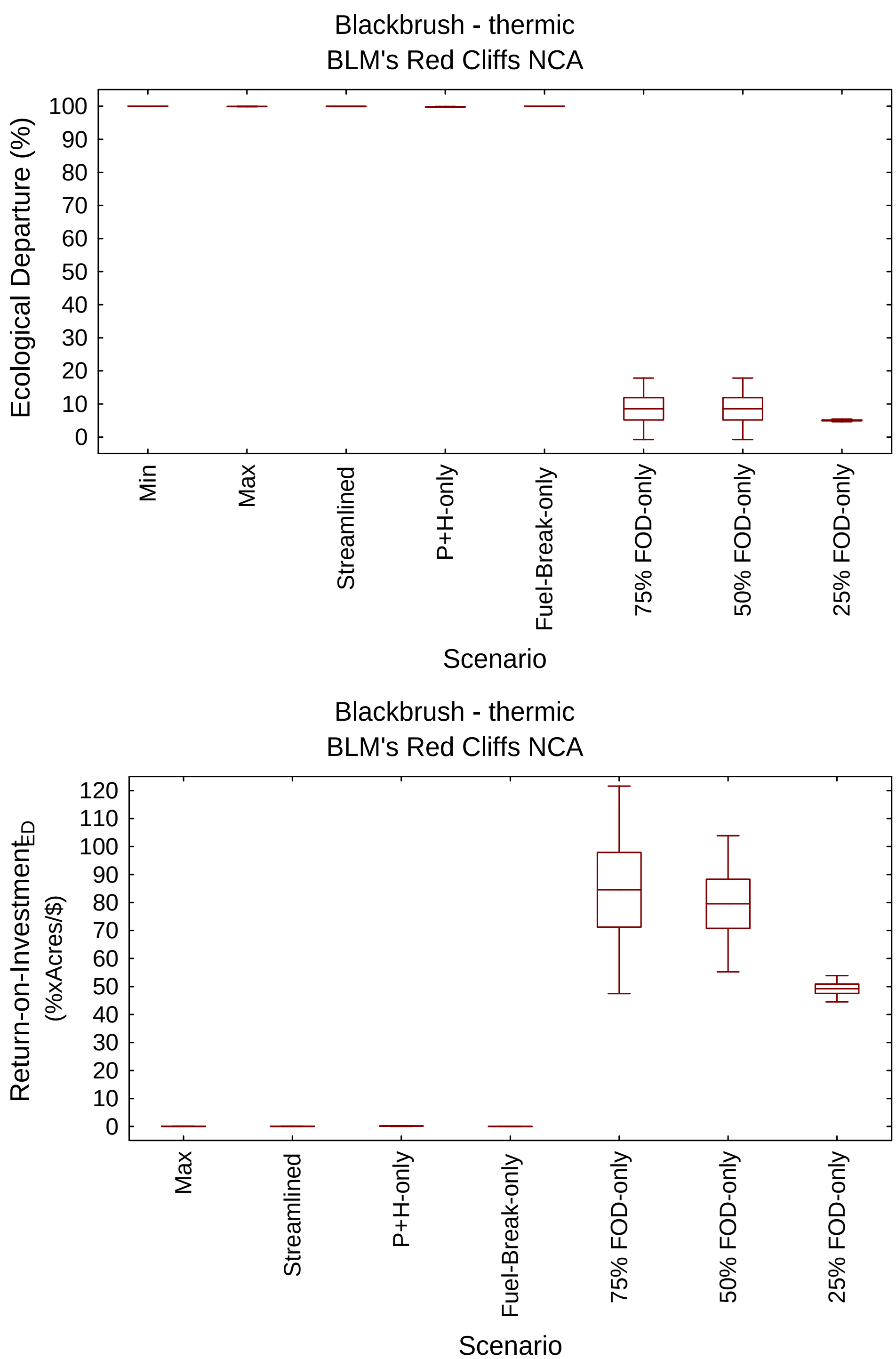


Figure 6. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of blackbrush–thermic after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

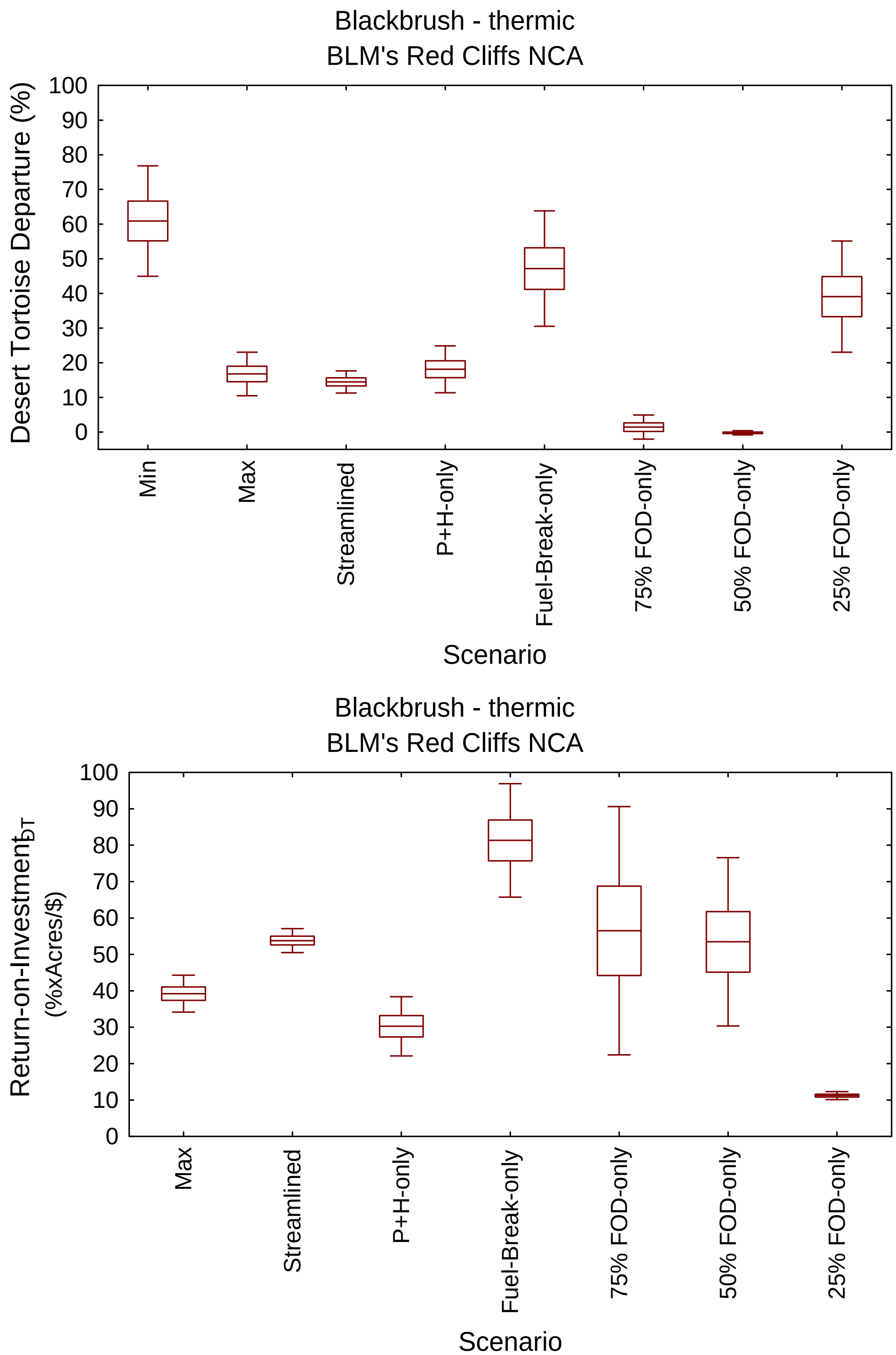


Figure 7. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of blackbrush–thermic after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

Red Cliffs NCA: Creosotebush-White Bursage

Creosotebush-white bursage is a small system, but important desert tortoise habitat, in the south-central part of Red Cliffs NCA. At present, this system exhibits complete ecological departure at 100%. Desert tortoise departure is moderate at 52%. The majority (55%) of the ecological system is non-native annual grasslands and forblands of low value to desert tortoise that resulted from the 2005 fires. Conversely, 45% remains as shrublands that provide shade and food to desert tortoise.

After 50 years in a regime of minimum management, ecological departure did not change because acres were shuffled among uncharacteristic vegetation classes. Desert tortoise departure decreased (i.e., became better) from 52% to ~40% because creosotebush and other shrubs have the ability to resprout and recover within 20 years if an area only burned once.

BLM and stakeholders focused on a variety of treatment actions (strategies) used alone or in combination including herbicide application, native species seeding and planting, and fuel breaks.

50-Year Management Objectives

- Protect creosotebush-white bursage shrublands from future fire.
- Increase native shrub and herbaceous cover in burned areas.
- Maintain desert tortoise departure below the current 40% score.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/ year			Cost/ acre	50-yr total cost
		1 to 4 yrs	5 to 19 yrs	20 to 50 yrs		
Maximum	Application of Plateau® followed by seeding of new native seed mix supplemented by germination innovations in non-native annual grasslands and forblands	0	0	51	$250	
	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	80	26	$650	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	615	1,036	1,200	$11	
						$2,148,198
Streamlined	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	80	27	$650	

	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	246	2,054	2,396	$11	
						$2,488,812
Planting+ Herbicide-only	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	84	34	$650	
						$1,491,679
Fuel Break only	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	621	1,074	1,011	$11	
						$549,173
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	10% of 3,043	10% of 3,043	10% of 3,043	$1	
						$15,215
75% BFOD only	Application of BFOD fungi at 75% success rate in shrublands invaded by non-native annuals	0	252	53	$450	
	Application of BFOD fungi at 75% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	15	16	$650	
						$2,061,399
50% BFOD only	Application of BFOD fungi at 50% success rate in shrublands invaded by non-native annuals	0	350	57	$450	
	Application of BFOD fungi at 50% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	15	16	$650	
						$2,535,144
25% BFOD only	Application of BFOD fungi at 25% success rate in shrublands invaded by non-native annuals	0	401	240	$450	
	Application of BFOD fungi at 25% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	15	21	$650	
						$4,602,307

The average annual cost of these treatments among scenarios for the Red Cliffs NCA varied between $10,983 and $92,045 per year of implementation.

50-Year Outcomes

- Without the BFOD scenarios, ecological departure remained departed at about 100% (Figure 8 top). All three scenarios with the BFOD fungi greatly reduced ecological departure from the 100% to <5% compared to the minimum management scenario (Figure 8 top).

- The ROI for ecological departure was zero without the BFOD scenario (Figure 8 bottom). ROI dramatically increased with application of the BFOD fungi. The ROI increased with the success rate of the BFOD fungi. Differences among the three success rates were strong in creosotebush-white bursage.

- Compared to the MINIMUM MANAGEMENT scenario, desert tortoise departure exhibited three levels (Figure 9 top). The lowest (best) average scores of desert tortoise departure (<0%) were achieved by the BFOD scenarios at all levels of success rates. The MAXIMUM, STREAMLINED, and PLANTING AND HERBICIDE-ONLY MANAGEMENT scenarios belonged to the second lowest group at about 12% desert tortoise departure. The FUEL-BREAK-ONLY MANAGEMENT scenario performed the least well and was only 10% better (lower) than the MINIMUM MANAGEMENT scenario.

- The PLANTING AND HERBICIDE-ONLY and the BFOD WITH 75% SUCCESS RATE scenarios showed the highest ROI for desert tortoise departure and were about equal. Due to its very low cost, the FUEL-BREAK-ONLY scenario was in second rank for ROI with the more expensive BFOD WITH 50% SUCCESS RATE scenario (Figure 9 bottom). Again, this indicates a real benefit to fuel breaks in the absence of more aggressive restoration.

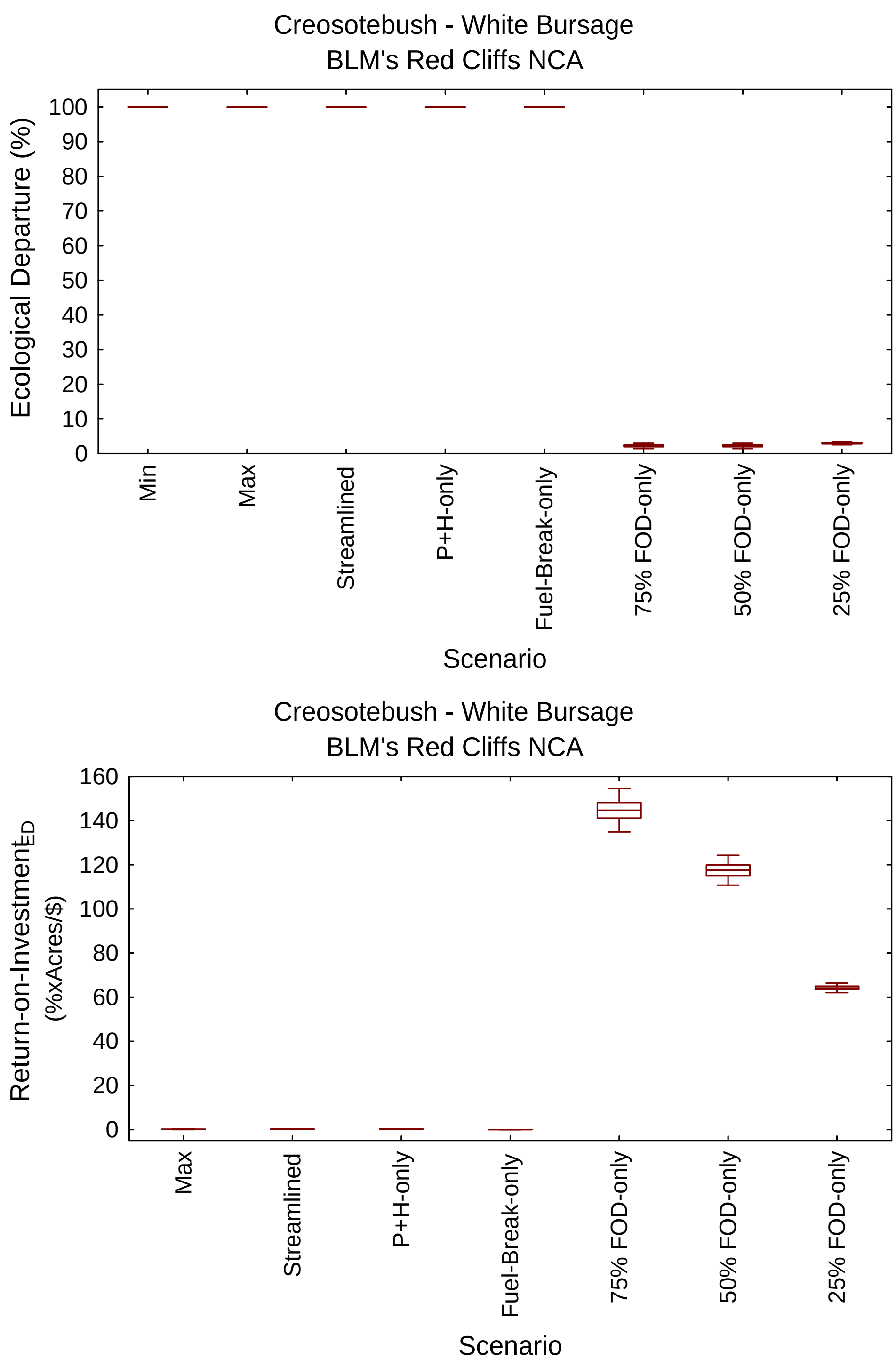


Figure 8. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of creosotebush-white bursage after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

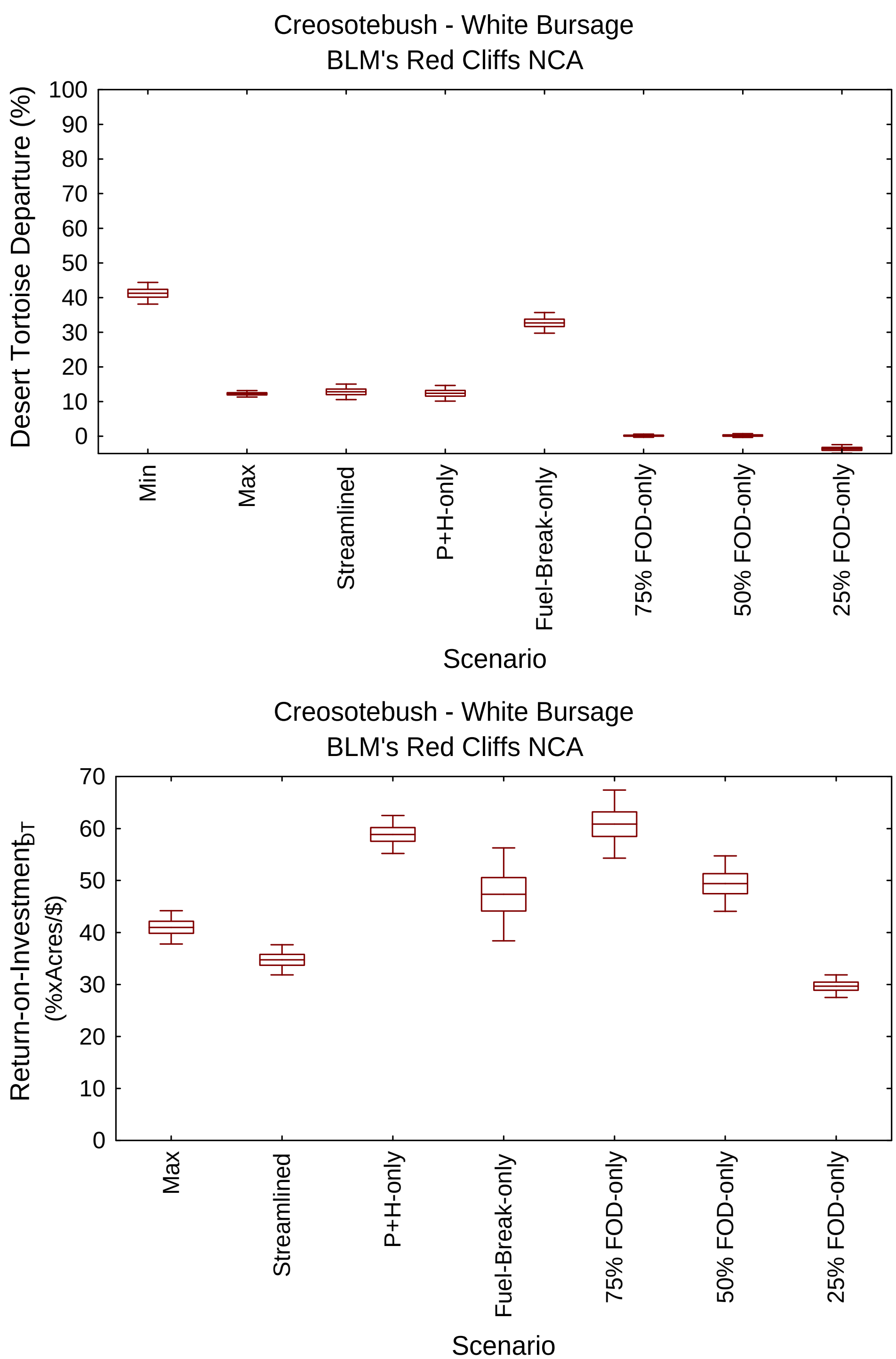


Figure 9. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of creosotebush-white bursage after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

Red Cliffs NCA: Desert Washes

Desert washes occupy 403 acres in the Red Cliffs NCA and are one of the most important desert tortoise habitats. Desert tortoise feed in the productive washes and take advantage of wash slopes for excavating dens. Desert washes are found throughout the NCA. At present, this system exhibits high ecological departure at 90%. Desert tortoise departure is moderate at 50%. Forty-three percent of the ecological system is in the early succession class due to high flood events experienced in December 2010. The remaining and majority of washes (57%) are shrublands invaded by non-native annuals and low cover of native herbaceous species.

After 50 years in a regime of minimum management, ecological departure decreased from 90% to 69% as vegetation transitioned from early to middle or late succession, thus approaching the NRV. Desert tortoise departure decreased (i.e., improved) from 50% to 36% as vegetation classes matured, although they were invaded by non-native annuals. The resulting vegetation class received higher desert tortoise suitability because increasing mature wash shrubs provide shade and food to desert tortoise.

BLM and stakeholders focused on a variety of treatment actions (strategies) used alone or in combination including aerial herbicide application, weed inventory, control of exotic saltcedar and forb species, and fuel breaks.

50-Year Management Objectives

- Protect shrublands from future fire.
- Control non-native annuals, trees, and forbs.
- Maintain desert tortoise departure below the current 36% score.

50-Year Management Strategies and Costs

Scenario	Action Description		Acres/ year		Cost/ acre	50-yr total cost
		1 to 4 yrs	5 to 19 yrs	20 to 50 yrs		
Maximum	Inventory of weeds and saltcedar for immediate control or future control	5	5	5	$55	
	Hand-cutting of saltcedar followed by immediate application of herbicide to stumps and herbicide application to exotic forbs	4	1	0	$200	
	Aerial application of Plateau® of wash shrubs invaded by non-native annuals	26	26	4	$25	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	83	145	163	$11	
						$113,194
Streamlined	Inventory of weeds and saltcedar for immediate control or future control	6	5	5	$55	

	Hand-cutting of saltcedar followed by immediate application of herbicide to stumps and herbicide application to exotic forbs	4	1	1	$200	
	Aerial application of Plateau® of wash shrubs invaded by non-native annuals	15	15	10	$11	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	33	289	787	$11	
						$187071
Fuel Break only	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	79	142	133	$11	
						$66,588
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	402	402	402	$1	
						$20,100
75% BFOD only	Application of BFOD fungi at 75% success rate in shrublands invaded by non-native annuals	0	35	3	$300	
						$137,971
50% BFOD only	Application of BFOD fungi at 50% success rate in shrublands invaded by non-native annuals	0	35	3	$300	
						$188,729
25% BFOD only	Application of BFOD fungi at 25% success rate in shrublands invaded by non-native annuals	0	100	49	$300	
						$350,985

The average annual cost of these treatments among scenarios for the Red Cliffs NCA varied between $1,332 and $7,020 per year of implementation.

50-Year Outcomes

- All scenarios, except the FUEL-BREAK-ONLY MANAGEMENT scenario, decreased ecological departure to about 20% (Figure 10 top). The FUEL-BREAK-ONLY MANAGEMENT and the MINIMUM MANAGEMENT scenario achieved similar departure at about 69% (Figure 10 top).

- The highest ROI for ecological departure was realized by the MAXIMUM MANAGEMENT scenario followed by the BFOD WITH 75% SUCCESS RATE scenario (Figure 10 bottom). Due to overlapping confidence intervals, the ROIs of the STREAMLINED and BFOD SCENARIO WITH 75% and 50% SUCCESS RATES were similar. The differences between the MAXIMUM MANAGEMENT and STREAMLINED MANAGEMENT scenarios were instructive: the former focused more on aerial spraying of non-native annuals in shrublands, whereas the latter placed more focused on increasing fuel breaks.

- Compared to the MINIMUM MANAGEMENT scenario, only four scenarios met the objective of desert tortoise departure less than 36% (Figure 11 top): MAXIMUM MANAGEMENT, STREAMLINED, and BFOD WITH 75% and 50% SUCCESS RATES. They achieved about 0% departure.

- The MAXIMUM MANAGEMENT and BFOD WITH 75% SUCCESS RATE scenarios showed the highest ROI based on desert tortoise departure (Figure 11 bottom). The STREAMLINED and BFOD WITH 50% SUCCESS RATE scenarios were close seconds for ROI.

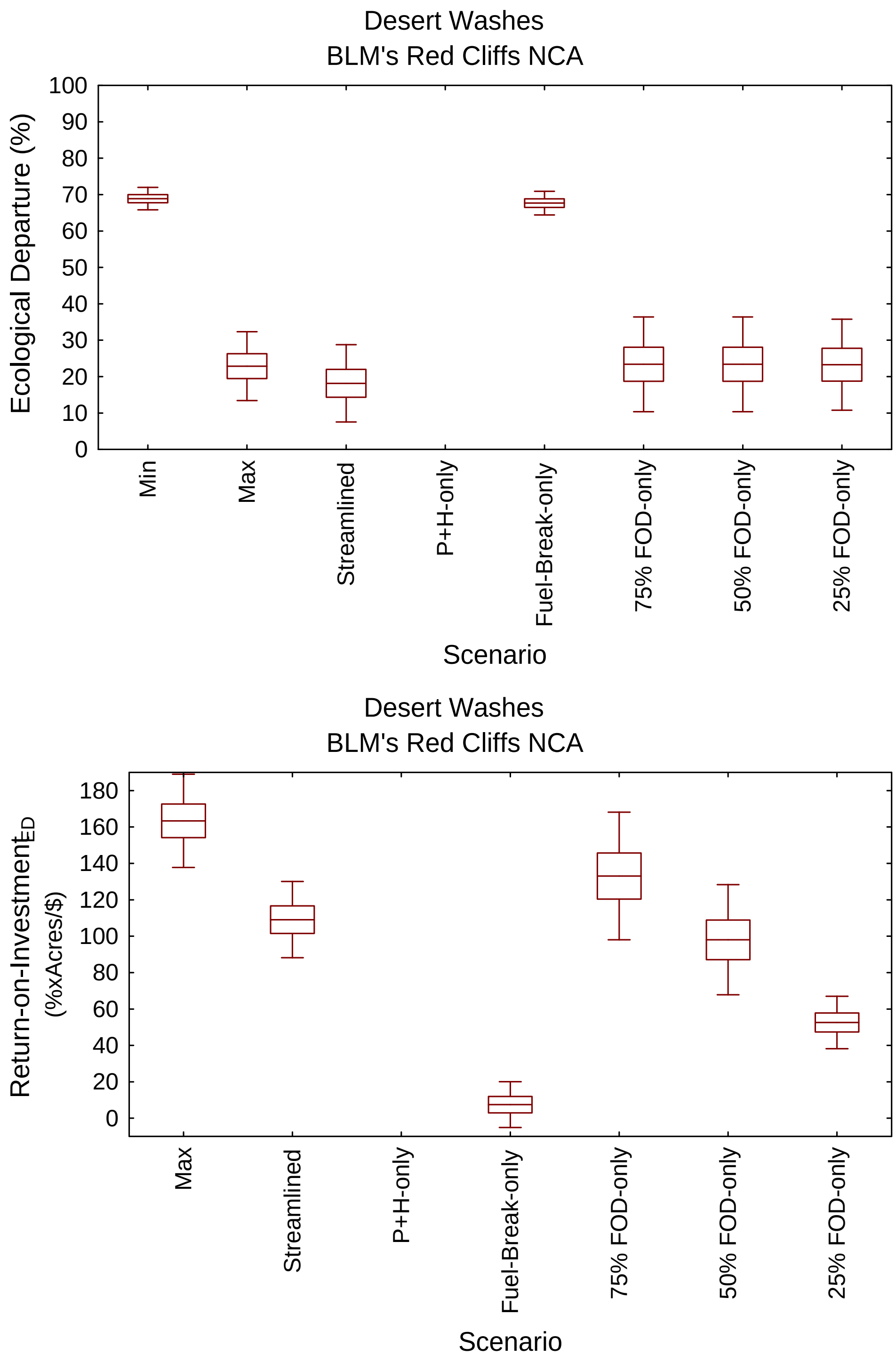
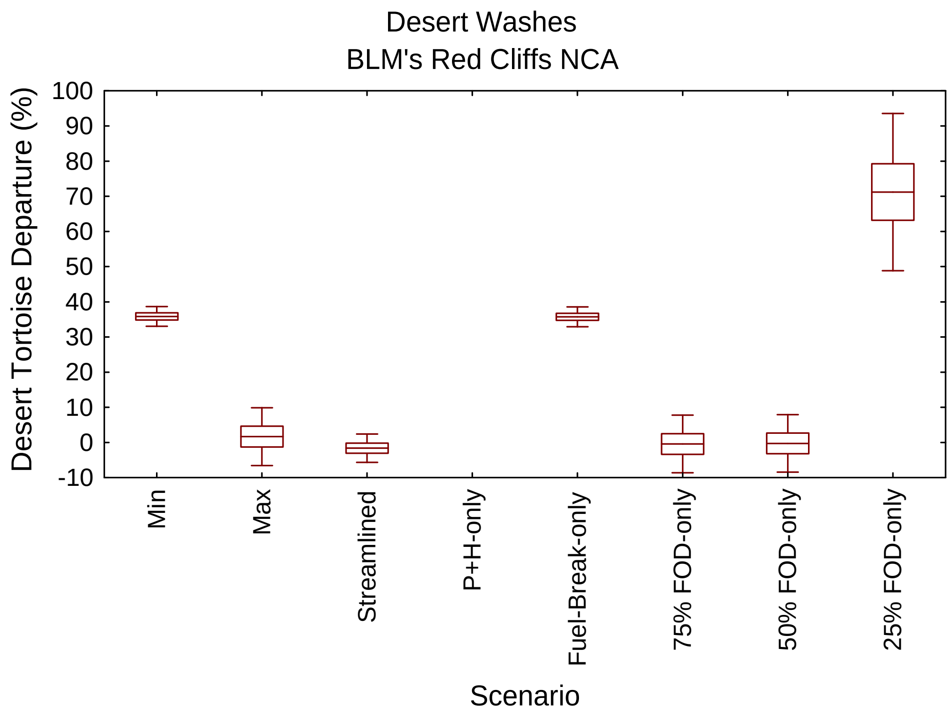


Figure 10. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of desert washes after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.



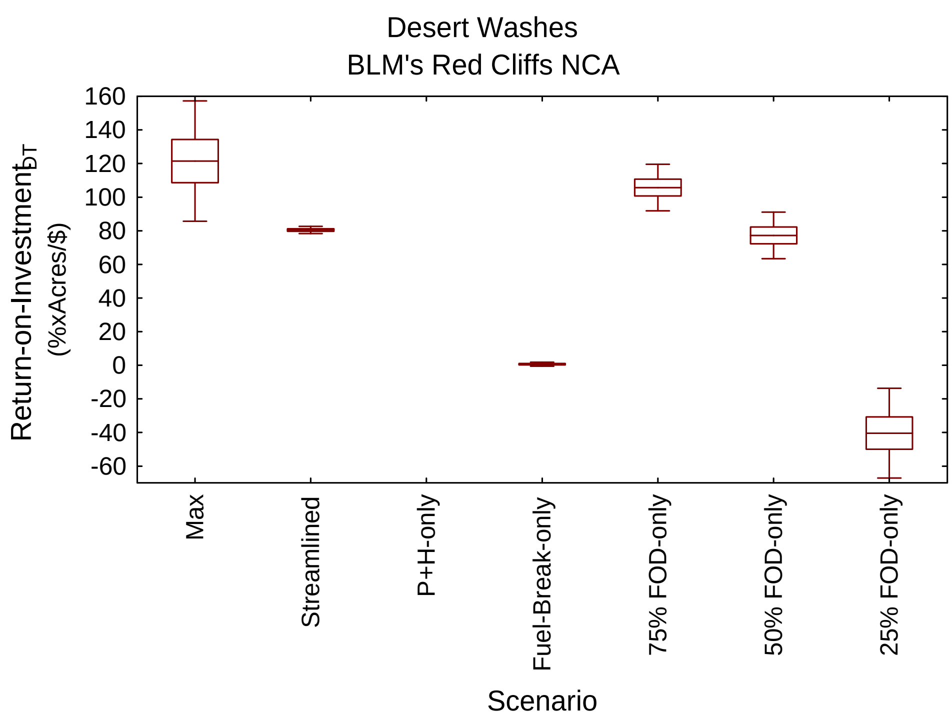


Figure 11. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of desert washes after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

Red Cliffs NCA: Desert Sand Sagebrush

The desert sand sagebrush ecological system is only found in deep sandy soils, and covers 1,586 acres of the Red Cliffs NCA. It is used by desert tortoise for borrowing and foraging. At present, this system exhibits complete ecological departure at 100% because all shrublands are invaded by non-native annuals. Desert tortoise departure is low at 13% as sand sagebrush resprouts after fire and other stand replacing disturbances.

After 50 years in a regime of minimum management, ecological departure and desert tortoise departure were not predicted to change because of the high resilience of the shrub species.

BLM and stakeholders focused on a variety of treatment actions (strategies) used in combination including aerial herbicide application and native plant seeding.

50-Year Management Objectives

- Protect shrublands from future fire.
- Control non-native annuals, trees, and forbs.
- Maintain desert tortoise departure below the current 36% score.

50-Year Management Strategies and Costs

Scenario	Action Description		Acres/ year		Cost/ acre	50-yr total cost
		1 to 4 yrs	5 to 19 yrs	20 to 50 yrs		
Maximum	Application of Plateau® to control non-native annuals followed by seeding of native grass species in non-native annual grasslands and forblands	50	50	35	$250	
						$511,748
75% BFOD only	Application of BFOD fungi at 75% success rate followed by seeding of native grass species in shrubland invaded by non-native annuals	0	99	39	$300	
						$1,219,311
50% BFOD only	Application of BFOD fungi at 50% success rate followed by seeding of native grass species in shrubland invaded by non-native annuals	0	101	50	$300	
						$1,376,278
25% BFOD only	Application of BFOD fungi at 25% success rate followed by seeding of native grass species in shrubland invaded by non-native annuals	0	100	49	$300	
						$1,357,067

The average annual cost of these treatments among scenarios for the Red Cliffs NCA varied between $10,235 and $27,526 per year of implementation.

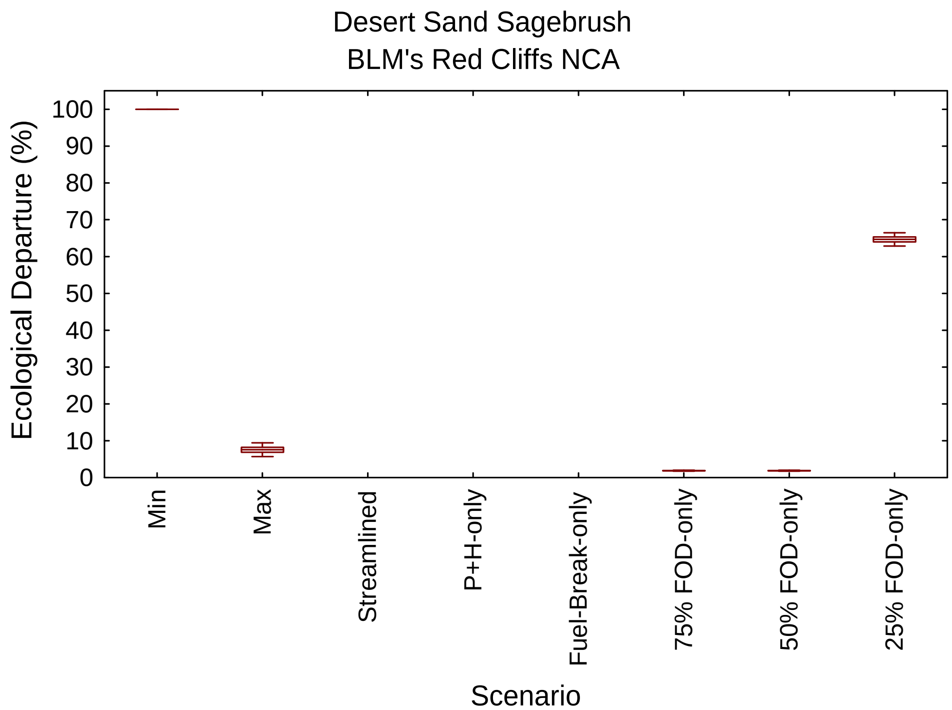
50-Year Outcomes

- The MAXIMUM MANAGEMENT and BFOD WITH 75% and 50% SUCCESS RATES scenarios reduced ecological departure to <10%. The BFOD WITH 25% SUCCESS RATE improved departure (~65%) compared to the 100% departure observed simulating the MINIMUM MANAGEMENT scenario (Figure 12 top).

- All scenarios had positive ROI based on ecological departure, but the highest ROI for ecological departure was clearly realized by the MAXIMUM MANAGEMENT scenario (Figure 12 bottom). Not surprisingly, the cost of the MAXIMUM MANAGEMENT scenario was half the price of other scenarios.

- All scenarios, except the BFOD WITH 25% SUCCESS RATE, achieved lower desert tortoise departure than the MINIMUM MANAGEMENT scenario (Figure 13 top). The BFOD WITH 75% and 50% SUCCESS RATES scenarios had lower desert tortoise departure values (0% to 5%) by 10% than the MAXIMUM MANAGEMENT scenario.

- The MAXIMUM MANAGEMENT and BFOD WITH 75% SUCCESS RATE scenario showed the highest ROI based on desert tortoise departure (FIGURE 13 BOTTOM). The ROI for the BFOD WITH 25% SUCCESS RATE scenario was strongly negative.



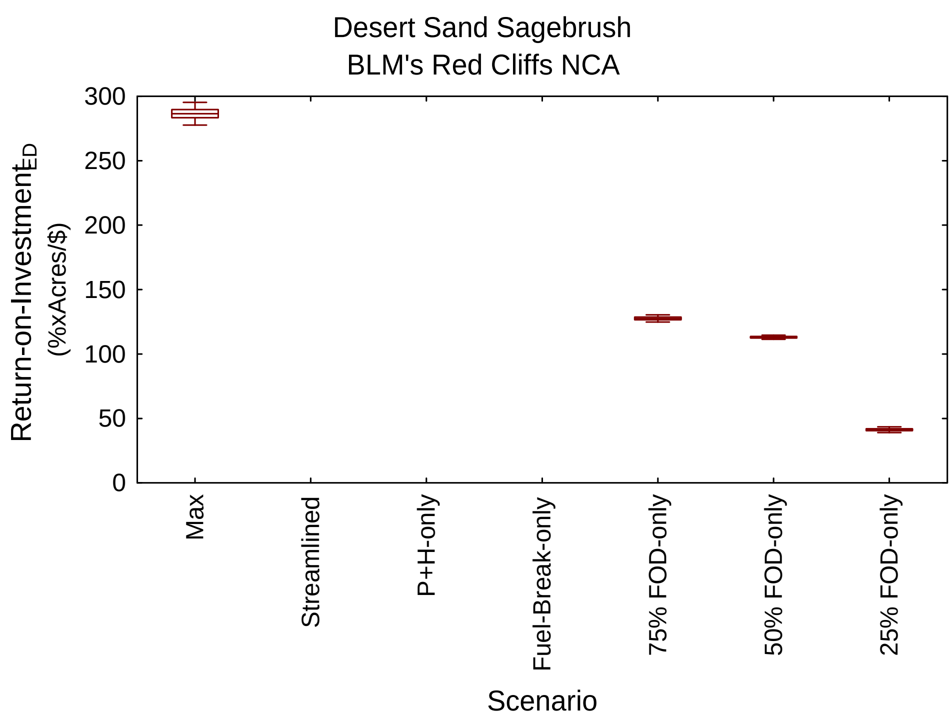
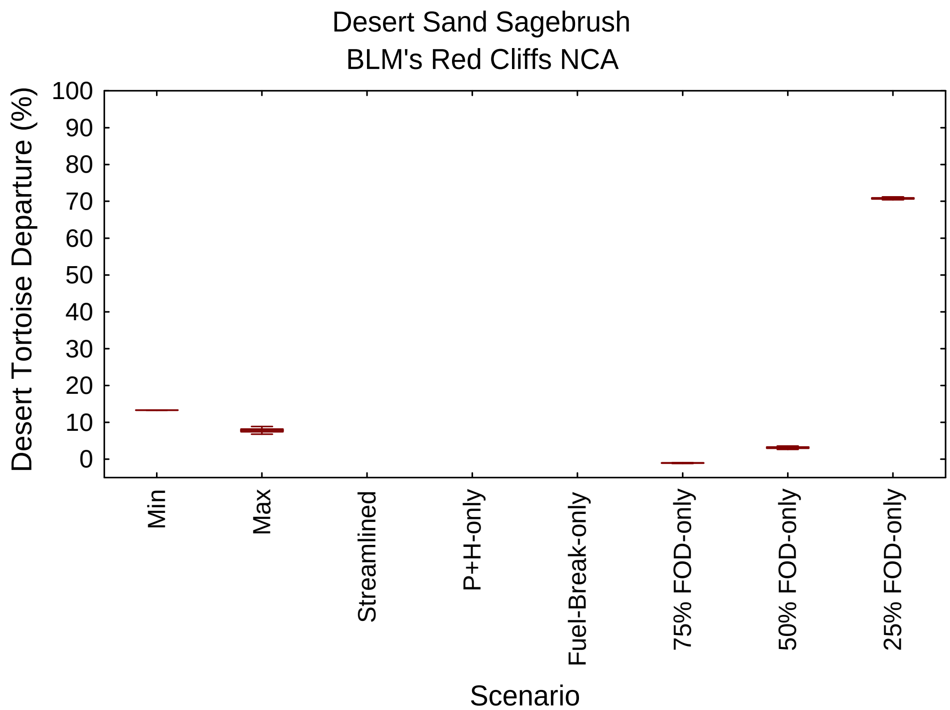


Figure 12. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of desert sand sagebrush after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.



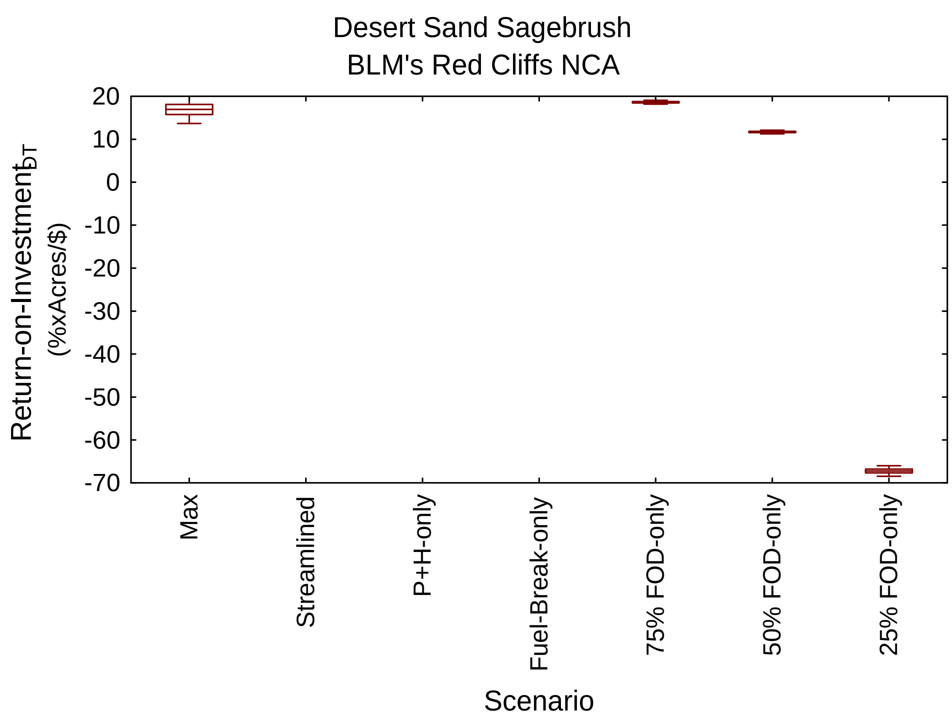


Figure 13. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of desert sand sagebrush after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

Red Cliffs NCA: Warm-Season Grassland

Warm-season grassland, at 118 acres, is only found in the fine soils and shallow depressions of the Red Cliffs NCA. It is used by desert tortoise for foraging. Grasslands currently exhibit complete ecological departure at 100% because they are all invaded by non-native annuals. Desert tortoise departure is low at 15%. Few areas of grassland are depleted of galleta grass, therefore desert tortoise scores are high.

After 50 years in a regime of minimum management, ecological departure and desert tortoise departure were not predicted to change because of the high resilience of the grassland to fire.

BLM and stakeholders focused on a variety of treatment actions (strategies) used in combination including herbicide application, native plant seeding, and fuel breaks.

50-Year Management Objectives

- Control non-native annuals.
- Restore grassland with low native grass cover.
- Maintain desert tortoise departure below 15%.

50-Year Management Strategies and Costs

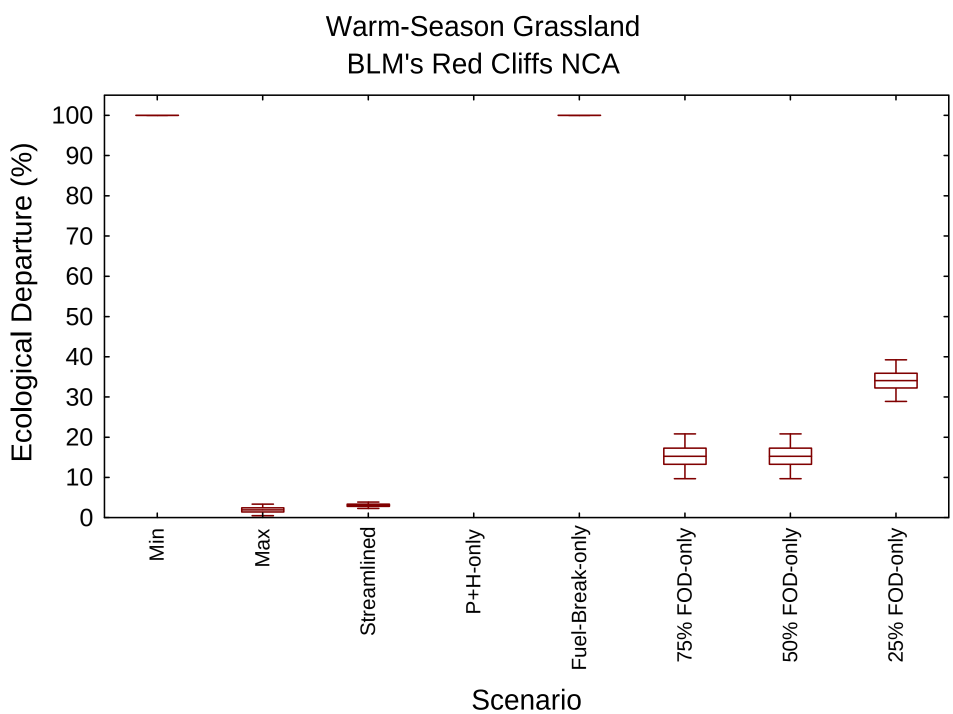
Scenario	Action Description	Acres/ year 1-4 yrs	5-19 yrs	20-50 yrs	Cost/ acre	50-yr total cost
Maximum	Application of Plateau® in grasslands invaded by non-native annuals	10	10	1	$50	
	Application of Plateau® followed by seeding of native grass species in depleted grasslands invaded by non-native annuals	2	0	0	$250	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	23	44	49	$11	
						$38,142
Streamlined	Application of Plateau® in grasslands invaded by non-native annuals	10	9	2	$50	
	Application of Plateau® followed by seeding of native grass species in depleted grasslands invaded by non-native annuals	1	0	0	$250	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	10	84	95	$11	
						$59,480
Fuel Break-only	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	23	41	39	$11	
						$21,216

75% BFOD only	Application of BFOD fungi at 75% success rate in grasslands invaded by non-native annuals	0	11	0	$300	
	Application of BFOD fungi at 75% success rate followed by seeding of native grass species in depleted grasslands invaded by non-native annuals	0	0.4	0	$450	
						$52,875
50% BFOD only	Application of BFOD fungi at 50% success rate in grasslands invaded by non-native annuals	0	101	50	$300	
	Application of BFOD fungi at 50% success rate followed by seeding of native grass species in depleted grasslands invaded by non-native annuals	0	16	0	$450	
						$73,673
25% BFOD only	Application of BFOD fungi at 25% success rate in grasslands invaded by non-native annuals	0	25	0	$300	
	Application of BFOD fungi at 25% success rate followed by seeding of native grass species in depleted grasslands invaded by non-native annuals	0	1	0		
						$119,575

The average annual cost of these treatments among scenarios for the Red Cliffs NCA varied between $424 and $2,392 per year of implementation.

50-Year Outcomes

- The MAXIMUM MANAGEMENT and STREAMLINED MANAGEMENT scenarios reduced ecological departure (<5%) more than the BFOD (15%-35%) and FUEL BREAK-ONLY scenarios (100%; Figure 14 top).
- All scenarios, except FUEL BREAK-ONLY had ROI based on ecological departure >0, but the highest ROI for ecological departure was realized by the MAXIMUM MANAGEMENT scenario (Figure 14 bottom). The FUEL BREAK-ONLY scenario was zero. The higher ROI of the MAXIMUM MANAGEMENT scenario was explained by its lower cost compared to other scenarios. The STREAMLINED and the BFOD WITH 75% SUCCESS RATE scenarios had the second highest ROIs.
- The MAXIMUM MANAGEMENT, STREAMLINED MANAGEMENT, and BFOD WITH 75% and 50% SUCCESS RATES MANAGEMENT scenarios achieved lower desert tortoise departure (~0%) than the MINIMUM MANAGEMENT scenario at 15% (Figure 15 top). Others scenarios did not meet management objectives.
- Among the four scenarios that met management objectives (<15% desert tortoise departure), the MAXIMUM MANAGEMENT scenario had the highest ROI based on desert tortoise departure (Figure 15 bottom). The cost of the MAXIMUM MANAGEMENT scenario was less than the price of other scenarios. The STREAMLINED MANAGEMENT and the BFOD WITH 75% SUCCESS RATE scenarios had the second highest ROIs. The ROI for the BFOD WITH 25% SUCCESS RATE SCENARIO was strongly negative.



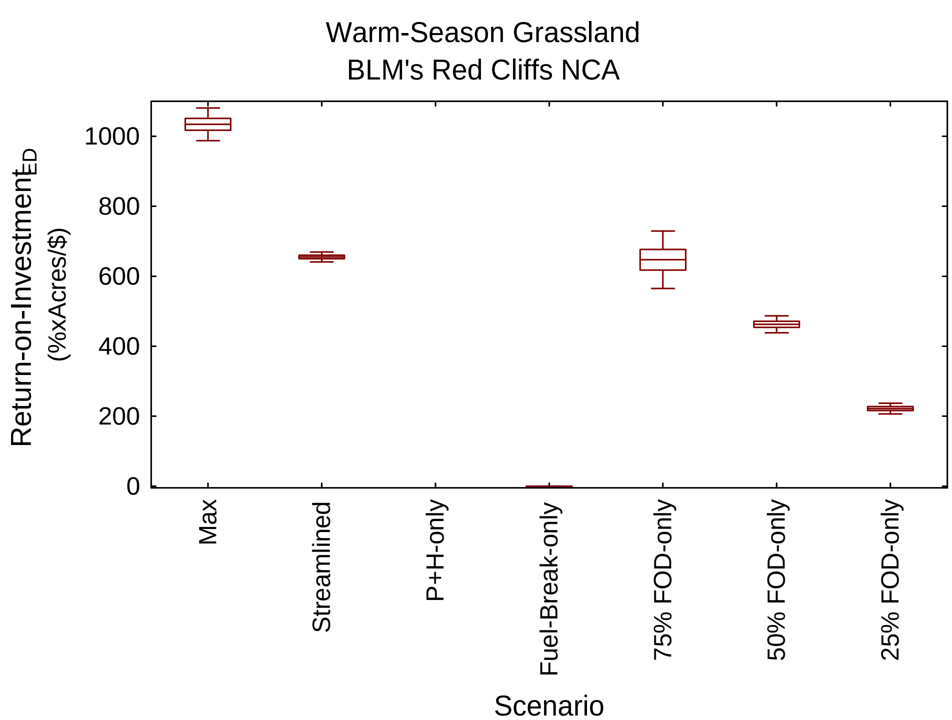


Figure 14. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of warm-season grassland after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

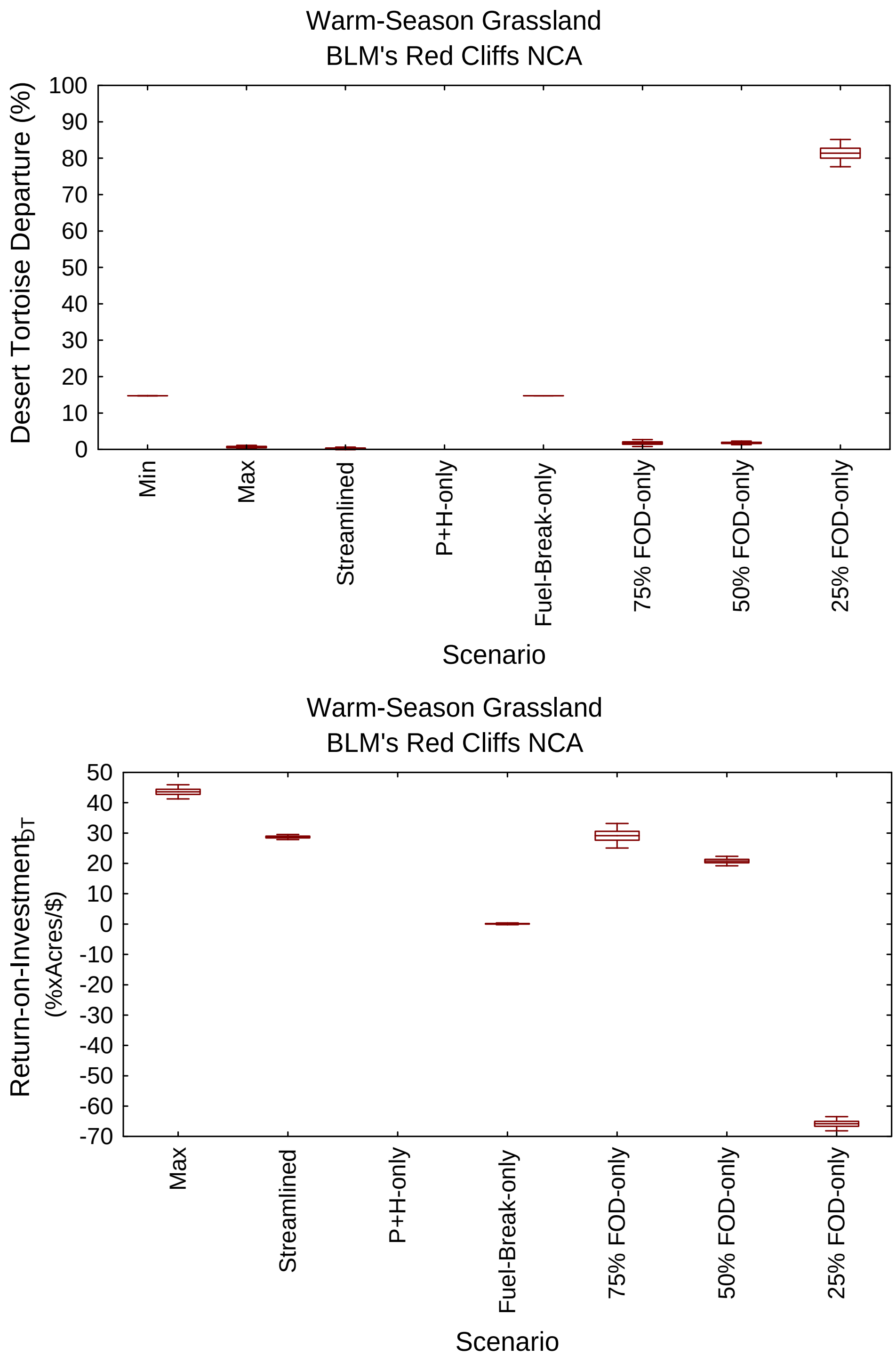


Figure 15. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of warm-season grassland after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide.

Red Cliffs NCA: Big Sagebrush Steppe

Big sagebrush steppe is found in both NCAs, but management actions were only simulated for the Red Cliffs NCA because the sagebrush acreage is too small (14 acres) in the Beaver Dam Wash NCA. Big sagebrush steppe is found above the blackbrush-mesic zone and is not used by desert tortoise. Sagebrush currently exhibits complete ecological departure at 100% because all vegetation classes are uncharacteristic. About 79% of the Red Cliff NCA's sagebrush burned in 2005 and, therefore, became non-native annual grassland. Seventeen percent of the ecological system that did not burn is shrubland, but invaded by non-native annual grasses. Tree-encroached sagebrush without visible non-native annual grasses occupies the remaining 5% of vegetation classes.

After 50 years in a regime of minimum management, ecological departure was predicted to barely change by 2%, i.e., from 100% to 98%.

BLM and stakeholders focused on one management action: herbicide application to control non-native annual grasses followed by native plant seeding, perhaps using a rangeland drill or aerial broadcasting. Therefore, there is no comparison of ROI among different scenarios. This action results in the expansion of a temporary seeded class, which is itself uncharacteristic.

50-Year Management Objectives

- Restore burned shrublands currently dominated by non-native annuals.
- Reduce the non-native annual grassland class to less than 10% of the ecological system.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/ year			Cost/ acre	50-yr total cost
		1 to 4 yrs	5 to 19 yrs	20 to 50 yrs		
Maximum	Application of Plateau® to control non-native annuals followed by seeding of native species in non-native annual grasslands and forblands	199	196	17	$250	
						$1,120,581

The average annual cost of the scenario for the Red Cliffs NCA was $24,412 per year of implementation.

50-Year Outcomes

- The MAXIMUM MANAGEMENT scenario reduced ecological departure from 98% to about 75% (Figure 16). Approximately 82% of vegetation classes were in the seeded state after 50 years, 10% in the late-closed class (class C), and 3% in the early succession class. The non-native annual grassland class was predicted to be less than 3%. The 75% departure overestimates the future ecological condition of big sagebrush steppe because of the size of the seeded class that will transition to reference classes with time.

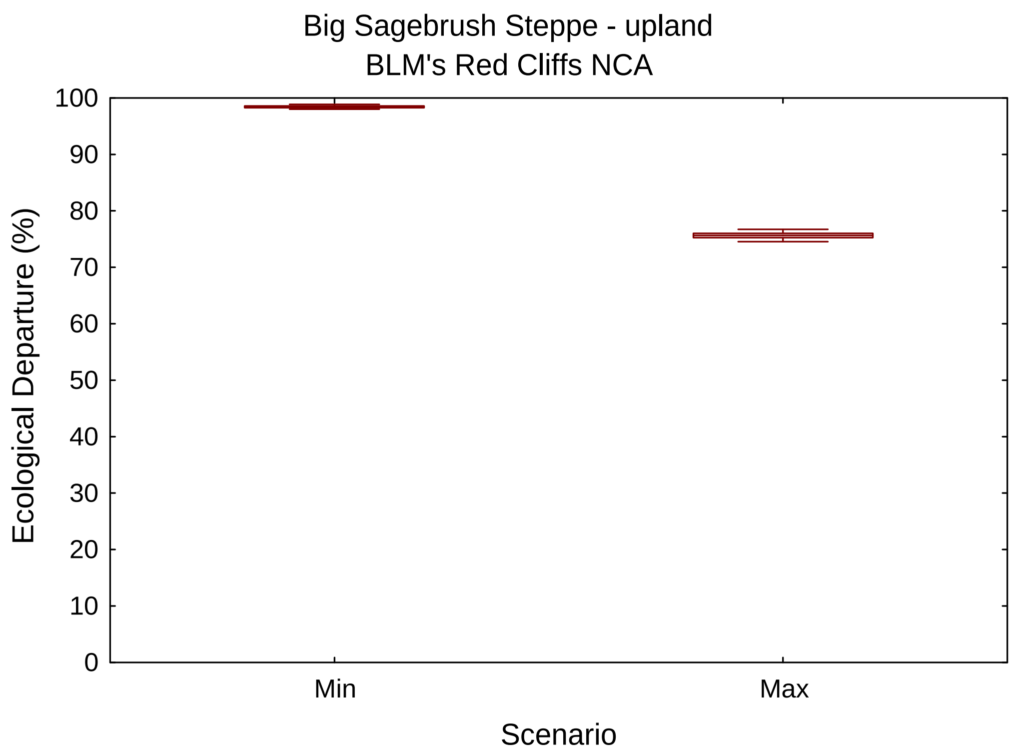


Figure 16. Ecological departure (%)of big sagebrush steppe after 50 years simulating different management scenarios for the Red Cliffs NCA. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates.

Red Cliffs NCA: Montane Riparian

The montane riparian ecological system is small (40 acres), heterogeneous, usually above the 12-inch precipitation zone, and found only in the eastern part of the Red Cliffs NCA. Plant and animal species diversity are high. Typical dominant woody species are Fremont cottonwood, willows (several species), other riparian trees and shrubs, and Wood's rose. At present, this system exhibits high ecological departure at 99%. Although many creeks appear to be in good hydrological condition, saltcedar is found throughout the system.

After 50 years in a regime of minimum management, ecological departure increased to 100% from 99% due to exotic tree and forb species invasion, even including saltcedar beetle biocontrol. These levels of departure and exotic forb invasion were judged unacceptable.

BLM and stakeholders focused on one management action: chainsaw cutting of saltcedar followed by immediate herbicide application to stumps and herbicide application to exotic forb species if found.

50-Year Management Objectives

- Restore the montane riparian ecological departure to <33% ecological departure.
- Contain uncharacteristic classes to <11%.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/ year			Cost/ acre	50-yr total cost
		1 to 4 yrs	5 to 19 yrs	20 to 50 yrs		
Maximum	Chainsaw cutting of saltcedar flowed by application of herbicide to control exotic saltcedar and forbs	9	3	1	$200	
						$113,193

The average annual cost of the scenario for the Red Cliffs NCA was $2,263 per year of implementation.

50-Year Outcomes

- The MAXIMUM MANAGEMENT scenario reduced ecological departure from 100% to about 26% (Figure 17), thus meeting management objective for ecological departure. Less than 8% of the montane riparian was occupied by exotic trees and forbs in all replicate simulations.

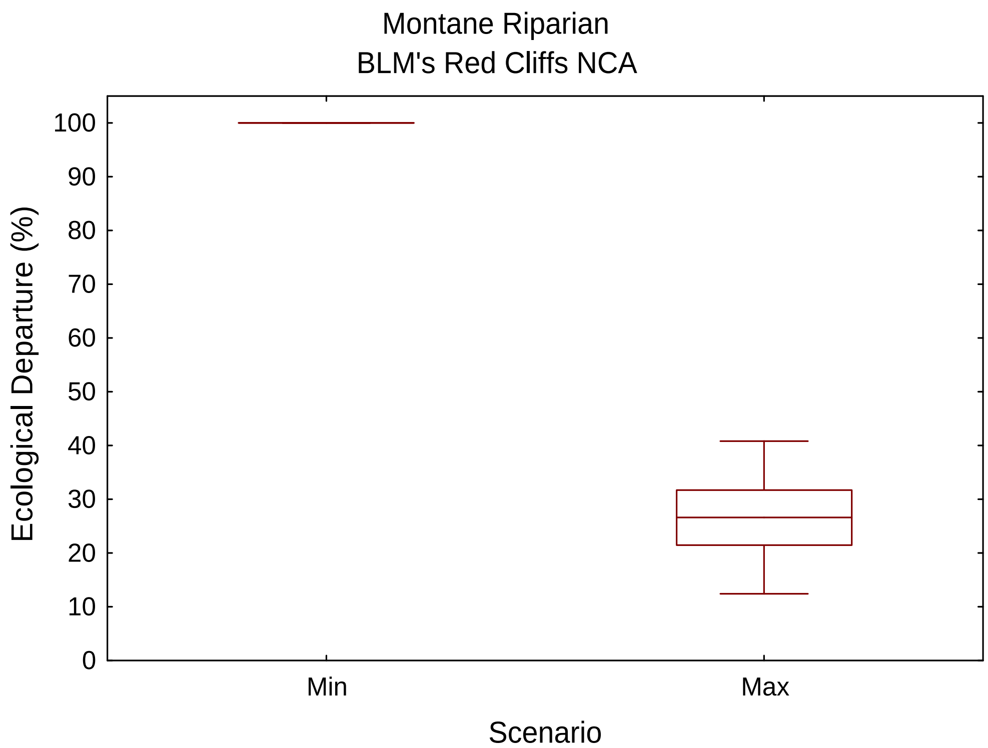


Figure 17. Ecological departure (%) of montane riparian after 50 years simulating different management scenarios for the Red Cliffs NCA. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates.

Red Cliffs NCA: Mountain Shrub

The mountain shrub ecological system is small (4.2 acres) and the presence of Stansbury cliffrose makes it critical mule deer winter range. Mountain shrubs are found within the big sagebrush steppe and pinyon-juniper woodland zone. In the Red Cliffs, the mountain shrub extends outside the NCA. Mountain shrub currently exhibits complete ecological departure at 100% because all vegetation classes are uncharacteristic. About 64% of the Red Cliff NCA's mountain shrub burned and is in the non-native annual grassland class. Seven percent of the ecological system that did not burn is shrubland, but invaded by non-native annual grasses. Tree-encroached mountain shrub without visible non-native annual grasses occupies 29% of vegetation classes.

After 50 years in a regime of minimum management, ecological departure remained at 100%. The vegetation class representing shrubs invaded by non-native annual grass were predicted to increase at the expense of non-native annual grasslands. Without increased fire activity, cliffrose could reestablish from seed within a few years.

BLM and stakeholders focused on two management actions in one scenario: herbicide application to control non-native annual grasses followed by cliffrose seeding in non-native annual grasslands, and herbicide application to control non-native annual grasses followed by native grass seeding in shrublands invaded by non-native annual grass. Cliffrose is commonly used in mine reclamation and mule deer habitat restoration projects, therefore these actions should be well established.

50-Year Management Objectives

- Restore ecological departure to at least moderate levels (<67%).
- Reduce the non-native annual grassland class to less than 10% of the ecological system.
- Reduce the shrublands invaded by non-native annual grass to less than 10%.

50-Year Management Strategies and Costs

Scenario	Action Description		Acres/ year		Cost/ acre	50-yr total cost
		1 to 4 yrs	5 to 19 yrs	20 to 50 yrs		
Maximum	Application of Plateau® to control non-native annuals followed by seeding of Stansbury cliffrose in non-native annual grasslands and forblands	<1	0	0	$100	
	Application of Plateau® to control non-native annuals followed by seeding of native grasses in shrublands invaded by non-native annuals	1	0	0	$250	
						$1,023

The average annual cost of the scenario for the Red Cliffs NCA was $20 per year of implementation.

50-Year Outcomes

- The MAXIMUM MANAGEMENT scenario reduced ecological departure from 100% to about 39% (Figure 18). There was large variability among replicates with ecological departure varying between 23% and 53%. The non-native annual grasslands and shrublands invaded by non-native annual grass were largely eliminated, however the tree-encroached class persisted (average of 20%) in many replicates that did not burn. Reference classes approached NRV.

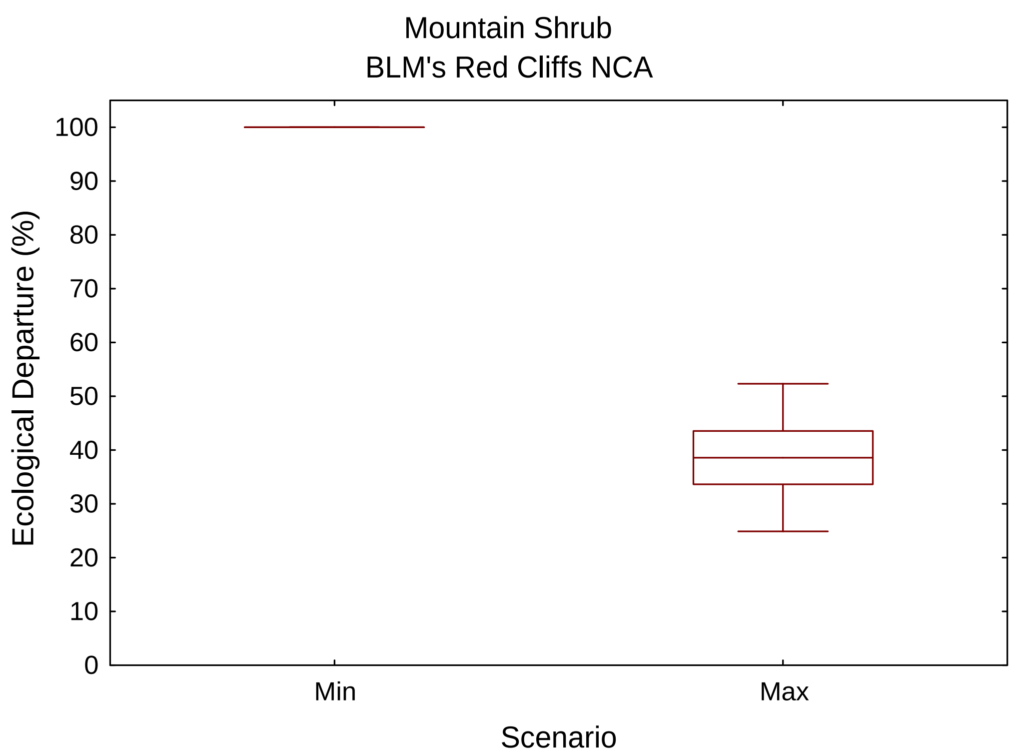


Figure 18. Ecological departure (%) of mountain shrub after 50 years simulating different management scenarios for the Red Cliffs NCA. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates.

Red Cliffs NCA: Pinyon-Juniper Woodland

Pinyon-juniper woodland is found in both NCAs, but management actions were only simulated for the Red Cliffs NCA because pinyon-juniper woodland is too small (270 acres) and very difficult to access in the Beaver Dam Wash NCA. A large fraction of pinyon-juniper woodland in the Red Cliffs NCA is located in the Red Mountain Wilderness. Pinyon-juniper woodland currently exhibits complete ecological departure at 100% because all vegetation classes are non-native annual grass.

After 50 years in a regime of minimum management, ecological departure was unchanged. Approximately 20% of woodlands burned in 50 years, resulting in non-native annual grasslands.

BLM and stakeholders focused on two management actions for one scenario: hand application of herbicide to control non-native annual grasses under the canopy of trees, and herbicide application to control non-native annual grasses followed by aerially applied native plant seeding. Therefore, there is no comparison of ROI among different scenarios.

50-Year Management Objectives

- Reduce ecological departure to moderate levels (<67%).
- Restore burned areas as they are created by future wildfires.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/ year 1 to 4 yrs	5 to 19 yrs	20 to 50 yrs	Cost/ acre	50-yr total cost
Maximum	Application of Plateau® to control non-native annuals under the canopy of trees	101	101	100	$50	
	Application of Plateau® to control non-native annuals followed by aerial seeding of native species in non-native annual grasslands and forblands	0	0	22	$250	
						$420,220

The average annual cost of the scenario for the Red Cliffs NCA was $8,404 per year of implementation.

50-Year Outcomes

- The MAXIMUM MANAGEMENT scenario reduced ecological departure from 100% to about 22% (Figure 19). Approximately 63% of vegetation classes were trees with non-native annual grass in the understory after 50 years and about 28% were in the late-closed class (class D) as a result of understory herbicide spraying.

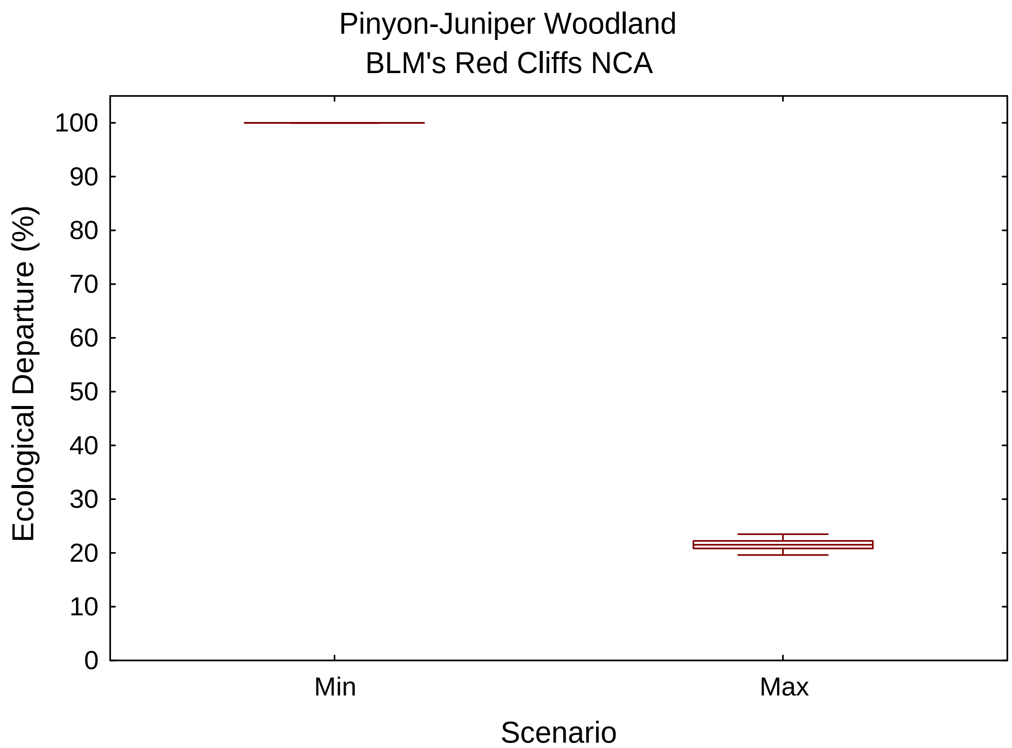


Figure 19. Ecological departure (%) of pinyon-juniper woodland after 50 years simulating different management scenarios for the Red Cliffs NCA. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates.

Red Cliffs NCA: Warm Desert Riparian

The warm desert riparian ecological system is small (160 acres) and consists of the Virgin River and low-elevation tributaries to it. Plant and animal species diversity are typically very high. Typical dominant woody species are Fremont cottonwood, Goodding's willow, mesquite, velvet ash, other willows (several species), and other riparian trees and shrubs. At present, this system exhibits complete ecological departure at 100%. Saltcedar is found in 21% of the system, whereas the remaining 79% of the warm desert riparian has an understory of non-native annual species.

After 50 years in a regime of minimum management, ecological departure decreased to 71% from 100% due to several factors. The saltcedar biocontrol beetle allowed recruitment into a) reference classes, and b) the exotic forb class (for example, Russian knapweed), a common pathway after removal of saltcedar. Severe flooding also caused transition of mature riparian vegetation to the early succession class. These levels of departure and exotic forb invasion were judged unacceptable.

BLM and stakeholders focused on several management actions: weed inventory, chainsaw cutting of saltcedar followed by immediate herbicide application to stumps, herbicide application to exotic forb species, hand spraying of herbicide to control non-native annuals in the understory of trees and shrubs, and law enforcement.

50-Year Management Objectives

- Restore the warm desert riparian ecological departure to <67% (moderate departure) ecological departure.
- Contain exotic trees and forbs to <11% cover.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/ year 1 to 4 yrs	5 to 19 yrs	20 to 50 yrs	Cost/ acre	50-yr total cost
Maximum	Inventory of weeds and saltcedar for immediate control or future control	5	5	5	$55	
	Hand-cutting of saltcedar followed by immediate application of herbicide to stumps and herbicide application to exotic forbs	4	1	0	$200	
	Application of herbicide to control exotic forbs	1	1	1	$50	
	Hand application of Plateau® to riparian woodland's understory invaded by non-native annuals	11	11	3	$50	
						$111,767
Streamlined	Inventory of weeds and saltcedar for immediate control or future control	6	5	5	$55	

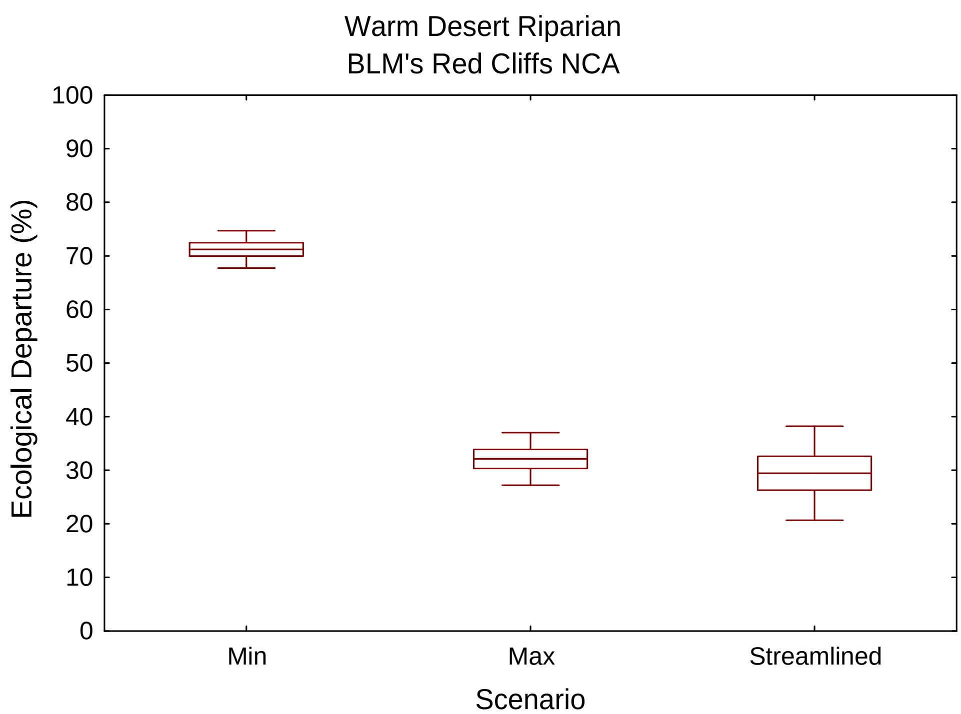
	Hand-cutting of saltcedar followed by immediate application of herbicide to stumps and herbicide application to exotic forbs	4	1	1	$200	
	Application of herbicide to control exotic forbs	2	1	1	$50	
	Hand application of Plateau® to riparian woodland's understory invade by non-native annuals	31	30	30	$50	
						$112,175
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	160	160	160	$1	
						$8,700

The average annual cost among scenarios for the Red Cliffs NCA varied between $2,235 and $2,243 per year of implementation.

50-Year Outcomes

- Differences in ecological departure between the MAXIMUM MANAGEMENT and STREAMLINED MANAGEMENT scenarios were small and ranged between 32% and 30% (Figure 20 top), thus meeting management objective for ecological departure. Exotic trees and forbs were <7% for the MAXIMUM MANAGEMENT scenario and <8% for the STREAMLINED MANAGEMENT scenario. Again, these results met management objectives. The largest difference between the two scenarios was the near elimination of trees with a non-native annual grass understory in the STREAMLINED MANAGEMENT scenario, whereas about 15% of this vegetation class persisted in the MAXIMUM MANAGEMENT scenario.

- There was no statistical difference for ROI between the two scenarios (Figure 20 bottom).



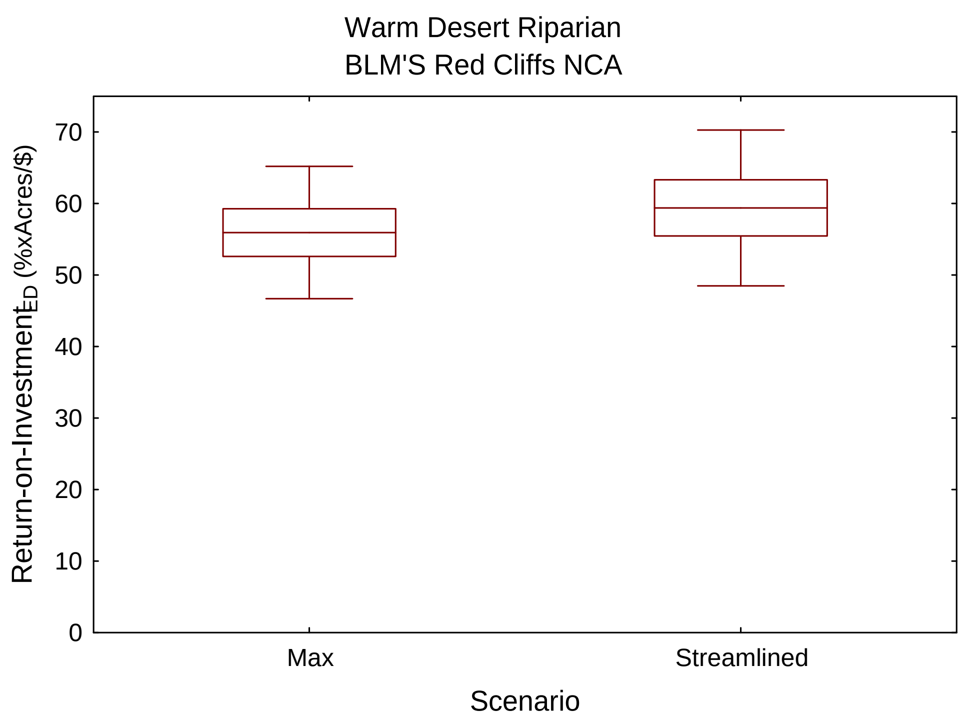


Figure 20. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of warm desert riparian after 50 years simulating different management scenarios for the Red Cliffs NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates.

Beaver Dam Wash NCA: Blackbrush-mesic

Mesic blackbrush is the largest ecological system of the Beaver Dam Wash NCA and is found from southeast to northwest in the NCA. At present, this system exhibits complete ecological departure at 100%. However, desert tortoise departure is moderate at 58% because shrublands invaded by non-native annual species represent 27% of the landscape. These shrublands provide shade and some food to desert tortoise. About 63% of the ecological system coverted to non-native annual grasslands and forblands, which have more limited value to desert tortoise, after the wildfires of 2005.

After 50 years in a regime of minimum management, ecological departure did not change because acres remained as non-native annual grasslands and forblands. Additional wildfires, which converted more shrublands with non-native annuals into non-native annual grasslands and forblands in shrublands, were limited. With respect to desert tortoise departure, the case of minimum management in the Beaver Dam Wash NCA was very different than for the Red Cliffs NCA: desert tortoise departure decreased from 58% to 20%. Mojave Desert shrubs and some forbs can either resprout or recover from **one** fire within 20 years; this recovery adds up as the area of recovery represents 63% of the largest ecological system. This additional vegetation structure provides shade and some food to desert tortoise and, as a result, desert tortoise departure decreased. This special outcome would not be possible after 2 or more fires in the same location (Callison et al. 1985; Abella et al. 2009a; Engel and Abella 2011).

BLM and stakeholders focused on a variety of treatment actions (strategies) used alone or in combination including herbicide application, native species seeding and planting, fuel breaks, special livestock management, and law enforcement.

50-Year Management Objectives

- Protect blackbrush shrublands from future fire.
- Increase native shrub and herbaceous cover in burned areas.
- Maintain desert tortoise departure below the current 20% score.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/ year 1 to 4 yrs	5 to 19 yrs	20 to 50 yrs	Cost/ acre	50-yr total cost
Maximum	Application of Plateau® followed by seeding of new native seed mix supplemented by germination innovations in non-native annual grasslands and forblands	0	0	20	$250	
	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	670	47	$650	

	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	7,786	6,835	7,636	$11	
	Prevent grazing of seedings and plantings for 10 years	0	44	69	$11	
						$14,782,333
Streamlined	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	348	253	$650	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	7,765	6,883	7,621	$11	
	Prevent grazing of seedings and plantings for 10 years	0	21	80	$11	
						$12,598,839
Planting+ Herbicide-only	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	676	332	$650	
						$13,293,550
Planting+ Herbicide & Livestock-Closure	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	674	299	$650	
	Prevent grazing of seedings and plantings for 10 years, and reduce livestock stocking rate in desert washes	0	66	110	$11	
						$12,587,570
No-Grazing only	Make public lands of NCA unavailable for livestock grazing; third-party purchase of AUMs from permittees	33,628 once			$11	
						$369,908
Fuel Break only	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	7,784	6,846	7,407	$11	
						$4,598,685
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	33,628	33,628	33,628	$1	
						$1,681,400
75% BFOD only	Application of BFOD fungi at 75% success rate in shrublands invaded by non-native annuals	0	497	1,304	$450	

	Application of BFOD fungi at 75% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	497	226	$650	
						$23,045,879
50% BFOD only	Application of BFOD fungi at 50% success rate in shrublands invaded by non-native annuals	0	499	1,700	$450	
	Application of BFOD fungi at 50% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	497	256	$650	
						$25,426,271
25% BFOD only	Application of BFOD fungi at 25% success rate in shrublands invaded by non-native annuals	0	498	1705	$450	
	Application of BFOD fungi at 25% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	491	279	$650	
						$26,264,125

The average annual cost of these treatments among scenarios for the Beaver Dam Wash NCA varied between $7,936 and $525,283 per year of implementation.

50-Year Outcomes

- Clear differences for ecological departure existed between scenarios with and without the BFOD fungi (Figure 21 top). Without the BFOD fungi, departure remained above 95%, although the MAXIMUM MANAGEMENT, PLANTING AND HERBICIDE-ONLY and PLANTING AND HERBICIDE & LIVESTOCK CLOSURE-ONLY scenarios achieved the greatest reductions to ecological departure. Actions with the BFOD fungi reaching 75% and 50% success rates greatly reduced ecological departure from the >95% to <23% compared to the MINIMUM MANAGEMENT scenario. At a 25% success rate, ecological departure only reached about an average of 58%. As observed for the Red Cliffs NCA, the promise of the BFOD fungi states the potential to restore reference classes from uncharacteristic shrublands.

- The ROI for ecological departure was close to zero and differences minimal among scenarios without the BFOD fungi (Figure 21 bottom). Given a fixed application rate of restoration actions ROI increased dramatically with the BFOD fungi. The ROI increased with the success rate of the BFOD fungi. The larger variability around the mean for the BFOD-ONLY WITH 50% SUCCESS RATE scenario compared to the 75% and 25% success rate may indicate that 50% might be a tipping point between excellent and weak performance for the BFOD fungi (Figure 21 top).

- All scenarios, except NO-GRAZING-ONLY, achieved a lower desert tortoise departure score than MINIMUM MANAGEMENT (Figure 22 top). The lowest (best) average scores of desert tortoise departure (about -3% to -7%) were achieved in the MAXIMUM, STREAMLINED, and PLANTING AND HERBICIDE-ONLY, and PLANTING AND HERBICIDE & LIVESTOCK CLOSURE-ONLY, and all three success rates of the BFOD-ONLY MANAGEMENT scenarios (Figure 22 top). The next lowest score was observed for the FUEL-BREAK-ONLY scenario at about 10%.

- Several scenarios achieve comparable high ROI for desert tortoise departure, with the highest being FUEL-BREAK-ONLY, PLANTING AND HERBICIDE & LIVESTOCK CLOSURE-ONLY, and STREAMLINED MANAGEMENT scenarios (Figure 22 bottom). The PLANTING AND HERBICIDE & LIVESTOCK CLOSURE-ONLY and MAXIMUM MANAGEMENT scenarios were close to the top performers. A clear second group with intermediate ROIs was the three BFOD management scenarios. The NO-GRAZING-ONLY scenario varied between having low and negative ROI depending on replicates.

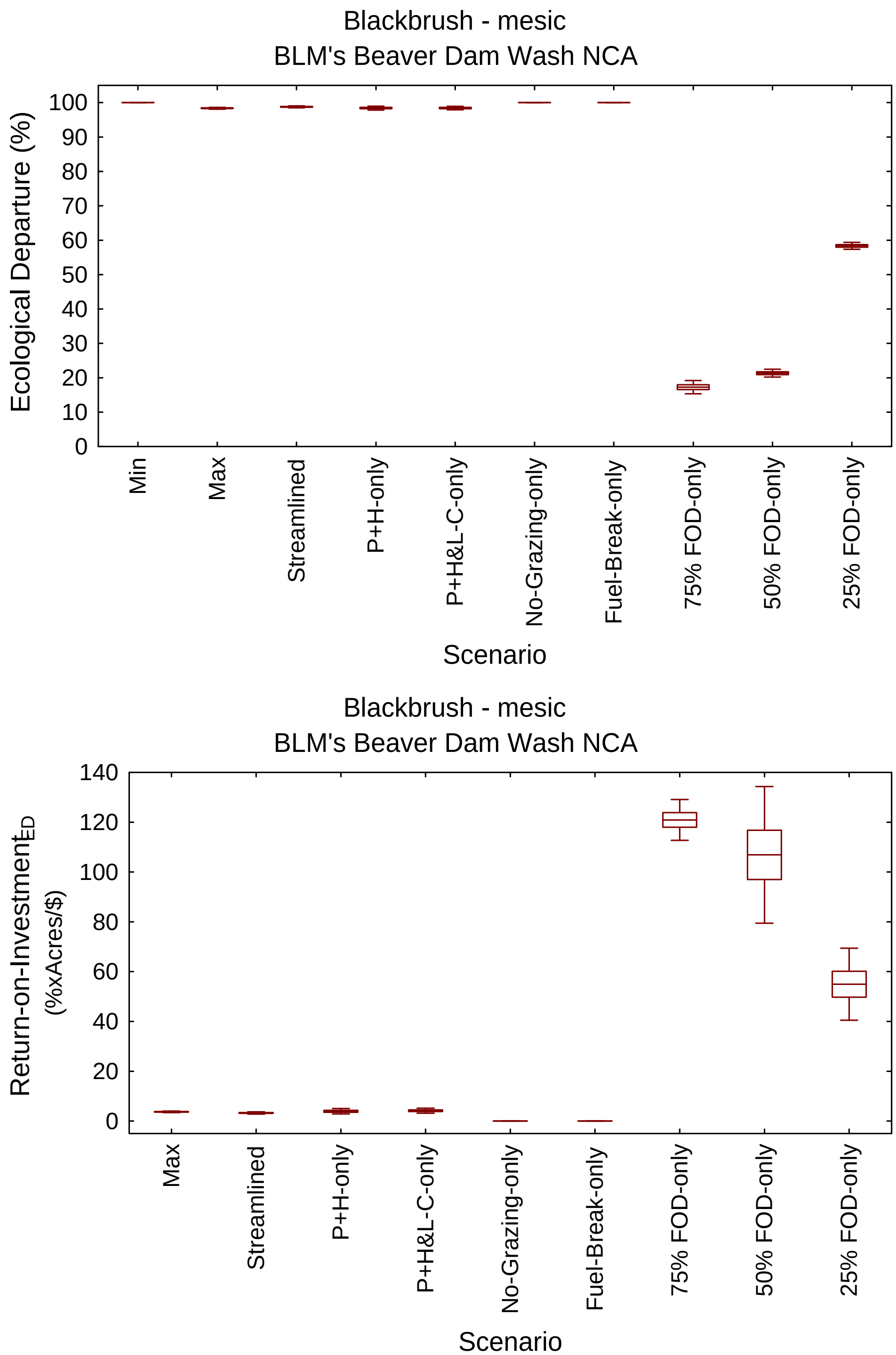


Figure 21. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of blackbrush–mesic after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

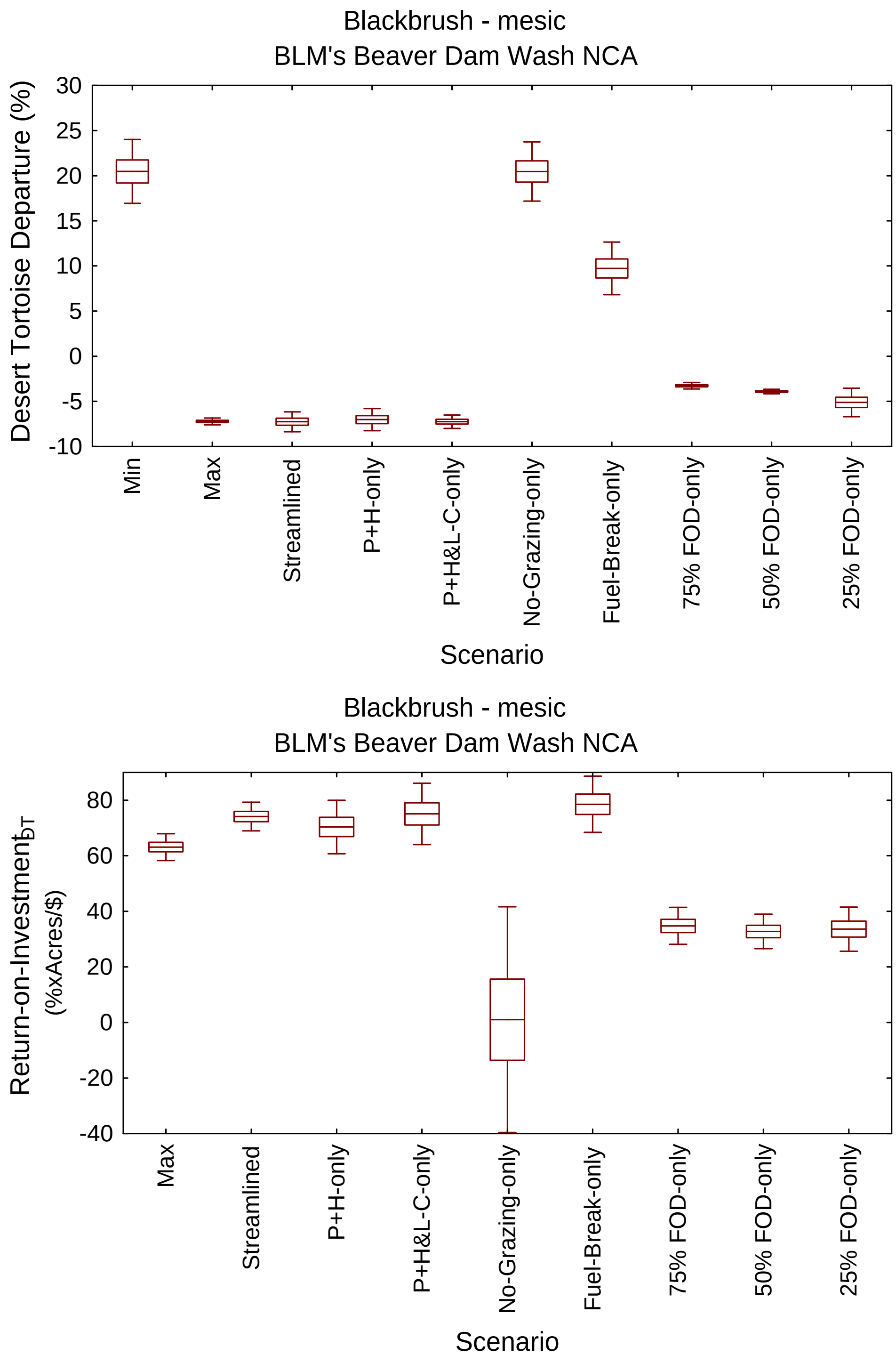


Figure 22. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of blackbrush–mesic after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

Beaver Dam Wash NCA: Blackbrush-thermic

Thermic blackbrush is a relatively small ecological system in the Beaver Dam Wash NCA. At present, this system exhibits complete ecological departure at 100%. Desert tortoise departure is moderately high at 37% because shrublands invaded by non-native annuals represent 67% of the landscape. These shrublands provide shade and some food to desert tortoise. The remaining 33% of the ecological system converted to non-native annual grasslands and forblands after the wildfires of 2005.

After 50 years in a regime of minimum management, ecological departure did not change because acres were shuffled among uncharacteristic vegetation classes. With minimum management, native shrubs and forbs resprouted and recovered within a 20-year period; therefore, vegetation structure providing shade and, perhaps, food for desert tortoise recovered. As a result, desert tortoise departure decreased (i.e., became better) from 37% to 21%.

BLM and stakeholders focused on a variety of treatment actions (strategies) used alone or in combination including herbicide application, native species seeding and planting, and fuel breaks, special livestock management, and law enforcement.

50-Year Management Objectives

- Protect blackbrush shrublands from future fire.
- Increase native shrub and herbaceous cover in burned areas.
- Maintain desert tortoise departure below the current 21% score.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/ year			Cost/ acre	50-yr total cost
		1 to 4 yrs	5 to 19 yrs	20 to 50 yrs		
Maximum	Application of Plateau® followed by seeding of new native seed mix supplemented by germination innovations in non-native annual grasslands and forblands	0	0	2	$250	
	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	37	4	$650	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	891	1,026	929	$11	
	Prevent grazing of seedings and plantings for 10 years	0	31	12	$11	
						$1,250,217

Streamlined	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	38	15	$650	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	915	1,020	936	$11	
	Prevent grazing of seedings and plantings for 10 years	0	31	12	$11	
						$1,235,476
Planting+ Herbicide-only	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	41	29	$650	
						$988,659
Planting+ Herbicide & Livestock-Closure	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	674	299	$650	
	Prevent grazing of seedings and plantings for 10 years	0	40	26	$11	
						$925,427
No-Grazing only	Make public lands of NCA unavailable for livestock grazing; third-party purchase of AUMs from permittees	33,628 once			$11	
						$40,183
Fuel Break only	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	909	1,026	885	$11	
						$521,988
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	3,653	3,653	3,653	$1	
						$182,650
75% BFOD only	Application of BFOD fungi at 75% success rate in shrublands invaded by non-native annuals	0	74	366	$450	
	Application of BFOD fungi at 75% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	37	8	$650	
						$4,227,812
50% BFOD only	Application of BFOD fungi at 50% success rate in shrublands invaded by non-native annuals	0	76	395	$450	

	Application of BFOD fungi at 50% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	36	8	$650	
						$4,396,139
25% BFOD only	Application of BFOD fungi at 25% success rate in shrublands invaded by non-native annuals	0	75	398	$450	
	Application of BFOD fungi at 25% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	36	8	$650	
						$4,436,544

The average annual cost of these treatments among scenarios for the Beaver Dam Wash NCA varied between $803 and $88,711 per year of implementation.

50-Year Outcomes

- Without the BFOD MANAGEMENT scenarios, ecological departure remained departed at about 100% (Figure 23 top). Scenarios with the BFOD fungi reaching 75% and 50% success rates greatly reduced ecological departure from the 100% to ~20% compared to the MINIMUM MANAGEMENT scenario (Figure 23 top). At a 25% success rate for the fungi, ecological departure reached an average departure of 33% with partial restoration of reference classes.

- The ROI for ecological departure was zero without the BFOD scenario (Figure 23 bottom). ROI increased dramatically. The ROI increased with the success rate of the BFOD fungi. Differences among the different fungi success rates were moderate.

- Compared to the MINIMUM MANAGEMENT scenario, desert tortoise departure exhibited three levels (Figure 24 top). The lowest (best) average scores of desert tortoise departure (about 2-8%) were achieved by the BFOD scenarios at all success rates. The MAXIMUM, STREAMLINED, and PLANTING AND HERBICIDE-ONLY, PLANTING AND HERBICIDE & LIVESTOCK CLOSURE-ONLY, and, to some extent, FUEL-BREAK-ONLY scenarios belonged to the second lowest group at about 10% to 18%. The NO-GRAZING-ONLY scenario performed the least well, being 10% worse than the MINIMUM MANAGEMENT scenario.

- With the exception of a NO-GRAZING-ONLY scenario, which had a negative ROI for desert tortoise departure, all scenarios achieved comparable and slightly positive ROIs (Figure 24 bottom).

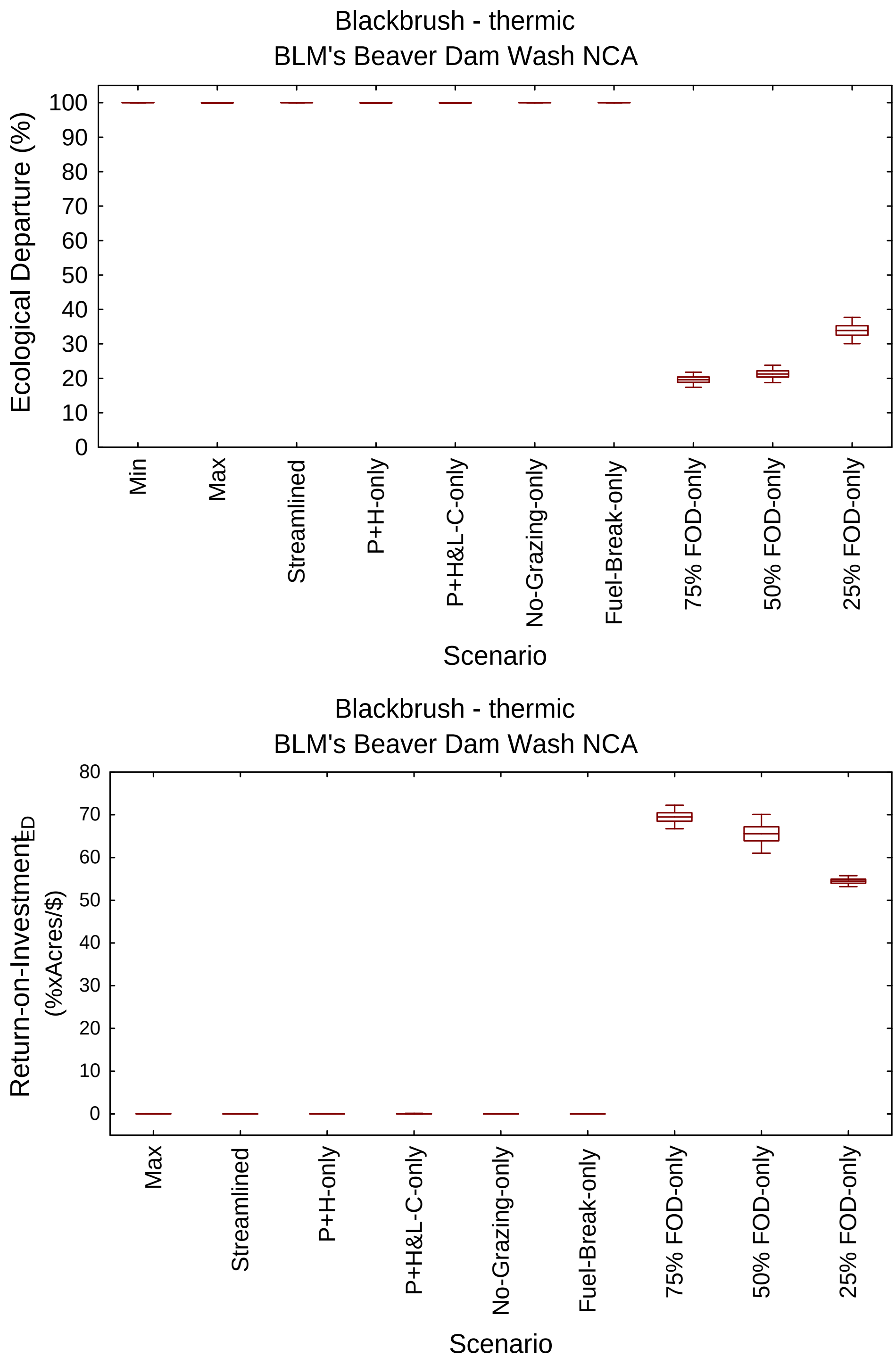


Figure 23. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of blackbrush–thermic after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

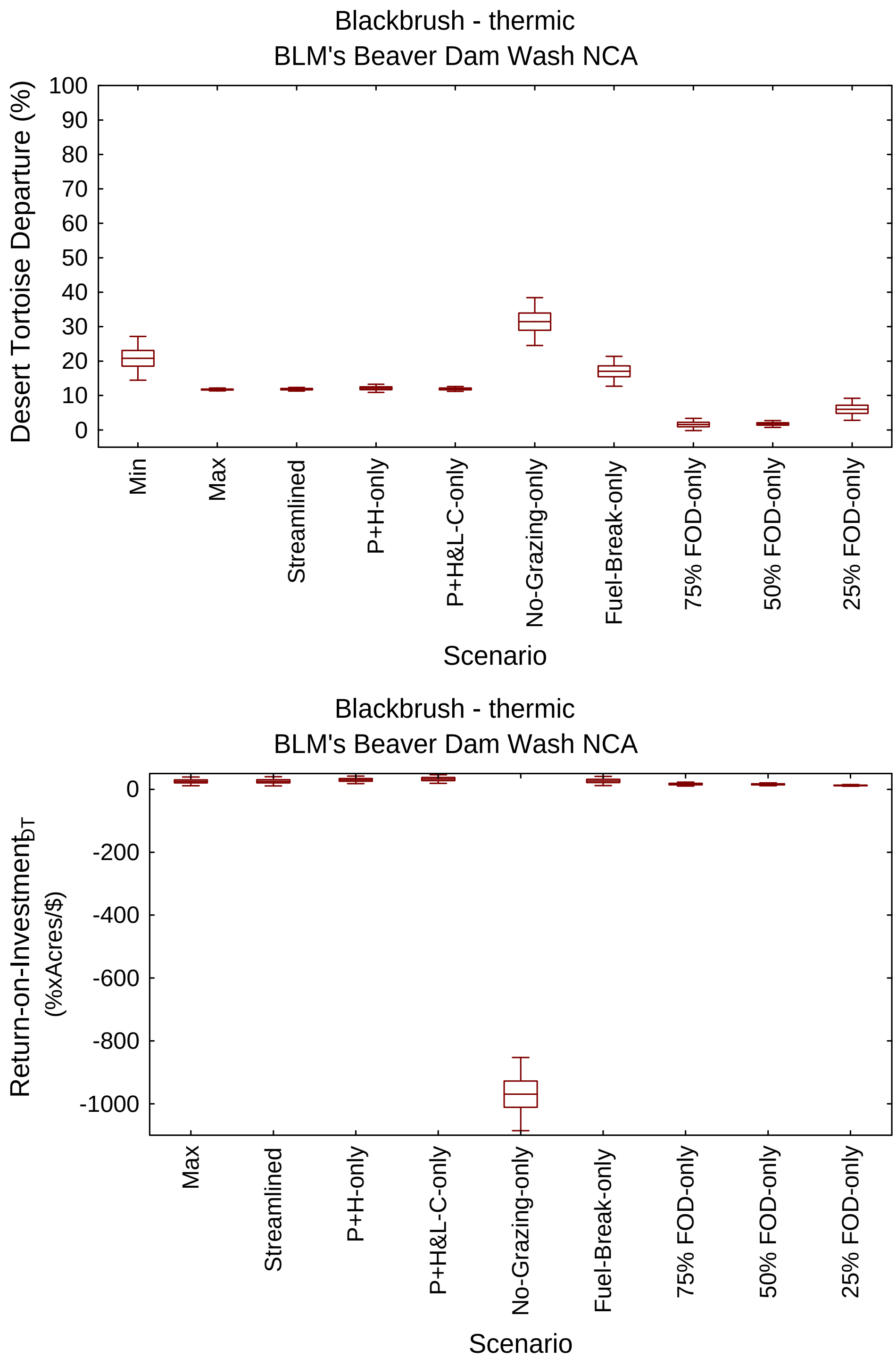


Figure 24. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of blackbrush–thermic after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

Beaver Dam Wash NCA: Creosotebush-White Bursage

Creosotebush-white bursage is the second largest ecological system of the Beaver Dam Wash NCA and is important desert tortoise habitat. At present, this system exhibits complete ecological departure at 100%. Desert tortoise departure is low at 18% because the majority of the ecological system did not burn in 2005; indeed, only 9% of the area is non-native annual grasslands and forblands. Of the remaining 91% in shrubland invaded by non-native annual species, a small fraction represents burned areas where creosotebush vigorously resprouted. Preservation of shrublands in this preferred desert tortoise habitat is therefore critical.

After 50 years in a regime of minimum management, ecological departure did not change because acres were shuffled among uncharacteristic vegetation classes. Desert tortoise departure, however, was predicted to increase (i.e., became worse) from 18% to 38% because of simulated wildfires causing a transition to non-native annual grasslands and forblands, which received low scores of habitat suitability.

BLM and stakeholders focused on a variety of treatment actions (strategies) used alone or in combination including herbicide application, native species seeding and planting, fuel breaks, special livestock management, and law enforcement.

50-Year Management Objectives

- Protect creosotebush-white bursage shrublands from future fire.
- Increase native shrub and herbaceous cover in burned areas.
- Maintain desert tortoise departure below the current 18% score.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/ year 1 to 4 yrs	5 to 19 yrs	20 to 50 yrs	Cost/ acre	50-yr total cost
Maximum	Application of Plateau® followed by seeding of new native seed mix supplemented by germination innovations in non-native annual grasslands and forblands	0	0	8	$250	
	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	281	60	$650	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	5,470	6,132	5,487	$11	
	Prevent grazing of seedings and plantings for 10 years	0	215	173	$11	
						$10,940,729

Streamlined	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	246	246	$650	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	5,467	6,151	5,530	$11	
	Prevent grazing of seedings and plantings for 10 years	0	188	201	$11	
						$10,592,300
Planting+ Herbicide-only	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	314	288	$650	
						$8,869,562
Planting+ Herbicide & Livestock-Closure	Application of Plateau® followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	293	266	$650	
	Prevent grazing of seedings and plantings for 10 years	0	234	206	$11	
						$8,330,064
No-Grazing only	Make public lands of NCA unavailable for livestock grazing; third-party purchase of AUMs from permittees	22,041 once			$11	
						$242,451
Fuel Break only	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	5,478	6,179	5,357	$11	
						$3,152,777
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	22,041	22,041	22,041	$1	
						$1,102,050
75% BFOD only	Application of BFOD fungi at 75% success rate in shrublands invaded by non-native annuals	0	995	497	$450	
	Application of BFOD fungi at 75% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	98	120	$650	
						$12,209,198
50% BFOD only	Application of BFOD fungi at 50% success rate in shrublands invaded by non-native annuals	0	994	499	$450	

	Application of BFOD fungi at 50% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	98	116	$650	
						$11,542,343
25% BFOD only	Application of BFOD fungi at 25% success rate in shrublands invaded by non-native annuals	0	996	498	$450	
	Application of BFOD fungi at 25% success rate followed by planting of containerized Mojave shrubs and herbaceous species in non-native annual grasslands and forblands	0	99	117	$650	
						$12,429,870

The average annual cost of these treatments among scenarios for the Beaver Dam Wash NCA varied between $4,849 and $248,597 per year of implementation.

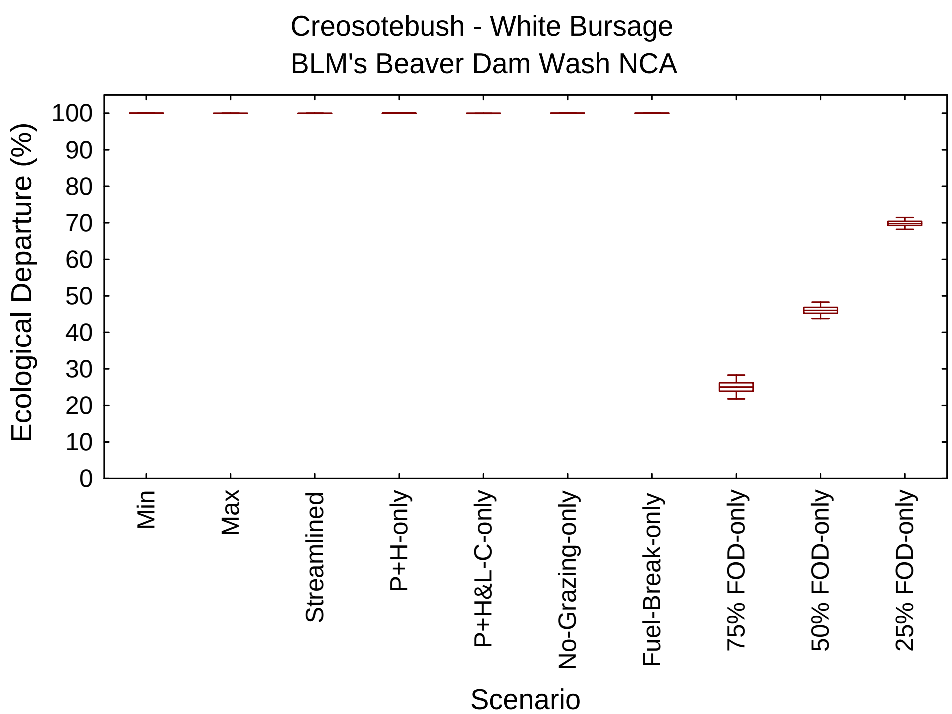
50-Year Outcomes

- Without the BFOD scenarios, ecological departure remained departed at about 100% (Figure 25 top). All three scenarios with the BFOD fungi reduced ecological departure from 100% to three different ecological departure scores compared to the MINIMUM MANAGEMENT scenario (Figure 23 top). Ecological departure decreased more (improved) with higher success rates of the fungi: for success rates of 75%, 50%, and 25%, respectively, departure was predicted to be 22%, 46%, and 70%.

- The ROI for ecological departure was zero without the BFOD MANAGEMENT scenarios (Figure 25 bottom). ROI dramatically increased with application of the BFOD fungi. The ROI increased with the success rate of the BFOD fungi. Differences among the three success rates were strong in creosotebush-white bursage.

- Compared to the MINIMUM MANAGEMENT scenario, all scenarios decreased (improved) desert tortoise departure (Figure 26 top). However, the stated objective of desert tortoise departure below 18% was only met by the following scenarios for smallest to largest departure <18%: BFOD WITH 75% SUCCESS RATE, MAXIMUM, STREAMLINED, and PLANTING AND HERBICIDE-ONLY and PLANTING AND HERBICIDE & LIVESTOCK CLOSURE-ONLY, and BFOD WITH 50% SUCCESS RATE. The FUEL-BREAK-ONLY AND NO-GRAZING-ONLY MANAGEMENT scenarios failed the objective.

- The PLANTING AND HERBICIDE-ONLY, PLANTING AND HERBICIDE & LIVESTOCK CLOSURE-ONLY, and the BFOD WITH 75% SUCCESS RATE scenarios showed the highest ROIs for desert tortoise departure and, as shown above, met management objectives (Figure 26 bottom). With the exception of the NO-GRAZING-ONLY scenario that achieved negative and highly variable ROIs, all other scenarios showed positive ROI.



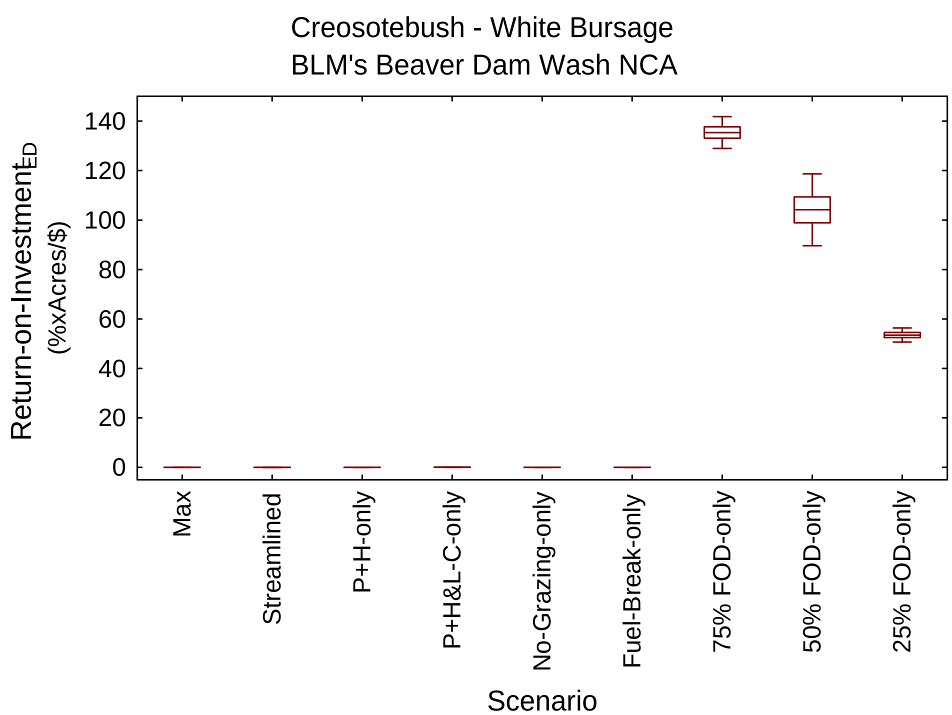


Figure 25. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of creosotebush-white bursage after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

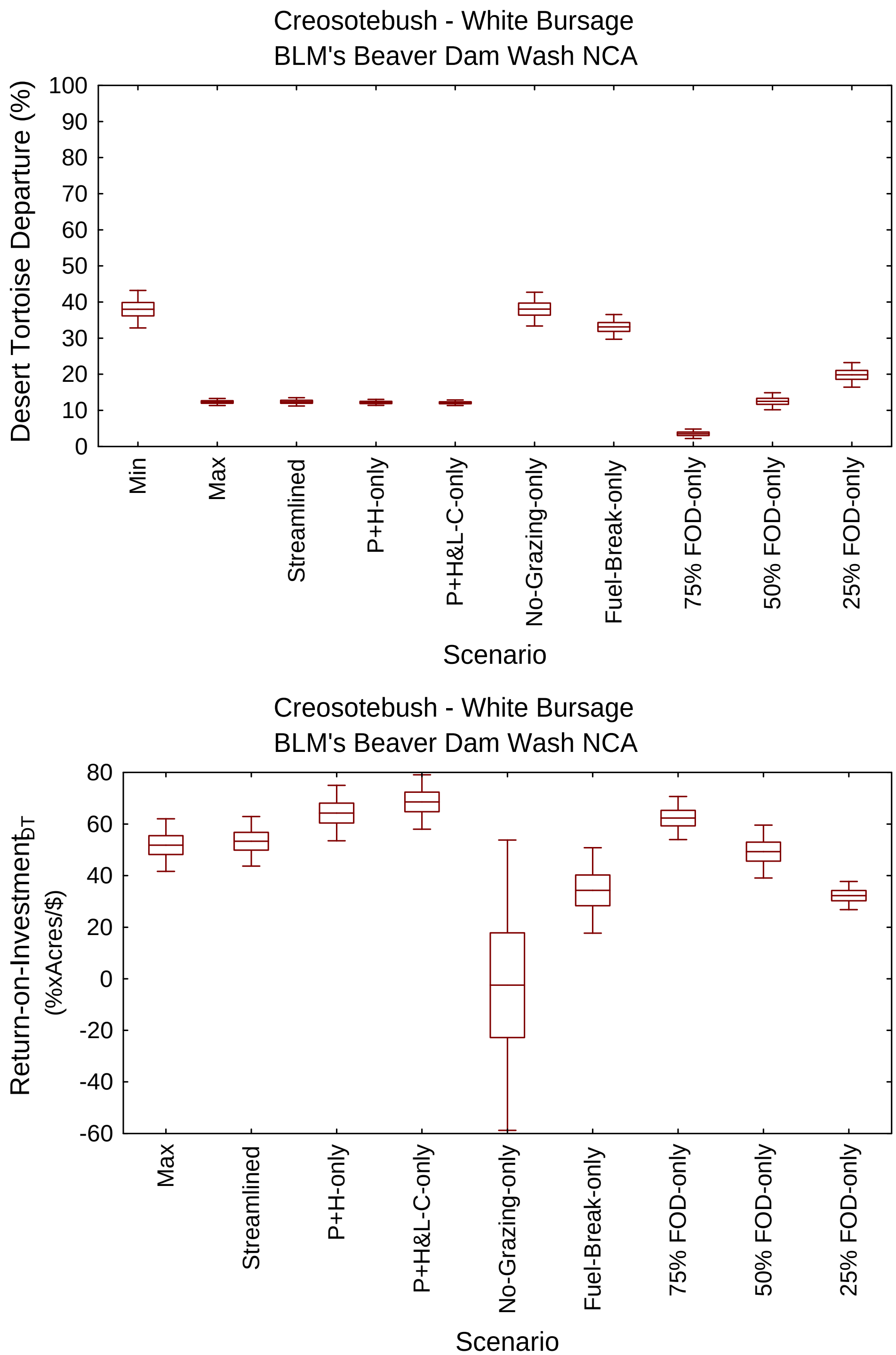


Figure 26. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of creosotebush-white bursage after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

Beaver Dam Wash NCA: Desert Washes

Desert washes occupy 3,345 acres in the Beaver Dam Wash NCA, thus making washes the third largest ecological system. Desert washes are also the most suitable desert tortoise habitat (Table 5). Desert tortoise feed in the productive washes and take advantage of wash slopes for excavating dens. Desert washes are distributed throughout the NCA. At present, this system exhibits high ecological departure at 90%. Desert tortoise departure is moderate at 40%. The majority (79%) of the ecological system is in the early succession class due to high flood events experienced in December 2010. The remaining 21% is shrublands invaded by non-native annuals.

After 50 years in a regime of minimum management, ecological departure decreased from 90% to 45% as vegetation transitioned from early to middle or late succession, thus approaching the NRV. Desert tortoise departure decreased (i.e., improved) from 40% to 21% as vegetation classes matured, although some acres were invaded by non-native annuals. The resulting vegetation class received higher desert tortoise suitability because more mature wash shrubs provide shade and food to desert tortoise.

BLM and stakeholders focused on a variety of treatment actions (strategies) used alone or in combination including aerial herbicide application, weed inventory, control of exotic saltcedar and forb species, and fuel breaks.

50-Year Management Objectives

- Protect shrublands from future fire.
- Control non-native annuals, trees, and forbs.
- Maintain desert tortoise departure below the predicted 21% score.

50-Year Management Strategies and Costs

Scenario	Action Description		Acres/ year		Cost/ acre	50-yr total cost
		1 to 4 yrs	5 to 19 yrs	20 to 50 yrs		
Maximum	Inventory of weeds and saltcedar for immediate control or future control	9	13	3	$55	
	Hand-cutting of saltcedar followed by immediate application of herbicide to stumps and herbicide application to exotic forbs	0.1	0.2	0.1	$200	
	Aerial application of Plateau® of wash shrubs invaded by non-native annuals	173	78	5	$25	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	422	541	491	$11	
	Reduce livestock stocking rate in desert washes	2,536	2,652	2,802	$11	
						$1,875,650

Streamlined	Inventory of weeds and saltcedar for immediate control or future control	10	13	13	$55	
	Hand-cutting of saltcedar followed by immediate application of herbicide to stumps and herbicide application to exotic forbs	0.16	0.30	0.22	$200	
	Aerial application of Plateau® of wash shrubs invaded by non-native annuals	95	53	36	$11	
	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	416	524	506	$11	
	Reduce livestock stocking rate in desert washes	2,627	2,693	2,769	$11	
						$1,875,899
No-Grazing only	Make public lands of NCA unavailable for livestock grazing; third-party purchase of AUMs from permittees	3,345 once			$11	
						$36,795
Fuel Break only	Create 200-ft wide fuels breaks along right-of-ways and boundaries by applying Plateau® at strategic landscape locations	814	926	861	$11	
						$472,279
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	3,345	3,345	3,345	$1	
						$1,102,050
75% BFOD only	Application of BFOD fungi at 75% success rate in shrublands invaded by non-native annuals	0	49	39	$300	
						$582,976
50% BFOD only	Application of BFOD fungi at 50% success rate in shrublands invaded by non-native annuals	0	50	49	$300	
						$685,453
25% BFOD only	Application of BFOD fungi at 25% success rate in shrublands invaded by non-native annuals	0	49	49	$300	
						$676,249

The average annual cost of these treatments among scenarios for the Beaver Dam Wash NCA varied between $736 and $37,518 per year of implementation.

50-Year Outcomes

- All scenarios, except the NO-GRAZING-ONLY and FUEL-BREAK-ONLY MANAGEMENT scenarios, decreased ecological departure below the 45% achieved by the MINIMUM MANAGEMENT scenario (Figure 27 top). Top performing scenarios were MAXIMUM and STREAMLINED MANAGEMENT scenarios both reaching about 15% departure (Figure 27 top). Interestingly, livestock temporary closure alone (i.e., PLANTING

AND HERBICIDE & LIVESTOCK CLOSURE-ONLY scenario) had a comparable effect on ecological departure as did any of the BFOD management scenarios.

- The highest ROIs for ecological departure were realized by the BFOD WITH 75% AND 50% SUCCESS RATES scenarios (Figure 27 bottom). The MAXIMUM, STREAMLINED, PLANTING AND HERBICIDE & LIVESTOCK CLOSURE-ONLY, and BFOD WITH 25% SUCCESS RATE scenarios showed the second highest ROI.

- All scenarios, except the FUEL-BREAK-ONLY, reduced desert tortoise departure below the 21% realized by the MINIMUM MANAGEMENT scenario (Figure 28 top). The lowest desert tortoise departure (~0%) was observed in the MAXIMUM, STREAMLINED, and BFOD WITH 75% AND 50% SUCCESS RATES management scenarios.

- The NO-GRAZING-ONLY management scenario's ROI based on desert tortoise departure outpaced all other scenarios by at least one order of magnitude (Figure 28 bottom). This scenario also had the lowest cost on implementation, which produce modest reduction to desert tortoise departure (Figure 28 top). The BFOD WITH 75% AND 50% SUCCESS RATES management scenarios were distant second highest. The FUEL-BREAK-ONLY management scenario performed the least well (0% ROI).

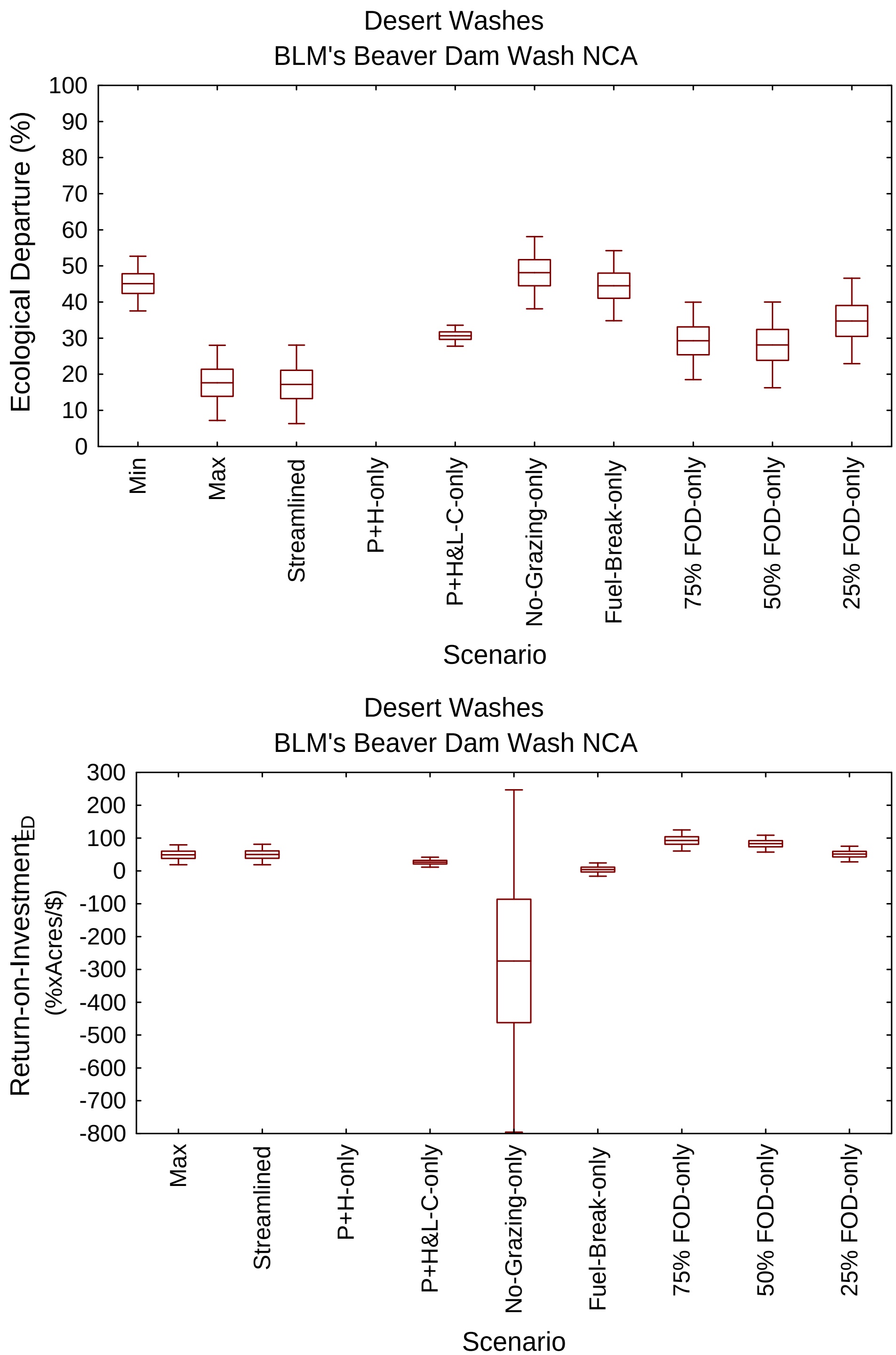


Figure 27. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of desert washes after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

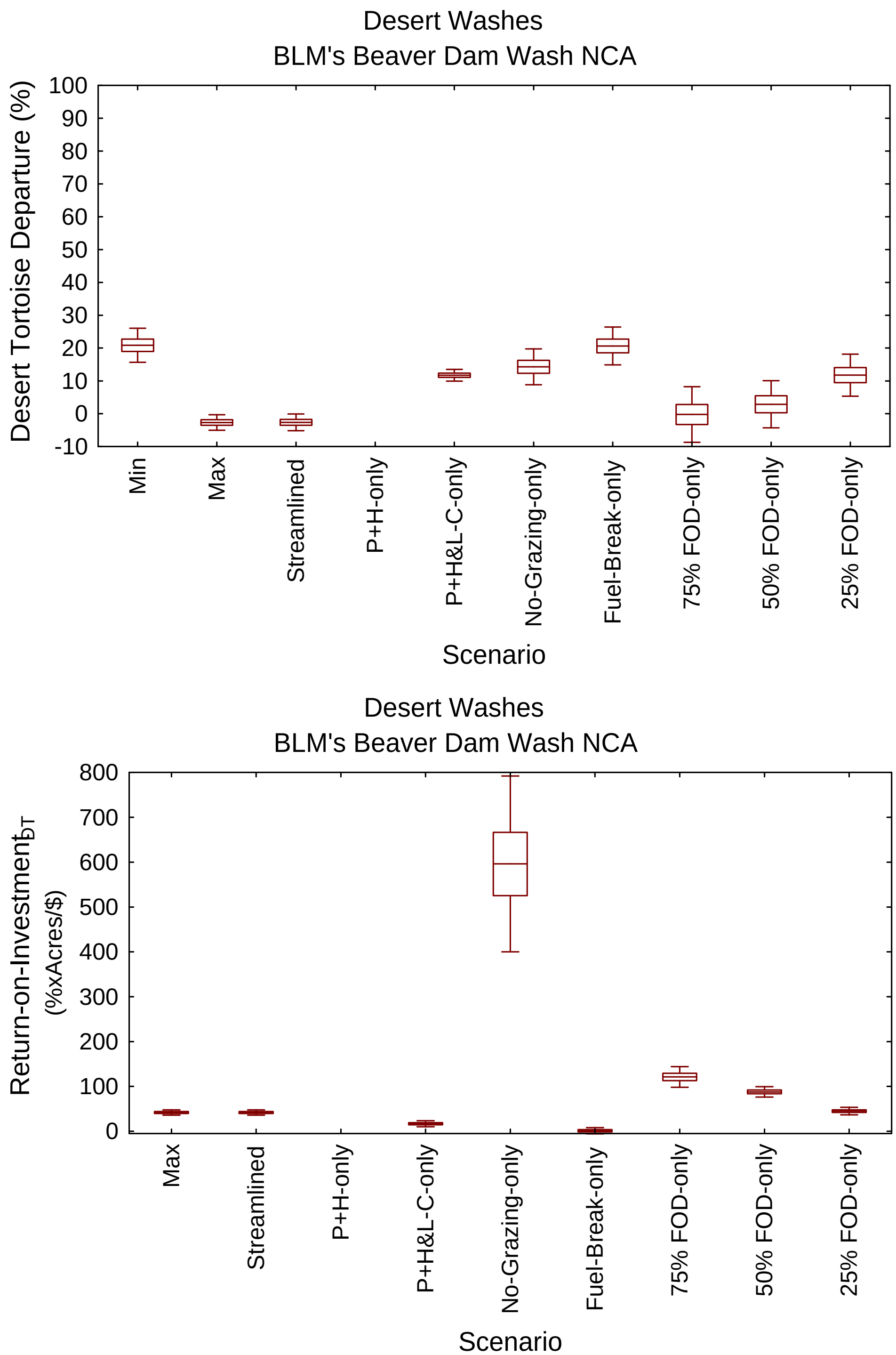


Figure 28. Desert tortoise departure (%) and return-on-investment for desert tortoise departure (subscript $_{DT}$) of desert washes after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

Beaver Dam Wash NCA: Mountain Shrub

The mountain shrub ecological system covers 143 acres and the presence of Stansbury cliffrose (lower elevations) and serviceberry (higher elevation) makes it critical mule deer winter range in the Beaver Dam Wash NCA. Mountain shrub is found within the upper blackbrush-mesic and pinyon-juniper woodland zone. Mountain shrub currently exhibits complete ecological departure at 100% because most areas burned in 2005 and were converted to non-native annual grasslands and forblands, or the few shrublands that escaped fire are invaded by non-native annual species.

After 50 years in a regime of minimum management, ecological departure remained at 100%. Depending on simulated wildfire activity, vegetation classes were either non-native annual grasslands and forblands or shrubs invaded by non-native annual grass. Cliffrose reestablishes from seed within a few years after fire. Variability among replicates for these two classes of vegetation was large and entirely depended on time since the last fire.

Two scenarios applied to the restoration of mountain shrub. One scenario was to make public lands of the NCA unavailable for livestock grazing, as considered for other ecological systems. Because this landscape-level NO-GRAZING-ONLY scenario applies to all grazed ecological systems, this scenario indirectly affected mountain shrub and required reporting (BLM and stakeholders did not select this scenario for mountain shrub). In the second scenario, workshop participants focused on two management actions: Herbicide application to control non-native annual grasses followed by cliffrose seeding in non-native annual grasslands, and herbicide application to control non-native annual grasses followed by native grass seeding in shrublands invaded by non-native annual grass. Cliffrose is commonly used in mine reclamation and mule deer habitat restoration projects, therefore these actions should be well established.

50-Year Management Objectives

- Restore ecological departure to at least moderate levels (<67%).
- Reduce the non-native annual grassland class to less than 10% of the ecological system.
- Reduce the shrublands invaded by non-native annual grass to less than 10%.

50-Year Management Strategies and Costs

Scenario	Action Description	Acres/year 1-4 yrs	5-19 yrs	20-50 yrs	Cost/acre	50-yr total cost
Maximum	Application of Plateau® to control non-native annuals followed by seeding of Stansbury cliffrose in non-native annual grasslands and forblands	71	4	0	$100	
	Application of Plateau® to control non-native annuals followed by seeding of native grasses in shrublands invaded by non-native annuals	8	5	0	$250	
						$66,024

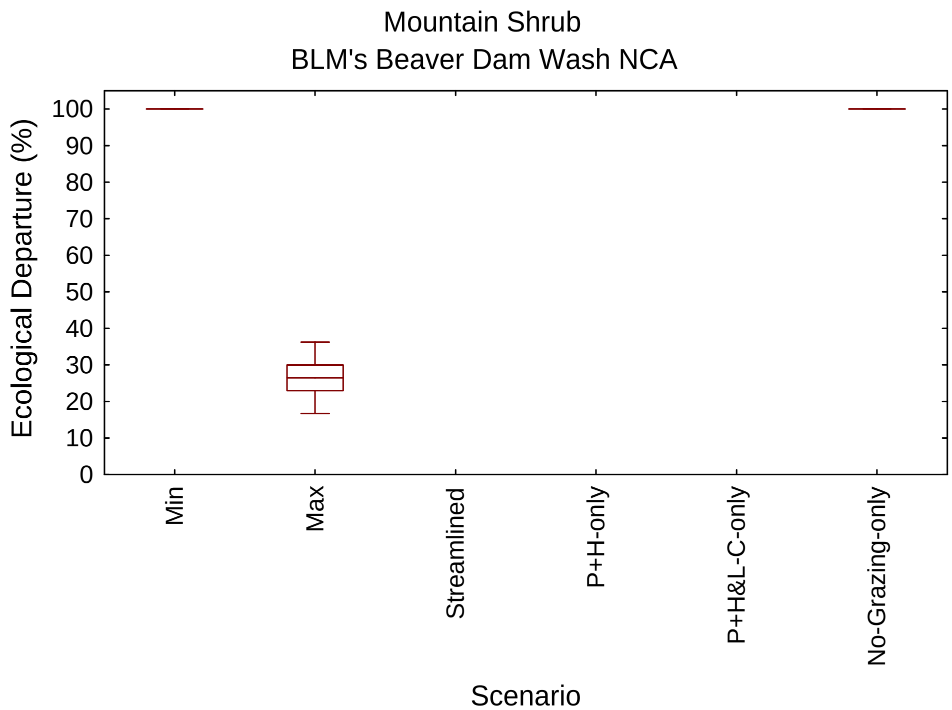
No-Grazing only	Make public lands of NCA unavailable for livestock grazing; third-party purchase of AUMs from permittees	143 once			$11	
						$1,573
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	143	143	143	$1	
						$7,150

The average annual cost of the scenario for the Beaver Dam Wash NCA varied among scenario between $32 and $1,320 per year of implementation.

50-Year Outcomes

- The MAXIMUM MANAGEMENT scenario reduced ecological departure from 100% to about 26% (Figure 29 top), therefore achieving low ecological departure. The NO-GRAZING-ONLY scenario had no effect compared to MINIMUM MANAGEMENT. There was large variability in the percentage of reference classes among replicates with ecological departure varying between 18% and 38%. The non-native annual grasslands and shrublands invaded by non-native annual grass were eliminated.

- The ROI based on ecological departure for the MAXIMUM MANAGEMENT scenario was positive and high compared to zero ROI for the NO-GRAZING-ONLY management scenario (Figure 29 bottom).



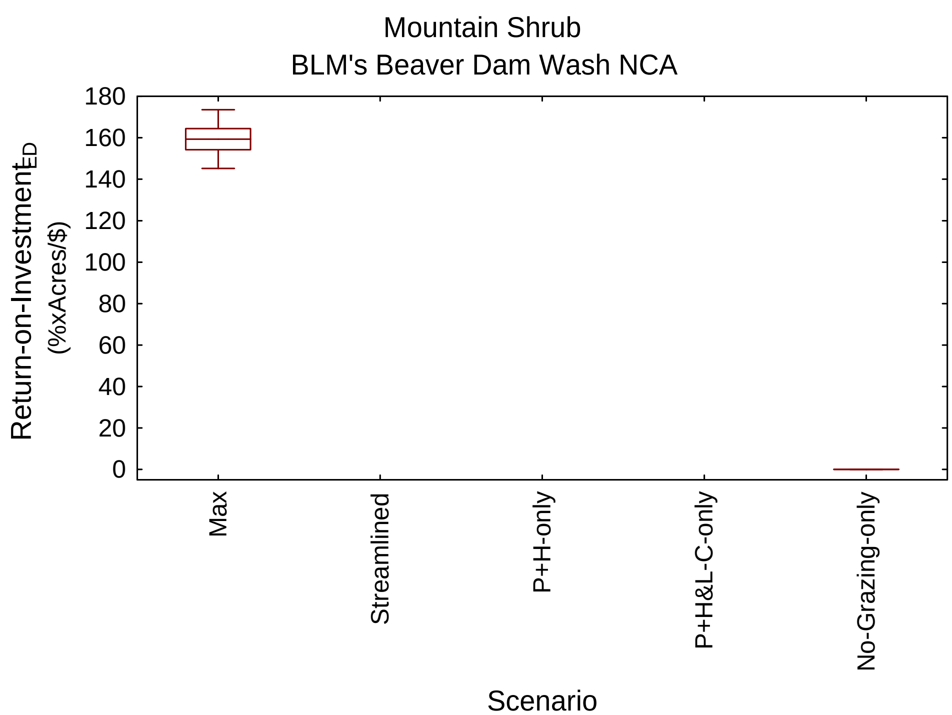


Figure 29. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of mountain shrub after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

Beaver Dam Wash NCA: Warm Desert Riparian

The warm desert riparian ecological system is small (114 acres) and consists of perennial reaches of Beaver Dam Wash and desert washes. Plant and animal species diversity are typically very high. Typical dominant woody species are Fremont cottonwood, Goodding's willow, mesquite, velvet ash, other willows (several species), other riparian trees and shrubs. At present, this system exhibits complete ecological departure at 100%. Saltcedar is found in 4% of the system, whereas the remaining 96% of the warm desert riparian woodlands and shrublands has an understory of non-native annual species.

After 50 years in a regime of minimum management, ecological departure decreased to 89% from 100% due to several factors. The saltcedar biocontrol beetle allowed recruitment into a) reference classes, and b) the exotic forb class (for example, Russian knapweed), a common pathway after control of saltcedar. Also, the wooded floodplain was invaded by exotic trees and forbs. The biocontrol beetle also attacked these exotic trees. Severe flooding also caused transition of mature riparian vegetation to the early succession class. These levels of departure and exotic forb invasion were judged unacceptable.

Two scenarios applied to the restoration of warm desert riparian. One scenario was to make public lands of the NCA unavailable for livestock grazing, as considered for other ecological systems. Because this landscape-level NO-GRAZING-ONLY scenario applies to all grazed ecological systems, this scenario indirectly affected warm desert riparian and required reporting (BLM and stakeholders did not select this scenario for warm desert riparian). For the other scenario (MAXIMUM MANAGEMENT), workshop participants focused on several management actions: Weed inventory, chainsaw cutting of saltcedar followed by immediate herbicide application to stumps, herbicide application to exotic forb species, hand spraying of herbicide to control non-native annuals in the understory of trees and shrubs, and law enforcement.

50-Year Management Objectives

- Restore the warm desert riparian ecological departure to <67% (moderate departure) ecological departure.
- Contain exotic trees and forbs to <11% cover.

50-Year Management Strategies and Costs

Scenario	Action Description		Acres/ year		Cost/ acre	50-yr total cost
		1 to 4 yrs	5 to 19 yrs	20 to 50 yrs		
Maximum	Inventory of weeds and saltcedar for immediate control or future control	31	30	7	$55	
	Hand-cutting of saltcedar followed by immediate application of herbicide to stumps and herbicide application to exotic forbs	1.2	0.4	0.1	$200	
	Application of herbicide to control exotic forbs	0.2	0.7	0.1	$50	

	Hand application of Plateau® to riparian woodland's understory invade by non-native annuals	10	10	0	$50	
						$100,771
Max	Inventory of weeds and saltcedar for immediate control or future control	31	30	30	$55	
	Hand-cutting of saltcedar followed by immediate application of herbicide to stumps and herbicide application to exotic forbs	1	0.4	0.3	$200	
	Application of herbicide to control exotic forbs	0.2	0.7	0.3	$50	
	Hand application of Plateau® to riparian woodland's understory invade by non-native annuals	10	10	2	$50	
						$100,770
No-Grazing only	Make public lands of NCA unavailable for livestock grazing; third-party purchase of AUMs from permittees	114 once			$11	
						$34,254
Law Enforcement only	Part-time patrolling by one law enforcement officer to prevent illegal use of OHVs	114	114	114	$1	
						$5,700

The average annual cost among scenarios for the Beaver Dam Wash NCA varied between $685 and $2,015 per year of implementation.

50-Year Outcomes

- Differences in ecological departure between the MAXIMUM and STREAMLINED MANAGEMENT scenarios were small and ranged between 38% and 45% (Figure 30 top), thus meeting management objective for ecological departure. The NO-GRAZING-ONLY scenario achieved 80% ecological departure, therefore did not meet management objective. Exotic trees and forbs were <4% for the MAXIMUM MANAGEMENT scenario and <1% for the STREAMLINED MANAGEMENT scenario. Again, this met the management objectives.

- There was no statistical difference for ROI between the MAXIMUM and STREAMLINED MANAGEMENT scenarios, although the STREAMLINED MANAGEMENT scenario reached the highest ROI (Figure 30 bottom).

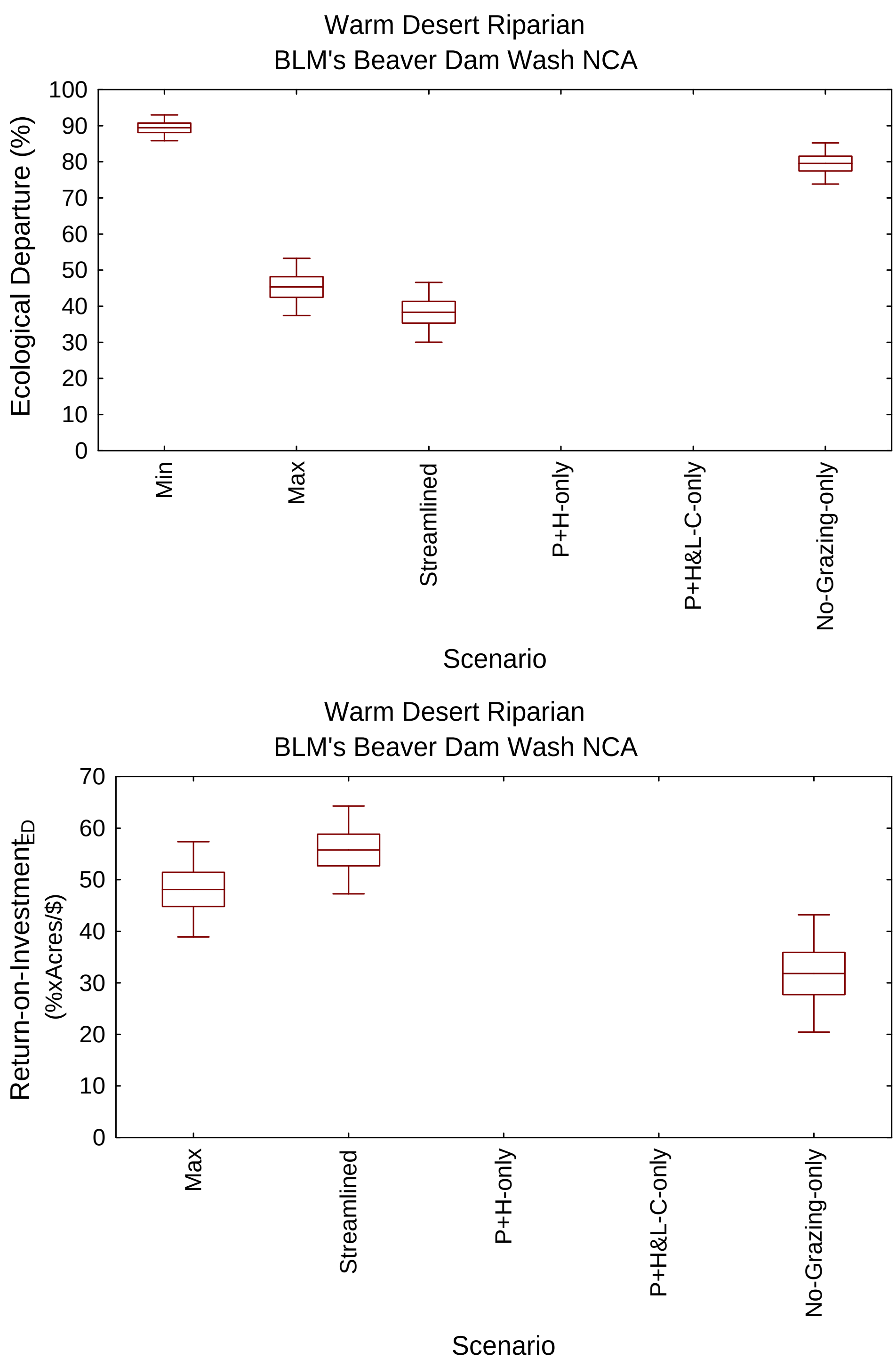


Figure 30. Ecological departure (%) and return-on-investment for ecological departure (subscript $_{ED}$) of warm desert riparian after 50 years simulating different management scenarios for the Beaver Dam Wash NCA. The MINIMUM MANAGEMENT scenario is not shown in the ROI graph because this scenario is used in the ROI calculation. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: P+H = planting and herbicide; L-C = livestock closure.

Prioritizing Actions among Ecological Systems: Return-on-Investment

Although ROIs were compared among SCENARIOS within an ecological system, ROI is also used to prioritize implementation of scenarios among or across ecological systems. Aross-system ROI was measured based on desert tortoise departure and ecological departure for each of the two NCAs, so there are four sets of results. Another added level of complexity is that some ROI values are based on future achievements of experimental restoration techniques.

Six ecological systems were used by desert tortoise in the Red Cliffs NCA. The highest ROI was reached in the desert wash system; however its ROI was comparable to that of blackbrush-mesic because of overlapping confidence intervals (Figure 31).

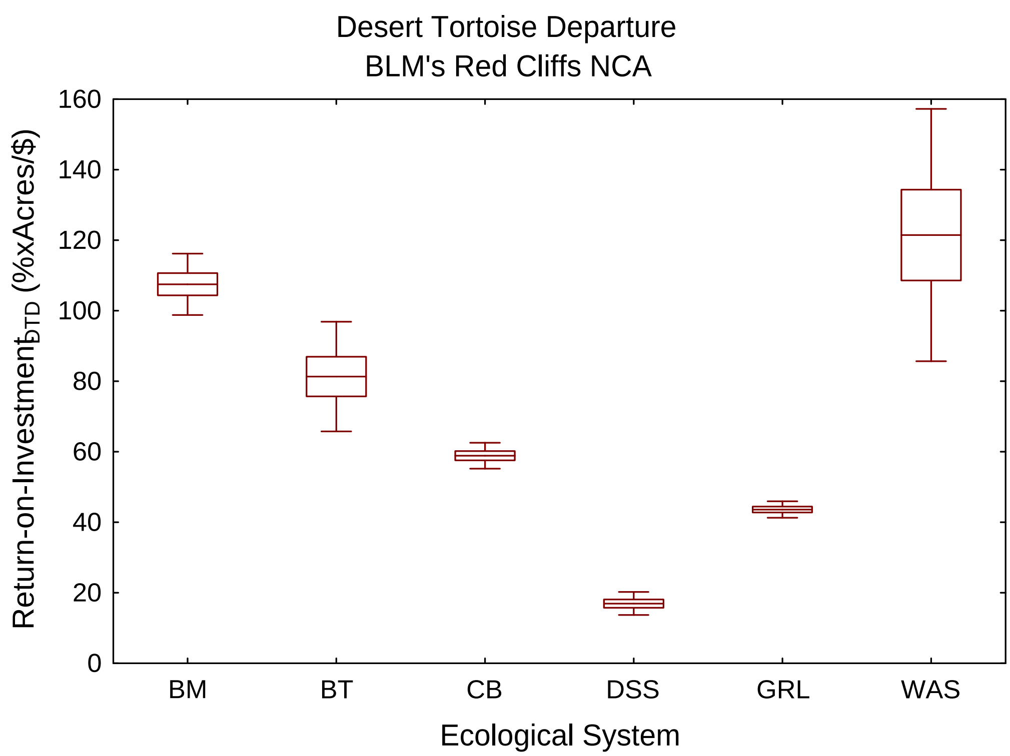


Figure 31. Average ecological system-wide return on investment (ROI) based on desert tortoise departure (subscript $_{DTD}$) for the six ecological systems of BLM's Red Cliffs NCA used by desert tortoise and selected for active management analyses. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: BM = Blackbrush-mesic, BT= Blackbrush-thermic, CB = Creosotebush-White Bursage, DSS = Desert Sand Sagebrush, GRL = Warm Season Grassland, WAS = Desert Washes.

Restoration of desert washes includes established actions, whereas work in mesic blackbrush involves the more experimental method of planting containerized shrubs and forbs followed by herbicide application. Importantly, fuel-breaks are deployed for both systems. Blackbrush-thermic showed the clear next highest ROI followed by creosotebush-white bursage. The only action deployed in thermic blackbrush is fuel breaks, which underscores the importance of this single action in the Red Cliffs NCA. Two comparable experimental methods (only one required) allowed creosotebush-white bursage to reach the third place in the ROI scale: planting containerized shrubs and forbs followed by herbicide application, OR application of the BFOD fungi assuming 75% success rate. If future research finds the fungi to be at best 50% successful, then the best method is planting containerized shrubs and forbs. In both cases, the fate of creosotebush-white bursage depends on future, experimental successes. Although not shown here, only using fuel break is an acceptable compromise with a lower ROI. In decreasing order, warm-season grassland and desert sand sagebrush had the lowest, but positive ROIs. None of these ecological systems required experimental methods, although grasslands would greatly benefit from application of the BFOD fungi.

Eleven ecological systems were considered for management based on ecological departure in the Red Cliffs NCA (Figure 32). It is noteworthy that thermic and mesic blackbrush, and creosotebush-white bursage would not be on Figure 32 without the application of the BFOD fungi with at least a 50% success rate.

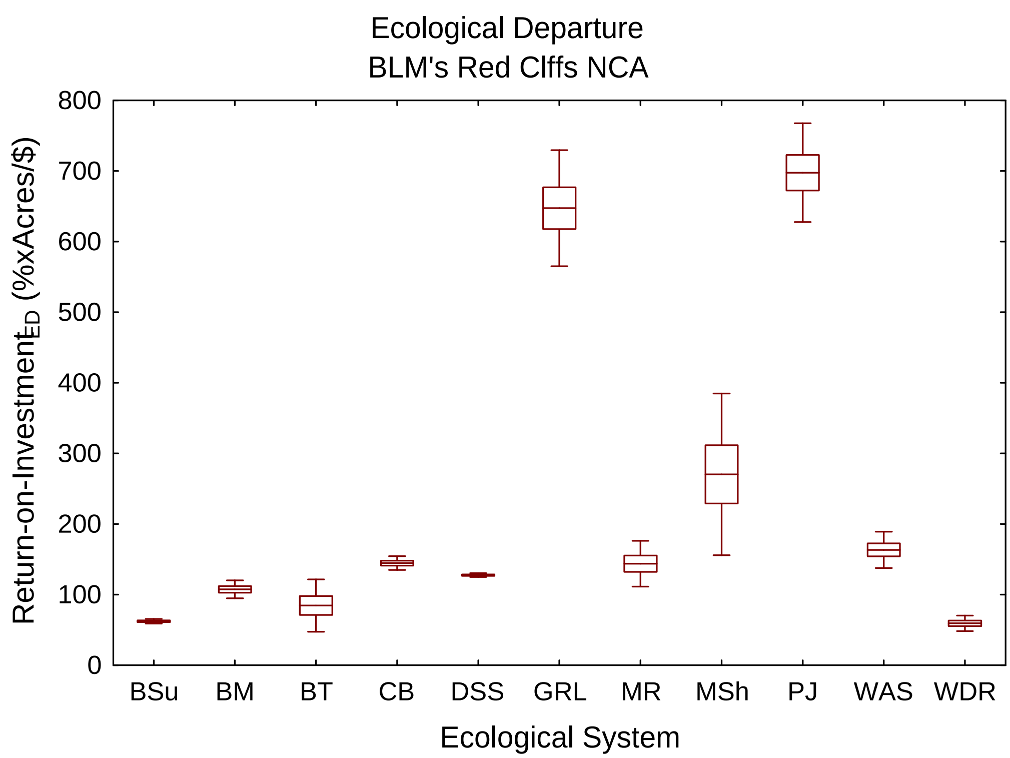


Figure 32. Average ecological system-wide return on investment (ROI) based on ecological departure (subscript $_{ED}$) for the 11 ecological systems of BLM's Red Cliffs NCA selected for active management analyses. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: BSu = Big Sagebrush Steppe-upland, BM = Blackbrush-mesic, BT= Blackbrush-thermic, CB = Creosotebush-White Bursage, DSS = Desert Sand Sagebrush, GRL = Warm Season Grassland, MR = Montane Riparian, MSh = Mountain Shrub, PJ = Pinyon-Juniper Woodland, WAS = Desert Washes, WDR = Warm-Desert Riparian.

Results were surprising with pinyon-juniper woodland and warm season grassland eclipsing other ecological systems with their high and statistically equal ROIs. These systems required only small, non-experimental investments in herbicide application and seeding to improve them. Although variable, the mountain shrub's ROI was the second largest because this system responds well to established restoration actions for relative low investments. Mountain shrub was also a tiny system in the Red Cliffs NCA. Other ecological systems are more grouped.

Desert washes, montane riparian, desert sand sagebrush, and creosotebush-white bursage were in the third tier of higher ROIs. Only creosotebush-white bursage required the experimental application of BFOD fungi. The bottom group included big sagebrush steppe-upland, mesic and thermic blackbrush, and warm desert riparian.

The Beaver Dam Wash NCA's ecological systems used by desert tortoise were mesic and thermic blackbrush, creosotebush-white bursage, and desert washes (Figure 33).

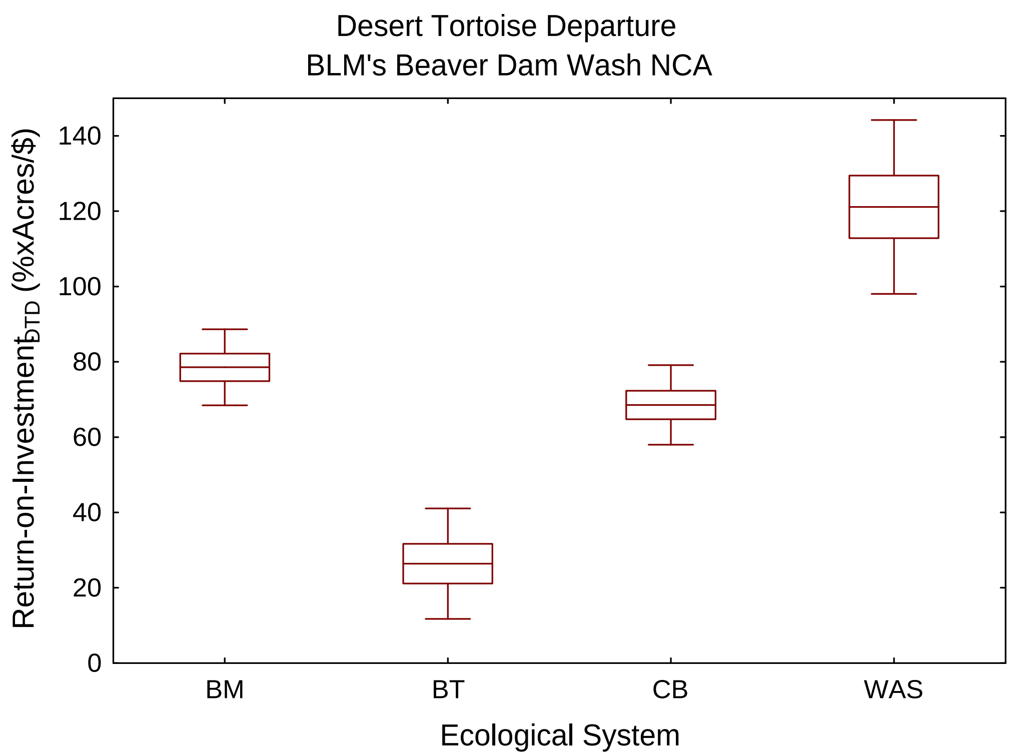


Figure 33. Average ecological system-wide return on investment (ROI) based on desert tortoise departure (subscript $_{DTD}$) for the four ecological systems of BLM's Red Cliffs NCA used by desert tortoise and selected for active management analyses. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: BM = Blackbrush-mesic, BT= Blackbrush-thermic, CB = Creosotebush-White Bursage, WAS = Desert Washes.

The ROI for desert washes reached the highest value, nearly twice of others. The management giving this result was only cessation of livestock grazing in desert washes because this management action is very inexpensive compared to other scenarios tested, although it did not achieve as large reduction in ecological departure as other actions.

The ROIs for mesic blackbrush and creosotebush-white bursage were second highest and statistically equal because of overlapping confidence intervals. These systems are the largest in

the NCA. The mesic blackbrush only required a fuel break; however statistically equal results were achieved with much lower desert tortoise departure with three other scenarios:
a) herbicide application followed by planting containerized shrub and forbs and excluding from livestock planted areas for 10 years, b) herbicide application followed by planting containerized shrub and forbs, and c) STREAMLINED MANAGEMENT.

Three scenarios, all experimental, performed equally well for creosotebush-white bursage:
a) herbicide application followed by planting containerized shrub and forbs and excluding planted areas from livestock for 10 years, b) herbicide application followed by planting containerized shrub and forbs, and c) BFOD with a 75% success rates. The latter scenario also achieved the lowest desert tortoise departure.

Blackbrush-thermic had clearly the lowest ROI. Several different scenarios achieved this ROI for thermic blackbrush with minor differences among them: a) herbicide application followed by planting containerized shrub and forbs and excluding planted areas from livestock for 10 years, b) herbicide application followed by planting containerized shrub and forbs, c) STREAMLINED MANAGEMENT, d) MAXIMUM MANAGEMENT, e) FUEL-BREAK-ONLY, and f) any of the BFOD-ONLY success rates. Overall, fuel breaks either alone or in combinations are beneficial to the tortoise.

Ecological departure applied to six ecological systems in the Beaver Dam Wash NCA. Mesic and thermic blackbrush, creosotebush-white bursage, and desert washes all required application of commercially available BFOD fungi, whereas mountain shrub and warm desert riparian did not. The highest ROI based on ecological departure is found for mountain shrub (Figure 34), as was the case for the Red Cliffs NCA. Success rates of actions are high and cost is relatively low for mountain shrub. Creosotebush-white bursage and mesic blackbrush occupy the second group of higher ROIs and both depended on the success rate of the BFOD fungi. These are the largest ecological systems in the NCA and have significant burned areas in need of restoration. Blackbrush-mesic, desert washes, and warm desert riparian had comparable ROIs and overlapping confidence intervals. Restoration of warm desert riparian did not utilize the BFOD fungi.

In summary, these various ROI values are useful tools for land managers to decide where to allocate scarce management resources among many possible choices on lands that they administer. As a rule of thumb, the higher ROI indicates a higher priority for implementation; therefore, managers should pay special attention to desert washes, warm-season grassland, mountain shrub, and mesic blackbrush (Figures 31-34). Of course, managers may also select final strategies or treatment areas based upon a variety of additional factors, such as listed species recovery plans, availability of financial resources, policy constraints, and other uses or societal objectives.

The ROI comparison also revealed two important facts:

- Fuel breaks alone can cost-effectively slow the loss of remaining shrublands needed by desert tortoise and prevent a devastating second fire in already burned areas.

- Restoration of the two NCAs is highly dependent on the commercial development of two experimental technologies: planting containerized Mojave shrubs and forbs and the BFOD fungi.

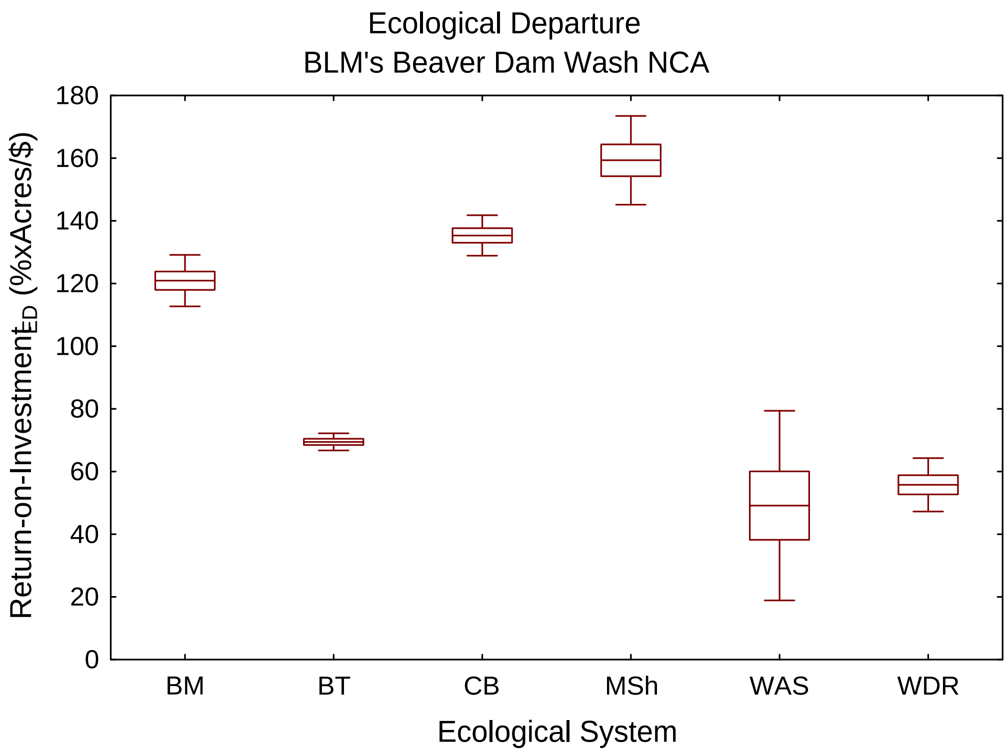


Figure 34. Average ecological system-wide return on investment (ROI) based on ecological departure (subscript $_{ED}$) for the six ecological systems of BLM's Beaver Dam Wash NCA selected for active management analyses. Center of box is the mean, edges of box are ± 1 SE, and bars are 95% confidence interval limits. N = 5 replicates. Legend: BM = Blackbrush-mesic, BT= Blackbrush-thermic, CB = Creosotebush-White Bursage, MSh = Mountain Shrub, WAS = Desert Washes, WDR = Warm-Desert Riparian.

Areas of Implementation

The state-and-transition modeling and analysis of simulation outcomes were not spatial. Workshop participants created two groups of actions with spatial consequences: landscape level (i.e. across ecological systems), and specific to vegetation classes.

Fuel breaks, special livestock management, and law enforcement are landscape level and broadly distributed. The area of implementation for special livestock management and law enforcement is potentially the whole Beaver Dam Wash NCA. Mapping fuel breaks is a more strategic exercise that requires a narrowing of a whole NCA down to selective strips of lands that are most likely to stop fires. Spatial fire behavior software is required to map fuel breaks and TNC has not conducted such analysis. BLM, however, has initiated such an analysis.

The vast majority of all other management actions target two widespread classes of vegetation: non-native annual grassland and forblands, and shrublands invaded by non-native annuals. In other words, these are burned and unburned areas, which are well defined (BLM has already obtained TNC's geodata), fairly homogenous, and widespread. All restoration actions that require seeding or planting are conducted in burned areas, whereas all actions that propose to control non-native annuals in the understory of shrublands with the BFOD fungi are conducted in unburned areas. Whether or not BLM decides to restore higher elevation shrublands and woodlands, including the upper mesic blackbrush not used by desert tortoise, is a management decision that would be applied as a mapping constraint. TNC cannot make that mapping decision for BLM and stakeholders.

Other ecological systems that do not fall into the burned *versus* unburned classes are montane riparian and warm desert riparian. The area of montane riparian is only 40 acres and nearly the whole area needs to be visited and spot treated. Again, a special map would not be more informative than the existing ecological system and vegetation class maps. The problems in warm desert riparian are more localized and difficult to find, but again the existing combined ecological system by vegetation class map is sufficient.

Context and Application of the LCF Process in the Project Area

The LCF process was developed mainly in the Great Basin of Nevada and western Utah. Early projects were primitive by current standards, such as in the Grouse Creek/Raft River Mountains of Utah, and the North Schell Creek Range of Nevada. The process has steadily evolved and improved over time, with recent projects in Great Basin National Park and the High Plateaus of south-central Utah representing modern versions of the method. Within all of the areas where it was applied through 2010, the LCF process covered habitats ranging from salt desert shrublands in basins at the lowest elevations, to subalpine forests in mountains at the highest elevations.

The 2011 application of LCF to the two NCAs in Washington County was a pioneering new reach for the process, from several standpoints. It was the first use of LCF at the much lower elevations of the Mojave Desert, where habitats are hotter and more harsh than those of the Great Basin. Major vegetation types that were "new" to LCF in this setting – not encountered in the Great Basin – include thermic shrublands of blackbrush and creosotebush. Further, never before had the LCF process dealt with such complete ecological departure nearly across-the-board: Most of the ecological systems in the two NCAs had departure values at the maximum of 100%, based on total dis-similarity from these systems' natural range of variability. Finally, never before had LCF encountered such a nearly-intractable problem as the pervasive presence and abundance of annual brome grasses in the two NCAs. These non-native grasses foster destructive wildfires of a size and intensity far greater than the fire regime with which Mojave Desert habitats developed over past millennia. The mutually-reinforcing adverse effects of annual brome grasses and fire lie at the root of most habitats' total departure scores in the NCAs.

Under these conditions, the predominant habitats of two NCAs – and the Mojave Desert at large – are fertile subjects for current scientific study. Specifically, science is rapidly developing in areas such as reduction of annual grass coverage via application of herbicides or fungal pathogens, and restoration methods in Mojave Desert habitats. Other studies are investigating the interactions of domestic livestock grazing with coverage of annual grasses and fire.

This rapidly-developing status of scientific inquiry in the Mojave Desert has significant implications for the LCF process. LCF uses state-and-transition ecological models to represent the functioning of coarse-scale habitats (such as blackbrush and creosotebush), and to forecast the results of specific management treatments or actions that may be done in those habitats. For these purposes, the models use a number of quantitative input parameters. Two examples of such parameters include the annual probability that an event such as a fire will occur in any given location (technically, the inverse of the event's "return-interval"); and the success/failure rate of a management action or treatment.

Ideally, quantitative values given to parameters in the models are derived from and grounded in credible scientific studies. But as noted above, the science that would underlie the determination of many such model-input values in Mojave Desert habitats is still in a state of development. In other words, this science has not yet "matured" to the point of its conclusions having widespread (though never universal) acceptance. Therefore, the partners conducting this LCF process in the two NCAs assigned some model values according to educated, experimental best-conclusions that seemed plausible to the group, in lieu of waiting for defensible values from the results of ongoing studies.

In a sense, the models in the two NCAs thus forecast the results of "experiments" – types, levels and combinations of management actions – that the partners believe to have some realistic chance of success for improving ecological conditions. The partners all acknowledge that the models are adaptive, and thus must be adapted in the future according to actual field results – degree of success – of management actions.

The uncertain nature of model input data is an issue that is not unique to the LCF process. It would be an issue in the two NCAs irrespective of the method used by managers to develop actions against major threats (invasives and fire) and restore some semblance of ecological integrity to the Mojave Desert landscapes.

One final issue slightly affected the conduct of NCAs project workshops due to a coincidence in timing. The modeling software used by LCF underwent a major upgrade in 2011, so that TNC's modeling practitioners had to work around some of the transition issues that inevitably accompany such an occurrence.

Key Conclusions

The primary conclusions of Landscape Conservation Forecasting™ for Washington County's NCAs are summarized below:

1. **At the current time, all ecological systems in each NCA are highly departed from their natural range of variability.** Only a very small occurrence of littleleaf mountain mahogany in the Beaver Dam Wash NCA was not highly departed. Accordingly, both NCAs fall within Ecological Departure Class (a.k.a., Fire Regime Condition Class) 3.
2. **The primary cause of ecological departure across the landscape is due to the nearly complete presence of non-native grasses and forbs in burned and unburned areas.** Desert washes, however, are also departed because vegetation is concentrated in one class (*early-succession*) after the heavy December 2010 floods; this current imbalance among reference classes would tend to "re-balance" and become less departed over time.
3. **Large areas of each NCA burned in 2005-06, and thereby converted from shrub to annual non-native grassland and forbland.**
4. **Desert tortoise habitat departure, a new metric developed by TNC and stakeholders, is slightly to moderately departed for relevant ecological systems in both NCAs. Four of six systems of the Red Cliffs NCA show low departure (Blackbrush-mesic, Blackbrush-thermic, Desert Sand Sagebrush, Warm Season Grassland); one of four systems of the Beaver Dam Wash NCA shows low departure (Creosotebush-White Bursage)**. Despite complete invasion by non-native annuals, sufficient vegetation remains available to provide most, though not necessarily all, *structural* habitat needs of the desert tortoise. Other tortoise needs such as food nutrition are beyond the ability of the LCF process to measure and model.
5. **Without active management, non-native grassland and forbland vegetation classes are projected to increase at the expense of shrublands that have been invaded by non-native grasses and forbs.**
6. **Without active management, exotic trees and forbs are predicted to increase in desert washes and riparian systems (montane and warm desert types).**
7. **A subset of ecological systems was selected for specific analyses of active management in the two NCAs.** Key ecological management issues by system include:
    a. ***Thermic and mesic blackbrush, and creosotebush-white bursage*** – burned areas are dominated by, and non-burned shrublands are invaded by, non-native annual species; burned areas are projected to increased with time.
    b. ***Mountain shrub and big sagebrush steppe*** – large proportions of burned areas are dominated by non-native annual grasses and forbs.
    c. ***Warm season grassland and desert sand sagebrush*** – these contain high percentages of late-succession classes with significant cover of non-native annual grasses and forbs.

   d. ***Riparian and desert washes*** – invasion by saltcedar and non-native annual grasses and forbs, and invasion by exotic forbs and trees.

8. **A variety of actions, some experimental with hypothetical success rates, were modeled for each ecological system selected for management. Multiple actions are required for most systems.**

   a. ***Thermic and mesic blackbrush, and creosotebush-white bursage*** management strategies include: a) herbicide application followed by planting containerized shrub and forbs (experimental); b) herbicide application followed by seeding of new and successful native plant species cultivars (experimental); c) exclusion of livestock for 10 years from planted areas; d) deployment of landscape-level fuel breaks; and e) application of the BFOD fungi with higher success rates of infection as a standalone "herbicide" and as a replacement for herbicide used in treatments (experimental).

   b. ***Mountain shrub and big sagebrush steppe*** management strategies include: herbicide application followed by seeding of native herbaceous and shrub species.

   c. ***Warm season grassland and desert sand sagebrush*** management strategies include: a) herbicide application to control non-native annuals; b) herbicide application followed by seeding native herbaceous species; and c) deployment of landscape-level fuel breaks.

   d. ***Riparian and desert washes*** management strategies include: a) weed inventory; b) cutting of saltcedar followed by stump painting with herbicide; c) spraying exotic forbs with herbicide; and d) controlling non-native annuals in riparian understory with herbicide. Replanting of native cottonwood and willow in reaches cleared of tamarisk to prevent its re-establishment is not proposed because the Virgin River, perennial reaches of Beaver Dam Wash, and warm-desert creeks already have abundant sources of riparian tree and shrub propagules, the tamarisk leaf beetle is active in the region, and the maintenance of modeled weed inventory and exotic control should address spot reinvasion.

9. **Scenarios using a single action or actions in combination were simulated for ecological systems used by desert tortoise.**

   a. **Landscape-level fuel breaks** alone can cost-effectively slow the loss of remaining shrublands needed by desert tortoise and prevent a devastating second fire in already burned areas. By preventing wildfires from returning, many Mojave Desert shrubs other than blackbrush can resprout or reestablish in non-native annual grasslands and forblands and provide beneficial shading structure to desert tortoise. Suggested implementation rates for fuel breaks are high. Strategic spatial analysis of fire risk from testing different positioning of fuel breaks is recommended.

   b. **Restoration of desert tortoise habitat** in the two NCAs is highly dependent on the <u>commercial</u> development of four experimental technologies: a) planting containerized Mojave shrubs and forbs; b) the BFOD fungi (mode of application and potency); c) highly-performing cultivars of Mojave Desert species; and d) methods of seed delivery that reduce granivory. The first two had the greatest simulated contributions to restoration of desert tortoise habitat. The fourth method, currently in experimental testing in Arizona, is subsumed in the third approach – i.e., simulations were not conducted assuming protected seed delivery and current seed mixes. Other potential technologies, such as enhancing soil carbon by application of sugar, were considered to be too speculative or too distant from commercial readiness to be included in this modeling process.

c. **Making public lands in the Beaver Dam Wash NCA unavailable for livestock grazing** benefitted desert washes, which are preferred desert tortoise habitat. However, this simulated action had small negative return-on-investments for creosotebush-white bursage and thermic and mesic blackbrush because of the tradeoff between livestock grazing slightly slowing down fire activity (desirable) and accelerating woody succession (undesirable). The effect of livestock grazing on fire ignitions was assumed to be very weak for two reasons: 1) only about 5% of the area available to livestock was effectively used due to reluctance of cattle to travel more than two miles from a water source; and 2) an area that had not seen cattle for three consecutive years (in the model) resumed normal fire activity, which was low (200-year mean fire return interval in mixed shrub and non-native annual species) except in annual grasslands and forblands, but otherwise fire was suppressed in the small grazed area until the three-year condition was met. The consequence of these constraints was that at most 95% of the Beaver Dam Wash NCA public lands never experienced (in the model) suppressed fire activity caused by cattle grazing. However, the 5+% of these lands affected by grazing did experience some reduced fire activity. Because this is the only difference between this NO GRAZING scenario and the MINIMUM MANAGEMENT scenario, a small negative ROI was generated for the creosotebush-white bursage and two blackbrush systems. Less fire is always beneficial to creosotebush-white bursage and blackbrush. Model results, however, were never meant to include other adverse effects of cattle grazing beyond the power of state-and-transition modeling – such as soil compaction, variation in species composition within a vegetation class, or tortoise burrow destruction by cattle – for the creosotebush-white bursage and blackbrush large-scale ecological systems.

d. **Simulated "livestock closure only"** – which was used to reduce stocking rates temporarily in desert washes and to protect plantings and seedings in creosotebush-white bursage and thermic and mesic blackbrush – always had small (i.e., not statistically significant) beneficial effects on desert tortoise departure when used in combination with planting and seeding, compared to the MINIMUM MANAGEMENT scenario. The primary cause of the small effect was not due to protection from cattle grazing, which worked, but to the emergence of the non-native annual species seedbank after 2-3 years that caused a transition back to the shrub with mixed exotic annual and native perennial species classes. Seedbank emergence eliminated nearly all benefits of restoration and temporary resting from livestock grazing.

10. **Comparison of ROIs alone indicates a higher priority for implementation in desert washes, warm-season grassland, mountain shrub, and mesic blackbrush**. It is understood, however, that planning for the recovery of desert tortoise may dictate

resources also to be delivered to creosotebush-white bursage and thermic blackbrush, especially because fuel breaks are most likely to be implemented in these systems.

11. **Workshop participants created two groups of actions with spatial consequences: landscape level (i.e. across ecological systems), and specific to vegetation classes.**

    a. The area of implementation for focused livestock management (public lands made unavailable for grazing, reduction of stocking rates, or ten-year closure/fencing of seeded or planted areas) and law enforcement is potentially the whole Beaver Dam Wash NCA. In this project, the role of law enforcement was strictly associated with reducing the production of bare ground from illegal OHV activity; law enforcement was not explicitly linked with desert tortoise protection.

    b. Mapping fuel breaks is a more strategic exercise that requires a narrowing of a whole NCA down to selective strips of lands that are most likely to stop fires.

    c. All restoration actions that require seeding or planting are conducted in burned areas, whereas all actions that propose to control non-native annuals in the understory of shrublands with the BFOD fungi are conducted in unburned areas.

    d. Other ecological systems that do not fall into burned *versus* unburned classes are montane riparian and warm desert riparian. The area of montane riparian is only 40 acres and nearly the whole area needs to be visited and treated. The problems in warm desert riparian are more localized and mapped.

Acknowledgments

This project was funded jointly by the Bureau of Land Management and The Nature Conservancy. We are thankful to the David and Lucile Packard Foundation for generous support to The Nature Conservancy for this important public/private partnership that brought together some amazing minds to address conservation on public lands.

The authors gratefully acknowledge the contributions of many to the success of this project, especially by the following individuals:

Bureau of Land Management (St. George Field Office)

- Jimmy Tyree
- Dawna Ferris-Rowley
- Kim Leany
- Dave Kiel
- Bob Douglas
- Marisa Monger
- Tim Croissant
- Dave Corry

Washington County, Utah

- Alan Gardner
- Bob Sandberg
- Cameron Rognan

Utah Division of Wildlife Resources

- Ann McLuckie
- Jason Jones
- Jimi Gragg

U.S. Fish and Wildlife Service

- Betsy Herrmann
- Renee Chi

Bureau of Land Management (Color Country District Office)

- Paul Briggs
- Keith Rigtrup

Bureau of Land Management (Arizona Strip Field Office)

- Kathleen Harcksen
- Richard Spotts

University of Nevada, Las Vegas

- Scott Abella

U.S. Geological Survey

- Leslie Defalco

Applied Conservation, Inc.

Enduring Conservation Outcomes, Inc.

Spatial Solutions, Inc.

The authors especially thank Dawna Ferris-Rowley, Richard Spotts, and Ann McLuckie for their thoughtful and thorough review comments on the draft report that were instrumental in improving the quality of the final report.

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Appendix 1. Descriptions of vegetation classes within ecological systems for the Red Cliffs and Beaver Dam Wash National Conservation Areas.

Big Sagebrush Steppe - upland (BSu)	
1126u	

Overview: The Big Sagebrush Steppe - upland site BpS (a.k.a., mountain big sagebrush) is found above and intergrades with the mesic sites (≥10 inch Precipitation Zone) of the Blackbrush BpS in the both NCAs. Elevation is generally above 8,000 ft (2,440 m) in the Mojave Desert. 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 Mojave Desert communities have received less taxonomic description than northern mapping zones. 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 and often diverse.*

A	**Early**; 0-10% canopy of mountain sage, mountain brush; 10-80% grass/forb cover; 0-12 yrs
B	**Mid-open**; 11-30% cover of mountain sage, mountain shrub; >50% herbaceous cover; 13-38 yrs
C	**Mid-closed**; 31-50% cover of mountain sage, mountain brush, occasional blackbrush; 25-50% herbaceous cover; <10% conifer sapling cover; 38+ yrs
D	**Late-open**; 10-30% cover pinyon-juniper <3m; 25-40% cover of mountain sage, mountain brush, occasional blackbrush; <30% herbaceous cover; 80-129 yrs
E	**Late-closed**; 31-40% pinyon-juniper cover <8m; 6-20% shrub cover; <20% herbaceous cover; 130+ yrs
U-*ES*	**Early-Shrub**; 20-50% cover of cholla, snakeweed or rabbitbrush species
U-*TE*	**Tree-Encroached**; 31-40% pinyon-juniper cover 10-25m; <5% shrub cover; <5% herbaceous cover
U-*DP*	**Depleted**; 20-50% cover of mountain sage, mountain brush, occasional blackbrush; <5% herbaceous cover; <10% conifer sapling cover
U-*SEP*	**Shrub-Exotic-Species-Perennial-Grass**; 11-50% cover of mountain sage, mountain brush, occasional blackbrush; >5% cover of native grass; >5% cheatgrass cover; <10% conifer sapling cover
U-*SES*	**Shrub-Exotic-Species**; 11-50% cover of mountain sage, mountain brush, occasional blackbrush; ≥5% cheatgrass cover; ≤5% cover of native grass; <10% conifer sapling cover
U-*EX*	**Exotic-Species**; 10-30% cover of cheatgrass; snakeweed or rabbitbrush may be present
U-*TEX*	**Tree- Exotic-Species;** 31-40% pinyon-juniper cover <8m; ≥5% cover of cheatgrass; <20% shrub cover; <20% herbaceous cover
U-*SD*	**Seeded (native)**; >10% seeded native grasses, forbs, and shrubs

Blackbrush - mesic (≥10 inch precipitation zone) (BM)
1082m

Overview: The Blackbrush-mesic BpS differs between the Beaver Dam Wash and Red Cliffs NCAs: Joshua trees are present on half the area in Beaver Dam Wash NCA, but absent in the Red Cliffs NCA. The description below includes all classes with and without Joshua trees. *Within the Mojave-Colorado Plateau ecotone, blackbrush is found on dry slopes and benches above the river canyons of southern Utah and northern Arizona. It is also found midslope on mountain ranges throughout this area. Soils are mesic, predominantly shallow to a root restrictive layer, on low hills and mountains and broad alluvial fans. Precipitation ranges from 10 to 12+ inches, with most occurring from November through April. Summers are hot and dry with many days reaching above 100 degrees F. The dominant shrub is blackbrush* (Coleogyne ramosissima). *Blackbrush is considered to be one of the most flammable native plant assemblages in the Mojave Desert, although this desert does not have a history of fire. Codominant shrub species include* Eriogonum fasciculatum, Ephedra nevadensis, Grayia spinosa, Menodora spinescens, Opuntia acanthocarpa, Yucca brevifolia, *or* Yucca schidigera. *Utah juniper is often associated with mesic blackbrush at higher elevations.*

Appendix 1. Descriptions of vegetation classes within ecological systems for the Red Cliffs and Beaver Dam Wash National Conservation Areas.

A	**Early**: 0-199 yrs; 0-40% cover of snakeweed, rabbbitbrush, big sagebrush, turpentine bush, yucca, and desert bitterbrush; young blackbrush may be present
B	**Mid-closed**: 200+ yrs; 10-50% cover blackbrush <1.0m; >1% cover of young Joshua trees; <10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present, pinyon or juniper saplings present
C	**Mid-open**: 200+ yrs; 10-50% cover blackbrush <1.0m; Joshua trees **absent**; <10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present, pinyon or juniper saplings present
D	**Late-open**: 400+ yrs; 10-40% of pinyon or juniper; 5-40% blackbrush cover; Joshua trees **absent**; <10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present
E	**Late-closed**: 400+ yrs; 10-40% of pinyon or juniper; 5-40% blackbrush cover; >1% cover of Joshua trees; <10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present
U-*ES*	**Early-Shrub**; 20-50% cover of cholla, snakeweed or rabbitbrush species
U-*SEPJ*	**Shrub-Exotic-Species-Perennial-Grass-Joshua-Tree**; 10-50% cover of blackbrush or other shrubs <1.0m tall; 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; >1% cover of Joshua trees; ≥5% native grass cover
U-*SEP*	**Shrub-Exotic-Species-Perennial-Grass**; 10-50% cover of blackbrush or other shrubs <1.0m tall; Joshua trees **absent**; 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; ≥5% native grass cover
U-*SES*	**Shrub-Exotic-Species**; 10-40% cover of blackbrush or other shrubs <1.0m tall, 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <5% native grass cover
U-*TEX*	**Tree- Exotic-Species**; 10-40% of pinyon or juniper; >5% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <20% blackbrush cover; Joshua trees may be present
U-*EX*	**Exotic-Species**; >10% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <10% cover of blackbrush or other shrubs; unburned and charred Joshua tree may be present
U-*EX2B*	**Exotic-Species-2nd-Burn**; identical to U-*EX*, except that it has experienced a second burn.
U-*SD*	**Seeded (native)**; >10% seeded native grasses, forbs, and shrubs
U-*SDI*	**Seeded (introduced)**; >10% seeded non-native grasses, forbs, and shrubs
U-*PL*	**Planted;** >5% planted shrubs and perennial herbaceous species; <5% non-native annual grasses and forbs
U-*BG*	**Bare ground**; mineral soil exposed by human disturbances

Blackbrush - thermic (≤10 inch precipitation zone) (BT)

1082t

Overview: The Blackbrush-thermic BpS differs between the Beaver Dam Wash and Red Cliffs NCAs: Joshua trees are present on half the area in Beaver Dam Wash NCA, but absent in the Red Cliffs NCA. The description below includes all classes with and without Joshua trees. Within the Mojave-Colorado Plateau ecotone, blackbrush is found on dry slopes and benches above the river canyons of southern Utah and northern Arizona. It is also found midslope on mountain ranges throughout this area. Soils are thermic, predominantly shallow to a root restrictive layer, on low hills and mountains and broad alluvial fans. Precipitation is <10 inches, with most occurring from November through April. Summers are hot and dry with many days reaching above 100 degrees F. The dominant shrubs are blackbrush (Coleogyne ramosissima) *and white bursage* (Ambrosia dumosa). *Blackbrush is considered to be one of the most flammable native plant assemblages in the Mojave Desert, although this desert does not have a history of fire. Codominant shrub species include* Eriogonum fasciculatum, Ephedra nevadensis, Grayia spinosa, Menodora spinescens, Opuntia acanthocarpa, Yucca brevifolia, *or* Yucca schidigera. *Utah juniper is never present.*

A	**Early**: 0-499 yrs; 0-50% cover of snakeweed, turpentine bush, yucca; <10% cover blackbrush

Appendix 1. Descriptions of vegetation classes within ecological systems for the Red Cliffs and Beaver Dam Wash National Conservation Areas.

B **Late-closed**: 500+ yrs; 10-40% cover blackbrush <1.0m; creosotebush present; >1% cover of Joshua trees; 0-10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn), other shrubs present

C **Late-open**: 500+ yrs; 10-40% cover blackbrush <1.0m; creosotebush present; 0-10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present

U-*ES* **Early-Shrub**; 20-50% cover of cholla, snakeweed or rabbitbrush species

U-*SEPJ* **Shrub-Exotic-Species-Perennial-Grass-Joshua-Tree**; 10-40% cover of blackbrush or other shrubs <1.0m tall, 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; >1% cover of Joshua trees; ≥5% native grass cover

U-*SEP* **Shrub- Exotic-Species-Perennial-Grass**; 10-40% cover of blackbrush or other shrubs <1.0m tall, 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; Joshua trees **absent**; ≥5% native grass cover

U-*SES* **Shrub-Exotic-Species**; 10-40% cover of blackbrush or other shrubs <1.0m tall, 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <5% native grass cover

U-EX **Exotic-Species**; >10% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <10% cover of blackbrush or other shrubs; unburned and charred Joshua tree may be present

U-*EX2B* **Exotic-Species-2nd-Burn**; identical to U-*EX*, except that it has experienced a second burn.

U-*PL* **Planted;** >5% planted shrubs and perennial herbaceous species; <5% non-native annual grasses and forbs

U-*BG* **Bare ground**; mineral soil exposed by human disturbances

Creosotebush-White Bursage Scrub (CB)
1087

*Overview: The Creosotebush-White Bursage BpS occupies the lowest elevations of both NCAs and is typically found below the blackbrush zone on well-drained alluvial flats. Elevations range from 5,000-6,000 ft (1,525-1,830 m) on lower mountain foot slopes. Soil types vary from shallow to very deep on erosional fan remnants, fan piedmonts, and sideslopes of hills and lower mountains. Slopes range from 2-75%, but slope of 2-15% are typical. Creosotebush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*) co-dominate, with bursage more prevalent in warmer and drier sites.*

A **Early**; 5-20% cover of creosote and white bursage builds up over time;5-20% grass cover depending on winter precipitation and season; 0-19 yrs

B **Mid-closed**; 21-40% creosote and white bursage cover; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); >1% cover of Joshua trees; 20+ yrs

C **Late-open**; 21-40% creosote and white bursage cover; Joshua trees **absent**; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); 20+ yrs

D **Late- closed;** 21-40% creosote and white bursage cover; >1% cover of Joshua trees; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); 400+ yrs

U-*ES* **Early-Shrub**; 20-50% cover of cholla, snakeweed or rabbitbrush species

U-*SEP* **Shrub-Exotic-Species-Perennial-Grass**; 21-40% cover of creosote and white bursage; 0-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); Joshua trees **absent**

U-*SEPJ* **Shrub- Exotic-Species-Perennial-Grass-Joshua-Tree**; 21-40% cover of creosote and white bursage; 0-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); >1% cover of Joshua trees

U-*SES* **Shrub-Exotic-Species**; 10-40% cover of creosotebush or other shrubs <1.0m tall; 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <5% cover of native grasses or forbs; Joshua tree **absent**

Appendix 1. Descriptions of vegetation classes within ecological systems for the Red Cliffs and Beaver Dam Wash National Conservation Areas.

U-*SESJ*	**Shrub-Exotic-Species-Joshua-Tree**; 10-40% cover of creosotebush or other shrubs <1.0m tall; 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; >1% cover of Joshua trees; <5% cover of native grasses and forbs
U-EX	**Exotic-Species**; >10% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <10% cover of creosotebush or other shrubs; unburned and charred Joshua tree may be present
U-*EX2B*	**Exotic-Species-2nd-Burn**; identical to U-*EX*, except that it has experienced a second burn.
U-*SD*	**Seeded (native)**; >10% seeded native grasses, forbs, and shrubs
U-*SDI*	**Seeded (introduced)**; >10% seeded non-native grasses, forbs, and shrubs
U-*PL*	**Planted;** >5% planted shrubs and perennial herbaceous species; <5% non-native annual grasses and forbs
U-*BG*	**Bare ground**; mineral soil exposed by human disturbances

Desert Sand Sagebrush (DSS)
1135ss

Overview: The Desert Sand Sagebrush BpS occupies deep sandy soils of the Red Cliffs NCA and Snow Canyon State Park. The dominant and diagnostic species is sand sagebrush, Artemisia filifolia*. The community is characterized by abundant sand and blowout areas. Subdominant shrubs include snakeweed and desert almond. Common grasses include big galleta, bush muhly, Indian ricegrass, and desert needlegrass*.

A	**Early**; 5-19% sand sagebrush and snakeweed/rabbitbrush cover; 5-20% cover of grasses (big galleta, bush muhly, Indian ricegrass, desert needlegrass); >40% bare ground (mostly sand); 0-2 yrs after fire
B	**Late-closed**; 20-40% cover of sand sagebrush, desert almond, and rabbitbrush; 5-20% grasses (big galleta, bush muhly, Indian ricegrass, desert needlegrass); scattered juniper may be present; >30% bare ground (mostly sand); 3+ yrs
U-*DP*	**Depleted**; 20-40% sand sagebrush, snakeweed, and rabbitbrush cover;<5% cover of grasses; >40% bare ground cover
U-*SEP*	**Shrub-Exotic-Species-Perennial-Grass**; 5-40% sand sagebrush and rabbitbrush cover; 5-10% cover of exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*); native grasses may be present to common; >30% bare ground (mostly sand)

Montane Riparian (MR)
1154

Overview: The Montane Riparian BpS is found within a broad elevation range from about 4,000 ft (1,220 m) to over 7,000 ft (2,135 m). Riparian forests and woodlands require flooding and gravel for reestablishment. The BpS is found in low- to mid-elevation canyons and draws, on floodplains, or in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff. Underlying gravels may keep the water table just below ground surface, and are favored substrates for cottonwood and willow. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Surface water is generally high for variable periods. Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Codominant and diagnostic species include willow, buffaloberry, cottonwood, velvet ash, conifers, and mesquite. Vegetation is very heterogeneous 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, young mesquite) 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

Appendix 1. Descriptions of vegetation classes within ecological systems for the Red Cliffs and Beaver Dam Wash National Conservation Areas.

U-*SFE*	**Shrub-Forb-Encroached**; 10-50% cover of Wood's rose or other unpalatable forbs and shrubs in open areas or under tree canopy
U-*EF*	**Exotic-Forb**; 10-100% cover of exotic forbs (knapweed, tall whitetop, purple loosestrife), salt cedar, or Russian olive)
U- *DE*	**Desertification**; Entrenched river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush, snakeweed, rabbitbrush); >5% native grass cover

Mountain Mahogany (Littleleaf Mountain Mahogany) (MM)

1062

*Overview: The Mountain Mahogany BpS is only found in Beaver Dam Wash NCA in small patches on limestone bedrock, coarse rock fragments, and very shallow dry limestone soils either at the base of limestone cliffs or on ledges. The dominant and diagnostic species is little-leaf mountain mahogany (*Cercocarpus intricatus*). Other shrubs include bitterbrush (*Purshia *sp.) and snowberry (*Symphoricarpos *sp.*).

A	**Early**; 10-55% cover little-leaf mountain mahogany (*Cercocarpus intricatus*) seedlings and saplings <0.5m high; mineral soil, bedrock, and rock abundant; grasses and shrubs present but not abundant; 0-9 yrs
B	**Mid-open**; 10-30% cover littleleaf mountain mahogany 0.5-1m high; mineral soil abundant; 10% native perennial grasses cover; 5% cover of mountain shrubs other than mahogany; mineral soil, bedrock, and rock abundant; 10-29 yrs
C	**Late-closed (formerly *E*)**; 30-45% cover of littleleaf mountain mahogany 1-2m high; 15% cover of mountain shrubs other than mahogany; 45% cover of mineral soil, bedrock, and rock; >30 yrs
U-*TEX*	**Tree-Exotic-Species**; 10-55% cover of littleleaf mountain mahogany; 5-10% cheatgrass cover; 40% cover of mineral soil, bedrock, and rock
U-*EX*	**Exotic-Species**; 5-20% cheatgrass cover; littleleaf mountain mahogany largely absent; 80% cover of mineral soil, bedrock, and rock

Mountain Shrub (MSh)

1126ms

*Overview: The Mountain Shrub BpS is found in primarily two compositional forms where either Stansbury cliffrose (*Purshia mexicana*) or snowberry (*Amelanchier *sp.) is the diagnostic shrub. The BpS is found in small patches on different montane landforms. The snowberry form is usually at higher elevations on moderate to steep slopes with deep mesic soils above 8,000 ft (2,440 m) elevation, sometimes with coarse fragments. Other shrubs, grasses, and forb species can be abundant. The cliffrose form is usually at lower elevations and adjacent or imbedded in the pinyon and juniper woodlands on moderate to steep slopes, and often follows linear geologic features (rock ledges).*

A	**Early**; 0-10% canopy of snowberry, desert bitterbrush, or Stansbury cliffrose; 10-80% grass and forb cover; 0-12 yrs
B	**Mid-open**; 11-30% cover of snowberry, desert bitterbrush, or Stansbury cliffrose; >50% herbaceous cover; 13-38 yrs
C	**Mid-closed**; 31-50% cover of snowberry, desert bitterbrush, or Stansbury cliffrose; 25-50% herbaceous cover;<10% conifer sapling cover; 38+ yrs
D	**Late-open**; 10-20% pinyon pine-juniper cover <5m; 25-40% cover of snowberry, desert bitterbrush, or Stansbury cliffrose; <30% herbaceous cover; 80-129 yrs
U-*ES*	**Early-Shrub**; 20-50% cover rabbitbrush species
U-*DP*	**Depleted**; 31-50% cover of snowberry, desert bitterbrush, Stansbury cliffrose; <5% herbaceous cover; <10% conifer sapling cover
U-*SEP*	**Shrub-Exotic-Species-Perennial-Grass**; 5-40% cover of mountain shrubs; 5-20% non-native grass cover; native herbaceous cover usually present; trees may be present
U-*TE*	**Tree-Encroached**; >21% pinyon pine-juniper cover 10-25m; <5% shrub cover; <5% herbaceous cover

Appendix 1. Descriptions of vegetation classes within ecological systems for the Red Cliffs and Beaver Dam Wash National Conservation Areas.

U-*TEX*	**Tree-Exotic-Species;** 10-20% pinyon pine-juniper cover <5m; ≥5% cover of non-native annual grasses and forbs; 25-40% cover of snowberry, desert bitterbrush, or Stansbury cliffrose; <30% herbaceous cover
U-*EX*	**Exotic-Species;** 10-30% cover of cheatgrass; snakeweed or rabbitbrush may be present; dead standing stems of cliffrose often present

Pinyon-Juniper (PJ) 1019	
*Overview: The Pinyon-Juniper Woodland BpS is typically found from 5,500-8,000 ft (1,675-2440 m) above the blackbrush (*Coleogyne ramosissima*) zone. This type 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 *and* Juniperus osteosperma*, pure or nearly pure occurrences of* Pinus monophylla*, 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; 0-9 yrs
B	**Mid1-open**; 11-20% cover big sage or black sage <1.0m; 10-40% herbaceous cover; 10-29 yrs
C	**Mid2-open**; 11-30% cover of pinyon and/or juniper <5m; 10-40% shrub cover; <20% herbaceous cover; 30-99 yrs
D	**Late-open**; 31-50% cover of pinyon and/or juniper <5m-9m; 10-40% shrub cover; <20% herbaceous cover; >99 yrs
U-*TEX*	**Tree- Exotic-Species**; 31-50% cover of pinyon and/or juniper <5m-9m; 5-20% cheatgrass cover 10-40% shrub cover;
U-*EX*	**Exotic-Species**; 5-30% cheatgrass cover; dead pinyon or juniper visible

Warm Desert Riparian (WDR) 1155	
Overview: The Warm Desert Riparian BpS occurs primarily along perennial streams/rivers along the Colorado, Salt, Virgin, Muddy, and Mojave River corridors adjacent to low elevation shrublands. Elevation is typically below 4,000 ft (1,220 m). When mesquite bosque is the dominant type outside of perennial waterways, it is also found at elevations lower than 3,600 ft (1,100 m) along intermittent streams or in valleys bottoms along playa edges with a perched water table. The vegetation is a mix of riparian woodlands, shrublands, and grasslands. Vegetation is very patchy in rivers with active flood regimes. Dominant species are Salix gooddingii, Populus fremontii, Salix exigua, Pluchea sericea, Distichlis spicata, Sporobolis airoides, Carex *spp*., Typha *sp., and* Prosopis *sp. Halophytic shrub-dominated patches occur on drier sediment deposits or saltier surfaces. Vegetation is dependent upon periodic flooding.*	
A	**Early**; 10-50% cover of Gooding willow and Fremont Cottonwood seedlings and shrubs; riparian and wetland graminoids may co-dominate; 0-4 yrs post-flooding
B	**Mid-closed**; 51-100% cover of willow and small trees (willow and cottonwood) <3 m; patches of graminoids and halophytic shrubs common; 5-19 yrs after flooding
C	**Mid-open**; 11-50% cover of fire resprouts of mesquite and Gooding willow; patches of graminoids frequent after fire; mesquite mature to larger trees several years after fire; 1-89 yrs after fire
D	**Late1-closed**; 51%-90% of mature Gooding willow and Fremont cottonwood; patches of graminoids in saturated soils and of halophytic shrubs on drier sediment deposits or more saline surfaces; 10-89 yrs
E	**Late2-closed**; 51-90% mesquite cover; Gooding willow and Fremont cottonwood minor component; understory often dominated by graminoids and forbs; >90 yrs
U-*DE*	**Desertified**; incised river bank caused by human disturbance; 10-90% native halophytic shrub or riparian tree cover; graminoid patches may be present
U-*DET*	**Desertified-Exotic-Tree**; >5% exotic tree species (tamarisk or Russian olive) regardless of native cover; river bank incised

Appendix 1. Descriptions of vegetation classes within ecological systems for the Red Cliffs and Beaver Dam Wash National Conservation Areas.

U-*DEF*	**Desertified-Exotic-Forb**; >5% exotic forb species regardless of native cover; river bank incised
U-*DEX*	**Desertified-Exotic-Species;** 5-40% exotic annual grasses and forbs; charred remnants of trees and shrubs often present; snakeweed often present to abundant; river bank incised
U-*TEX*	**Tree- Exotic-Species;** 51%-90% of young or mature Gooding willow and Fremont cottonwood; >5% cover of exotic annual grass and forb species; patches of graminoids in saturated soils and of halophytic shrubs on drier sediment deposits or more saline surfaces
U-*EF*	**Exotic Forb**; >5% exotic forb species regardless of native cover; river bank not incised
U-*ET*	**Exotic-Tree**; >5% exotic tree species (tamarisk or Russian olive) regardless of native cover; river bank not incised
U-*EX*	**Exotic-Species;** 5-40% exotic annual grasses and forbs; charred remnants of trees and shrubs often present; snakeweed often present to abundant
U-*BG*	**Bare ground**; mineral soil exposed by human-caused disturbances

Warm Desert Riparian-Wash (Shallow & Deep combined) (SWA)
1155w

Overview: The Warm Desert Riparian-Wash BpS comprises intermittent to dry warm-desert drainages with mostly subsurface flow whose banks are deeply incised. The distinction between shallow and deep washes is primarily from the perspective of whether or not a desert tortoise could climb out of the wash. 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.

A	**Early**; 20-50% cover may be gravel, sands, and/or flood debris;10-19% cover of desert almond, burrobrush, rabbitbrush, creosotebush, desert willows present; 5-15% cover of grasses (big galleta, bush muhly); forbs present to abundant; 0-5 yrs
B	**Mid-closed**; 20-50% cover of desert almond, bursage, bladdersage, burrobrush, creosotebush, Anderson's wolfberry, rabbitbrush; 5-10% cover of grasses (big galleta, bush muhly); forbs present to abundant; <30% of gravel and rocks; 5-19 yrs
C	**Late-closed**; 30-50% cover of bursage, burrobrush, creosotebush, desert almond, bladdersage, Anderson's wolfberry, rabbitbrush, mesquite; Joshua tree present; 5-10% cover of grasses (big galleta, bush muhly); forbs present to abundant; <10% of gravel and rocks; >20 yrs
U-*SEP*	**Shrub-Exotic-Species-Perennial-Grass**; >5% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; 0-50% small mesquite, Joshua tree, and shrubs, 5-10% cover of grasses (big galleta, bush muhly); mineral soil may be common
U-*SES*	**Shrub-Exotic Species**; >5% 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-*ES*	**Early-Shrub**; 20-50% cover of cholla, snakeweed or rabbitbrush species
U-*ET*	**Exotic-Tree (formerly *EX*)**; >5% cover of salt cedar; 0-50% cover of bursage, burrobrush, creosotebush, Anderson's wolfberry, rabbitbrush, mesquite, Joshua tree
U-*BG*	**Bare ground**; mineral soil exposed by human-caused disturbances

Warm-Season Grassland (GRL)
11212

*Overview: The Warm-Season Grassland BpS is only found in the Red Cliffs NCA and Snow Canyon State Park. Grasslands are located on fine soils, sometimes fine sandy soils, at the toe of slopes, in shallow bottoms with gentle to moderate slopes, and on gentle slopes. Galleta grass (*Hilaria *sp.) is the dominant species and usually abundant, although Indian ricegrass (*Stipa hymenoides) *may be present to abundant. With time since fire or other disturbances, woody shrub cover will increase.*

A	**Early**; 20-70% cover of warm-season grasses (big galleta); forbs may be present; trace amount of resprouting shrubs may be present; woody vegetation largely absent; 30% mineral soil cover typical but ranges from 30 to 80% with time since fire; 0-19 yrs

Appendix 1. Descriptions of vegetation classes within ecological systems for the Red Cliffs and Beaver Dam Wash National Conservation Areas.

B	**Late-open**; 5-20% cover of shrub and succulents; 50-70% cover of warm-season grasses (big galleta); forbs may be present; 30% mineral soil cover typical; >20 yrs
U-*DP*	**Depleted;** 5-20% cover of shrub and succulents; <10% cover of warm-season grasses (big galleta); forbs may be present; 30% mineral soil cover typical; >20 yrs
U-*SES*	**Shrub-Exotic-Species-Perennial-Grass**; 5-20% cover of exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*); 5-20% cover of shrub and succulents; 10-60% cover of warm-season grasses (big galleta); forbs may present
U-*EEX*	**Early-Exotic-Species**; <20% cover of warm-season grasses (big galleta); 5-30% cover of exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*); 50-70% cover of mineral soil
U-EX	**Exotic-Species**; 5-30% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; 20-70% native grass species (big galleta); 5% cover of mineral soil

Appendix 2. Description of ecological model dynamics for the Red Cliffs and Beaver Dam Wash NCAs.

Non-spatial state-and-transition models of ecological systems were created with the software PATH and Vegetation Dynamics Development Tool (VDDT from ESSA Technologies, Ltd.; Barrett 2001; Beukema et al. 2003). Although PATH is the general architecture of the simulation, VDDT is "called in" by PATH to perform runs. In VDDT, succession and disturbance are simulated in a semi-Markovian framework. Each vegetation state has one possible deterministic transition based on time in the state (usually succession) and several possible probabilistic transitions (natural and management). Each of these transitions has a new destination state and probability associated with it. Based on the timing of the deterministic transition and the probabilities of the stochastic transitions, at each time step a polygon may remain the same, undergo a deterministic transition based on elapsed time in the current state or undergo a probabilistic transition based on a random draw (for example, replacement fire). Model parameters (succession duration and disturbance rates) are presented in Appendix 3.

We created 11 state-and-transition models for each of the ecological systems in Table 2 (except the very small littleleaf mountain mahogany). Appendix 1 presents the different states, phases, and their abbreviations for each ecological system. Although each model represented a distinct ecological system, some models were grouped on the same VDDT project page (i.e., Uber model) to allow for seamless system conversions should models be used for climate change analysis (it was not):

- Low-to-high elevation Uber VDDT project contained 9 ecological systems: Big Sagebrush Steppe-upland, Blackbrush-mesic, Blackbrush-thermic, Creosotebush-White Bursage, Desert Washes, Montane Riparian, Pinyon-Juniper Woodland, Mountain Shrub, and Warm-Season Grassland;
- Single project: Desert sand sagebrush; and
- Single project: Warm desert riparian.

All models had at their core the LANDFIRE reference condition represented by some variation around the A-B-C-D-E classes (Table 2; Appendix 1). Essentially, this meant that models had an early development class and mid-development and/or late-development classes. Mid- and late-development classes may be expressed as open or closed canopy. Several models contained <5 boxes that did not follow the classic nomenclature. The A-E class models simply represented succession from usually herbaceous vegetation to increasing woody species dominance where the dominant woody vegetation might be shrubs or trees. For the models to also reflect the effects of management, we added uncharacteristic vegetation classes that represented different states that only exist because of direct or indirect human activity (Appendix 1).

In all models, any disturbance was quantified by a rate expressed as a probability per year. This rate is the inverse of the return interval of a disturbance or a frequency of spatial events. For example, a mean fire return interval of 100 years is equal to a rate of 0.01/year (0.01 = 1/100). The probability/year rate is used in VDDT because it has the very convenient property of being additive, whereas return intervals are not additive. This rate was further multiplied by a proportion that partitioned the main rate in terms of success and failure outcomes, allocation of resources to realize different management objectives, or extent of application (for example, 5% of the biophysical setting was grazed at a rate of 1.0/year – livestock grazed every year [not a current practice in the Red Cliffs NCA], thus the return interval is 1 year). The rate that was ultimately used was the probability/year multiplied by proportions of allocation. Any rate, which is generally based on return intervals, is converted to a spatial draw per year as a necessary time for space substitution. Although VDDT is a non-spatial simulation software, the underlying process imitates temporal rates with virtual pixel draws. To pursue the fire return interval example, a probability/year of 0.01 means that 1 out of every 100 pixels on average receives fire within a year. Temporal multipliers described in the main text can be used to modify how many pixels are selected per year while maintaining a temporally average rate of 0.01/year (Appendix 4).

Models contained more management activities than were actually employed in final simulations to explore possibilities with workshop participants. The rate of application of each management action was set by Treatment Details in PATH or area limit function of VDDT that was reflective of management budgets and minimum treatments required to achieve objectives. Because area limits overrule rates, we generally used a default rate of 0.01 for all actions –another arbitrary rate could have been chosen; however, the proportional allocation of the area limit to different outcomes of the same management action was controlled by VDDT entries (Appendix 3). Some outcomes represented failure rates for an action, such as when a plant seeding failed and was replaced by a non-native annual species.

The format of model descriptions that follow will consist of a standard template of entries by ecological system (alphabetical order). Some entries will be repetitive among ecological systems and with Appendix 1. Each ecological system's model is intended to be self contained.

Big Sagebrush Steppe-upland (BSu) 1126u

Area of Application and Context:

- **Red Cliffs and Beaver Dam Wash National Conservation Areas of southwestern Utah**
- **Livestock grazing on Beaver Dam Wash only**
- **Full fire suppression management**
- **Date created: July 2011**

Vegetation classes:

- A-**Early**: 0-10% canopy of mountain sage, mountain brush; 10-80% grass/forb cover; 0-12 yrs
- B-**Mid-open**: 11-30% cover of mountain sage, mountain shrub; >50% herbaceous cover; 13-38 yrs
- C-**Mid-closed**: 31-50% cover of mountain sage, mountain brush, occasional blackbrush; 25-50% herbaceous cover; <10% conifer sapling cover; 38+ yrs
- D-**Late-open**: 10-30% cover pinyon-juniper <3m; 25-40% cover of mountain sage, mountain brush, occasional blackbrush; <30% herbaceous cover; 80-129 yrs
- E-**Late-closed**: 31-40% pinyon-juniper cover <8m; 6-20% shrub cover; <20% herbaceous cover; 130+ yrs
- U-*ES*: **Early-Shrub**: 20-50% cover snakeweed or rabbitbrush species
- U-*TE*: **Tree-Encroached**: 31-40% pinyon-juniper cover 10-25m; <5% shrub cover; <5% herbaceous cover
- U-*DP:* **Depleted**: 20-50% cover of mountain sage, mountain brush, occasional blackbrush; <5% herbaceous cover; <10% conifer sapling cover
- U-*SEP:* **Shrub-Exotic-Species-Perennial-Grass**: 11-50% cover of mountain sage, mountain brush, occasional blackbrush; >5% cover of native grass; >5% cheatgrass cover; <10% conifer sapling cover
- U-*SES:* **Shrub-Exotic-Species**: 11-50% cover of mountain sage, mountain brush, occasional blackbrush; ≥5% cheatgrass cover; ≤5% cover of native gass; <10% conifer sapling cover
- U-*EX:* **Exotic-Species**; 10-30% cover of cheatgrass; snakeweed or rabbitbrush may be present
- U-*TEX:* **Tree- Exotic-Species:** 31-40% pinyon-juniper cover <8m; ≥5% cover of cheatgrass; <20% shrub cover; <20% herbaceous cover
- U-*SD:* **Seeded (native)**: >10% seeded native grasses, forbs, and shrubs

Reference Condition:

- **Natural Range of Variability**
  - 30%: A-*Early*
  - 47%: B-*Mid-open*
  - 20%: C-*Mid--closed*
  - 1%: D-*Late-open*
  - 2%: E-*Late-closed*
  - 0%: U

Succession:

Succession follows the 5-box pathway with vegetation starting as predominantly herbaceous and ending with pinyon and juniper dominance and a viable shrub and herbaceous understory. The succession pathway is not entirely deterministic as the *tree-invasion* probabilistic disturbance is used to cause a transition from the mid-succession closed (*BSu-C*) to the late-succession open (*BSu-D*) classes. This rate of transition is 0.01 probability/year pixels starting at age 100 in the mid-succession closed class (BSu-*C*). This rate is consistent with the transition from Phase 1 to Phase 2 by Miller and Tausch (2001): this rate approximately replicated encroachment levels proceeding in three phases of about 50 years each.

Deterministic succession transitions occur at the following ages:

- Early-succession to mid-succession open: 19 years
- Mid-succession open to closed: 75 years
- Mid-succession closed to late-succession open: ≥100 years (probabilistic)
- Late-succession open to closed: 134 years

Natural Disturbances:

Replacement fire was the primary stochastic disturbance. *Replacement fire* restarts the succession clock at age zero within the reference condition, which was labeled the *early-succession* or *BSu-A* class. The mean return interval of *replacement fire* changed with vegetation classes:

- 80 years (0.0125/year) in the *early-succession* class (*BSu-A*);
- 50 years (0.02/year) in the *mid-succession classes* and *late-succession open* classes (*BSu-B*, *BSu-C* and *BSu-D*); and
- 75 years (0.013/year) in the wooded *late-succession closed* class (*BSu-E*).

Replacement fire in vegetation classes that already experienced a threshold transition also caused a threshold transition to other uncharacteristic classes:

- Fire in the *tree-encroached shrubland* (*TE*) has a mean fire return interval of 120 years (0.0085/year) and causes the following transitions:
    - 45% of times *to the exotic species* class (*EX*);
    - 45% to the *early shrub* class (*ES*); and
    - 10% to the *shrub exotic species class* (*SES*).
- Fire in the *tree-encroached shrubland with exotic annual species class* (*TEX*) has a mean fire return interval of 120 years (0.0085/year) and causes a transition to the *exotic species* class (*EX*) 45% of times.
- The *depleted shrubland* class (*DP*) burns with a 50-year return interval (0.02/year) and converts to the *early shrub* class (*ES*). Fire in this latter class (50-year fire return interval) simply promotes rabbitbrush as a self-loop for 100% of outcomes.
- A 10-year fire cycle applies to the *exotic species* class (*EX*) and behaves as a self-loop.
- Due to the presence of non-native annual species, the fire return interval is shorter (25 years or 0.04/year) in the *shrub with exotic annual species* class (*SES*) than in the *depleted shrub* class (*DP*). Fire in this class causes a conversion to the *exotic-species* class (*EX*).
- With a *replacement fire* of 25 years (0.04/year), the *shrubland with exotic annual and native perennial grasses* class (*SEP*) will become two classes:
    - *Exotic annual species* (*EX*) 90% of times; and
    - *Early-succession* class (*BSu-A*) the other 10% of occurrences.
- *Replacement fire* varied with the age of the *seeded* class (SD) and acted as a self-loop:
    - 80-year fire return interval (0.0125/year) from 0 to 19 years and after age 135 years; and
    - 50-year fire return interval (0.02/year) from 20 to 134 years.

Drought is found in most classes and causes stand replacing events (generally 10% of times) or stand thinning (90% of times). In most cases *drought* created tree and shrub mortality under the assumption that prolonged and decreased soil moisture weakens plants that might ultimately be killed by insects or disease. Therefore, we did not double-count mortality. A *drought* return interval rate of every 178 years (a rate of 0.0056/year) is used based on the frequency of severe drought intervals estimated by Biondi *et al*. (2007) from 2,300 years of western juniper (*Juniperus occidentalis)* tree ring data from the Walker River drainage of eastern California and western Nevada. Although we recognize that droughts may be more common than every 178 years, severe droughts, which were >7-year drought events with consecutive far-below average soil moisture (narrow tree rings), kill naturally drought resistant shrubs and trees. For vegetation classes in the reference condition, drought affects the *mid-succession closed* (*BSu-C*) to *late-succession* closed (*BSu-E*) classes (i.e., not the first two classes of succession) in different ways.

- The *mid-succession closed* class (*BSu-C*) follows the more traditional outcome of 90% thinning within the class (to its beginning) and 10% to the *early-succession* class (*BSu-A*).
- Drought partitions the *late-succession open* class (*BSu-D*) into three pathways that results from thinning young pinyon, juniper, or old shrubs:
  - 10% thinning within the class;
  - 60% thinning to the previous class (*mid-succession closed* or *BSu-C*); and
  - 30% to the *mid-succession open* class (*BSu-B*).
- The *late-succession closed* class (BSu-*E*), which is wooded, behaves differently than others to drought. Because trees have already suppressed the understory,
  - 10% of the thinning effect kills trees but releases shrubs and grass at a low cover value more typical of the *mid-succession open* class (*BSu-B*); and
  - The remaining 90% of *drought* effects accelerates woody succession by 5 years when a pixel is chosen because increased resource competition is to the detriment of shrubs and the herbaceous understory.

Drought affects four uncharacteristic classes.

- D*rought* in the *depleted* shrubland class (*DP*) causes a transition to:
  - *Early-succession shrub* (*ES*) 10% of times; and
  - Selectively thins older shrubs to age zero within the *depleted* class (*DP*) 90% of times.
- The fate of the *shrub-exotic-species* class (*SES*) is similar to the *depleted shrubland* class (*DP*) except the *exotic annual species* class *(EX*) replaces *early-succession shrubs* (*ES*).
- Drought thins the *tree-encroached shrubland with exotic annual species* (*TEX*) to two classes:
  - 10% to the *exotic annual species* class (*EX*); and
  - 90% as a self-loop to the beginning of the class.
- The *tree-encroached shrubland* class (*TE*) is thinned by drought:
  - 5% of times to the *early-shrub* class (*ES*);
  - 5% to the *exotic annual species* class (*EX*); and
  - 90% of times vegetation remained in the originating class.
- The *shrubland with mixed exotic annual species and perennial grasses* class (*SEP*) responds to drought by thinning to the following classes:
  - 1% to the *early-succession* class (*BSu-A*);
  - 9% to the *exotic species* class (*EX*); and
  - 90% as a self-loop.
- Drought also affects the *seeded* class (*SD*) by setting age back to zero.

Exotic annual species invasion (*EX-invasion*) is set at a moderate rate of 0.005/year (1 out of 200 pixels converted to a cheatgrass-invaded class per year). A base rate of 0.001/year was estimated from data of northwest Utah collected by the Utah Division of Wildlife Resources in black sagebrush semi-desert. Black sagebrush semi-desert is usually considered more resistant to cheatgrass invasion than Wyoming big sagebrush semi-desert or other big sagebrush dominated ecological systems. Because workshop participants did not have similar data, we defaulted to five times the rate estimated from the Utah data. The higher rates indicate greater susceptibility to non-native annual species because soils are more productive.

- Exotic annual species invasion (*EX-invasion*) starts in the mid-succession open class (*BSu-B*) and continues in the *late-succession open* class (*BSu-D*), causing a transition to the *shrubland with* *mixed exotic annual species and perennial grasses* class (*SEP*).

- *Exotic annual species invasion* is absent from the *late-succession closed* (wooded; *BSu-E*) and the *tree-encroached class* (*TE*) due to shading.
- The *depleted shrub* (*DP*) converts to the *shrub with non-native annual grass* class (*SES*) with *exotic annual species invasion* at a rate of 0.005/year.
- The rate of invasion in the *seeded* class, generally 0.005/year, was smaller from ages 20 to 134: 0.001/year because the class is more resistant to exotic annual species invasion.

Management Actions:

Modeled management activities included herbicide coupled with native plant seeding or thinning.

- Herbicide (Plateau®) application to control exotic annual grasses in exotic annual grassland and forblands (i.e., burned areas) followed by seeding native plant species. Failure rate is 20%, leading to the *exotic annual species* class (*EX*). Success causes a transition to the *seeded* class (*SD*).
- Chainsaw thinning of older trees in *tree-encroached shrublands with or without exotic annual species* (*TE and TEX*), conducting herbicide application for exotic annual species, and followed by seeding native plant species. Failure rate is 20%, causing a transition *exotic annual species* class (*EX*) if the originating class was *TEX* or a transition to the *early shrub* class (*ES*).

In theory, other management actions, such as prescribed fire, can be used. Because the big sagebrush steppe-upland ecological system is at elevations with heavy presence of exotic annual species and near housing in the Red Cliffs NCA, prescribed fire is avoided.

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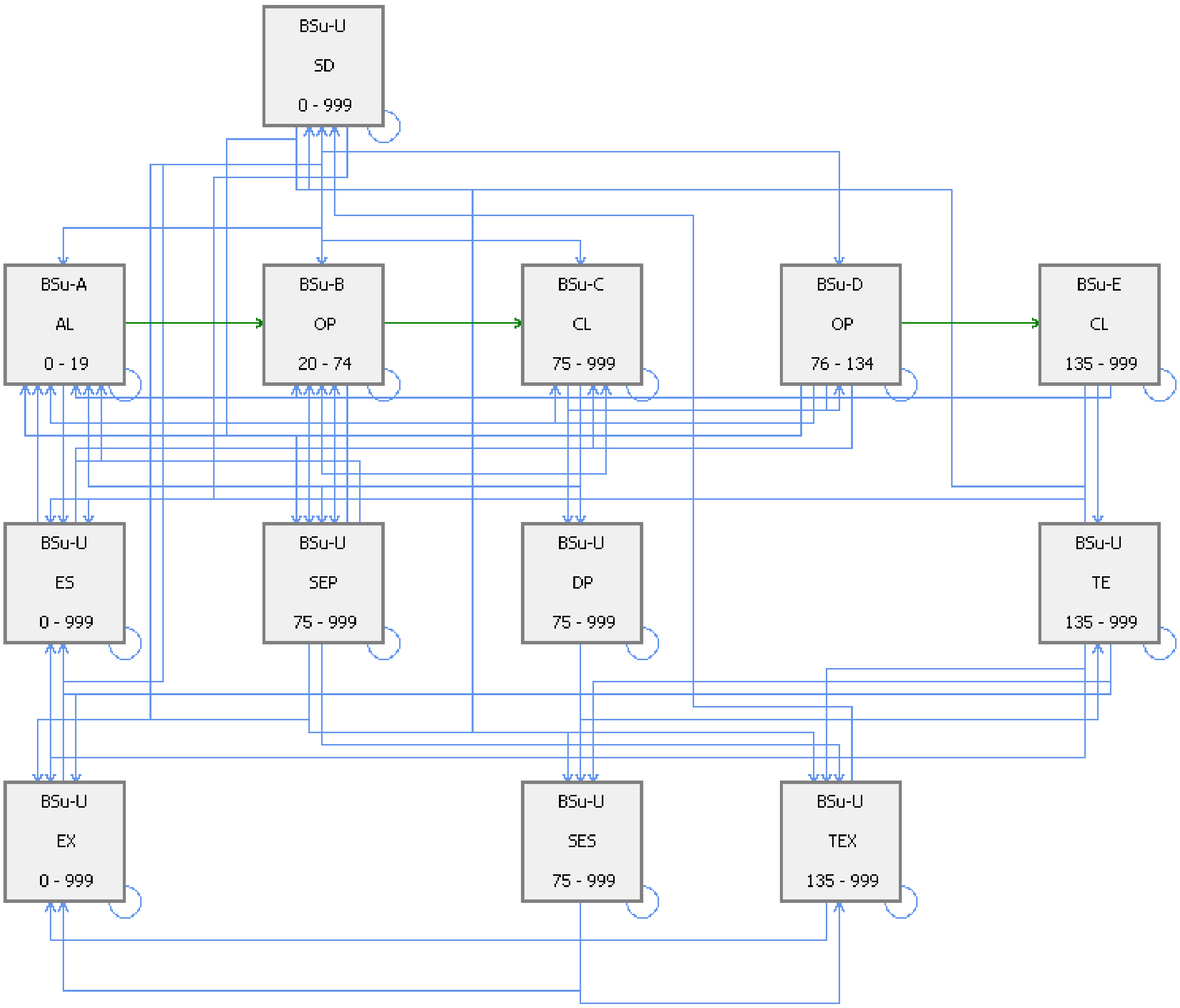

Blackbrush-mesic (BM) 1082m

Area of Application and Context:

- **Red Cliffs and Beaver Dam Wash National Conservation Areas of southwestern Utah**
- **Livestock grazing on Beaver Dam Wash only**
- **Full fire suppression management**
- **Date created: July 2011**

Vegetation classes:

Two versions of mesic blackbrush were developed at the request of stakeholders: with and without Joshua Trees. USDA's Natural Resource Conservation Service (NRCS), however, does not recognize Joshua tree woodlands as a distinct ecological site because the soils on which Joshua tree grow are the same the soils as creosotebush-white bursage, thermic and mesic blackbrush, and Great Basin mixed salt desert ecological sites. Joshua tree is absent from the Red Cliffs NCA and from some areas of the Beaver Dam Wash NCA (thus boxes B, E, and U-*SEPJ* below do not exist). Joshua tree is present in a large fraction o f the Beaver Dam Wash NCA and the description below applies in its entirety:

- **A-Early**: 0-199 yrs; 0-40% cover of snakeweed, rabbbitbrush, big sagebrush, turpentine bush, yucca, and desert bitterbrush; young blackbrush may be present
- **B-Mid-closed**: 200+ yrs; 10-50% cover blackbrush <1.0m; >1% cover of young Joshua trees; <10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present, pinyon or juniper saplings present
- C-**Mid-open**: 200+ yrs; 10-50% cover blackbrush <1.0m; Joshua trees **absent**; <10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present, pinyon or juniper saplings present
- D-**Late-open**: 400+ yrs; 10-40% of pinyon or juniper; 5-40% blackbrush cover; Joshua trees **absent**; <10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present
- E-**Late-closed**: 400+ yrs; 10-40% of pinyon or juniper; 5-40% blackbrush cover; >1% cover of Joshua trees; <10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present
- U-*ES:* **Early-Shrub**; 20-50% cover of cholla, snakeweed or rabbitbrush species
- U-*SEPJ:* **Shrub-Exotic-Species-Perennial-Grass-Joshua-Tree**; 10-50% cover of blackbrush or other shrubs <1.0m tall; 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; >1% cover of Joshua trees; ≥5% native grass cover
- U-*SEP:* **Shrub-Exotic-Species-Perennial-Grass**; 10-50% cover of blackbrush or other shrubs <1.0m tall; Joshua trees **absent**; 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; ≥5% native grass cover
- U-*SES:* **Shrub-Exotic-Species**; 10-40% cover of blackbrush or other shrubs <1.0m tall, 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <5% native grass cover
- U-*TEX:* **Tree- Exotic-Species**; 10-40% of pinyon or juniper; >5% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <20% blackbrush cover; Joshua trees may be present
- U-*EX:* **Exotic-Species**; >10% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <10% cover of blackbrush or other shrubs; unburned and charred Joshua tree may be present
- U-*EX2B:* **Exotic-Species-2nd-Burn**; identical to U-*EX*, except that it has experienced a second burn.
- U-*SD:* **Seeded (native)**; >10% seeded native grasses, forbs, and shrubs
- U-*SDI:* **Seeded (introduced)**; >10% seeded non-native grasses, forbs, and shrubs
- U-*PL:* **Planted;** >5% planted shrubs and perennial herbaceous species; <5% non-native annual grasses and forbs

- U-*BG:* **Bare ground**; mineral soil exposed by human disturbances

Reference Condition:

- **Natural Range of Variability without Joshua tree**
  - 11%: A-*Early*
  - 0%: B-*Mid-closed*
  - 73%: C-*Mid-open*
  - 16%: D-*Late-open*
  - 0%: E-*Late-closed*
  - 0%: U
- **Natural Range of Variability with Joshua tree**
  - 10%: A-*Early*
  - 39%: B-*Mid-closed*
  - 35%: C-*Mid-open*
  - 8%: D-*Late-open*
  - 8%: E-*Late-closed*
  - 0%: U

Succession:

Succession varies with the presence of Joshua trees.

In the absence of Joshua trees, succession follows the 3-box pathway with vegetation starting as predominantly dominated by snakeweed and herbaceous species and ending with pinyon or juniper dominance and a viable shrub understory. Deterministic succession transitions occur in the first two boxes, whereas the last step of succession is probabilistic:

- Early-succession to mid-succession open: 200 years
- Mid-succession open to late-succession open: ≥400 years (probabilistic)

With Joshua trees, succession is a 5-box model with parallel open and closed branches originating from the *early-succession* class (*BM-A*). Deterministic transitions govern succession between the *early-succession* (BM-A) and both *mid-succession* classes (*BM-B* and *BM-C*). The deterministic transition is not a true succession and reflects a partitonning of acres proportional to the current area without and with Joshua tree. *Tree-invasion* acts as a probabilistic succession disturbance between the mid-succession and late-succession classes.

- Early-succession to mid-succession open and closed: 200 years
- Mid-succession open or closed, respectively, to late-succession open or closed: ≥400 years (probabilistic)

Natural Disturbances:

Very few natural disturbances affect blackbrush: replacement fire, drought, and tree invasion. Blackbrush is an ancient vegetation type whose individual plants resisted disturbances for hundreds of years (Pendleton et al. 1986). Moreover, blackbrush is not fire adapted and has not evolved with fire (Callison et al. 1985).

Replacement fire is present at very low rates in most classes. The fire return interval of *replacement fire* changes with vegetation classes:

- From 10,000 years (0.0001/year) in the *early-succession* class (*BM*-A);
- 2,000 years (0.0005/year) in both *mid-succession with or without Joshua tree* classes (*BM-B and BM-C*); and
- 1,000 years (0.001/year) in both wooded *late-succession with or without Joshua tree* classes (*BM-D and BM-E*).

Replacement fire in vegetation classes that already experienced a threshold transition also causes a threshold transition to other uncharacteristic classes.

- Fire experienced every 400 years (0.0025/year) on average in the *tree encroached shrubland with exotic annual species* class (*TEX*) causes a transition to the *exotic annual species* class (*EX*).
- The *shrubland with mixed exotic annual and native perrennial species* class (*SEP*) burns every 200 years (0.005/year) on average, causing a transition to the *once-burned exotic annual species* class (*EX*) or twice-*burned exotic annual species* class (*EX2B*), respectively, for shrubland with previously unburned and burned (i.e., absent) blackbrush.
- The *twiced-burned exotic annual species* class (*EX2B*) and *once-burned exotic annual species* class (*EX*) *classes* burn every 10 years (0.1/year) on average from ages 0 to 20 years classes (self loop), whereas the *EX* class older than 20 years burns every 20 years on average. When the *once-burned exotic annual species* class (*EX*) class burns, it becomes the twice-*burned exotic annual species* class (*EX2B*) from which shrub natural recovery is nearly impossible without dedicated management.
- *Planted* (*PL*) and *seeded* (*SD*) classes, whose exotic annual fine fuel component is temporally suppressed, burn every 1,000 years (0.001/year). These classes transition to age zero in the same class (this possibility is very remote because residence time in these classes is short due to exotic annual seedbank emergence).

Blackbrush is assumed drought adapted. Older reference classes with juniper and pinyon and some uncharacteristic classes are affected. *Drought* causes stand replacing events (generally 1% to 10% of events) and stand thinning (99% to 90%, respectively, of events) in classes with trees. A *drought* return interval rate of every 178 years (a rate of 0.0056/year) is used based on the frequency of severe drought intervals estimated by Biondi *et al*. (2007) from 2,300 years of western juniper (*Juniperus occidentalis)* tree ring data from the Walker River drainage of eastern California and western Nevada. Although we recognize that droughts may be more common than every 178 years, severe droughts, which are >7-year drought events with consecutive far-below average soil moisture (narrow tree rings), kill naturally drought resistant shrubs and trees.

- For the *late-succession closed with Joshua tree* class (*BM-E*), drought-induced mortality either:
  - Causes a transition to the previous succession class (*BM-B*) 99% of times by thinning juniper and pinyon; or
  - Kills shrubs and trees as a rare stand replacing event (1% of events), causing a transition to the *early succession* class (*BM-A*).
- For the *late-succession open without Joshua tree* class (*BM-D*), drought-induced mortality either:
  - Causes a transition to the previous succession class (*BM-C*) 99% of times by thinning juniper and pinyon; or
  - Kills shrubs and trees as a rare stand replacing event (1% of events) causing a transition to the *early succession* class (*BM-A*).
- The *tree-encroached shrubland with exotic annual species* class (*TEX*) experiences drought with:
  - Thinning back to age 400 years within the class for about 90% of times. We chose 90% thinning, as opposed to 99%, because trees are at the elevational lower limit of their tolerance to warmer climate and competition for soil mositure is assumed more intense

among denser tree stands.
  - The remaining 10% of drought mortality is partitonned as 1% going to the *once-burned exotic annual species* class (*EX*) and 9% to the *mid-succession* classes (reflecting their landscape proportions of 5.7% and 3.3%, respectively, for *shrubs with exotic annual species with and without Joshua trees* [*SEPJ* and *SEP*]).
- The *shrubs with exotic annual species with and without Joshua trees* classes (respectively, *SEPJ* and *SEP*) each experience drought following:
  - The self-thinning proportion of 99% (and woody succession reversal to the beginning ages of the class); and
  - Transition to the *once-burned exotic annual grassland and forbland* class (*EX*) for the remaining 1% of events.
- The *seeded* (*SD*), but not the *planted* (*PL*) class:
  - Is thinned by drought within the class causing a reversal of woody succession 90% of times; whereas
  - The remaining 10% of times the transition is to the *once-burned exotic annual grassland and forbland* class (*EX*). We use a 10% stand-replacing event proportion to reflect that plantings are more fragile than natural shrublands.

Tree (pinyon and juniper) invasion is responsible for the last succession step between both *mid-succession* classes (*BM-B* and *BM-C*) and their respective *late-succession* classes (*BM-E* and *BM-D, respectively*). This disturbance also determines succession between both *shrubland with mixed exotic annual and native perrennial species* classes (*SEP* and *SEPJ*) and the *tree-encroached shrubland with exotic annual species* class (*TEX*). Pinyon and juniper invade shrublands at a rate 0.0025/year after 400 years of age.

A few anthropogenic disturbances cause accelerated woody succession in reference classes and transitions to uncharacteristic classes of vegetation.

Present only in Beaver Dam Wash NCA, *managed herbivory* and *excessive herbivory* have return intervals of one year (livestock is present every year) but different impact areas based on the distance livestock is willing to travel away from water. The impact of grazing is modeled with fixed rates of implementation (around an average) because grazing permits have fixed stocking rates, season of use, distribution. It is assumed that *managed herbivory* utilizes 5% of all grazable areas in the Beaver Dam Wash NCA (not just blackbrush); therefore, only 5% of the area is selected for *managed herbivory* and vegetation classes in blackbrush “compete” for selection. This method of modeling livestock grazing can only be implemented with the PATH software; VDDT cannot achieve landscape-level disturbances. Similarly, *excessive herbivory* affects 0.1% of the Beaver Dam Wash NCA causing a transition to the *early shrub* class (ES); however, *excessive herbivory* is caused by the movement of livestock through the same areas near or on the way to water sources. Therefore, once areas dominated by early shrubs are created, they become permanent and no new areas are created unless watering sources are moved or created. As a consequence, 0.1% of the Beaver Dam Wash is chosen among candidate vegetation classes to become the *early shrub* class (*ES*) in the first years of simulations, and then the process is stopped.

Managed herbivory causes the following:

- Accelerates woody succession by
  - One year in the *early-succession* class (*BM-A*) and *once-burned exotic annual grassland and forbland* class (*EX*); and
  - Three years in other classes through consumption of palatable herbaceous species.
- The *tree-encroached shrubland with exotic annual species* class (*TEX*) is not grazed.

- *Managed-herbivory* in the *planted* (*PL*) or *seeded* (*SD*) classes causes a transition to the *once-burned exotic annual grassland and forbland* class (*EX*).

Excessive herbivory is present in the *early-succession (BM-A), mid-succession closed* (*BM-B*), *midsuccession-open* (*BM-C*), *shrubland with mixed exotic annual species and perennial grasses* (*BM-SEP* and *BM-SEPJ*), *once-burned exotic annual grassland and forbland* class (*EX*), *planted* (*PL*), and *seeded* (*SD*) classes. The disturbance only causes a transition to the *early shrub* class (*ES*) during the first five years of simulation.

Exotic invasion affects the reference (*BM-A*, *BM-B*, *BM-C, BM-D,* and *BM-E*), *early-shrub* (*ES*), *planted* (*PL*) and, *seeded* classes at a rate of 0.005/year. We chose an invasion rate equal to that of the big sagebrush steppe-upland ecological system because of the mesic condition of the blackbrush ecological system.

- Before age 5, e*xotic invasion* of the *early-succession* class (*BM-A*) causes a transition to the *exotic annual species* class (*EX*); whereas
- After age 5, the transition will be to both *shrubland with mixed exotic annual species and perennial grasses* classes (*BM-SEP* and *BM-SEPJ*) (if Joshua tree is present, the transiton is partitonned according to the proportion of Joshua tree *versus* no Joshua tree in the ecological system).
- The *planted* class (*PL*) transitions to both *shrubland with mixed exotic annual species and perennial grasses* classes (*BM-SEP* and *BM-SEPJ*) as above.
- The *seeded* class (*SD*) converts to the *once-burned exotic annual grassland and forbland* class (*EX*).

Seedbank-emergence is a disturbance specific to the *planted* (*PL*) and *seeded* (*SD*) classes. These classes are created with an application of herbicide or biocide that inhibits germination, thus controlling exotic annuals. In the Mojave Desert, the duration of the herbicide or biocide's residual effect is 2-3 years. Therefore, the seedbank emerges at a high rate of 0.2/year (it takes about 5+ years for full conversion) after this period:

- The planting reverts to either *shrubland with mixed exotic annual species and perennial grasses* classes (*BM-SEP* and *BM-SEPJ*) classes; and
- The seeding transforms to the o*nce-burned exotic annual forbland and forbland* class (*EX*).

Natural-recovery is also a disturbance specific to the *planted* (*PL*) and *seeded* (*SD*) classes. After 20 years in these classes without 10 years of consecutive grazing from age 10 to 20, the class will transition to the *early-succession* class (*BM-A*).

The *Utilities* disturbance is predominantly the establishment of right-of-ways (pipelines and powerlines) made of excavated or cleared areas that become the *once-burned exotic annual forbland and forbland* (*EX*) class. The rate is low (0.0001/year) and present in all classes.

The *OHV* disturbance creates the *bare ground* class (*BG*) from illegal recreational use of off-highway vehicles. All classes are source classes. The rate is 10% of 0.0001/year to reflect that users predominantly reuse existing disturbed areas and only incrementally add new areas of illegal driving.

Management Actions:

Modeled management activities included fuel breaks, livestock closure (localized), law-enforcement, cessation of livestock grazing, and herbicide or BFOD fungi used alone and coupled with native plant seeding and planting:

- Fuel breaks are 250 feet wide strips of vegetation aerially sprayed with herbicide (Plateau®) to remove the continuous fine fuel beds created by exotic annual species. Strips are placed throughout the landscape and benefit all ecological systems by slowing or stopping wildfires. Spraying is only conducted during years of higher precipitation (perhaps following a 7-year El Nino cycle) or during of years of seedbank emergence not associated with high precipitation.
- Livestock-closure is a landscape-level treatment of the Beaver Dam Wash NCA that is applied to seedings and plantings. Closure results in the protection of seedings and plantings from livestock grazing for 10 consecutive years to the extent that enough resources (funding) allow it. Funding is shared with other ecological systems.
- Law enforcement only affects the creation of one vegetation class from OHV activity in several ecological systems of the Beaver Dam Wash NCA: *bare groud* (*BG*). Increased law-enforcement reduces the OHV disturbance by 50% (to 5% from 10%) using a static transition multiplier in PATH.
- Complete cessation of livestock grazing of the Beaver Dam Wash NCA was achieved by setting the static transition multiplier (in PATH) for livestock grazing to zero.
- Herbicide (Plateau®) application to control exotic annual grasses in the *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by seeding native plant species with the current mix of seed sources. Failure rate is 99%, leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *seeded* class (*SD*).
- Herbicide (Plateau®) application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by seeding native plant species with new high-performance cultivars whose commercial release is scheduled to be 20 years in the future. Failure rate is 95%, leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *seeded* class (*SD*).
- Herbicide (Plateau®) application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by planting of containerized native shrubs and forbs. Failure rate is 25%, leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *planted* class (*SD*).
- BFOD fungi application to control exotic annual species in the *shrubland with mixed exotic annual and perennial grass species (SEP*) and *shrubland with mixed exotic annual, and perennial grass and Joshua tree (SEPJ*) classes. Failure rate is 25% to 75% (no change of class), whereas success causes a transition to the *mid-succession (BM-B* and *BM-C)* and *late-succession* classes (*BM-D* and *BM-E*) depending on the age of originating vegetation and the presence of Joshua tree in the originating class.
- BFOD fungi application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by seeding native plant species with new high-performance cultivars whose commercial release is scheduled to be 20 years in the future. Failure rate is 95%, leading to the *exotic annual grassland and forblands* class (*EX*), because seedling establishment and survival remains the limiting factor even with the BFOD fungi. Success causes a transition to the *seeded* class (*SD*).
- BFOD fungi application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by planting of containerized native shrubs and forbs. Two levels of failure rates apply to the treatment. Failure rate of planting is 25% (no change in vegetation class), leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *planted* class (*PL*). After shrubs and forbs are planted, the fungi-of-death fungi failure rate was tested at three different levels: 25%, 50%, and 75%. If the BFOD fungi fails to control the seedbank of exotic annual species, the *planted* class (*PL*) transitions to the

shrubland with mixed exotic annual and perennial grass species (SEP) and *shrubland with mixed exotic annual and perennial grass, and Joshua tree (SEPJ*) classes. The amount of either class created depends on the proportion of area with and without Joshua tree in the ecological system. Success keeps vegetation in the *planted* class (*PL*) until either future invasion by exotic species or natural recovery to *early-succession* class (*BM-A*).

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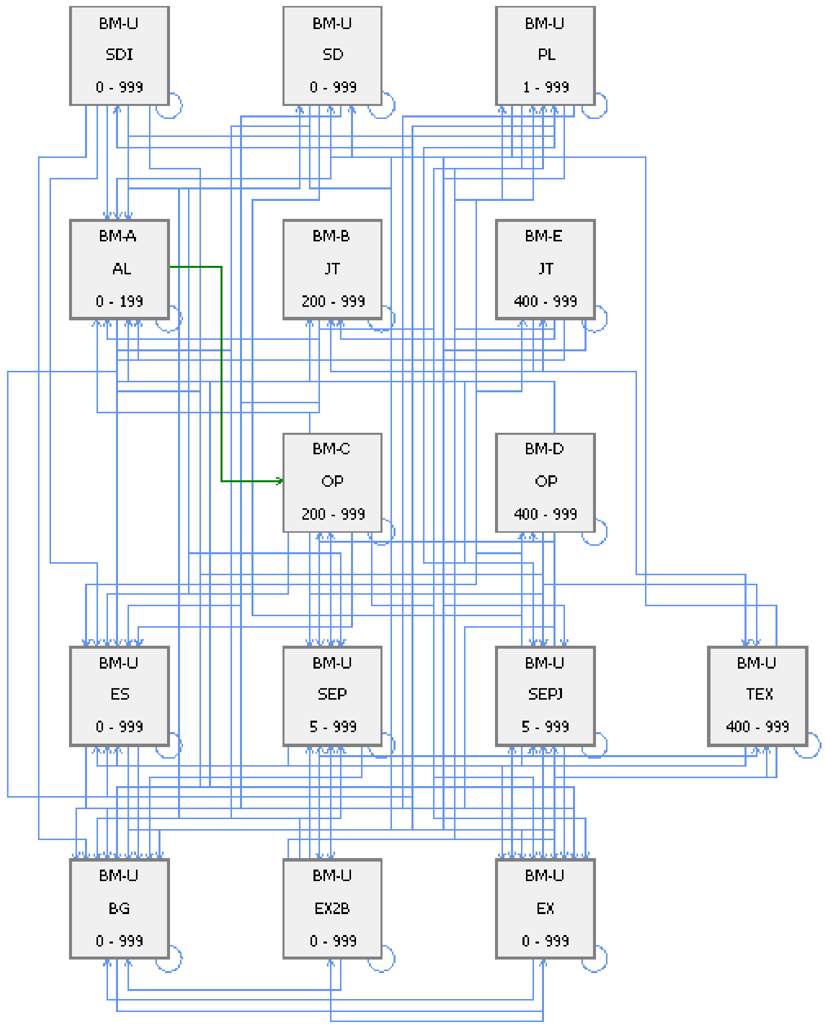

Blackbrush - thermic (BT) 1082t

Area of Application and Context:

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- **Livestock grazing on Beaver Dam Wash only**
- **Full fire suppression management**
- **Date created: July 2011**

Vegetation classes:

Two versions of thermic blackbrush were developed at the request of stakeholders: with and without Joshua Trees. USDA's Natural Resource Conservation Service (NRCS), however, does not recognize Joshua tree woodlands as a distinct ecological site because the soils on which it grows are the same the soils as creosotebush-white bursage, thermic and mesic blackbrush, and Great Basin mixed salt desert ecological sites. Joshua tree is absent from the Red Cliffs NCA and from some areas of the Beaver Dam Wash NCA (thus boxes B and U-*SEPJ* below do not exist). Joshua tree is present in a large fraction o f the Beaver Dam Wash NCA and the description below apply in its entirety:

- *BM-A:* **Early**; 0-50% cover of snakeweed, turpentine bush, yucca; <10% cover blackbrush; 0-499 yrs
- *BM-B:* **Late-closed**; 10-40% cover blackbrush <1.0m; creosotebush present; >1% cover of Joshua trees; 0-10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn), other shrubs present; 500+ yrs
- *BM-C*: **Late-open**; 10-40% cover blackbrush <1.0m; creosotebush present; 0-10% cover of grasses (desert needlegrass, Indian ricegrass, galleta grass, fluff grass, and threeawn); other shrubs present; 500+ yrs
- *U-ES:* **Early-Shrub**; 20-50% cover of cholla, snakeweed or rabbitbrush species
- *U-SEPJ:* **Shrub-Exotic-Species-Perennial-Grass-Joshua-Tree**; 10-40% cover of blackbrush or other shrubs <1.0m tall, 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; >1% cover of Joshua trees; ≥5% native grass cover
- *U-SEP:* **Shrub- Exotic-Species-Perennial-Grass**; 10-40% cover of blackbrush or other shrubs <1.0m tall, 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; Joshua trees **absent**; ≥5% native grass cover
- *U-SES:* **Shrub-Exotic-Species**; 10-40% cover of blackbrush or other shrubs <1.0m tall, 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <5% native grass cover
- *U-EX:* **Exotic-Species**; >10% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <10% cover of blackbrush or other shrubs; unburned and charred Joshua tree may be present
- *U-EX2B:* **Exotic-Species-2nd-Burn**; identical to U-*EX*, except that it has experienced a second burn.
- *U-PL:* **Planted;** >5% planted shrubs and perennial herbaceous species; <5% non-native annual grasses and forbs
- *U-BG:* **Bare ground**; mineral soil exposed by human disturbances

Reference Condition:

- **Natural Range of Variability without Joshua tree**
  - 5%: A-*Early*
  - 0%: B-*Mid-closed*
  - 95%: C-*Mid-open*
  - 0%: U

- **Natural Range of Variability with Joshua tree**
    - 5%: A-*Early*
    - 48%: B-*Mid-closed*
    - 47%: C-*Mid-open*
    - 0%: U

Succession:

Succession varies with the presence of Joshua trees.

In the absence of Joshua trees, succession follows the 2-box pathway with vegetation starting as predominantly dominated by snakeweed and herbaceous species and ending with a shrublands with a significant cover of blackbrush. Deterministic succession transitions occur between the first two boxes:

- Early-succession to mid-succession open: 500 years

With Joshua trees, succession is a 3-box model with parallel open and closed branches originating from the *early-succession* class (*BT-A*). Deterministic transitions govern succession between the *early succession* (*BM-A*) and both *mid-succession* classes (*BM-B* and *BM-C*). The deterministic transition is not a true succession and reflects a partitonning of acres proportional to the current area without and with Joshua tree.

- Early-succession to mid-succession open and closed: 500 years

Natural Disturbances:

Very few natural disturbances affect thermic blackbrush: replacement fire and drought. Blackbrush is an ancient vegetation type whose individual plants resisted disturbances for hundreds of years (Pendleton et al. 1986). Moreover, blackbrush is not fire adapted and has not evolved with fire (Callison et al. 1985).

Replacement fire was present at very low rates in most classes. The fire return interval of *replacement fire* was 10,000 years (0.0001/year) in all reference classes. *Replacement fire* in vegetation classes that already experienced a threshold transition also cause a threshold transition to other uncharacteristic classes:

- The *shrubland with mixed exotic annual and native perrennial species* classes (*SEP and SEPJ*) burn every 200 years (0.005/year) on average, causing a transition to the *once-burned exotic annual species* class (*EX*) or twice-*burned exotic annua species* class (*EX2B*), respectively, for shrubland with previously unburned and burned (i.e., absent) blackbrush (the arbitrary difference is an age of 500 years).
    - From ages 0 to 20 years, the *EX2B* and *EX* classes burn every 10 years (0.1/year) on average (self loop);
    - For vegetation older than 20 years, the *once-burned exotic annual species* class (*EX*) class burns every 20 years on average. When the EX class burns, it becomes the twice-*burned exotic annual species* class (*EX2B*) from which shrub natural recovery is nearly impossible without dedicated management.
- *Planted* (*PL*) and *seeded* (*SD*) classes, whose exotic annual fine fuel component is temporally suppressed, burn every 1,000 years (0.001/year) on average. Burned vegetation transitions to

age zero in the same class (this possibility is very remote because residence in these classes is short due to exotic annual seedbank emergence).

- The *early-shrub* (*ES*) class also burns every 1,000 years (0.001/year) on average; resulting vegetation stays in the class and returns to age zero.

Blackbrush is drought adapted. Only uncharacteristic classes are affected. *Drought* causes stand replacing events (generally 1% to 10% of times) and stand thinning (99% to 90%, respectively, of times). A *drought* return interval rate of every 178 years (a rate of 0.0056/year) is used based on the frequency of severe drought intervals estimated by Biondi *et al*. (2007) from 2,300 years of western juniper (*Juniperus occidentalis)* tree ring data from the Walker River drainage of eastern California and western Nevada. Although we recognize that droughts may be more common than every 178 years, severe droughts, which are >7-year drought events with consecutive far-below average soil moisture (narrow tree rings), kill naturally drought resistant shrubs and trees.

- The *shrubland with mixed exotic annual and native perrennial species* classes (*SEP and SEPJ*) each experience drought with the self-thinning proportion of 99%, whereas vegetation transitons to the *once-burned exotic annual grassland and forbland* class (*EX*) for the remaining 1% of events.
- The same partitioning of drought effects applies to the *planted* (*PL*) class with 1% transitioning to the *once-burned exotic annual grassland and forbland* class (*EX*) and the remaining 99% staying in the *planted* (*PL*) class but at an age of zero.
- The *seeded* (*SD*) class is thinned by drought within the class causing a reversal of woody succession 90% of times, whereas the remaining 10% of times the transition is to the *once-burned exotic annual grassland and forbland* class (*EX*). We used a 10% stand-replacing event proportion to reflect that plantings are more fragile than natural shrublands.

A few anthropogenic disturbances cause accelerated woody succession in reference classes and some transition to uncharacteristic classes of vegetation.

Present only in Beaver Dam Wash NCA, *managed herbivory* and *excessive herbivory* have return intervals of one year (livestock is present every year) but different impact areas based on the distance livestock is willing to travel away from water. The impact of grazing is modeled with fixed rates of implementation (around an average) because grazing permits have fixed stocking rates, season of use, distribution. It is assumed that *managed herbivory* utilizes 5% of all grazable areas in the Beaver Dam Wash NCA (not just blackbrush); therefore, only 5% of the area is selected for *managed herbivory* and vegetation classes in blackbrush “compete” for selection. This method of modeling livestock grazing can only be implemented with the PATH software; VDDT cannot achieve landscape-level disturbances. Similarly, *excessive herbivory* affects 0.1% of the Beaver Dam Wash NCA causing a transition to the *early shrub* class (ES); however, *excessive herbivory* is caused by the movement of livestock through the same areas near or on the way to water sources. Therefore, once areas dominated by early shrubs are created, they become permanent and no new areas are created unless watering sources are moved or created. As a consequence, 0.1% of the Beaver Dam Wash is chosen among candidate vegetation classes to become the *early shrub* class (*ES*) in the first years of simulations, and then the process is stopped.

Managed herbivory accelerates woody succession by:

- Two years in the *reference* classes (*BT-A, BT-B,* and *BT-C*) and both *shrubland with mixed exotic annual and native perrennial species* classes (*SEP and SEPJ*); and
- By one year in the *once-burned exotic annual grassland and forbland* class (*EX*) accelerates

woody succession (succession to a shrub class too young to have blackbrush is likely), but has no effect in the *twice-burned exotic annual grassland and forbland* class (*EX2B*).

Managed-herbivory in the *planted* (*PL*) or *seeded* (*SD*) classes have different outcomes:

- A transition to the *once-burned exotic annual grassland and forbland* class (*EX*) for the highly exposed and vulnerable *planted* (*PL*) class; and
- A self loop with a one-year reversal of woody succession within the *seeded* (*SD*) class (the seeds of this class do not all emerge at once from the seedbank and become immediately vulnerable).

Excessive herbivory is present in the *early-succession (BT-A), mid-succession closed* (*BT-B*), *mid-succession-open* (*BT-C*), *shrubland with mixed exotic annual species and perennial grasses* (*BT-SEP* and *BT-SEPJ*), *once-burned exotic annual grassland and forbland* class (*EX*), *planted* (*PL*), and *seeded* (*SD*) classes. The disturbance only causes a transition to the *early shrub* class (*ES*) during the first five years of simulation.

Exotic invasion affects the reference (*BT-A*, *BT-B* [Beaver Dam Wash NCA only]), and *BT-C), bare ground* (*BG*), *early-shrub* (*ES*), *planted* (*PL*), and *seeded* (*SD*) classes at a rate of 0.005/year, the same as for mesic blackbrush.

- For the *early-succession* class (*BT-A*):
  - Before age 5, *exotic invasion* causes a transition to the *exotic annual grassland and forbland* class (*EX*); whereas
  - After age 5, the transition will be to both *shrubland with mixed exotic annual species and perennial grasses* (*BT-SEP* and *BT-SEPJ*) (if Joshua tree is present, the transiton is partitonned according to the proportion of Joshua tree *versus* no Joshua tree in the ecological system).
- The *planted* class (*PL*) converts to both *shrubland with mixed exotic annual species and perennial grasses* classes (*BT-SEP* and *BT-SEPJ*) as above,
- The *seeded* (*SD*) and *bare ground* (*BG*) classes transitions to the *once-burned exotic annual grassland and forbland* class (*EX*).

Seedbank-emergence is a disturbance specific to the *planted* (*PL*) and *seeded* (*SD*) classes. These classes are created with an application of herbicide or biocide that inhibits germination to control exotic annual species. In the Mojave Desert, the duration of the herbicide or biocide's residual effect is 2-3 years. Therefore, the seedbank emerges at a high rate of 0.2/year (it takes about 5+ years for full conversion) after this period:

- Plantings revert to both *shrubland with mixed exotic annual species and perennial grasses* (*BT-SEP* and *BT-SEPJ*) classes; and
- Seedings transition to the *once-burned exotic annual forbland and forbland* (*EX*) class.

Natural-recovery is also a disturbance specific to the *planted* (*PL*) and *seeded* (*SD*) classes. After 20 years in these classes without 10 years of consecutive grazing from age 10 to 20, the class will transition to the *early-succession* class (*BT-A*) at a slow rate of 0.1/year (1 of 10 pixels per year).

The *Utilities* disturbance is predominantly the establishment of right-of-ways (pipelines and powerlines) made of excavated or cleared areas that become the *once-burned exotic annual forbland and forbland* (*EX*) class. The rate is low (0.0001/year) and present in all classes.

The *OHV* disturbance creates the *bare ground* (*BG*) class from illegal recreational use of off-highway vehicle, primarily in the Beaver Dam Wash NCA. All classes are source classes. The rate is 10% of 0.0001/year to reflect that users predominantly reuse existing disturbed areas and only incrementally add new areas of illegal driving.

Management Actions:

Modeled management activities included fuel breaks, livestock closure (localized), law-enforcement, cessation of livestock grazing, and herbicide or BFOD fungi used alone and coupled with native plant seeding and planting:

- Fuel breaks are 250 feet wide strips of vegetation aerially sprayed with herbicide (Plateau®) to remove the continuous fine fuel beds created by exotic annual species. Strips are placed throughout the landscape and benefit all ecological systems by slowing or stopping wildfires. Spraying is only conducted during years of higher precipitation (perhaps following a 7-year El Nino cycle) or during of years of seedbank emergence not associated with high precipitation.
- Livestock-closure is a landscape-level treatment of the Beaver Dam Wash NCA that is applied to seedings and plantings. Closure results in the protection of seedings and plantings from livestock grazing for 10 consecutive years to the extent that enough resources (funding) allow it. Funding is shared with other ecological systems.
- Law enforcement only affected the creation of one vegetation class from OHV activity in several ecological systems of the Beaver Dam Wash NCA: *bare groud* (*BG*). Increased law-enforcement reduces the OHV disturbance by 50% (to 5% from 10%) using a static transition multiplier.
- Complete cessation of livestock grazing of the Beaver Dam Wash NCA was achieved by setting the static transition multiplier for livestock grazing to zero.
- Herbicide (Plateau®) application to control exotic annual grasses in the *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by seeding native plant species with the current mix of seed sources. Failure rate is 99%, leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *seeded* class (*SD*).
- Herbicide (Plateau®) application to control exotic annual grasses in the *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by seeding native plant species with new high-performance cultivars whose commercial release is scheduled to be 20 years in the future. Failure rate is 95%, leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *seeded* class (*SD*).
- Herbicide (Plateau®) application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by planting of containerized native shrubs and forbs. Failure rate is 25%, leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *planted* class (*SD*).
- BFOD fungi application to control exotic annual species in the *shrubland with mixed exotic annual and perennial grass species (SEP*) and *shrubland with mixed exotic annual, and perennial grass and Joshua tree (SEPJ*) classes. Failure rate is 25% to 75% (no change of class), whereas success causes a transition to the *mid-succession (BT-B* and *BT-C)* and *late-succession* classes (*BT-D* and *BT-E*) depending on the age of originating vegetation and the presence of Joshua tree in the originating class.
- BFOD fungi application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by seeding native plant species with new high-performance cultivars whose commercial release is scheduled to be 20 years in the future. Failure rate is 95%, leading to the *exotic annual grassland and forblands* class (*EX*), because seedling establishment and survival remains the limiting factor even with the BFOD fungi. Success causes a transition to the *seeded* class (*SD*).
- BFOD fungi application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by planting of containerized native

shrubs and forbs. Two levels of failure rates apply to the treatment. Failure rate of planting is 25% (no change in vegetation class), leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *planted* class (*PL*). After shrubs and forbs are planted, the fungi-of-death fungi failure rate was tested at three different levels: 25%, 50%, and 75%. If the BFOD fungi fails to control the seedbank of exotic annual species, the *planted* class (*PL*) transitions to the *shrubland with mixed exotic annual and perennial grass species (SEP*) and *shrubland with mixed exotic annual and perennial grass, and Joshua tree (SEPJ*) classes. The amount of either class created depends on the proportion of area with and without Joshua tree in the ecological system. Success keeps vegetation in the *planted* class (*PL*) until either future invasion by exotic species or natural recovery to *early-succession* class (*BM-A*).

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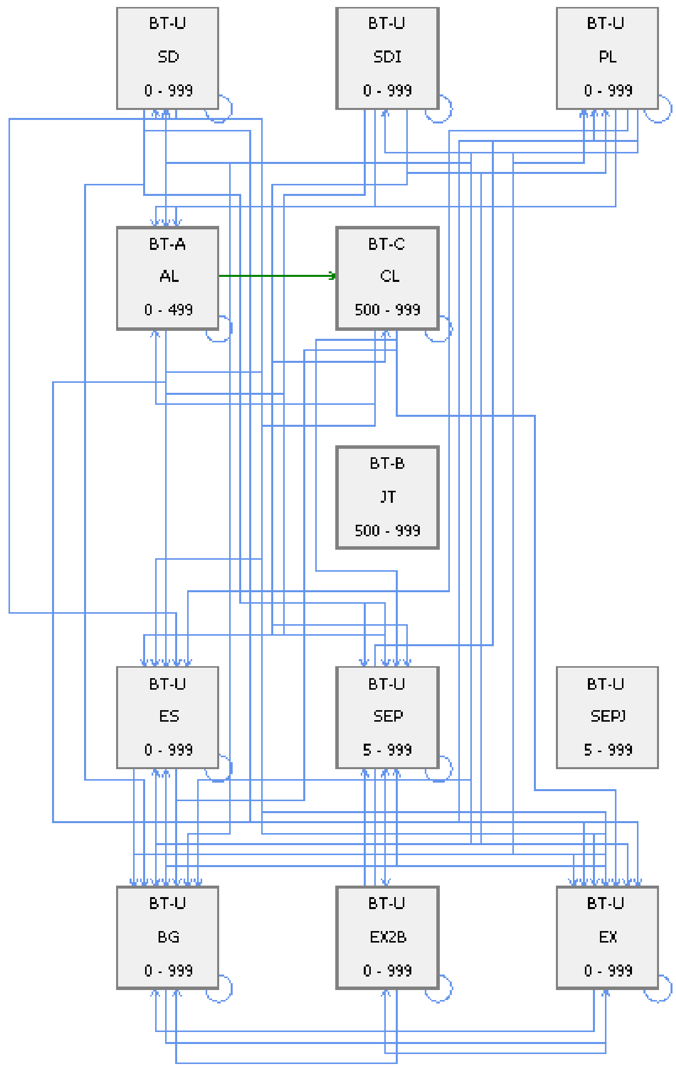
State-and-Transition Model:



Creosotebush-White Bursage (CB) 1087

Area of Application and Context:

- **Red Cliffs and Beaver Dam Wash National Conservation Areas of southwestern Utah**
- **Livestock grazing on Beaver Dam Wash only**
- **Full fire suppression management**
- **Date created: July 2011**

Vegetation classes:

Two versions of creosotebush-white bursage were developed at the request of stakeholders: with and without Joshua Trees. USDA's Natural Resource Conservation Service (NRCS), however, does not recognize Joshua tree woodlands as a distinct ecological site because the soils on which it grows are the same the soils as creosotebush-white bursage, thermic and mesic blackbrush, and Great Basin mixed salt desert ecological sites. Joshua tree is absent from the Red Cliffs NCA and from some areas of the Beaver Dam Wash NCA (thus boxes B, D, and U-*SEPJ* below do not exist). Joshua tree is present in a large fraction o f the Beaver Dam Wash NCA and the description below apply in its entirety:

- *CB-A:***Early**; 5-20% cover of creosote and white bursage builds up over time;5-20% grass cover depending on winter precipitation and season; 0-19 yrs
- *CB-B*: **Mid-closed**; 21-40% creosote and white bursage cover; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); >1% cover of Joshua trees; 20+ yrs
- *CB-C*: **Late-open**; 21-40% creosote and white bursage cover; Joshua trees **absent**; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); 20+ yrs
- *CB-D*: **Late- closed;** 21-40% creosote and white bursage cover; >1% cover of Joshua trees; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); 400+ yrs
- U-*ES:* **Early-Shrub**; 20-50% cover of cholla, snakeweed or rabbitbrush species
- U-*SEP:* **Shrub-Exotic-Species-Perennial-Grass**; 21-40% cover of creosote and white bursage; 0-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); Joshua trees **absent**
- U-*SEPJ:* **Shrub- Exotic-Species-Perennial-Grass-Joshua-Tree**; 21-40% cover of creosote and white bursage; 0-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; 5-20% grass and forb cover (depending on winter precipitation, soil productivity, and season); >1% cover of Joshua trees
- U-*SES:* **Shrub-Exotic-Species**; 10-40% cover of creosotebush or other shrubs <1.0m tall; 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <5% cover of native grasses or forbs; Joshua tree **absent**
- U-*SESJ:* **Shrub-Exotic-Species-Joshua-Tree**; 10-40% cover of creosotebush or other shrubs <1.0m tall; 5-20% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; >1% cover of Joshua trees; <5% cover of native grasses and forbs
- *U-EX:* **Exotic-Species**; >10% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; <10% cover of creosotebush or other shrubs; unburned and charred Joshua tree may be present
- U-*EX2B:* **Exotic-Species-2nd-Burn**; identical to U-*EX*, except that it has experienced a second burn
- U-*SD:* **Seeded (native)**; >10% seeded native grasses, forbs, and shrubs
- U-*SDI:* **Seeded (introduced)**; >10% seeded non-native grasses, forbs, and shrubs
- U-*PL:* **Planted;** >5% planted shrubs and perennial herbaceous species; <5% non-native annual grasses and forbs
- U-*BG:* **Bare ground**; mineral soil exposed by human disturbances

Reference Condition:

- **Natural Range of Variability without Joshua tree**
  - 8%: A-*Early*
  - 0%: B-*Mid-closed*
  - 92%: C-*Mid-open*
  - 0%: U
- **Natural Range of Variability with Joshua tree**
  - 9%: A-*Early*
  - 36%: B-*Mid-closed*
  - 38%: C-*Mid-open*
  - 17%: D-*Late-closed*
  - 0%: U

Succession:

Succession varies with the presence of Joshua trees.

In the absence of Joshua trees, succession follows the 2-box pathway with vegetation starting as predominantly dominated by respouting (mostly from vegetative recolonization) and herbaceous species and ending with a sometimes diverse community of creosotebush (loamier soil) and/or white bursage (harsher, warmer soils). Deterministic succession transitions occur between the first two boxes:

- Early-succession to mid-succession open: 20 years

With Joshua trees, succession is a 4-box model with parallel open (shorter) and closed (longer) branches originating from the *early-succession* class (*CB-A*). Deterministic transitions govern succession between the *early succession* (*CB-A*) and both *mid-succession* classes (*CB-B* and *CB-C*). The deterministic transition is not a true succession and reflects a partitonning of acres proportional to the current area without and with Joshua tree. A second succession step occurs at age 399 in the closed branch with Joshua trees.

- Early-succession to mid-succession open and closed: 20 years
- Mid-succession closed to late-succession closed: 399 years

Natural Disturbances:

Very few natural disturbances affect creosotebush-white bursage: drought and replacement fire. Creosotebush-white bursage is not fire adapted and has not evolved with fire.

Replacement fire is present at very low rates in most classes:

- The fire return interval is 2,000 years (0.0005/year) in all reference classes, except the late-succession closed (*CB-D*) class that contains more fuel (interval of 1,000 years or a rate of 0.001/year).
- *Replacement fire* in vegetation classes that already experienced a threshold transition also cause a threshold transition to other uncharacteristic classes.
  - The *shrubland with mixed exotic annual and native perrennial species* classes (*SEP and SEPJ*) burns every 600 years (0.0015+/year) on average, causing a transition to the *once-burned exotic annual species* class (*EX*).
  - The *twiced-burned exotic annual grassland and forbland* class (*EX2B*) burns every 10

years (0.1/year) on average (self loop); and
  - The *once-burned exotic annual grassland and forbland* class (*EX*), which contains recovering shrubs, is converted to the *twice-burned exotic annual grassland and forbland* class (*EX2B*) class by fire occurring every 20 years (0.05/year) on average.
  - *Planted* (*PL*) and *seeded* (*SD*) classes, whose exotic annual fine fuel component is temporally suppressed, burn every 600 years (0.0015+/year) on average and transitions to age zero in the same class (this possibility is very remote because residence in these classes is short due to exotic annual seedbank emergence).
  - The *early-shrub* (*ES*) class also burns every 1,000 years (0.001/year) on average and resulting vegetation stays in the class and returns to age zero.

Creosotebush is not as drought adapted as blackbrush is assumed to be. Drought is the strongest natural disturbance in this ecological system. A *drought* return interval rate of every 178 years (a rate of 0.0056/year) is used based on the frequency of severe drought intervals estimated by Biondi *et al*. (2007) from 2,300 years of western juniper (*Juniperus occidentalis)* tree ring data from the Walker River drainage of eastern California and western Nevada. Although we recognize that droughts may be more common than every 178 years, severe droughts, which were >7-year drought events with consecutive far-below average soil moisture (narrow tree rings), kill naturally drought resistant shrubs and trees:

- The *mid-succession closed* (*CB-B*) class and both *late-succession* classes (*CB-C* and *CB-D*) transition to the early-succession (*CB-A*) class;
- The *shrubland with mixed exotic annual and perennial grass species* classes (*SEPJ* and *SEP*) each transition to the *once-burned exotic annual grassland and forbland* class (*EX*); and
- The *planted* (*PL*) class experiences
  - self-thinning to age zero for 99% of drought events, and
  - a transition to the *once-burned exotic annual grassland and forbland* class (*EX*) for the other 1% of events.

A few anthropogenic disturbances cause accelerated woody succession in reference classes and transitions to uncharacteristic classes of vegetation.

Present only in Beaver Dam Wash NCA, *managed herbivory* and *excessive herbivory* have return intervals of one year (livestock is present every year) but different impact areas based on the distance livestock is willing to travel away from water. The impact of grazing is modeled with fixed rates of implementation (around an average) because grazing permits have fixed stocking rates, season of use, distribution. It is assumed that *managed herbivory* utilizes 5% of all grazable areas in the Beaver Dam Wash NCA (not just creosotebush-white bursage); therefore, only 5% of the area is selected for *managed herbivory* and vegetation classes in creosotebush-white bursage “compete” for selection. This method of modeling livestock grazing can only be implemented with the PATH software; VDDT cannot achieve landscape-level disturbances. Similarly, *excessive herbivory* affects 0.1% of the Beaver Dam Wash NCA causing a transition to the *early shrub* class (ES); however, *excessive herbivory* is caused by the movement of livestock through the same areas near or on the way to water sources. Therefore, once areas dominated by early shrubs are created, they become permanent and no new areas are created unless watering sources are moved or created. As a consequence, 0.1% of the Beaver Dam Wash is chosen among candidate vegetation classes to become the *early shrub* class (*ES*) in the first years of simulations, and then the process is stopped.

Managed herbivory accelerates woody succession by:

- Two years in the *reference* class (*CB-A, CB-B, CB-C*, and *CB-D*) and both *shrubland with mixed exotic annual and native perrennial species* classes (*SEP and SEPJ*) when a pixel is chosen for grazing;

- One year in the *once-burned exotic annual grassland and forbland* class (*EX*) (succession to non-blackbrush shrub phase is likely); but has no effect in the *twice-burned exotic annual grassland and forbland* class (*EX*) (succession to non-blackbrush shrubs state is very unlikely).

Managed-herbivory in the *planted* (*PL*) or *seeded* (*SD*) classes have different outcomes:

- A transition to the *once-burned exotic annual grassland and forbland* class (*EX*) for the highly exposed and vulnerable *planted* (*PL*) class; and
- A self loop with a one-year reversal of woody succession within the *seeded* (*SD*) class (the seeds of this class do not all emerge at once from the seedbank and become immediately vulnerable).

Excessive herbivory is present in all classes, except the *bare ground (BG), early-shrub* (*ES;* the recipient class of this disturbance)*, and twice-burned exotic annual grassland and forbland* class (*EX2B*), during the first five years of simulation.

Exotic invasion affects the reference (*CB-A*, *CB-B* [Beaver Dam Wash NCA only]), and *CB-C), bare ground* (*BG*), *early-shrub* (*ES*), *planted* (*PL*) and *seeded* (*SD*) classes at a rate of 0.005/year.

- For the *early succession* class (*CB-A*), *exotic invasion* causes:
    - Before age 19, a transition to the *exotic annual grassland and forbland* class (*EX*); whereas
    - After age 19, the transition proceeds from classes *CB-B*, *CB-C*, *CB-D*, and *ES* to both *shrubland with mixed exotic annual species and perennial grasses* classes (*CB-SEP* and *CB-SEPJ*) (if Joshua tree is present, the transiton is partitonned according to the proportion of Joshua tree *versus* no Joshua tree in the ecological system).
- The *planted* class (*PL*) converts to both *shrubland with mixed exotic annual species and perennial grasses* classes (*BT-SEP* and *BT-SEPJ*) as above,
- The seeded (SD) and bare ground (*BG*) classes transition to the *once burned exotic annual grassland and forbland* class (*EX*).

Seedbank-emergence is a disturbance specific to the *planted* (*PL*) and *seeded* (*SD*) classes. These classes are created with an application of herbicide or biocide that inhibits germination to control exotic annual species. In the Mojave Desert, the duration of the herbicide or biocide's residual effect is 2-3 years. Therefore, the seedbank emerges at a high rate of 0.2/year (it takes about 5+ years for full conversion) after this period:

- Plantings revert to both *shrubland with mixed exotic annual species and perennial grasses* (*CB-SEP* and *CB-SEPJ*) classes according to the proportion of creosotebush-white bursage with Joshua trees in Beaver Dam Wash NCA (no Joshua tree in Red Cliffs NCA); and
- Seedings transition to the *once-burned exotic annual forbland and forbland* (*EX*) class.

Natural-recovery is also a disturbance specific to the *planted* (*PL*) and *seeded* (*SD*) classes. After 20 years in these classes without 10 years of consecutive grazing from age 10 to 20, the class will transition to the *early-succession* class (*CB-A*) at a slow rate of 0.1/year (1 of 10 pixels per year).

The *Utilities* disturbance is predominantly the establishment of right-of-ways (pipelines and powerlines) with excavated or cleared areas that become the *once-burned exotic annual forbland and forbland* (*EX*) class. The rate is low (0.0001/year) and present in all classes.

The *OHV* disturbance creates the *bare ground* (*BG*) class from illegal recreational use of off-highway vehicles, primarily in the Beaver Dam Wash NCA. All classes are source classes. The rate is 10% of 0.0001/year to reflect that users predominantly reuse existing disturbed areas and only incrementally add new areas of illegal driving.

Management Actions:

Modeled management activities included fuel breaks, livestock closure (localized), law-enforcement, cessation of livestock grazing, and herbicide or BFOD used alone and coupled with native plant seeding and planting:

- Fuel breaks are 250 feet wide strips of vegetation aerially sprayed with herbicide (Plateau®) to remove the continuous fine fuel beds created by exotic annual species. Strips are placed throughout the landscape and benefit all ecological systems by slowing or stopping wildfires. Spraying is only conducted during years of higher precipitation (perhaps following a 7-year El Nino cycle) or during of years of seedbank emergence not associated with high precipitation.
- Livestock-closure is a landscape-level treatment of the Beaver Dam Wash NCA that is applied to seedings and plantings. Closure results in the protection of seedings and plantings from livestock grazing for 10 consecutive years to the extent that enough resources (funding) allow it. Funding is shared with other ecological systems.
- Law enforcement only affects the creation of one vegetation class from OHV activity in several ecological systems of the Beaver Dam Wash NCA: *bare groud* (*BG*). Increased law-enforcement reduces the OHV disturbance by 50% (to 5%) using a static transition multiplier.
- Complete cessation of livestock grazing of the Beaver Dam Wash NCA is achieved by setting the static transition multiplier for livestock grazing to zero.
- Herbicide (Plateau®) application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by seeding native plant species with the current mix of seed sources. Failure rate is 99%, leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *seeded* class (*SD*).
- Herbicide (Plateau®) application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by seeding native plant species with new high-performance cultivars whose commercial release is scheduled to be 20 years in the future. Failure rate is 95%, leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *seeded* class (*SD*).
- Herbicide (Plateau®) application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by planting of containerized native shrubs and forbs. Failure rate is 25%, leading to the *exotic annual grassland and forblands* class (*EX*). Success causes a transition to the *planted* class (*SD*).
- BFOD fungi application to control exotic annual species in the *shrubland with mixed exotic annual and perennial grass species (SEP*) and *shrubland with mixed exotic annual, and perennial grass and Joshua tree (SEPJ*) classes. Failure rate is 25% to 75% (no change of class), whereas success causes a transition to the *mid-succession (CB-B* and *CB-C)* and *late-succession* classes (*CB-D* and *CB-E*) depending on the age of originating vegetation and the presence of Joshua tree in the originating class.
- BFOD fungi application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by seeding native plant species with new high-performance cultivars whose commercial release is scheduled to be 20 years in the future. Failure rate is 95%, leading to the *exotic annual grassland and forblands* class (*EX*), because seedling establishment and survival remains the limiting factor even with the BFOD fungi. Success causes a transition to the *seeded* class (*SD*).
- BFOD fungi application to control exotic annual grasses in *once-burned and twice-burned exotic annual grassland and forblands* classes (*EX* and *EX2B*) followed by planting of containerized native shrubs and forbs. Two levels of failure rates apply to the treatment. Failure rate of planting is 25% (no change in vegetation class), leading to the *exotic annual grassland and forblands* class (*EX*).

Success causes a transition to the *planted* class (*PL*). After shrubs and forbs are planted, the fungi-of-death fungi failure rate was tested at three different levels: 25%, 50%, and 75%. If the BFOD fungi fails to control the seedbank of exotic annual species, the *planted* class (*PL*) transitions to the *shrubland with mixed exotic annual and perennial grass species (SEP*) and *shrubland with mixed exotic annual and perennial grass, and Joshua tree (SEPJ*) classes. The amount of either class created depends on the proportion of area with and without Joshua tree in the ecological system. Success keeps vegetation in the *planted* class (*PL*) until either future invasion by exotic species or natural recovery to *early-succession* class (*CB-A*).

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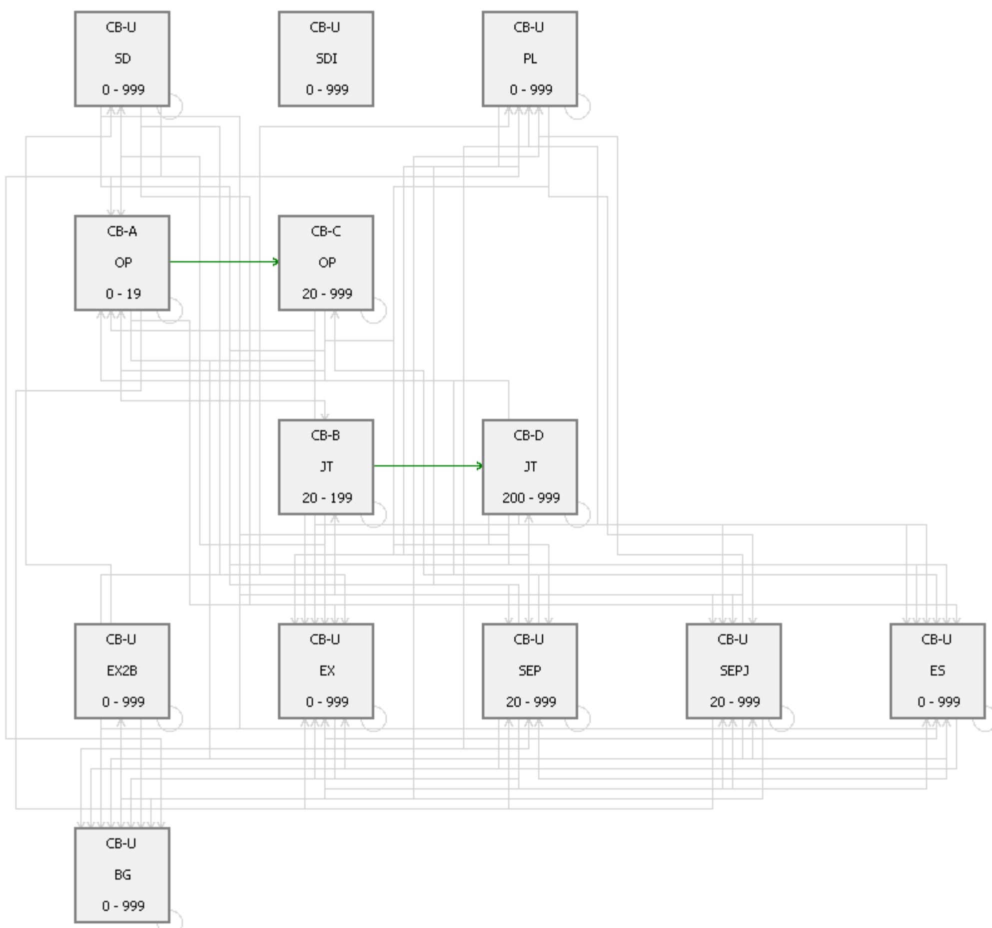
State-and-Transition Model:



Desert Sand Sagebrush (DSS) 1135ss
Area of Application and Context: • **Red Cliffs National Conservation Areas of southwestern Utah** • **No livestock grazing** • **Very limited off-highway travel east of Interstate-15** • **Full fire suppression management** • **Date created: July 2011**
Vegetation classes: • DSS-A: **Early**; 5-19% sand sagebrush and snakeweed/rabbitbrush cover; 5-20% cover of grasses (big galleta, bush muhly, Indian ricegrass, desert needlegrass); >40% bare ground (mostly sand); 0-2 yrs after fire • DSS-B: **Late-closed**; 20-40% cover of sand sagebrush, desert almond, and rabbitbrush; 5-20% grasses (big galleta, bush muhly, Indian ricegrass, desert needlegrass); scattered juniper may be present; >30% bare ground (mostly sand); 3+ yrs • U-*DP:* **Depleted**; 20-40% sand sagebrush, snakeweed, and rabbitbrush cover;<5% cover of grasses; >40% bare ground cover • U-*SEP:* **Shrub-Exotic-Species-Perennial-Grass**; 5-40% sand sagebrush and rabbitbrush cover; 5-10% cover of exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*); native grasses may be present to common; >30% bare ground (mostly sand)

Reference Condition:
 	
• **Natural Range of Variability**
    ➢ 2%: A-*Early*
    ➢ 98%: B-*Late-closed*
    ➢ 0%: U

Succession: Succession follows the 2-box pathway with vegetation starting as resprouting desert sand sagebrush and ending as denser desert sand sagebrush with 20-40% of shrubs. Sand sagebrush dominates all phases of succession. The succession pathway is entirely deterministic with transitions occurring at the following ages: ➢ Early-succession to late-succession closed: 2 years
Natural Disturbances: *Replacement fire* and variation in precipitation, therefore the frequency of *drought*, are the primary natural stochastic disturbances in desert sand sagebrush. Native herbivory by small mammals is a marginal disturbance that only applies to the *early-succession* class while grass is present. Sand sagebrush resprouts after fire and has been observed to return to pre-fire structural levels within 3 years. We assume that the likelihood on ignition increases with fuel buildup. *Replacement fire* is present in all classes at a mean fire return interval of: • 120 years (rate of 0.0083/year) in the *early-succession* class (*DSS-A*); • 95 years (0.0106/year) in the *late-succession closed* class (*DSS-B*); and • 120 years in the *depleted* class (*DP*) because of the absence of fine fuel despite mature shrub structure.

The fire return interval varies in the *shrubland* with *exotic annual and native grass species* class (*SEP*):

- 20 years (0.05/year) during the first 2 years of succession essentially dominated by non-native annual grasses; and
- 95 years as woody structure builds up while non-native annual grasses persist.

Drought causes shrub thinning in the older vegetation class under the assumption that prolonged and decreased soil moisture weakened plants that might ultimately be killed by insects or disease. Therefore, we do not double-count mortality. A *drought* return interval rate of every 178 years (a rate of 0.0056/year) is used based on the frequency of severe drought intervals estimated by Biondi *et al*. (2007) from 2,300 years of western juniper (*Juniperus occidentalis)* tree ring data from the Walker River drainage of eastern California and western Nevada. Although we recognize that droughts may be more common than every 178 years, severe droughts, which were >7-year drought events with consecutive far-below average soil moisture (narrow tree rings), kill naturally drought resistant shrubs.

- Drought kills some, but not all shrubs in the *late-succession closed* class (*DSS-B*); therefore drought thins this class under the assumption that older shrubs succumb first and the class is reset at 3 years.
- In the two uncharacteristic classes, *drought* is only a thinning agent resetting to zero the age of the following classes:
  - *Depleted* desert sand sagebrush (*DP); and*
  - *Shrubland with exotic annual and perennial grass species* class (*SEP*).

Lagomorphs and small mammals accelerate woody succession by the consumption of grasses and forbs during the early outburst of herbaceous vegetation (for example, Indian ricegrass and galleta grass) after a stand replacing event. We assume a small rate (5 out of 1,000 pixels per year) that advances succession by one extra year when chosen for *native herbivory*.

Exotic annual species invasion (*EX-invasion*) only affects uninvaded classes (*DSS-A*, *DSS-B*, and *DP*). The rate of is tied to a base rate of 0.001/year estimated from data of northwest Utah collected by the Utah Division of Wildlife Resources in black sagebrush semi-desert, which is usually considered more resistant to cheatgrass invasion than big sagebrush dominated biophysical settings. Sandy soils also appear resistant to non-native annual species. *EX-invasion* transforms the *early-succession* (*DSS-A*), *late-succession* (*DSS-B*), and depleted (*DP*) classes into the *exotic annual and native grass species* class (*SEP*) with the age of pixels maintained.

Management Actions:

Modeled management activities include herbicide or BFOD fungi coupled with native plant seeding:

- Application of Plateau® to control non-native annuals followed by seeding of native grass species in *shrub with mixed annual and perennial grass species class* (*DSS-SEP*). The combined success rates of herbicide application and seeding is 50% leading to the *late-closed succession* classs (*DSS-B*). Failure results in vegetation staying in the originating class (*DSS-SEP*).
- Application of the finger-of-death fungi followed by seeding of native grass species in *shrubland invaded by non-native annuals* (*SEP*). Failure rate of the finger-of-death fungi iss varied from 25% to 75%%, leading to the shrubs with mixed *exotic annual and perennial grass species* class (*SEP*). The combined success rates of herbicide application and seeding varies from 18% to 56% leading to the *late-closed succession* classs (*DSS-B*). Failure results in vegetation staying in the originating class (*SEP*).

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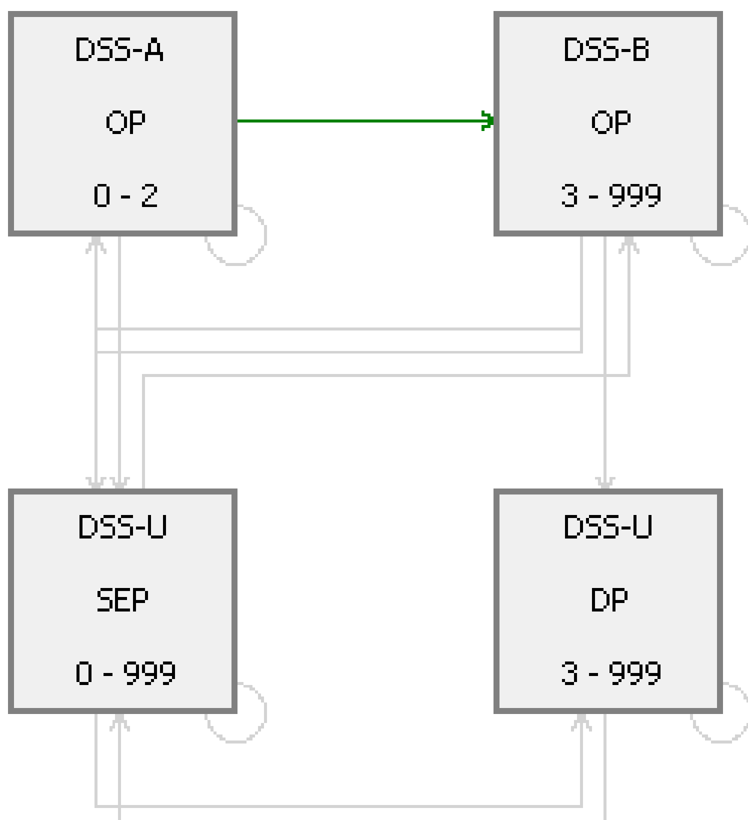
State-and-Transition Model (cropped):



Desert Washes (SWA) 1155w

Area of Application and Context:

- **Red Cliffs and Beaver Dam Wash National Conservation Areas of southwestern Utah**
- **Livestock grazing on Beaver Dam Wash only**
- **Full fire suppression management**
- **Date created: July 2011**

Vegetation:

- *SWA-A*: **Early**; 20-50% cover may be gravel, sands, and/or flood debris;10-19% cover of desert almond, burrobrush, rabbitbrush, creosotebush, desert willows present; 5-15% cover of grasses (big galleta, bush muhly); forbs present to abundant; 0-5 yrs
- *SWA-B*: **Mid-closed**; 20-50% cover of desert almond, bursage, bladdersage, burrobrush, creosotebush, Anderson's wolfberry, rabbitbrush; 5-10% cover of grasses (big galleta, bush muhly); forbs present to abundant; <30% of gravel and rocks; 5-19 yrs
- SWA-C: **Late-closed**; 30-50% cover of bursage, burrobrush, creosotebush, desert almond, bladdersage, Anderson's wolfberry, rabbitbrush, mesquite; Joshua tree present; 5-10% cover of grasses (big galleta, bush muhly); forbs present to abundant; <10% of gravel and rocks; >20 yrs
- U-*SEP:* **Shrub-Exotic-Species-Perennial-Grass**; >5% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; 0-50% small mesquite, Joshua tree, and shrubs, 5-10% cover of grasses (big galleta, bush muhly); mineral soil may be common
- U-*SES:* **Shrub-Exotic Species**; >5% 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-*ES* **Early-Shrub**; 20-50% cover of cholla, snakeweed or rabbitbrush species
- U-*ET:* **Exotic-Tree (formerly *EX*)**; >5% cover of saltcedar; 0-50% cover of bursage, burrobrush, creosotebush, Anderson's wolfberry, rabbitbrush, mesquite, Joshua tree
- U-*BG:* **Bare ground**; mineral soil exposed by human-caused disturbances

Reference Condition:

- **Natural Range of Variability**
  - 10%: A-*Early*
  - 18%: B-*Mid-closed*
  - 72%: C-*Late-closed*
  - 0%: U

Succession:

Succession follows the 3-box pathway with heterogeneous vegetation starting with abundant flood material (gravel, sand, and cobble) mixed with snakeweed and herbaceous species ending with a denser cover of shrubs and small trees. The succession pathway is entirely deterministic with transitions occurring at the following ages:

- Early-succession to mid-succession closed: 4 years
- Mid-succession closed to late-succession closed: 19 years

Natural Disturbances:

Flash flooding dominates the dynamics of desert washes, which do not have perennial water. Three levels of *flooding* were:

- 7-year events (0.14/year) that kills or removes only herbaceous vegetation in the *early-*

succession class (*SWA-A*);

- 20-year events (0.05/year) that kills or removes shrubs and young trees in the *mid-succession closed* class (*SWA-B*); and
- 100-year events (0.01/year) that top-kills larger trees and everything else in the *late-succession closed* class (*SWA-C*).

One hundred-year *flash floods* affect three uncharacteristic classes: *exotic tree* (*ET*), *shrubs with non-native annual and perennial grass species* (*SEP*), and *shrubs with non-native annual species* (*SES*). Outcomes are similar for these three classes:

- 1% of each class is converted to to the early succession class as flood debris (sand, gravel, rock, and wood); and
- The remaining 99% of vegetation stays within the original classes while experiencing a return to age zero.

Replacement fire generally originates from the surrounding landscape and restarts the succession clock to age zero after sweeping through the riparian corridor. Fire is possible in all classes. Fuel breaks will prevent fire activity for three consecutive years after their implementation. Fire is rare because the surrounding blackbrush and creosotebush-white bursage ecological systems do not carry fire, unless they are invaded by non-native annual grasses. The mean fire return interval is set at:

- 1,000 years (rate of 0.001/year) for the *mid-succession closed* (*SWA-B*) and *late-succession closed* (*SWA-C*) classes; and
- 10,000 years (0.0001/year) for the *early-succession* class (*SWA-A*), which is dominated by sand and gravel.

Fire return intervals are shorter in uncharacteristic classes:

- The *early shrub* (*ES*) class burns every 650 years (0.0015/year) on average and burned vegetation resets to age zero within the class.
- The *exotic tree* (*ET*) and *shrubs with non-native annual and perennial grass species* (*SEP*) class both have a 50-year return intervals (0.02/year) because the added fine fuels from non-native annual grass or saltcedar increase ignition probabilities. Vegetation in these classes remains in them, although at a younger age.
- The shortest fire return interval (50 years or 0.02/year) was in the *shrubs with non-native annual species* (*SES*) class because of the importance of non-native annual grass species. Again, fire is a self-loop.

Present only in Beaver Dam Wash NCA, *managed herbivory* and *excessive herbivory* have return intervals of one year (livestock is present every year) but different impact areas based on the distance livestock is willing to travel away from water. The impact of grazing is modeled with fixed rates of implementation (around an average) because grazing permits have fixed stocking rates, season of use, distribution. It is assumed that *managed herbivory* utilizes 5% of all grazable areas in the Beaver Dam Wash NCA (not just desert washes); therefore, only 5% of the area is selected for *managed herbivory* and vegetation classes in desert washes “compete” for selection. This method of modeling livestock grazing can only be implemented with the PATH software; VDDT cannot achieve landscape-level disturbances. Similarly, *excessive herbivory* affects 0.1% of the Beaver Dam Wash NCA causing a transition to the *early shrub* class (ES); however, *excessive herbivory* is caused by the movement of livestock through the same areas near or on the way to water sources. Therefore, once areas dominated by early shrubs are created, they become permanent and no new areas are created unless watering sources are moved or created. As a consequence, 0.1% of the Beaver Dam Wash is chosen among candidate vegetation classes to become the *early shrub* class (*ES*) in the first years of simulations, and then the process is stopped.

Managed herbivory accelerates woody succession by one year for selected pixels in all grazable classes (SWA-A, SWA-B, SWA-C, *SEP, and SES*). *Excessive herbivory* is present in all classes except the *bare ground (BG) and early-shrub* (*ES)* class. It causes a transition to the *early-shrub* (*ES)* class.

An important disturbance is the invasion by exotic trees (*exotic-tree-invasion*) represented by saltcedar. *Exotic-tree-invasion* causes a transition to the *exotic tree* class (*ET*). Saltcedar's tiny seeds are wind dispersed. Workshop participants agreed to a low rate (0.0001/year) for most classes because washes lack perennial water, but a rate five times higher for the *bare ground* (*BG*) and *early shrub* (*ES*) classes that have more disturbed soils and vegetation. It is assumed that invasion will happen at specified rates if a weed detection effort and follow-up treatment has not occurred for five consecutive years. *Exotic tree invasion* occurs in seven classes: *early-succession closed* (*SWA-A*), *mid-succession closed* (*SWA-B*), *late-succession closed* (*SWA-C*), *bare ground* (*BG*), *early shrub* (*ES*), *shrubs with non-native annual and perennial grass species* (*SEP*), and *shrubs with non-native annual species* (*SES*).

An important source of saltcedar mortality is the introduced biocontrol beetle (*beetle-mortality*), which is present to abundant in the Virgin River drainage. Workshop participants decided that beetles kill saltcedars after 4 consecutive years of defoliation; therefore, the return interval for beetle induced mortality was 4 years (rate of 0.25/year). Beetle induced mortality cause age-dependent transitions from the *exotic-tree* class (*ET*) to the early-succession (*SWA-A*), *mid-succession* (*SWA-B*), and *late-succession* (*SWA-C*) classes.

Another invasion is by non-native annual species (*EX-invasion*) occurring at a rate of 0.005/year (5 of 1,000 pixels per year) in all uninvaded classes: *early-succession closed* (*SWA-A*), *mid-succession closed* (*SWA-B*), *late-succession closed* (*SWA-C*), *bare ground* (*BG*), and *early shrub* (*ES*). A base rate of 0.001/year was estimated for cheatgrass from data of northwest Utah collected by the Utah Division of Wildlife Resources in black sagebrush semi-desert. We defaulted to five times the rate estimated from the Utah data because desert washes are more productive systems. Invasion of:

- Reference classes causes an age-dependent transition to the *shrubs with non-native annual and perennial grass species* (*SEP*); and
- The *early shrub* (*ES*) and *bare ground* (*BG*) classes causes a transition to *shrubs with non-native annual species* (*SES*).

The *Utilities* disturbance is predominantly the establishment of right-of-ways (pipelines and powerlines). Excavated or cleared areas become:

- *Early-succession* (*SWA-A*) class no different than the wash channel for 30% of the cleared area; and
- The remaining 70% of the area becomes the *shrub with non-native annual* class (*SES*) for vegetation originating from the reference (*SWA-A*, *SWA-B*, and *SWA-C*), *bare ground* (*BG*), *early-shrub* (*ES*), and *shrubs with non-native annual and perennial grass species* (*SEP*) classes. For the *exotic tree* (*ET*) class, the remaining 70% of the cleared area stays in the *exotic tree* class.

The *OHV* disturbance creates the *bare ground* (*BG*) class from illegal recreational use of off-highway vehicle in the Beaver Dam Wash NCA only. All classes are source classes. The rate is 10% of 0.0001/year to reflect that users predominantly reuse existing disturbed areas and only incrementally add new areas of illegal driving.

Management Actions:

Several actions (six in Beaver Dam Wash and five in Red Cliffs NCAs, respectively) are used in this ecological system:

- Inventory of weeds and saltcedar on a rotation (i.e., revisit the same reach every *X* years) for identification of occurrences for immediate or future treatment (w*eed-inventory-WAS).*
- Control of saltcedar and exotic forbs: *exotic-control-MR*. Action consists of cutting saltcedar and immediately painting the stumps with the herbicide Garlon IV®. If exotic forbs are found, they are sprayed with a different herbicide. Failure rate is 10% (no change of class), whereas success causes a transition to the *early-succession* (*SWA-A*), *mid-succession (SWA-B),* and *late-succession* classes (*SWA-C*) depending on the age of originating vegetation class.
- In the Beaver Dam Wash NCA, reduction of livestock stocking rates (*livestock-closure*) in desert washes whose effect last for 10 consecutive years.
- Fuel breaks are 250 feet wide strips of vegetation aerially sprayed with herbicide (Plateau®) to remove the continuous fine fuel beds created by exotic annual species. Strips are placed throughout the landscape and benefit all ecological systems by slowing or stopping wildfires. Spraying is only conducted during years of higher precipitation (perhaps following a 7-year El Nino cycle) or during of years of seedbank emergence not associated with high precipitation. The effect of fuel breaks persists for 3 years.
- Herbicide Plateau® application to control exotic annual species in the *shrubland with mixed exotic annual and perennial grass species (SEP*) class. Failure rate is 50% (no change of class), whereas success causes a transition to the *early-succession* (*SWA-A*), *mid-succession (SWA-B)* and *late-succession* classes (*SWA-C*) depending on the age of originating vegetation class.
- BFOD fungi application to control exotic annual species in the *shrubland with mixed exotic annual and perennial grass species (SEP*) and *shrubland with mixed exotic annual and perennial grass (SES*) classes. Failure rate is 25% to 75% (no change of class), whereas success causes a transition to the *early-succession* (*SWA-A*), *mid-succession (SWA-B),* and *late-succession* classes (*SWA-C*) depending on the age of originating vegetation class.

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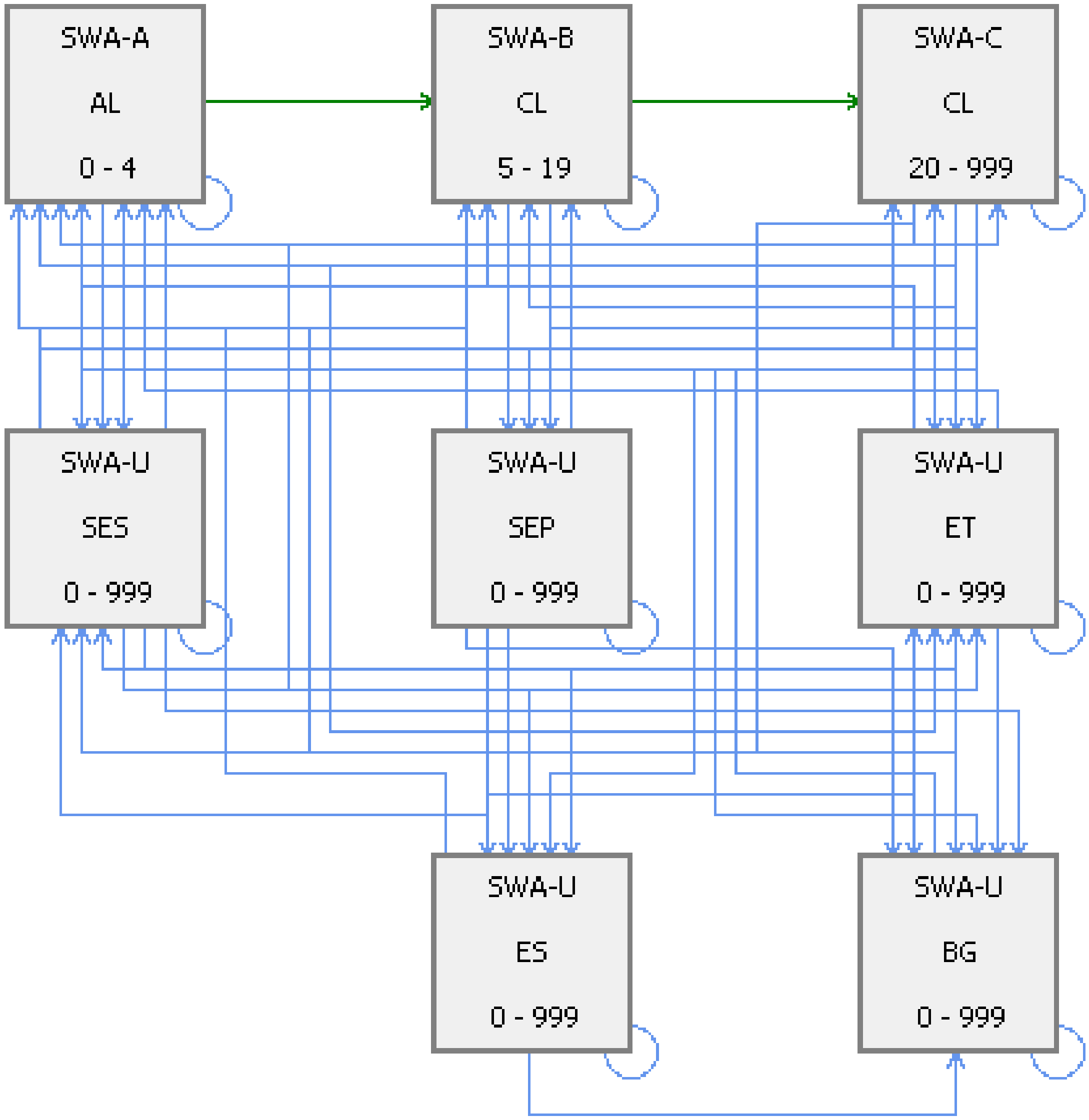
State-and-Transition Model (cropped):



Montane Riparian (MR) 1154

Area of Application and Context:

- **Red Cliffs and Beaver Dam Wash National Conservation Areas of southwestern Utah**
- **Livestock grazing on Beaver Dam Wash only**
- **Full fire suppression management**
- **Date created: July 2011**

Vegetation:

- 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, young mesquite) 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-*SFE:* **Shrub-Forb-Encroached**; 10-50% cover of Wood's rose or other unpalatable forbs and shrubs in open areas or under tree canopy
- U-*EF*-**Exotic-Forb**: 10-100% cover of exotic forbs (knapweed, tall whitetop, purple loosestrife), salt cedar, or Russian olive)
- U- *DE*-**Desertification**: Entrenched river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush, snakeweed, rabbitbrush); >5% native grass cover

Reference Condition:

- **Natural Range of Variability**
  - 10%: A-*Early*
  - 19%: B-*Mid-closed*
  - 71%: C-*Late-closed*
  - 0%: U

Succession:

Succession follows the 3-box pathway with heterogeneous vegetation starting with willow and Fremont cottonwood, and wet meadows and ending with a forested mix of willow, cottonwood, pinyon, juniper, alder, and wet meadows. The succession pathway is entirely deterministic with transitions occurring at the following ages:

- Early-succession to mid-succession closed: 4 years
- Mid-succession closed to late-succession closed: 19 years

Natural Disturbances:

Flooding dominates the dynamics of the montane riparian system. Three levels of *flooding* are:

- 7-yr events (0.14/year) that killed or removed only herbaceous vegetation in the *early-succession* class (*MR-A*);
- 20-year events (0.05/year) that killed or removed shrubs and young trees in the *mid-succession closed* class (*MR-B*); and
- 100-year events (0.01/year) that top-killed larger trees and everything else in the *late-succession closed* class (*MR-C*).

Replacement fire originates from the surrounding landscape and restarts the succession clock to age zero after sweeping through the riparian corridor. Fire is possible in all classes. However, fire is rare because the surrounding blackbrush, creosotebush-white bursage, and sand sagebrush ecological systems only rarely burn. The mean fire return interval is set at 1,000 years (rate of 0.001/year). Fire in reference classes causes a stand replacing event and recruitment into the *early-succession* class (*MR-A*), whereas fire in uncharacteristic classes acts as a self-loop and resets all vegetation to age zero.

An important disturbance was the invasion by exotic trees and forbs (*exotic-riparian-invasion*) represented mainly by saltcedar, tall whitetop, knapweeds, and thistles. *Exotic-riparian-invasion* causes a transition to the *exotic forb* class (*EF;* old terminology that actually contains exotic riparian trees). Workshop participants agreed to a moderately high rate (0.01/year) to plan for a worst case scenario. Roadways, off-highway vehicles, and animals are usually the greatest vectors of exotic forbs. Saltcedar is wind dispersed. *Exotic invasion* occurs in four classes: *early-succession closed* (*MR-A*), *mid-succession closed* (*MR-B*), *late-succession closed* (*MR-C*), and *shrub and forb encroached* (*SFE*).

An important source of saltcedar mortality is the introduced biocontrol beetle (*beetle-mortality*), which is present to abundant in the Virgin River drainage. Workshop participants decided that beetles kill saltcedars after 4 consecutive years of defoliation; therefore, the return interval for beetle induced mortality was 4 years (rate of 0.25/year). Beetle induced mortality causes age-dependent transitions from the *exotic-tree* class (*ET*) to the early-succession (*SWA-A*), *mid-succession* (*SWA-B*), and *late-succession* (*SWA-C*) classes.

A class reflecting historic grazing is the dominance of riparian corridors by native forbs and shrub species unpalatable to domestic sheep and cattle (*shrub and forb encroached* or *SFE*). Wood's rose (*Rosa woodsii*) and shinkbush (*Rhus trilobata*) are classic examples. The dynamics crating this class are retained in the model but the class was not detected by remote sensing and livestock no longer graze in the Red Cliffs NCA. Due to the proximity of creeks, *100-year flooding* events have the power to:

- Substantially rework sediments over 1% of the area of the class and cause a transition to the *early-succession* class (*MR-A*);whereas
- 99% of the remaining area is returned to age zero of the *shrub and forb encroached* class (*SFE*).

Desertification (or incision) of riparian vegetation, largely from past management, opens up dynamics more typical of upland communities. Incision causes a drop of water table and dries out riparian vegetation in favor of upland species. Due to the proximity of creeks, *100-year flooding* events have the power to

- Substantially rework sediments over 1% of the area of the class and cause a transition to the *early-succession* class (*MR-A*); whereas
- 99% of the remaining area is returned to age zero of the *desertified* class (*DE*).

One other natural disturbance can "restore" desertified riparian vegetation: flows will naturally rework banks and promote riparian vegetation at a low rate of 0.001/year (*floodplain recovery* disturbance) if and only if livestock grazing is absent for 10 consecutive years, which should happen in the Red Cliffs NCA.

Management Actions:

The only action retained for this small ecological system is control of saltcedar and exotic forbs: e*xotic-control-MR*. Small saltcedar saplings and trees are peppered throughout the montane riparian and relatively easy to locate. Action consists of cutting saltcedar and immediately painting the stumps with the herbicide Garlon IV®. If exotic forbs are found, they are sprayed with a different herbicide.

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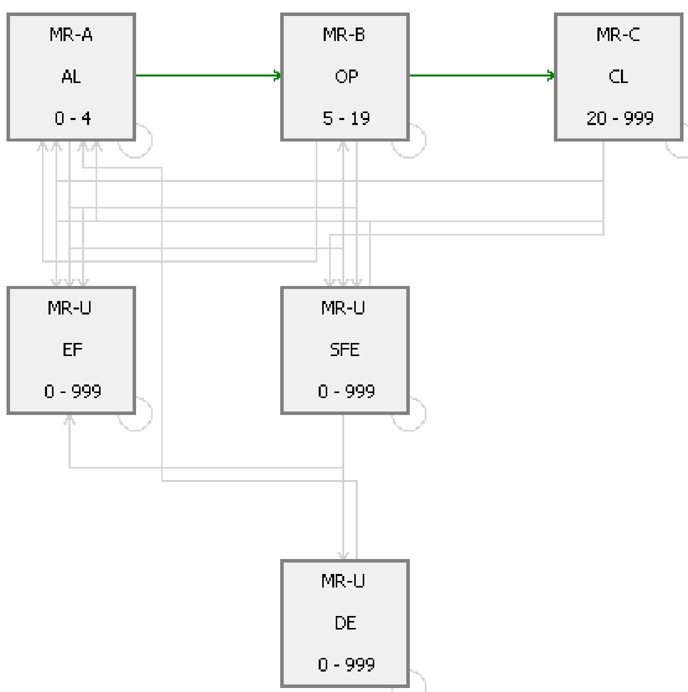
State-and-Transition Model (cropped):



Mountain Shrub (MSb) 1126ms

Area of Application and Context:

- **Red Cliffs and Beaver Dam Wash National Conservation Areas of southwestern Utah**
- **Livestock grazing on Beaver Dam Wash only**
- **Full fire suppression management**
- **Date created: July 2011**

Vegetation classes:

- A-**Early**: 0-10% canopy of snowberry, desert bitterbrush, or Stansbury cliffrose; 10-80% grass and forb cover; 0-12 yrs
- B-**Mid-open**: 11-30% cover of snowberry, desert bitterbrush, or Stansbury cliffrose; >50% herbaceous cover; 13-38 yrs
- C-**Mid-closed**: 31-50% cover of snowberry, desert bitterbrush, or Stansbury cliffrose; 25-50% herbaceous cover;<10% conifer sapling cover; 38+ yrs
- D-**Late-open**: 10-20% pinyon pine-juniper cover <5m; 25-40% cover of snowberry, desert bitterbrush, or Stansbury cliffrose; <30% herbaceous cover; 80-129 yrs
- U-*ES:* **Early-Shrub**; 20-50% cover rabbitbrush species
- U-*DP:* **Depleted**; 31-50% cover of snowberry, desert bitterbrush, Stansbury cliffrose; <5% herbaceous cover; <10% conifer sapling cover
- U-*SEP:* **Shrub-Exotic-Species-Perennial-Grass**; 5-40% cover of mountain shrubs; 5-20% non-native grass cover; native herbaceous cover usually present; trees may be present
- U-*TE:* **Tree-Encroached**; >21% pinyon pine-juniper cover 10-25m; <5% shrub cover; <5% herbaceous cover
- U-*TEX:* **Tree-Exotic-Species;** 10-20% pinyon pine-juniper cover <5m; ≥5% cover of non-native annual grasses and forbs; 25-40% cover of snowberry, desert bitterbrush, or Stansbury cliffrose; <30% herbaceous cover
- U-*EX:* **Exotic-Species;** 10-30% cover of cheatgrass; snakeweed or rabbitbrush may be present; dead standing stems of cliffrose often present

Reference Condition:

- **Natural Range of Variability**
  - 7%: A-*Early*
  - 15%: B-*Mid-open*
  - 63%: C-*Mid-closed*
  - 14%: D-*Late-open*
  - 0%: U

Succession:

Succession follows the 4-box pathway with vegetation starting as predominantly herbaceous and ending with pinyon or juniper, dominance and a viable shrub and herbaceous understory. Deterministic succession transitions occur in the first three boxes, whereas the last step of succession is probabilistic:

- Early-succession to mid-succession open: 4 years
- Mid-succession open to mid-succession closed: 19 years
- Mid-succession closed to late-succession open: ≥50 years (probabilistic)

Natural Disturbances:

Replacement fire is the primary stochastic disturbance. We chose a fire return interval slightly longer than that of the big sagebrush steppe-upland ecological system because mountain shrub dominated by cliffrose or desert bitterbrush is located on harsher, thinner soils. The mean return interval of *replacement fire* changes with vegetation classes:

- 70 years (0.014/year) in the *mid-succession* class (*MSb-B*) and in the *late-succession* class; to
- 150 years (0.0067/year) in the more wooded *late-succession open* class (*MSb-D*).

Replacement fire in vegetation classes that already experienced a threshold transition also causes a threshold transition to other uncharacteristic classes:

- For a 150-year fire return interval;
  - The *tree encroached shrubland* class (*TE*) converts to the *early shrub* class (*ES*), and
  - The *tree encroached shrubland with exotic annual species* class (*TEX*) transitions to the *exotic annual species* class (*EX*);
- With a 70-year (0.014/year) fire return interval, the *early shrub* class (*ES*) simply promotes rabbitbrush as a self-loop; and
- The *shrubland with mixed exotic annual and native perrennial species* class (*SEP*) burns every 40 years (0.025/year) on average, causing a transition to the *exotic annual species* class (*EX*).

Cliffrose is drought adapted. Seedling germination and survival is higher during dry years because drought reduces competition from grasses (Price and Botherson 1987). *Drought* causes stand replacing events (generally 10% of times) and stand thinning (90% of times) in classes with trees. A *drought* return interval rate of every 178 years (a rate of 0.0056/year) is used based on the frequency of severe drought intervals estimated by Biondi *et al*. (2007) from 2,300 years of western juniper (*Juniperus occidentalis)* tree ring data from the Walker River drainage of eastern California and western Nevada. Although we recognize that droughts may be more common than every 178 years, severe droughts, which were >7-year drought events with consecutive far-below average soil moisture (narrow tree rings), kill naturally drought resistant shrubs and trees.

- In the *late-succession closed* class (*MSh-D*):
  - For 10% of events, drought-induced mortality converts vegetation to the previous succession class (*MSh-C*); and
  - For the remaining 90% of events, *drought* reverses woody succession within the same vegetation class the originating class (*MSh-D*).
- In the *tree-encroached shrubland* class and *tree-encroached shrubland with exotic annual species* class, respectively, *drought* causes a transition to *early-shrub* (*ES*) and *exotic annual species* class (*ES*) 10% of times (otherwise, self thinning within each originating class).

Because cliffrose is drought adapted, the *wet-year* disturbance reverses succession by one year in the *early-succession* class (*MSh-A*); therefore making this a weak disturbance. The *wet-year* disturbance is caused by the 7-year El Nino cycle (rate of 0.14/year).

Tree (pinyon and juniper) invasion is responsible for the last succession step between the *mid-succession closed* (*MSh-C*) and *late-succession closed* (*MSh-D*) classes. This disturbance also causes succession from the *shrubland with mixed exotic annual and native perrennial species* class (*SEP*) to the *tree-encroached shrubland with exotic annual species* class (*TEX*). Pinyon and juniper invade shrublands at two different rates:

- 0.001/year from ages 50 to 99 years; and

- 0.005/year from ages after 100 years.

Pinyon and juniper require mature shrubs (usually sagebrush and bitterbrush) as nurse plants for seed germination and seedling establishment; therefore, the rate of tree invasion accelerates with time since succession.

A few anthropogenic disturbances cause accelerated woody succession in reference classes and transitions to uncharacteristic classes of vegetation.

Present only in Beaver Dam Wash NCA, *managed herbivory* and *excessive herbivory* have return intervals of one year (livestock is present every year) but different impact areas based on the distance livestock is willing to travel away from water. The impact of grazing is modeled with fixed rates of implementation (around an average) because grazing permits have fixed stocking rates, season of use, distribution. It is assumed that *managed herbivory* utilizes 5% of all grazable areas in the Beaver Dam Wash NCA (not just mountain shrub); therefore, only 5% of the area is selected for *managed herbivory* and vegetation classes in mountain shrub "compete" for selection. This method of modeling livestock grazing can only be implemented with the PATH software; VDDT cannot achieve landscape-level disturbances. Similarly, *excessive herbivory* affects 0.1% of the Beaver Dam Wash NCA causing a transition to the *early shrub* class (*ES*); however, *excessive herbivory* is caused by the movement of livestock through the same areas near or on the way to water sources. Therefore, once areas dominated by early shrubs are created, they become permanent and no new areas are created unless watering sources are moved or created. As a consequence, 0.1% of the Beaver Dam Wash is chosen among candidate vegetation classes to become the *early shrub* class (*ES*) in the first years of simulations, and then the process is stopped.

Managed herbivory reverses woody succession to age zero (i.e., stand replacing event) in the *early succession* class (*MSh-A*) through consumption of palatable cliffrose seedlings and grasses.

- After cliffrose establishes, managed herbivory accelerates woody succession by one year for every year selected for grazing by removal of grasses in the *mid-succession open* (*MSh-B*), *mid-succession-closed* (*MSh-C*), and *shrubland with mixed exotic annual species and perennial grasses* (*MSh-SEP*) classes.
- The wooded *late-succession closed* class (*MSh-D*) is not grazed.
- *Managed herbivory* is present but does not have any successional effect in the *early shrub* (*ES*) and the *exotic annual species* (*EX*) classes.

Excessive herbivory is present in the *mid-succession open* (*MSh-B*), *mid-succession-closed* (*MSh-C*), and *shrubland with mixed exotic annual species and perennial grasses* (*MSh-SEP*) classes and only causes a transition to the *early shrub* class (*ES*) during the first five years of simulation.

Exotic invasion affects the reference (*MSH-A*, *MSh-B*, *MSh-C,* and *MSh-D*) and *tree-encroached* (*TE*) classes at a rate of 0.0025/year. We chose an invasion rate half that of the big sagebrush steppe-upland ecological system because cliffrose grows on harsher, thinner soils. *Exotic invasion* of:

- The *early succession* class (*MSH-A*) causes a transition to the *exotic annual species* class (*EX*);
- The *mid-succession* (*MSh-B* and *MSh-C*) and *late-succession* (*MSh-D*) classes convert to the *shrubland with mixed exotic annual species and perennial grasses* class (*MSh-SEP*); and
- The *tree-encroached shrublands* (*TE*) converts to the *tree-encroached shrubland with exotic annual species* class (*TEX*).

Management Actions:

Two restoration actions are proposed:

- Spraying the herbicide Plateau® to control exotic annual species followed by seeding cliffrose in the *exotic annual grassland and forbland* class (*EX*).
- Spraying the herbicide Plateau® to control exotic annual species followed by seeding perennial native grasses in the *shrubland* with *exotic annual species* class (*SES*).

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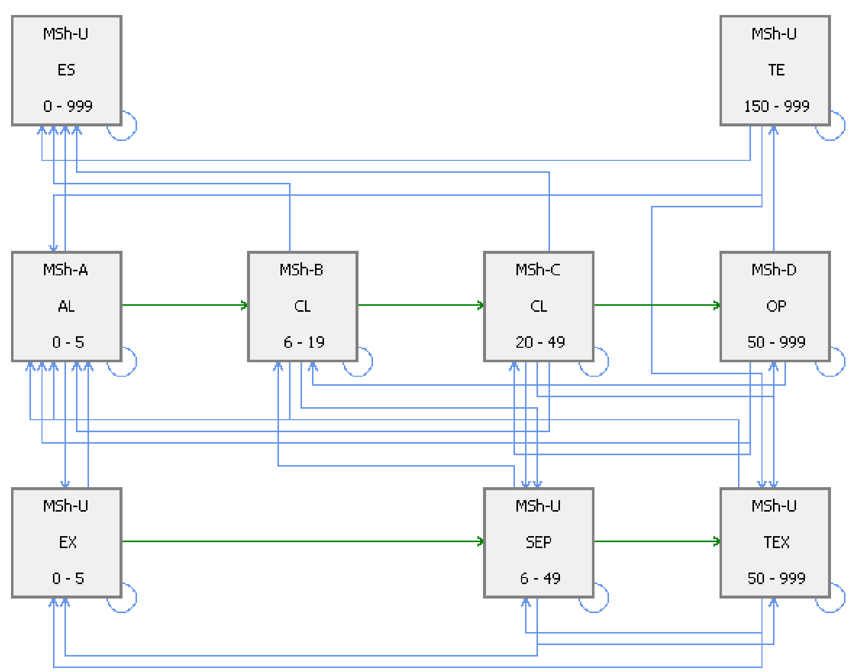
State-and-Transition Model:



Pinyon-Juniper Woodland (PJ) 1019

Area of Application and Context:

- **Red Cliffs and Beaver Dam Wash National Conservation Areas of southwestern Utah**
- **Livestock grazing on Beaver Dam Wash only**
- **Full fire suppression management**
- **Date created: July 2011**

Vegetation classes:

- A-**Early-open**: 5-20% herbaceous cover; 0-9 yrs
- B-**Mid1-open**: 11-20% cover big sage or black sage <1.0m; 10-40% herbaceous cover; 10-29 yrs
- C-**Mid2-open**: 11-30% cover of pinyon and/or juniper <5m; 10-40% shrub cover; <20% herbaceous cover; 30-99 yrs
- D-**Late-open**: 31-50% cover of pinyon and/or juniper <5m-9m; 10-40% shrub cover; <20% herbaceous cover; >99 yrs
- U-TEX: **Tree- Exotic-Species**; 31-50% cover of pinyon and/or juniper <5m-9m; 5-20% cheatgrass cover 10-40% shrub cover
- U-*EX:* **Exotic-Species**; 5-30% cheatgrass cover; dead pinyon or juniper visible

Reference Condition:

- **Natural Range of Variability**
  - 2%: A-*Early*
  - 3%: B-*Mid1-open*
  - 13%: C-*Mid2--open*
  - 82%: D-*Late-open*
  - 0%: U

Succession:

Succession follows the 4-box pathway with vegetation starting as predominantly native annual and perennial herbaceous species and ending with old (>300 years) pinyon and juniper and generally with a viable shrub and herbaceous understory. The succession pathway is entirely deterministic. Deterministic succession transitions occur at the following ages:

- Early-succession to mid-succession open: 9 years
- Mid1-succession open to mid2-succession open: 29 years
- Mid2-succession open to late-succession open: 99 years

Natural Disturbances:

Replacement fire restarts the succession clock to age zero within the reference condition, which is the *early-succession* or *PJ-A* class. The mean return interval of *replacement fire* is:

- 300 years (0.003/year) in the *early-succession* class (*PJ-A*);
- 200 years (0.005/year) in *mid1-succession open,* and *mid2-succession open* classes*; and*
- 1,000 years (0.001/year) in the *late-succession open* classes (*PJ-D*).

Replacement fire in vegetation classes that already experienced a threshold transition also causes a threshold transition to other uncharacteristic classes. The fire return interval is;

- 200 years in the *tree with exotic annual species* class (*TEX*). Fire causes a conversion to the *exotic annual grassland and forbland* class (*EX*); and

- 10 years in the *exotic annual grassland and forbland* class (*EX*), where vegetation remains in the class (self-loop).

Drought operates in the *mid2-succession open* (*PJ-C*), *late-succession open* (*PJ-D*) and *tree with exotic annual species* (*TEX*) class. *Drought* causes thinning to the previous succession class (generally 10% of times) and thinning within a class (90% of times). In most cases *drought* created tree and shrub mortality under the assumption that prolonged and decreased soil moisture weakened plants that might ultimately be killed by insects or disease. Therefore, we do not double-count mortality. A *drought* return interval rate of every 178 years (a rate of 0.0056/year) is used based on the frequency of severe drought intervals estimated by Biondi *et al*. (2007) from 2,300 years of western juniper (*Juniperus occidentalis)* tree ring data from the Walker River drainage of eastern California and western Nevada. Although we recognize that droughts may be more common than every 178 years, severe droughts, which were >7-year drought events with consecutive far-below average soil moisture (narrow tree rings), kill naturally drought resistant shrubs and trees.

- The *mid2-succession closed* class (*PJ-C*) is thinned by *drought*:
  - Within the class (to its beginning) for 90% of events; and
  - To the previous succession class, *mid1-succession open* class (*PJ-B*), for the other 10% of events, which assumes older trees are more affected.
- The *late-succession open* class (*PJ-D*) responds differently to *drought* because older trees become more vulnerable to the baseline 178-year return interval of severe *droughts* and additional insect attacks (both sources are assumed in the total 0.0168/year rate [60 years] for *drought* in the model):
  - 90% of mortality is expressed as thinning to age 100 year within the class;
  - 7% of thinning is to the previous succession class (*mid2-succession open* or *PJ-C*); and
  - 3% of thinning results in the *mid1-succession open* class (*PJ-B*).
- The only uncharacteristic class affected is *trees with exotic annual species* (*TEX*) class:
  - 90% of the class is thinned from within; and
  - 10% of the class converts to the *exotic annual grassland and forbland* class (*EX*).

Exotic annual species invasion (*EX-invasion*) is set at a slow rate of 0.001/year (1 out of 1,000 pixels converted to a cheatgrass-invaded class per year). A base rate of 0.001/year is estimated from data of northwest Utah collected by the Utah Division of Wildlife Resources in black sagebrush semi-desert. Black sagebrush semi-desert is usually considered more resistant to cheatgrass invasion than Wyoming big sagebrush semi-desert or other big sagebrush dominated biophysical settings. We default to five times the rate estimated from the Utah data. The soils of pinyon-juniper woodlands are either harsher or similar to those of black sagebrush. Exotic annual species invasion (*EX-invasion*) starts in the *mid2-succession open* class (*PJ-C*) and continues in the *late-succession open* class (*PJ-D*), causing a transition to the *tree with annual grass* class (*TA*).

Management Actions:

Two management actions were retained for pinyon and juniper woodlands invaded by exotic annual species:

- In mostly wilderness areas, hand spraying of herbicide (Plateau®) to control exotic annual species followed by aerial seeding of native species in *exotic annual grasslands and forblands* (*EX*). Success rate is 60% and restores the *early-succession* class (*PJ-A*). Failure simply keeps vegetation in the originating class.

- In mostly wilderness areas, hand spraying of herbicide (Plateau®) under the canopy of trees to control exotic annual species in the *tree with exotic annual species* class (*TEX*). Herbicide succeeds 60% of times causing recruitment to the *mid2-succession closed* class (*PJ-C*) for vegetation from 60-99 years and to the *late-succession closed* class (*PJ-D*) for vegetation older than 99 years.

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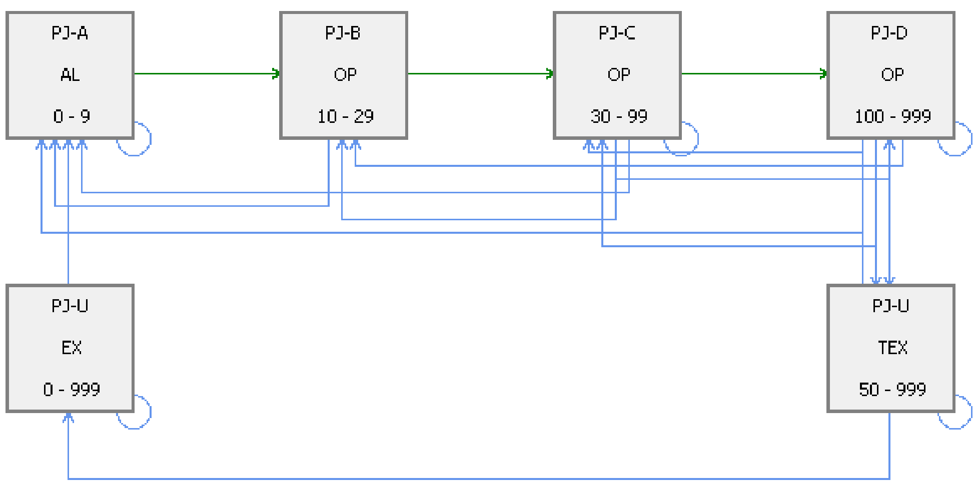
State-and-Transition Model:



Warm Desert Riparian (WDR) 1155

Area of Application and Context:

- **Red Cliffs and Beaver Dam Wash National Conservation Areas of southwestern Utah**
- **Livestock grazing on Beaver Dam Wash only**
- **Full fire suppression management**
- **Date created: July 2011**

Vegetation:

- *WDR-A*: **Early**; 10-50% cover of Gooding willow and Fremont Cottonwood seedlings and shrubs; riparian and wetland graminoids may co-dominate; 0-4 yrs post-flooding
- *WDR-B*: **Mid-closed**; 51-100% cover of willow and small trees (willow and cottonwood) <3 m; patches of graminoids and halophytic shrubs common; 5-19 yrs after flooding
- *WDR-C*: **Mid-open**; 11-50% cover of fire resprouts of mesquite and Gooding willow; patches of graminoids frequent after fire; mesquite mature to larger trees several years after fire; 1-89 yrs after fire
- *WDR-D*: **Late1-closed**; 51%-90% of mature Gooding willow and Fremont cottonwood; patches of graminoids in saturated soils and of halophytic shrubs on drier sediment deposits or more saline surfaces; 10-89 yrs
- *WDR-E*: **Late2-closed**; 51-90% mesquite cover; Gooding willow and Fremont cottonwood minor component; understory often dominated by graminoids and forbs; >90 yrs
- *U-DE:* **Desertified**; incised river bank caused by human disturbance; 10-90% native halophytic shrub or riparian tree cover; graminoid patches may be present
- *U-DET:* **Desertified-Exotic-Tree**; >5% exotic tree species (tamarisk or Russian olive) regardless of native cover; river bank incised
- *U-DEF:* **Desertified-Exotic-Forb**; >5% exotic forb species regardless of native cover; river bank incised
- *U-DEX:* **Desertified-Exotic-Species;** 5-40% exotic annual grasses and forbs; charred remnants of trees and shrubs often present; snakeweed often present to abundant; river bank incised
- *U-TEX:* **Tree- Exotic-Species;** 51%-90% of young or mature Gooding willow and Fremont cottonwood; >5% cover of exotic annual grass and forb species; patches of graminoids in saturated soils and of halophytic shrubs on drier sediment deposits or more saline surfaces
- *U-EF:* **Exotic Forb**; >5% exotic forb species regardless of native cover; river bank not incised
- *U-ET:* **Exotic-Tree**; >5% exotic tree species (tamarisk or Russian olive) regardless of native cover; river bank not incised
- *U-EX:* **Exotic-Species;** 5-40% exotic annual grasses and forbs; charred remnants of trees and shrubs often present; snakeweed often present to abundant
- *U-BG:* **Bare ground**; mineral soil exposed by human-caused disturbances

Reference Condition:

- **Natural Range of Variability**
    - 10%: A-*Early*
    - 19%: B-*Mid-closed*
    - 8%: C-*Mid-open*
    - 40%: D-*Late1-closed*
    - 23%: E-*Late2-closed*
    - 0%: U

Succession:

Succession follows the 4-box pathway with one lateral pathway. The succession pathway is determined most by flooding has heterogeneous vegetation starting with young Goodding's willow and Fremont cottonwood, and graminoids (*WDR-A*) and finishing with mature mesquite, Goodding's willow, and Fremont cottonwood (*WDR-E*). When any of the late-closed classes (*WDR-D* and *WDR-E*) burn, they transition to the *mid-succession open* (*WDR-C*) class dominated by resprouting mesquite, which succeeds to the *late2-succession closed* (*WDR-E*) class. Therefore, fire has a key role in this succession pathway. Succession is entirely deterministic with transitions occurring at the following ages:

- Early-succession to mid-succession closed: 4 years
- Mid-succession closed to late1-succession closed: 19 years
- Late1-succession closed to late2-succession closed: 89 years
- Mid-succession open to late2-succession closed: 89 years

Natural Disturbances:

Flooding dominates the dynamics of the warm desert riparian system. Three levels of *flooding* are:

- 7-yr events (0.14/year) that kills or removes only herbaceous vegetation in the *early-succession* class (*WDR-A*);
- 20-year events (0.05/year) that kills or removs shrubs and young trees in the *mid-succession classes* (*WDR-B* and *WDR-C*); and
- 100-year events (0.01/year) that top-kills larger trees and everything else in the *late-succession closed* classes (*WDR-D* and *WDR-E*).

One-hundreth-year flooding events also transformed uncharacteristic classes:

- In all classes except *exotic forbs* (*EF*), 100-year flooding acted as a self-loop (class stays the same) in 99% of cases with the age of the class being reset to the age at the beginning of the class;
- Variation exists for the remaining 1% of events:
  - Most classes transition to the *early-succession* class (*WDR-A*) due to pure scouring; but
  - The *trees with exotic annual species* class (*TEX*) will become the *exotic-annual-species* class (*EX*) because trees are toppled; and
  - The *desertified exotic tree* (*DET*) and *desertified exotif forb* (*DEF*) classes, respectively, transition to the *exotic tree* (*ET*) and *exotic forbs* (*EF*) classes as the energy of the flow reworks the sediments of the perched river bank (i.e., eliminates it) but does not entirely remove roots of exotic species that could then resprout.
- The *exotic-forb* class (*EF*) remains the same in 100% of cases due to a resprouting and extensive root system.

Replacement fire originates from the surrounding landscape and restarts the succession clock to age zero after sweeping through the riparian corridor. Fire is possible in both *late-succession closed* classes (*WDR-D* and *WDR-E*), because greater woody debris and drier vegetation classes are more prone to lightning strikes in addition to fire importation. Fire in reference classes causes a stand replacing event and recruitment into the *mid-succession* open class (*WDR-C*). However, fire is rare because the surrounding blackbrush and creosotebush-white bursage ecological systems do not carry fire, unless invaded by non-native annual grasses. The mean fire return interval is set at:

- About 750 years (rate of 0.0013/year) in the *late1-succession closed* (*WDR-D*) class; and
- 250 years (rate of 0.004/year) *late2-succession closed* (*WDR-E*) class.

Fire in most uncharacteristic classes often acts as a self-loop, returning all vegetation to age zero.

- These classes are *desertified-exotic-tree* (*DET*), *exotic-tree* (*ET*), *desertified-exotic-annual-species* (*DEX*), and *exotic-annual-species* (*EX*) and they all have a 20-year fire return interval (rate of 0.05/year). In other words, saltcedar, red brome, and *Erodium* spp. either strongly resprout after or strive with fire.
- The *tree with exotic annual species* class (*TEX*) converts to the *exotic-annual-species* (*EX*) class after fire experienced, on average, about every 650 years (rate of 0.0015/year).

An important disturbance is the invasion by exotic trees (*exotic-tree-invasion*) represented mainly by saltcedar. This invasion is triggered if weed inventory and follow-up control has not happened in a pixel for five consecutive years. *Exotic-tree-invasion* causes a transition to the *exotic-tree* class (*ET*) on un-incised river banks and to the *desertified-exotic-tree* (*DET*) class. Workshop participants agreed to moderate rates of invasion varying from 0.005/year to 0.01/year to plan for a worst case scenario. Saltcedar is wind dispersed. *Exotic-tree-invasion* occurs in several classes: *early-succession closed* (*WDR-A*), *mid-succession closed* and *open* classes (*WDR-B and WDR-C, respectively*), *late1-succession closed* (*WDR-D*), *late2-succession closed* class (*WDR-E*), *desertified* (*DE*), *desertified-exotic-annual-species* (*DEX*), *exotic-annual-species* (*EX*), and *tree with exotic annual species* class (*TEX*). Invasion rates vary:

- The highest rate of invasion of 0.01/year is found in classes with exposed mineral soil or substrate: *early-succession* (*WDR-A*) and the first four years of *mid-succession open* class (*WDR-C*);
- As vegetation builds up, the invasion rate decreases to 0.0075/year in the following classes: *mid-succession closed* (*WDR-B*), from year 5 to 89 of the *mid-succession open* (*WDR-C*), *exotic-annual-species* (*EX*), *desertified* (*DE*), and *tree with exotic annual species* (*TEX*); and
- The lowest rate of invasion of 0.005/year is observed in either the most mature reference classes or desertified (drier) classes: *late1-succession closed* (*WDR-D*), *late2-succession closed* (*WDR-E*), and *desertified-exotic-annual-species* (*DEX*).

An important source of saltcedar mortality is the introduced biocontrol beetle (*beetle-mortality*), which is present to abundant in the Virgin River drainage. Workshop participants decided that beetles kill saltcedars after 4 consecutive years of defoliation; therefore, the return interval for beetle induced mortality is 4 years (rate of 0.25/year). *Beetle-mortality* has a failure rate of 75% (vegetation remains in the same class), whereas success (25%) is a transition. Beetle induced mortality causes age-dependent transitions from:

- The *exotic-tree* class (*ET*) to the early-succession (*DWR-A*), *mid-succession* closed (*DWR -B*), *mid-succession* open (*DWR-C*), *late1-succession closed* (*DWR -D*), and *late2-succession closed* (*DWR -E*) classes; and
- The *desertified-exotic-tree* class (*DET*) to the *desertified* class (*DE*).

In the warm desert riparian system, *exotic-forb-invasion* is decoupled from *exotic-tree-invasion* (it is not in other riparian ecological systems). Exotic forbs are represented mainly by knapweed species and tall whitetop. *Exotic-forb-invasion* causes a transition to the *exotic-forb* class (*EF*) on un-incised river banks and to the *desertified-exotic-tree* (*DEF*) class. Classes affected and rates of invasion of the *exotic-forb* class (*EF*) are identical to those of the *exotic-tree* (*ET*) class. There is not, however, a biocontrol beetle for exotic forb control.

A third form of invasion is by non-native annual species (*EX-invasion*) occurring at a rate of 0.005/year (5 of 1,000 pixels per year) in all uninvaded classes: *early-succession closed* (*DWR-A*), *mid-succession closed* (*DWR-B*), *mid-succession open* (*DW-C*), *late1-succession closed* (*DWR-D*), and *late2-succession closed* (*DWR-E*). Exotic annual species invasion (*EX-invasion*) is set at a moderate rate of 0.005/year (1 out of 200 pixels converted to a cheatgrass-invaded class per year. A base rate of 0.001/year was estimated for cheatgrass from data of northwest Utah collected by the Utah Division of Wildlife Resources in black sagebrush semi-desert. We default to five times the rate estimated from the Utah data because desert riparian systems are more productive systems. Invasion of reference classes causes an age-dependent transition to the *trees with non-native annual species* (*TEX*).

Present in Beaver Dam Wash only, *managed herbivory* and *excessive herbivory* have return intervals of one year (livestock is present every year) but different impact areas based on the distance livestock is willing to travel away from water. In theory, water is in this ecological system. The impact of grazing was modeled with area limits, because grazing permits have fixed stocking rates, season of use, and distribution. It was assumed that *managed herbivory* utilizes 5% of all grazable areas in the Beaver Dam Wash NCA (not just desert riparian); therefore, only 5% of the area is selected for *managed herbivory* and vegetation classes in desert riparian "compete" for selection. This method of modeling livestock grazing can only be implemented with the PATH software; VDDT cannot achieve landscape-level disturbances. Similarly, *excessive herbivory* affects 0.1% of the Beaver Dam Wash NCA causing a transition to the *desertified* class (*DE*); however, *excessive herbivory* is caused by the movement of livestock through the same areas near or on the way to water sources. Therefore, once areas dominated by incised river banks are created, they become permanent and no new areas are created. As a consequence, 0.1% of the Beaver Dam Wash is chosen among candidate vegetation classes to become the *desertified* class (*DE*) in the first years of simulations, and then the process is stopped.

Managed herbivory has different effects on woody succession depending on the age of the grazable vegetation classes:

- The *early-succession* class (*WDR-A*) is very vulnerable to grazing; therefore, new vegetation is largely eliminated and the age of grazed vegetation is reset at zero years;
- A similar effect is found in the *exotic-annual-species* class (*EX*) because livestock is concentrated in riparian areas and livestock will focus on non-native annual species because, during winter grazing (the permit is primarily for winter grazing), these species are often the only green forage available;
- In both *mid-succession* classes (*WDR-B* and *WDR-C*), grazing of more established vegetation has a small negative effect that consist of a one year reversal of woody vegetation after vegetation is grazed. This effect reverses woody succession through the reduction of preferentially herbaceous and nutrient-rich soft woody vegetation;
- Preference for these food types in more developed woody vegetation of the *late1-succession closed* (*WDR-D*), *desertified with exotic annual species* (*DEX*), and *tree with exotic species* (*TEX*) classes causes a small acceleration of woody succession by favoring unpalatable or hardened woody species; and
- Grazing has no effect on the succession age of the *late2-succession closed* class (*WDR-E*).

Excessive herbivory is present in all classes except the *desertified (DE), exotic-tree* (*ET*)*, exotic forb* (*EF*),

desertified exotic tree (*DET*), and *desertified exotic forb* (*DEF*) classes. *Excessive herbivory* primarily causes a transition to the *desertified* (DE*)* class, however the *desertified with exotic annual species* (*DEX*) is one exception. This class cannot be further incised but the shade from trees and presence of green winter forage creates a strong grazing pressure that accelaerates woody succession by three years for every pixel chosen.
Management Actions: Several actions (six in Beaver Dam Wash and five in Red Cliffs NCAs, respectively) are used in this ecological system: • Inventory of weeds and saltcedar on a rotation (i.e., revisit the same reach every *X* years) for identification of occurrences for future treatment (*weed-inventory).* • Control of saltcedar: *exotic-tree-control*. Action consists of cutting saltcedar and immediately painting the stumps with the herbicide Garlon IV® in the *exotic-tree* (*ET*) and *desertified-exotic-tree* (*DET*) classes. Two types of failures occur: 10% of times there is no change of class because saltcedar resprout immediately and vigorously and 10% of times exotic forb species (knapweeds and tall whitetop) emerge (therefore, the *exotic-forb* [*EF*] or *desertified-exotic-forb* [*DEF*] classes). Success rate, therefore, is 80% and results in a transition to the *early-succession* (*WDR-A*) class for the non-desertified river reaches or the *desertified* (*DE*) class for saltcedar originally growing on incised river banks. • Control of exotic forbs: *exotic-forb-control*. Action consists of spraying exotic forbs in the *exotic-forb* (*EF*) and *desertified-exotic-forb* (*DEF*) classes. On incised river banks, failure rate is 40% (no change of class), whereas "success" occurs 60% of time leaving a desertified and seeded (native species) river bank. On un-incised river banks, the treatment fails 40% of times with no change of class, whereas the treatment succeeds 60% of times resulting in a transition to the *early-succession* (*WDR-A*) class. • In the Beaver Dam Wash NCA, cessation of livestock grazing by having a third party purchase all AUMs and retire grazing permits (i.e., by turning off grazing with one transition multiplier). • Hand spraying of the herbicide Plateau® to control exotic annual species in the *tree with exotic species* (*TEX*) class. Failure rate is 50% (no change of class), whereas success causes a transition to the *early-succession* (*WDR-A*), *mid-succession closed (WDR-B), late1-succession closed* (*WDR-D*), and *late2-succession closed* (*WDR-D*) classes that depends on the age of originating vegetation class. • Law enforcement only affected the creation of one vegetation class from OHV activity in several ecological systems of the Beaver Dam Wash NCA: *bare groud* (*BG*). Increased law-enforcement reduces the OHV disturbance by 50% (to 5% absolute rate) using a static transition multiplier in PATH.

Appendix 3. Probabilistic transitions for ecological systems of the Red Cliffs and Beaver Dam Wash NCAs. Output obtained from PATH database. Legend: BSu = Big Sagebrush Steppe-upland, BM = Blackbrush-mesic, BT= Blackbrush-thermic, CB = Creosotebush-White Bursage, DSS = Desert Sand Sagebrush, GRL = Warm Season Grassland, MR = Montane Riparian, MSh = Mountain Shrub, PJ = Pinyon-Juniper Woodland, WAS = Desert Washes, WDR = Warm-Desert Riparian.

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
Red Cliffs NCA										
DSS-A:OP	DSS-A:OP	NativeHerbivory	0.0050	1.0000	0	2	1	No	0	9999
DSS-A:OP	DSS-A:OP	ReplacementFire	0.0083	1.0000	0	2	-2	No	0	9999
DSS-A:OP	DSS-U:SEP	EX-Invasion	0.0010	1.0000	0	2	0	Yes	0	9999
DSS-B:OP	DSS-A:OP	ReplacementFire	0.0106	1.0000	3	999	0	No	0	9999
DSS-B:OP	DSS-B:OP	Drought	0.0056	1.0000	3	999	-999	No	0	9999
DSS-B:OP	DSS-B:OP	Managed-Herbivory	1.0000	0.0500	3	999	2	No	0	9999
DSS-B:OP	DSS-U:DP	Excessive-Herbivory	0.0010	1.0000	10	10	0	Yes	0	9999
DSS-B:OP	DSS-U:SEP	EX-Invasion	0.0010	1.0000	3	999	0	Yes	0	9999
DSS-U:DP	DSS-U:DP	Drought	0.0056	1.0000	0	999	-999	No	0	9999
DSS-U:DP	DSS-U:DP	ReplacementFire	0.0083	1.0000	0	999	-999	No	0	9999
DSS-U:DP	DSS-U:SEP	EX-Invasion	0.0010	1.0000	0	999	0	Yes	0	9999
DSS-U:SEP	DSS-B:OP	FOD+Seed-DSS	0.0100	0.6000	0	999	0	Yes	0	9999
DSS-U:SEP	DSS-B:OP	Hrbx+Seed-DSS	0.0100	0.5000	0	999	0	Yes	0	9999
DSS-U:SEP	DSS-U:DP	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	0	9999
DSS-U:SEP	DSS-U:SEP	Drought	0.0056	1.0000	0	999	-999	No	0	9999
DSS-U:SEP	DSS-U:SEP	FOD+Seed-DSS	0.0100	0.4000	0	999	0	No	0	9999
DSS-U:SEP	DSS-U:SEP	Hrbx+Seed-DSS	0.0100	0.5000	0	999	0	No	0	9999
DSS-U:SEP	DSS-U:SEP	Managed-Herbivory	1.0000	0.0500	0	999	1	No	0	9999
DSS-U:SEP	DSS-U:SEP	ReplacementFire	0.0106	1.0000	3	999	-999	No	0	9999
DSS-U:SEP	DSS-U:SEP	ReplacementFire	0.0500	1.0000	0	2	-999	No	0	9999
BM-A:AL	BM-A:AL	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-A:AL	BM-A:AL	Managed-Herbivory	1.0000	0.0500	2	199	1	No	0	9999
BM-A:AL	BM-A:AL	ReplacementFire-Mojave	0.0001	1.0000	0	199	-999	No	3	9999
BM-A:AL	BM-U:BG	OHV	1.0000	0.0001	0	199	0	No	2	9999
BM-A:AL	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	0	9999
BM-A:AL	BM-U:EX	EX-Invasion	0.0050	1.0000	0	4	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-A:AL	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-A:AL	BM-U:SEP	EX-Invasion	0.0050	1.0000	5	199	0	Yes	0	9999
BM-C:OP	BM-A:AL	ReplacementFire-Mojave	0.0005	1.0000	200	999	0	No	3	9999
BM-C:OP	BM-C:OP	FuelBreak	0.0100	1.0000	200	999	0	No	0	9999
BM-C:OP	BM-C:OP	Managed-Herbivory	1.0000	0.0500	200	999	3	No	0	9999
BM-C:OP	BM-D:OP	Tree-Invasion	0.0025	1.0000	400	999	0	Yes	0	9999
BM-C:OP	BM-U:BG	OHV	1.0000	0.0001	200	999	0	No	2	9999
BM-C:OP	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	210	210	0	Yes	0	9999
BM-C:OP	BM-U:EX	Utilities	0.0001	1.0000	200	999	0	No	0	9999
BM-D:OP	BM-A:AL	Drought	0.0056	0.0100	400	999	0	No	0	9999
BM-D:OP	BM-A:AL	ReplacementFire-Mojave	0.0010	1.0000	400	999	0	No	3	9999
BM-D:OP	BM-C:OP	Drought	0.0056	0.9900	400	999	0	No	0	9999
BM-D:OP	BM-D:OP	FuelBreak	0.0100	1.0000	400	999	0	No	0	9999
BM-D:OP	BM-D:OP	Managed-Herbivory	1.0000	0.0500	400	999	3	No	0	9999
BM-D:OP	BM-U:BG	OHV	1.0000	0.0001	400	999	0	No	2	9999
BM-D:OP	BM-U:EX	Utilities	0.0001	1.0000	400	999	0	No	0	9999
BM-D:OP	BM-U:TEX	EX-Invasion	0.0050	1.0000	400	999	0	Yes	0	9999
BM-D:OP	BM-U:TEX	Tree-Encroachment	0.0050	1.0000	600	999	0	No	0	9999
BM-U:BG	BM-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
BM-U:BG	BM-U:EX	EX-Invasion	0.0050	1.0000	0	999	0	No	0	9999
BM-U:BG	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:ES	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:ES	BM-U:ES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:ES	BM-U:ES	ReplacementFire-Mojave	0.0010	1.0000	0	999	-999	No	3	9999
BM-U:ES	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:ES	BM-U:SEP	EX-Invasion	0.0050	1.0000	0	999	0	No	0	9999
BM-U:EX	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:EX	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	No	0	9999
BM-U:EX	BM-U:EX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:EX	BM-U:EX	Hrbx+Current-Native-Seed-BM	0.0100	0.9900	0	999	-999	No	0	9999
BM-U:EX	BM-U:EX	Hrbx+Introduced-Seed-BM	0.0100	0.9500	0	999	-999	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-U:EX	BM-U:EX	Hrbx+New-Seed-BM	0.0100	0.9500	0	999	0	Yes	0	9999
BM-U:EX	BM-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	1	No	0	9999
BM-U:EX	BM-U:EX	Planting+FOD-BM	0.0100	0.1000	0	999	0	No	0	9999
BM-U:EX	BM-U:EX	Planting+Herbicde-BM	0.0100	0.1000	0	999	0	No	0	9999
BM-U:EX	BM-U:EX2B	ReplacementFire-Mojave	0.0500	1.0000	21	999	-999	No	3	9999
BM-U:EX	BM-U:EX2B	ReplacementFire-Mojave	0.1000	1.0000	0	20	-999	No	3	9999
BM-U:EX	BM-U:EX2B	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:EX	BM-U:PL	Planting+FOD-BM	0.0100	0.6950	0	999	0	No	0	9999
BM-U:EX	BM-U:PL	Planting+Herbicde-BM	0.0100	0.4500	0	999	0	Yes	0	9999
BM-U:EX	BM-U:SD	Hrbx+Current-Native-Seed-BM	0.0100	0.0100	0	999	0	Yes	0	9999
BM-U:EX	BM-U:SD	Hrbx+New-Seed-BM	0.0100	0.0500	0	999	0	Yes	0	9999
BM-U:EX	BM-U:SDI	Hrbx+Introduced-Seed-BM	0.0100	0.0500	0	999	0	Yes	0	9999
BM-U:EX	BM-U:SEP	Non-Joshua-Succession	0.1000	1.0000	20	999	0	No	0	9999
BM-U:EX	BM-U:SEP	Planting+FOD-BM	0.0100	0.2050	0	999	0	No	0	9999
BM-U:EX	BM-U:SEP	Planting+Herbicde-BM	0.0100	0.4500	0	999	0	Yes	0	9999
BM-U:EX2B	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:EX2B	BM-U:EX2B	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Hrbx+New-Seed-BM	0.0100	0.9500	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Managed-Herbivory	1.0000	0.0500	2	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Planting+FOD-BM	0.0100	0.1000	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Planting+Herbicde-BM	0.0100	0.1000	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	ReplacementFire-Mojave	0.1000	1.0000	0	999	-999	No	3	9999
BM-U:EX2B	BM-U:PL	Planting+FOD-BM	0.0100	0.6950	0	999	0	No	0	9999
BM-U:EX2B	BM-U:PL	Planting+Herbicde-BM	0.0100	0.4500	0	999	0	No	0	9999
BM-U:EX2B	BM-U:SD	Hrbx+New-Seed-BM	0.0100	0.0500	0	999	0	No	0	9999
BM-U:EX2B	BM-U:SEP	Planting+FOD-BM	0.0100	0.2050	0	999	0	No	0	9999
BM-U:EX2B	BM-U:SEP	Planting+Herbicde-BM	0.0100	0.4500	0	999	0	No	0	9999
BM-U:PL	BM-A:AL	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
BM-U:PL	BM-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
BM-U:PL	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	10	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-U:PL	BM-U:EX	Drought	0.0056	0.1000	0	999	0	No	0	9999
BM-U:PL	BM-U:EX	Managed-Herbivory	1.0000	0.0500	0	999	0	No	10	9999
BM-U:PL	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:PL	BM-U:PL	Drought	0.0056	0.9000	0	999	-999	No	0	9999
BM-U:PL	BM-U:PL	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BM-U:PL	BM-U:SEP	Seedbank-Emergence	0.2000	1.0000	0	999	0	Yes	2	9999
BM-U:SD	BM-A:AL	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
BM-U:SD	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:SD	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	10	9999
BM-U:SD	BM-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
BM-U:SD	BM-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	0	No	10	9999
BM-U:SD	BM-U:EX	Seedbank-Emergence	0.2000	1.0000	0	999	0	Yes	2	9999
BM-U:SD	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:SD	BM-U:SD	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:SD	BM-U:SD	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BM-U:SD	BM-U:SD	ReplacementFire-Mojave	0.0010	1.0000	0	999	-999	No	3	9999
BM-U:SD	BM-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
BM-U:SDI	BM-A:AL	Natural-Recovery	0.0010	1.0000	20	199	0	Yes	10	9999
BM-U:SDI	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:SDI	BM-U:ES	Excessive-Herbivory	1.0000	0.0001	10	10	0	Yes	10	9999
BM-U:SDI	BM-U:EX	EX-Invasion	0.0010	1.0000	0	19	0	Yes	0	9999
BM-U:SDI	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:SDI	BM-U:SDI	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:SDI	BM-U:SDI	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BM-U:SDI	BM-U:SDI	Managed-Herbivory	1.0000	0.0500	2	999	1	No	10	9999
BM-U:SDI	BM-U:SDI	ReplacementFire-Mojave	0.0001	1.0000	0	999	-999	No	3	9999
BM-U:SDI	BM-U:SEP	EX-Invasion	0.0010	1.0000	20	999	0	Yes	0	9999
BM-U:SDI	BM-U:SEP	Seedbank-Emergence	0.2000	1.0000	0	999	0	Yes	2	9999
BM-U:SEP	BM-C:OP	Fingers-of-Death-BM	0.0100	0.7500	5	399	0	Yes	0	9999
BM-U:SEP	BM-D:OP	Fingers-of-Death-BM	0.0100	0.7500	400	999	0	Yes	0	9999
BM-U:SEP	BM-U:BG	OHV	1.0000	0.0001	20	999	0	No	2	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-U:SEP	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	30	30	0	Yes	0	9999
BM-U:SEP	BM-U:EX	Drought	0.0056	0.0100	20	999	0	No	0	9999
BM-U:SEP	BM-U:EX	ReplacementFire-Mojave	0.0050	1.0000	199	999	0	No	3	9999
BM-U:SEP	BM-U:EX	Utilities	0.0001	1.0000	20	999	0	No	0	9999
BM-U:SEP	BM-U:EX2B	ReplacementFire-Mojave	0.0500	1.0000	0	199	0	No	3	9999
BM-U:SEP	BM-U:EX2B	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:SEP	BM-U:PL	Herbicide-BM	0.0100	0.5000	5	15	0	No	1	9999
BM-U:SEP	BM-U:SEP	Drought	0.0056	0.9900	20	999	-999	No	0	9999
BM-U:SEP	BM-U:SEP	Fingers-of-Death-BM	0.0100	0.2500	5	999	0	No	0	9999
BM-U:SEP	BM-U:SEP	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
BM-U:SEP	BM-U:SEP	Herbicide-BM	0.0100	0.5000	5	15	0	No	1	9999
BM-U:SEP	BM-U:SEP	Managed-Herbivory	1.0000	0.0500	20	999	1	No	0	9999
BM-U:SEP	BM-U:TEX	Tree-Invasion	0.0025	1.0000	400	999	0	Yes	0	9999
BM-U:TEX	BM-U:EX	Drought	0.0056	0.0100	400	999	0	No	0	9999
BM-U:TEX	BM-U:EX	ReplacementFire-Mojave	0.0025	1.0000	400	999	0	No	3	9999
BM-U:TEX	BM-U:SD	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:TEX	BM-U:SEP	Chainsaw-Lopping-BM	0.0100	1.0000	0	999	0	No	0	9999
BM-U:TEX	BM-U:SEP	Drought	0.0056	0.1000	400	999	0	No	0	9999
BM-U:TEX	BM-U:TEX	Drought	0.0056	0.9000	400	999	-999	No	0	9999
BM-U:TEX	BM-U:TEX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BSu-A:AL	BSu-A:AL	Managed-Herbivory	1.0000	0.0500	2	19	1	No	0	9999
BSu-A:AL	BSu-A:AL	ReplacementFire	0.0125	1.0000	0	19	-999	No	0	9999
BSu-A:AL	BSu-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	0	9999
BSu-B:OP	BSu-A:AL	ReplacementFire	0.0200	1.0000	20	74	0	No	0	9999
BSu-B:OP	BSu-B:OP	Managed-Herbivory	1.0000	0.0500	20	74	1	No	0	9999
BSu-B:OP	BSu-U:ES	Excessive-Herbivory	1.0000	0.0010	30	30	0	Yes	0	9999
BSu-B:OP	BSu-U:SEP	EX-Invasion	0.0050	1.0000	20	74	0	Yes	0	9999
BSu-C:CL	BSu-A:AL	ReplacementFire	0.0200	1.0000	75	999	0	No	0	9999
BSu-C:CL	BSu-B:OP	Drought	0.0060	0.1000	75	999	0	No	0	9999
BSu-C:CL	BSu-C:CL	Drought	0.0056	0.9000	75	999	-999	No	0	9999
BSu-C:CL	BSu-C:CL	Managed-Herbivory	1.0000	0.0500	75	999	1	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BSu-C:CL	BSu-D:OP	Tree-Invasion	0.0050	1.0000	100	999	0	Yes	0	9999
BSu-C:CL	BSu-U:DP	Excessive-Herbivory	1.0000	0.0010	85	85	0	Yes	0	9999
BSu-C:CL	BSu-U:SEP	EX-Invasion	0.0050	1.0000	75	999	0	Yes	0	9999
BSu-D:OP	BSu-A:AL	ReplacementFire	0.0200	1.0000	76	134	0	No	0	9999
BSu-D:OP	BSu-B:OP	Drought	0.0056	0.3000	76	134	0	No	0	9999
BSu-D:OP	BSu-C:CL	Drought	0.0056	0.6000	76	134	0	No	0	9999
BSu-D:OP	BSu-D:OP	Chainsaw-Thinning-BSu	0.0100	1.0000	76	134	-999	No	0	9999
BSu-D:OP	BSu-D:OP	Drought	0.0056	0.1000	76	134	-999	No	0	9999
BSu-D:OP	BSu-D:OP	Excessive-Herbivory	0.0010	0.7500	86	86	3	No	0	9999
BSu-D:OP	BSu-D:OP	Managed-Herbivory	1.0000	0.0500	76	134	1	No	0	9999
BSu-D:OP	BSu-U:DP	Excessive-Herbivory	0.0010	0.2500	86	86	0	Yes	0	9999
BSu-D:OP	BSu-U:SEP	EX-Invasion	0.0050	1.0000	76	134	0	No	0	9999
BSu-E:CL	BSu-A:AL	Chainsaw-Thinning-BSu	0.0100	1.0000	135	999	0	No	0	9999
BSu-E:CL	BSu-A:AL	ReplacementFire	0.0130	1.0000	135	999	0	No	0	9999
BSu-E:CL	BSu-B:OP	Drought	0.0056	0.1000	135	999	0	No	0	9999
BSu-E:CL	BSu-E:CL	Drought	0.0056	0.9000	135	999	5	No	0	9999
BSu-E:CL	BSu-U:TE	Tree-Encroachment	0.0200	1.0000	250	999	0	Yes	0	9999
BSu-U:DP	BSu-U:DP	Chainsaw-Lopping-BSu	0.0100	1.0000	100	999	-999	No	0	9999
BSu-U:DP	BSu-U:DP	Drought	0.0056	0.9000	75	999	-999	No	0	9999
BSu-U:DP	BSu-U:ES	Drought	0.0056	0.1000	75	999	0	No	0	9999
BSu-U:DP	BSu-U:ES	ReplacementFire	0.0200	1.0000	75	999	0	No	0	9999
BSu-U:DP	BSu-U:SES	EX-Invasion	0.0050	1.0000	75	999	0	Yes	0	9999
BSu-U:DP	BSu-U:TE	Tree-Invasion	0.0050	1.0000	134	999	0	No	0	9999
BSu-U:ES	BSu-A:AL	ReplacementFire	0.0200	0.0100	0	999	0	No	0	9999
BSu-U:ES	BSu-B:OP	Natural-Recovery	0.0010	1.0000	12	49	10	Yes	0	9999
BSu-U:ES	BSu-C:CL	Natural-Recovery	0.0010	1.0000	50	999	10	Yes	0	9999
BSu-U:ES	BSu-U:ES	ReplacementFire	0.0200	0.9900	0	999	0	No	0	9999
BSu-U:EX	BSu-U:EX	Herbicide+Seed-BSu	0.0100	0.2000	0	999	0	No	0	9999
BSu-U:EX	BSu-U:EX	ReplacementFire	0.1000	0.1000	0	999	-999	No	0	9999
BSu-U:EX	BSu-U:SD	Herbicide+Seed-BSu	0.0100	0.8000	0	999	0	No	0	9999
BSu-U:SD	BSu-A:AL	Natural-Recovery	0.0010	1.0000	5	19	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BSu-U:SD	BSu-B:OP	Natural-Recovery	0.0100	1.0000	20	74	0	Yes	0	9999
BSu-U:SD	BSu-C:CL	Natural-Recovery	0.0500	1.0000	75	999	0	Yes	0	9999
BSu-U:SD	BSu-D:OP	Tree-Invasion	0.0050	1.0000	75	999	0	No	0	9999
BSu-U:SD	BSu-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	0	9999
BSu-U:SD	BSu-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
BSu-U:SD	BSu-U:SD	Drought	0.0056	1.0000	0	999	-999	No	0	9999
BSu-U:SD	BSu-U:SD	Managed-Herbivory	1.0000	0.0500	2	999	1	No	0	9999
BSu-U:SD	BSu-U:SD	ReplacementFire	0.0125	1.0000	0	19	-999	No	0	9999
BSu-U:SD	BSu-U:SD	ReplacementFire	0.0125	1.0000	135	999	-999	No	0	9999
BSu-U:SD	BSu-U:SD	ReplacementFire	0.0200	1.0000	20	134	-999	No	0	9999
BSu-U:SD	BSu-U:SEP	EX-Invasion	0.0010	1.0000	20	134	0	Yes	0	9999
BSu-U:SD	BSu-U:TEX	EX-Invasion	0.0050	1.0000	135	999	0	Yes	0	9999
BSu-U:SEP	BSu-A:AL	Drought	0.0056	0.0100	75	999	0	No	0	9999
BSu-U:SEP	BSu-A:AL	ReplacementFire	0.0400	0.1000	75	999	0	No	0	9999
BSu-U:SEP	BSu-C:CL	Herbicide+Seed-BSu	0.0100	0.9000	75	999	0	No	0	9999
BSu-U:SEP	BSu-C:CL	Natural-Recovery	0.0010	1.0000	75	999	0	Yes	10	9999
BSu-U:SEP	BSu-U:EX	Drought	0.0056	0.0900	75	999	0	No	0	9999
BSu-U:SEP	BSu-U:EX	ReplacementFire	0.0400	0.9000	75	999	0	No	0	9999
BSu-U:SEP	BSu-U:SEP	Chainsaw-Lopping-BSu	0.0100	1.0000	0	999	-999	No	0	9999
BSu-U:SEP	BSu-U:SEP	Drought	0.0056	0.9000	75	999	-999	No	0	9999
BSu-U:SEP	BSu-U:SEP	Herbicide+Seed-BSu	0.0100	0.1000	75	999	0	No	0	9999
BSu-U:SEP	BSu-U:SEP	Managed-Herbivory	1.0000	0.0500	75	99	1	No	0	9999
BSu-U:SEP	BSu-U:SES	Excessive-Herbivory	0.0010	1.0000	85	85	0	Yes	0	9999
BSu-U:SEP	BSu-U:SES	Managed-Herbivory	1.0000	0.0500	100	999	0	No	0	9999
BSu-U:SEP	BSu-U:TEX	Tree-Invasion	0.0050	1.0000	134	999	0	No	0	9999
BSu-U:SES	BSu-U:EX	Drought	0.0056	0.1000	75	999	0	No	0	9999
BSu-U:SES	BSu-U:EX	ReplacementFire	0.0400	1.0000	75	999	0	No	0	9999
BSu-U:SES	BSu-U:SES	Drought	0.0056	0.9000	75	999	-999	No	0	9999
BSu-U:SES	BSu-U:TEX	Tree-Invasion	0.0050	1.0000	134	999	0	Yes	0	9999
BSu-U:TE	BSu-U:ES	Drought	0.0056	0.0500	135	999	0	No	0	9999
BSu-U:TE	BSu-U:ES	ReplacementFire	0.0085	0.4500	135	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BSu-U:TE	BSu-U:EX	Drought	0.0056	0.0500	135	999	0	No	0	9999
BSu-U:TE	BSu-U:EX	ReplacementFire	0.0085	0.4500	135	999	0	No	0	9999
BSu-U:TE	BSu-U:EX	Thin+Herbicide+Seed-BSu	0.0100	0.1000	0	999	0	No	0	9999
BSu-U:TE	BSu-U:SD	Thin+Herbicide+Seed-BSu	0.0100	0.9000	0	999	0	No	0	9999
BSu-U:TE	BSu-U:SES	ReplacementFire	0.0085	0.1000	135	999	0	No	0	9999
BSu-U:TE	BSu-U:TE	Drought	0.0056	0.9000	135	999	-999	No	0	9999
BSu-U:TE	BSu-U:TEX	EX-Invasion	0.0050	1.0000	135	999	0	Yes	0	9999
BSu-U:TEX	BSu-U:EX	Drought	0.0056	0.1000	135	999	0	No	0	9999
BSu-U:TEX	BSu-U:EX	ReplacementFire	0.0085	1.0000	135	999	0	No	0	9999
BSu-U:TEX	BSu-U:EX	Thin+Herbicide+Seed-BSu	0.0100	0.2000	135	999	0	No	0	9999
BSu-U:TEX	BSu-U:SD	Thin+Herbicide+Seed-BSu	0.0100	0.8000	135	999	0	No	0	9999
BSu-U:TEX	BSu-U:TEX	Drought	0.0056	0.9000	0	999	-999	No	0	9999
BT-A:AL	BT-A:AL	FuelBreak	0.0100	1.0000	0	499	0	No	0	9999
BT-A:AL	BT-A:AL	Managed-Herbivory	1.0000	0.0500	2	499	2	No	0	9999
BT-A:AL	BT-A:AL	ReplacementFire-Mojave	0.0001	1.0000	0	499	-999	No	3	9999
BT-A:AL	BT-U:BG	OHV	1.0000	0.0001	0	499	0	No	2	9999
BT-A:AL	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	0	9999
BT-A:AL	BT-U:EX	EX-Invasion	0.0050	1.0000	0	4	0	Yes	0	9999
BT-A:AL	BT-U:SEP	EX-Invasion	0.0050	1.0000	5	499	0	Yes	0	9999
BT-C:CL	BT-A:AL	ReplacementFire-Mojave	0.0001	1.0000	500	999	0	No	3	9999
BT-C:CL	BT-C:CL	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-C:CL	BT-C:CL	Managed-Herbivory	1.0000	0.0500	500	999	2	No	0	9999
BT-C:CL	BT-U:BG	OHV	1.0000	0.0001	500	999	0	No	2	9999
BT-C:CL	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	510	510	0	Yes	0	9999
BT-C:CL	BT-U:EX	Utilities	0.0001	1.0000	500	999	0	No	0	9999
BT-C:CL	BT-U:SEP	EX-Invasion	0.0050	1.0000	500	999	0	Yes	0	9999
BT-U:BG	BT-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
BT-U:BG	BT-U:EX	EX-Invasion	0.0050	1.0000	0	999	0	No	0	9999
BT-U:BG	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:ES	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:ES	BT-U:ES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BT-U:ES	BT-U:ES	ReplacementFire-Mojave	0.0010	1.0000	0	999	-999	No	3	9999
BT-U:ES	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:ES	BT-U:SEP	EX-Invasion	0.0050	1.0000	0	999	0	No	0	9999
BT-U:EX	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:EX	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	No	0	9999
BT-U:EX	BT-U:EX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-U:EX	BT-U:EX	Hrbx+Current-Native-Seed-BT	0.0100	0.9900	0	999	-999	No	0	9999
BT-U:EX	BT-U:EX	Hrbx+Introduced-Seed-BT	0.0100	0.9500	0	999	-999	No	0	9999
BT-U:EX	BT-U:EX	Hrbx+New-Seed-BT	0.0500	0.9500	0	999	0	Yes	0	9999
BT-U:EX	BT-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	1	No	0	9999
BT-U:EX	BT-U:EX	Planting+FOD-BT	0.0100	0.1000	0	999	0	No	0	9999
BT-U:EX	BT-U:EX	Planting+Herbicide-BT	0.0100	0.1000	0	999	0	No	0	9999
BT-U:EX	BT-U:EX2B	ReplacementFire-Mojave	0.0500	1.0000	0	999	-999	No	3	9999
BT-U:EX	BT-U:EX2B	Utilities	0.0001	1.0000	0	999	-999	No	0	9999
BT-U:EX	BT-U:PL	Planting+FOD-BT	0.0100	0.6950	0	999	0	No	0	9999
BT-U:EX	BT-U:PL	Planting+Herbicide-BT	0.0100	0.4500	0	999	0	No	0	9999
BT-U:EX	BT-U:SD	Hrbx+Current-Native-Seed-BT	0.0100	0.0100	0	999	0	Yes	0	9999
BT-U:EX	BT-U:SD	Hrbx+New-Seed-BT	0.0100	0.0500	0	999	0	Yes	0	9999
BT-U:EX	BT-U:SDI	Hrbx+Introduced-Seed-BT	0.0100	0.0500	0	999	0	Yes	0	9999
BT-U:EX	BT-U:SEP	Non-Joshua-Succession	0.1000	1.0000	20	999	0	Yes	0	9999
BT-U:EX	BT-U:SEP	Planting+FOD-BT	0.0100	0.2050	0	999	0	No	0	9999
BT-U:EX	BT-U:SEP	Planting+Herbicide-BT	0.0100	0.4500	0	999	0	No	0	9999
BT-U:EX2B	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:EX2B	BT-U:EX2B	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-U:EX2B	BT-U:EX2B	Hrbx+New-Seed-BT	0.0100	0.9500	0	999	0	No	0	9999
BT-U:EX2B	BT-U:EX2B	Managed-Herbivory	1.0000	0.0500	2	999	0	No	0	9999
BT-U:EX2B	BT-U:EX2B	Planting+FOD-BT	0.0100	0.1000	0	999	0	No	0	9999
BT-U:EX2B	BT-U:EX2B	Planting+Herbicide-BT	0.0100	0.1000	0	999	0	No	0	9999
BT-U:EX2B	BT-U:EX2B	ReplacementFire-Mojave	0.1000	1.0000	0	999	-999	No	3	9999
BT-U:EX2B	BT-U:EX2B	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:EX2B	BT-U:PL	Planting+FOD-BT	0.0100	0.6950	0	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BT-U:EX2B	BT-U:PL	Planting+Herbicide-BT	0.0100	0.4500	0	999	0	No	0	9999
BT-U:EX2B	BT-U:SD	Hrbx+New-Seed-BT	0.0100	0.0500	0	999	0	No	0	9999
BT-U:EX2B	BT-U:SEP	Planting+FOD-BT	0.0100	0.2050	0	999	0	No	0	9999
BT-U:EX2B	BT-U:SEP	Planting+Herbicide-BT	0.0100	0.4500	0	999	0	No	0	9999
BT-U:PL	BT-A:AL	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
BT-U:PL	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:PL	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	No	10	9999
BT-U:PL	BT-U:EX	Drought	0.0056	0.0100	0	999	0	No	0	9999
BT-U:PL	BT-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	-3	No	10	9999
BT-U:PL	BT-U:EX	Seedbank-Emergence	0.2000	1.0000	0	999	0	Yes	2	9999
BT-U:PL	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:PL	BT-U:PL	Drought	0.0056	0.9900	0	999	-999	No	0	9999
BT-U:PL	BT-U:PL	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BT-U:SD	BT-A:AL	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
BT-U:SD	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:SD	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	10	9999
BT-U:SD	BT-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
BT-U:SD	BT-U:EX	Seedbank-Emergence	0.2000	1.0000	0	999	0	Yes	2	9999
BT-U:SD	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:SD	BT-U:SD	Drought	0.0056	0.1000	0	999	-999	No	0	9999
BT-U:SD	BT-U:SD	Drought	0.0056	0.9000	0	999	0	No	0	9999
BT-U:SD	BT-U:SD	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-U:SD	BT-U:SD	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BT-U:SD	BT-U:SD	Managed-Herbivory	1.0000	0.0500	2	999	-1	No	10	9999
BT-U:SD	BT-U:SD	ReplacementFire-Mojave	0.0010	1.0000	0	19	-999	No	3	9999
BT-U:SD	BT-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
BT-U:SDI	BT-A:AL	Natural-Recovery	0.0020	1.0000	0	999	0	No	10	9999
BT-U:SDI	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:SDI	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	10	9999
BT-U:SDI	BT-U:EX	EX-Invasion	0.0010	1.0000	0	19	0	Yes	0	9999
BT-U:SDI	BT-U:EX	Seedbank-Emergence	0.2000	1.0000	0	999	0	Yes	2	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BT-U:SDI	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:SDI	BT-U:SDI	Drought	0.0056	0.1000	0	999	-999	No	0	9999
BT-U:SDI	BT-U:SDI	Drought	0.0056	0.9000	0	999	0	No	0	9999
BT-U:SDI	BT-U:SDI	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-U:SDI	BT-U:SDI	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BT-U:SDI	BT-U:SDI	Managed-Herbivory	1.0000	0.0500	2	999	-1	No	10	9999
BT-U:SDI	BT-U:SDI	ReplacementFire-Mojave	0.0001	1.0000	0	999	-999	No	3	9999
BT-U:SDI	BT-U:SEP	EX-Invasion	0.0010	1.0000	20	999	0	No	0	9999
BT-U:SEP	BT-C:CL	Fingers-of-Death-BT	0.0100	0.7500	5	999	0	Yes	0	9999
BT-U:SEP	BT-U:BG	OHV	1.0000	0.0001	20	999	0	No	2	9999
BT-U:SEP	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	30	30	0	No	0	9999
BT-U:SEP	BT-U:EX	Drought	0.0056	0.0100	20	999	0	No	0	9999
BT-U:SEP	BT-U:EX	ReplacementFire-Mojave	0.0050	1.0000	499	999	0	No	3	9999
BT-U:SEP	BT-U:EX	Utilities	0.0001	1.0000	20	999	0	No	0	9999
BT-U:SEP	BT-U:EX2B	ReplacementFire-Mojave	0.0500	1.0000	0	499	0	No	3	9999
BT-U:SEP	BT-U:EX2B	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:SEP	BT-U:PL	Herbicide-BT	0.0100	0.5000	5	15	0	Yes	1	9999
BT-U:SEP	BT-U:SEP	Drought	0.0056	0.9900	20	999	-999	No	0	9999
BT-U:SEP	BT-U:SEP	Fingers-of-Death-BT	0.0100	0.2500	5	999	0	No	0	9999
BT-U:SEP	BT-U:SEP	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
BT-U:SEP	BT-U:SEP	Herbicide-BT	0.0100	0.5000	5	15	0	Yes	1	9999
BT-U:SEP	BT-U:SEP	Managed-Herbivory	1.0000	0.0500	20	999	2	No	0	9999
CB-A:OP	CB-A:OP	FuelBreak	0.0100	1.0000	0	19	0	No	0	9999
CB-A:OP	CB-A:OP	Managed-Herbivory	1.0000	0.0500	2	19	1	No	0	9999
CB-A:OP	CB-A:OP	ReplacementFire-Mojave	0.0005	1.0000	0	19	-999	No	3	9999
CB-A:OP	CB-U:BG	OHV	1.0000	0.0001	0	19	0	No	2	9999
CB-A:OP	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	No	0	9999
CB-A:OP	CB-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	No	0	9999
CB-A:OP	CB-U:EX	Utilities	0.0050	1.0000	0	19	0	No	0	9999
CB-C:OP	CB-A:OP	Drought	0.0056	1.0000	20	399	0	No	0	9999
CB-C:OP	CB-A:OP	ReplacementFire-Mojave	0.0005	1.0000	20	999	0	No	3	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
CB-C:OP	CB-C:OP	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
CB-C:OP	CB-C:OP	Managed-Herbivory	1.0000	0.0500	20	999	3	No	0	9999
CB-C:OP	CB-U:BG	OHV	1.0000	0.0001	20	999	0	No	2	9999
CB-C:OP	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	30	30	0	Yes	0	9999
CB-C:OP	CB-U:EX	Utilities	0.0001	1.0000	20	999	0	No	0	9999
CB-C:OP	CB-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
CB-U:BG	CB-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
CB-U:BG	CB-U:BG	Utilities	0.0001	1.0000	0	999	0	No	0	9999
CB-U:BG	CB-U:EX	EX-Invasion	0.0050	1.0000	0	999	0	No	0	9999
CB-U:ES	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:ES	CB-U:ES	Drought	0.0056	1.0000	0	999	-999	No	0	9999
CB-U:ES	CB-U:ES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
CB-U:ES	CB-U:ES	ReplacementFire-Mojave	0.0015	1.0000	0	999	-999	No	3	9999
CB-U:ES	CB-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
CB-U:ES	CB-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
CB-U:ES	CB-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
CB-U:EX	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:EX	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	No	0	9999
CB-U:EX	CB-U:EX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
CB-U:EX	CB-U:EX	Hrbx+New-Seed-CB	0.0100	0.9500	0	999	0	Yes	0	9999
CB-U:EX	CB-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	1	No	0	9999
CB-U:EX	CB-U:EX	Planting+FOD-CB	0.0100	0.1000	0	999	0	No	0	9999
CB-U:EX	CB-U:EX	Planting+Herbicide-CB	0.0100	0.1000	0	999	0	No	0	9999
CB-U:EX	CB-U:EX2B	ReplacementFire-Mojave	0.0500	1.0000	0	999	-999	No	3	9999
CB-U:EX	CB-U:EX2B	Utilities	0.0001	1.0000	0	999	-999	No	0	9999
CB-U:EX	CB-U:PL	Planting+FOD-CB	0.0100	0.6950	0	999	0	No	0	9999
CB-U:EX	CB-U:PL	Planting+Herbicide-CB	0.0100	0.4500	0	999	0	No	0	9999
CB-U:EX	CB-U:SD	Hrbx+New-Seed-CB	0.0100	0.0500	0	999	0	No	0	9999
CB-U:EX	CB-U:SEP	Non-Joshua-Succession	0.1000	1.0000	20	999	0	Yes	0	9999
CB-U:EX	CB-U:SEP	Planting+FOD-CB	0.0100	0.2050	0	999	0	No	0	9999
CB-U:EX	CB-U:SEP	Planting+Herbicide-CB	0.0100	0.4500	0	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
CB-U:EX2B	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:EX2B	CB-U:EX2B	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	Hrbx+New-Seed-CB	0.0100	0.9500	0	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	Managed-Herbivory	1.0000	0.0500	2	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	Planting+FOD-CB	0.0100	0.1000	0	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	Planting+Herbicide-CB	0.0100	0.1000	0	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	ReplacementFire-Mojave	0.1000	1.0000	0	999	0	No	3	9999
CB-U:EX2B	CB-U:PL	Planting+FOD-CB	0.0100	0.6950	0	999	0	No	0	9999
CB-U:EX2B	CB-U:PL	Planting+Herbicide-CB	0.0100	0.4500	0	999	0	No	0	9999
CB-U:EX2B	CB-U:SD	Hrbx+New-Seed-CB	0.0100	0.0500	0	999	0	No	0	9999
CB-U:EX2B	CB-U:SEP	Planting+FOD-CB	0.0100	0.2050	0	999	0	No	0	9999
CB-U:EX2B	CB-U:SEP	Planting+Herbicide-CB	0.0100	0.4500	0	999	0	No	0	9999
CB-U:PL	CB-A:OP	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
CB-U:PL	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:PL	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	No	10	9999
CB-U:PL	CB-U:EX	Drought	0.0056	0.0100	0	999	0	No	0	9999
CB-U:PL	CB-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	-3	No	10	9999
CB-U:PL	CB-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
CB-U:PL	CB-U:PL	Drought	0.0056	0.9900	0	999	-999	No	0	9999
CB-U:PL	CB-U:PL	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
CB-U:PL	CB-U:SEP	Seedbank-Emergence	0.2000	1.0000	0	999	0	No	2	9999
CB-U:SD	CB-A:OP	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
CB-U:SD	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:SD	CB-U:ES	Excessive-Herbivory	0.0010	1.0000	10	10	0	No	10	9999
CB-U:SD	CB-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
CB-U:SD	CB-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	0	No	10	9999
CB-U:SD	CB-U:EX	Seedbank-Emergence	0.2000	1.0000	0	19	0	No	2	9999
CB-U:SD	CB-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
CB-U:SD	CB-U:SD	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
CB-U:SD	CB-U:SD	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
CB-U:SD	CB-U:SD	ReplacementFire-Mojave	0.0015	1.0000	0	999	-999	No	3	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
CB-U:SD	CB-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
CB-U:SEP	CB-C:OP	Fingers-of-Death-CB	0.0100	0.7500	20	999	0	Yes	0	9999
CB-U:SEP	CB-U:BG	OHV	1.0000	0.0001	20	999	0	No	2	9999
CB-U:SEP	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	30	30	0	No	0	9999
CB-U:SEP	CB-U:EX	Drought	0.0056	1.0000	21	999	0	No	0	9999
CB-U:SEP	CB-U:EX	ReplacementFire-Mojave	0.0015	1.0000	21	999	0	No	3	9999
CB-U:SEP	CB-U:EX	Utilities	0.0001	1.0000	21	999	0	No	0	9999
CB-U:SEP	CB-U:PL	Herbicide-CB	0.0100	0.0500	20	999	0	No	1	9999
CB-U:SEP	CB-U:SEP	Fingers-of-Death-CB	0.0100	0.2500	20	999	0	No	0	9999
CB-U:SEP	CB-U:SEP	FuelBreak	0.0100	1.0000	21	999	0	No	0	9999
CB-U:SEP	CB-U:SEP	Herbicide-CB	0.0100	0.0500	20	999	0	No	1	9999
CB-U:SEP	CB-U:SEP	Managed-Herbivory	1.0000	0.0500	21	999	3	No	0	9999
DSS-U:SEP	DSS-B:OP	FOD+Seed-DSS	0.0100	0.8000	0	999	0	No	0	9999
DSS-U:SEP	DSS-U:SEP	FOD+Seed-DSS	0.0100	0.2000	0	999	0	No	0	9999
GRL-A:AL	GRL-A:AL	Drought	0.0056	1.0000	0	19	-10	No	0	9999
GRL-A:AL	GRL-A:AL	FuelBreak	0.0100	1.0000	0	19	0	No	0	9999
GRL-A:AL	GRL-A:AL	Managed-Herbivory	1.0000	0.0500	2	19	1	No	0	9999
GRL-A:AL	GRL-A:AL	ReplacementFire-Mojave	0.0015	1.0000	0	19	-999	No	3	9999
GRL-A:AL	GRL-U:DP	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	0	9999
GRL-A:AL	GRL-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
GRL-B:OP	GRL-A:AL	Drought	0.0056	0.1000	20	999	0	No	0	9999
GRL-B:OP	GRL-A:AL	ReplacementFire-Mojave	0.0015	1.0000	20	999	0	No	3	9999
GRL-B:OP	GRL-B:OP	Drought	0.0056	0.9000	20	999	-999	No	0	9999
GRL-B:OP	GRL-B:OP	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
GRL-B:OP	GRL-B:OP	Managed-Herbivory	1.0000	0.0500	20	999	1	No	0	9999
GRL-B:OP	GRL-U:DP	Excessive-Herbivory	1.0000	0.0010	30	30	0	Yes	0	9999
GRL-B:OP	GRL-U:SES	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
GRL-U:DP	GRL-U:DP	Drought	0.0056	1.0000	0	999	-10	No	0	9999
GRL-U:DP	GRL-U:DP	Excessive-Herbivory	1.0000	0.0010	0	999	3	No	0	9999
GRL-U:DP	GRL-U:DP	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
GRL-U:DP	GRL-U:DP	Managed-Herbivory	1.0000	0.0500	0	999	1	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
GRL-U:DP	GRL-U:DP	ReplacementFire-Mojave	0.0015	1.0000	0	999	-999	No	3	9999
GRL-U:DP	GRL-U:EEX	EX-Invasion	0.0050	1.0000	0	999	0	Yes	0	9999
GRL-U:EEX	GRL-A:AL	FOD+Seed-GRL	0.0100	0.6000	0	999	0	No	0	9999
GRL-U:EEX	GRL-A:AL	Hrbx+Seed-GRL	0.0100	0.4000	0	999	0	No	0	9999
GRL-U:EEX	GRL-U:EEX	Drought	0.0056	1.0000	0	999	-10	No	0	9999
GRL-U:EEX	GRL-U:EEX	FOD+Seed-GRL	0.0100	0.4000	0	999	0	No	0	9999
GRL-U:EEX	GRL-U:EEX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
GRL-U:EEX	GRL-U:EEX	Hrbx+Seed-GRL	0.0100	0.6000	0	999	0	No	0	9999
GRL-U:EEX	GRL-U:EEX	Managed-Herbivory	1.0000	0.0500	0	999	1	No	0	9999
GRL-U:EEX	GRL-U:EEX	ReplacementFire-Mojave	0.0015	1.0000	0	999	-999	No	3	9999
GRL-U:EEX	GRL-U:SES	Excessive-Herbivory	1.0000	0.0010	20	20	0	Yes	0	9999
GRL-U:EX	GRL-A:AL	Herbicide-GRL	0.0100	0.5000	0	19	0	No	0	9999
GRL-U:EX	GRL-B:OP	Fingers-of-Death-GRL	0.0100	0.7500	0	19	0	No	0	9999
GRL-U:EX	GRL-U:EEX	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	0	9999
GRL-U:EX	GRL-U:EX	Drought	0.0056	1.0000	0	19	-10	No	0	9999
GRL-U:EX	GRL-U:EX	Fingers-of-Death-GRL	0.0100	0.2500	0	19	0	No	0	9999
GRL-U:EX	GRL-U:EX	FuelBreak	0.0100	1.0000	0	19	0	No	0	9999
GRL-U:EX	GRL-U:EX	Herbicide-GRL	0.0100	0.5000	0	999	0	No	0	9999
GRL-U:EX	GRL-U:EX	Managed-Herbivory	1.0000	0.0500	2	19	1	No	0	9999
GRL-U:EX	GRL-U:EX	ReplacementFire-Mojave	0.0500	1.0000	0	19	-999	No	3	9999
GRL-U:SES	GRL-B:OP	Fingers-of-Death-GRL	0.0100	0.7500	20	999	0	Yes	0	9999
GRL-U:SES	GRL-B:OP	Herbicide-GRL	0.0100	0.6000	20	999	0	Yes	0	9999
GRL-U:SES	GRL-U:SES	Drought	0.0056	1.0000	20	999	-10	No	0	9999
GRL-U:SES	GRL-U:SES	Excessive-Herbivory	1.0000	0.0010	30	30	3	No	0	9999
GRL-U:SES	GRL-U:SES	Fingers-of-Death-GRL	0.0100	0.2500	20	999	0	No	0	9999
GRL-U:SES	GRL-U:SES	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
GRL-U:SES	GRL-U:SES	Herbicide-GRL	0.0100	0.4000	20	999	0	No	0	9999
GRL-U:SES	GRL-U:SES	Managed-Herbivory	1.0000	0.0500	20	999	1	No	0	9999
GRL-U:SES	GRL-U:SES	ReplacementFire-Mojave	0.0100	1.0000	20	999	-999	No	3	9999
MM-A:AL	MM-A:AL	NativeHerbivory	0.0200	1.0000	0	9	-999	No	0	9999
MM-A:AL	MM-A:AL	ReplacementFire	0.0020	1.0000	0	9	-999	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
MM-A:AL	MM-A:AL	Wet-Year	0.1500	1.0000	0	999	-1	No	0	9999
MM-B:OP	MM-A:AL	ReplacementFire	0.0070	1.0000	10	29	0	No	0	9999
MM-C:CL	MM-A:AL	ReplacementFire	0.0070	1.0000	60	999	0	No	0	9999
MM-C:CL	MM-U:TEX	EX-Invasion	0.0001	1.0000	60	999	0	Yes	0	9999
MM-U:EX	MM-U:EX	ReplacementFire	0.0500	1.0000	0	999	-999	No	0	9999
MM-U:TEX	MM-U:EX	ReplacementFire	0.0070	1.0000	150	999	0	No	0	9999
MR-A:AL	MR-A:AL	Flooding-7yr	0.1300	1.0000	0	4	-5	No	0	9999
MR-A:AL	MR-A:AL	Managed-Herbivory	1.0000	0.0500	0	4	-5	No	0	9999
MR-A:AL	MR-A:AL	ReplacementFire	0.0010	1.0000	0	999	-999	No	0	9999
MR-A:AL	MR-A:AL	Weed-Inventory-MR	0.2500	1.0000	0	4	0	No	0	9999
MR-A:AL	MR-U:EF	Exotic-Riparian-Invasion-MR	0.0100	1.0000	0	4	0	No	5	9999
MR-A:AL	MR-U:SFE	Excessive-Herbivory	0.0010	1.0000	0	4	0	No	0	9999
MR-B:OP	MR-A:AL	Flooding-20yr	0.0500	1.0000	5	19	0	No	0	9999
MR-B:OP	MR-A:AL	ReplacementFire	0.0010	1.0000	5	19	0	No	0	9999
MR-B:OP	MR-B:OP	Managed-Herbivory	1.0000	0.0500	5	19	-1	No	0	9999
MR-B:OP	MR-B:OP	Weed-Inventory-MR	0.0100	1.0000	5	19	0	No	0	9999
MR-B:OP	MR-U:EF	Exotic-Riparian-Invasion-MR	0.0100	1.0000	5	19	0	No	5	9999
MR-B:OP	MR-U:SFE	Excessive-Herbivory	0.0010	1.0000	5	19	0	No	0	9999
MR-C:CL	MR-A:AL	Flooding-100yr	0.0100	1.0000	20	999	0	No	0	9999
MR-C:CL	MR-A:AL	ReplacementFire	0.0010	1.0000	20	999	0	No	0	9999
MR-C:CL	MR-C:CL	Managed-Herbivory	1.0000	0.0500	20	999	1	No	0	9999
MR-C:CL	MR-C:CL	Weed-Inventory-MR	0.0100	1.0000	20	999	0	No	0	9999
MR-C:CL	MR-U:EF	Exotic-Riparian-Invasion-MR	0.0100	1.0000	20	999	0	No	5	9999
MR-C:CL	MR-U:SFE	Excessive-Herbivory	0.0010	1.0000	20	999	0	No	0	9999
MR-U:DE	MR-A:AL	Flooding-100yr	0.0100	0.0100	0	999	0	No	0	9999
MR-U:DE	MR-A:AL	Floodplain-Recovery	0.0010	1.0000	0	999	0	No	10	9999
MR-U:DE	MR-A:AL	Floodplain-Restoration	0.0100	1.0000	0	999	0	No	0	9999
MR-U:DE	MR-U:DE	Flooding-100yr	0.0100	0.9900	0	999	-999	No	0	9999
MR-U:DE	MR-U:DE	ReplacementFire	0.0200	1.0000	0	999	-999	No	0	9999
MR-U:EF	MR-B:OP	Exotic-Control-MR	0.6000	1.0000	0	999	0	No	0	20
MR-U:EF	MR-U:EF	Exotic-Control-MR	0.4000	1.0000	0	999	0	No	0	20

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
MR-U:EF	MR-U:EF	ReplacementFire	0.0001	1.0000	0	999	-999	No	0	9999
MR-U:SFE	MR-A:AL	Flooding-100yr	0.0100	0.0100	0	999	0	No	0	9999
MR-U:SFE	MR-U:DE	Excessive-Herbivory	1.0000	0.0010	0	999	0	No	0	9999
MR-U:SFE	MR-U:EF	Exotic-Riparian-Invasion-MR	0.3300	1.0000	0	999	0	No	5	9999
MR-U:SFE	MR-U:SFE	Flooding-100yr	0.0100	0.9900	20	999	-999	No	0	9999
MR-U:SFE	MR-U:SFE	ReplacementFire	0.0010	1.0000	0	999	-999	No	0	9999
MR-U:SFE	MR-U:SFE	Weed-Inventory-MR	0.0100	1.0000	0	999	0	No	0	9999
MSD-A:AL	MSD-A:AL	Managed-Herbivory	1.0000	0.0500	2	4	1	No	0	9999
MSD-A:AL	MSD-A:AL	Very-Wet-Year	0.0100	1.0000	0	4	-4	No	0	9999
MSD-B:OP	MSD-A:AL	Managed-Herbivory	1.0000	0.0500	5	999	0	No	0	9999
MSD-B:OP	MSD-A:AL	ReplacementFire	0.0001	1.0000	5	999	0	No	0	9999
MSD-B:OP	MSD-A:AL	Very-Wet-Year	0.0180	1.0000	5	999	0	No	0	9999
MSD-B:OP	MSD-C:OP	Drought	0.0056	1.0000	5	999	0	No	0	9999
MSD-B:OP	MSD-U:SES	EX-Invasion	0.0050	1.0000	5	999	0	Yes	0	9999
MSD-C:OP	MSD-A:AL	Very-Wet-Year	0.0500	1.0000	10	59	0	No	0	9999
MSD-C:OP	MSD-C:OP	Drought	0.0056	1.0000	10	59	-999	No	0	9999
MSD-C:OP	MSD-U:SES	EX-Invasion	0.0050	1.0000	10	59	0	Yes	0	9999
MSD-U:EX	MSD-U:EX	ReplacementFire	0.1000	1.0000	0	999	-999	No	0	9999
MSD-U:SD	MSD-A:AL	Natural-Recovery	0.0010	1.0000	0	4	0	Yes	0	9999
MSD-U:SD	MSD-B:OP	Natural-Recovery	0.0050	1.0000	5	999	0	Yes	0	9999
MSD-U:SD	MSD-U:EX	EX-Invasion	0.0050	1.0000	0	4	0	No	0	9999
MSD-U:SD	MSD-U:SD	Drought	0.0056	1.0000	0	4	-999	No	0	9999
MSD-U:SD	MSD-U:SD	Drought	0.0056	1.0000	5	999	-1	No	0	9999
MSD-U:SD	MSD-U:SD	Managed-Herbivory	1.0000	0.0500	3	999	1	No	0	9999
MSD-U:SD	MSD-U:SD	Very-Wet-Year	0.0180	1.0000	0	999	-999	No	0	9999
MSD-U:SD	MSD-U:SES	EX-Invasion	0.0050	1.0000	5	999	0	No	0	9999
MSD-U:SES	MSD-U:EX	ReplacementFire	0.0250	1.0000	5	999	0	No	0	9999
MSD-U:SES	MSD-U:EX	Very-Wet-Year	0.0500	1.0000	5	999	0	No	0	9999
MSh-A:AL	MSh-A:AL	Managed-Herbivory	1.0000	0.0500	2	5	-999	No	0	9999
MSh-A:AL	MSh-A:AL	NativeHerbivory	1.0000	0.0200	0	999	-1	No	0	9999
MSh-A:AL	MSh-A:AL	Wet-Year	0.1500	1.0000	0	5	-1	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
MSh-A:AL	MSh-U:ES	Excessive-Herbivory	0.0010	1.0000	5	5	0	Yes	0	9999
MSh-A:AL	MSh-U:EX	EX-Invasion	0.0025	1.0000	0	5	0	Yes	0	9999
MSh-B:CL	MSh-A:AL	ReplacementFire	0.0140	1.0000	6	19	0	No	0	9999
MSh-B:CL	MSh-B:CL	Managed-Herbivory	1.0000	0.0500	6	19	1	No	0	9999
MSh-B:CL	MSh-U:ES	Excessive-Herbivory	0.0010	1.0000	10	10	0	Yes	0	9999
MSh-B:CL	MSh-U:SEP	EX-Invasion	0.0025	1.0000	20	49	0	Yes	0	9999
MSh-C:CL	MSh-A:AL	ReplacementFire	0.0140	1.0000	20	999	0	No	0	9999
MSh-C:CL	MSh-C:CL	Managed-Herbivory	1.0000	0.0500	20	999	1	No	0	9999
MSh-C:CL	MSh-D:OP	Tree-Invasion	0.0010	1.0000	50	99	0	No	0	9999
MSh-C:CL	MSh-D:OP	Tree-Invasion	0.0050	1.0000	99	999	0	No	0	9999
MSh-C:CL	MSh-U:ES	Excessive-Herbivory	1.0000	0.0010	30	30	0	Yes	0	9999
MSh-C:CL	MSh-U:SEP	EX-Invasion	0.0025	1.0000	20	999	0	Yes	0	9999
MSh-D:OP	MSh-A:AL	Chainsaw-Thinning-MSh	0.0100	0.2000	50	999	0	No	0	9999
MSh-D:OP	MSh-A:AL	ReplacementFire	0.0067	1.0000	50	999	0	No	0	9999
MSh-D:OP	MSh-B:CL	Chainsaw-Thinning-MSh	0.0100	0.8000	50	999	0	No	0	9999
MSh-D:OP	MSh-C:CL	Drought	0.0056	0.1000	50	999	0	No	0	9999
MSh-D:OP	MSh-D:OP	Drought	0.0056	0.9000	50	999	-999	No	0	9999
MSh-D:OP	MSh-U:TE	Tree-Encroachment	0.0067	1.0000	150	999	0	Yes	0	9999
MSh-D:OP	MSh-U:TEX	EX-Invasion	0.0025	1.0000	50	999	0	Yes	0	9999
MSh-U:ES	MSh-U:ES	Managed-Herbivory	1.0000	0.0500	0	999	0	No	0	9999
MSh-U:ES	MSh-U:ES	ReplacementFire	0.0140	1.0000	0	999	-999	No	0	9999
MSh-U:EX	MSh-A:AL	Herbicide+SeedRose-MSh	0.0100	0.5000	0	999	0	No	0	9999
MSh-U:EX	MSh-U:EX	Herbicide+SeedRose-MSh	0.0100	0.5000	0	999	0	No	0	9999
MSh-U:EX	MSh-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	0	No	0	9999
MSh-U:EX	MSh-U:EX	Planting+FOD-BM	0.1000	1.0000	0	999	-999	No	0	9999
MSh-U:EX	MSh-U:EX	Wet-Year	0.1500	1.0000	0	5	-5	No	0	9999
MSh-U:SEP	MSh-B:CL	Hrbx+SeedGrass-MSh	0.0100	0.7000	0	999	0	Yes	0	9999
MSh-U:SEP	MSh-U:EX	ReplacementFire	0.0250	1.0000	6	300	0	No	0	9999
MSh-U:SEP	MSh-U:SEP	Excessive-Herbivory	1.0000	0.0010	6	999	3	No	0	9999
MSh-U:SEP	MSh-U:SEP	Hrbx+SeedGrass-MSh	0.0100	0.3000	6	999	0	No	0	9999
MSh-U:SEP	MSh-U:SEP	Managed-Herbivory	1.0000	0.0500	6	999	1	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
MSh-U:SEP	MSh-U:TEX	Tree-Invasion	0.0010	1.0000	50	99	0	No	0	9999
MSh-U:SEP	MSh-U:TEX	Tree-Invasion	0.0050	1.0000	100	999	0	No	0	9999
MSh-U:TE	MSh-A:AL	Thin+Hrbx+SeedRose-MSh	0.0100	0.9000	150	999	0	No	0	9999
MSh-U:TE	MSh-U:ES	Drought	0.0056	0.1000	150	999	0	No	0	9999
MSh-U:TE	MSh-U:ES	ReplacementFire	0.0067	1.0000	150	999	0	No	0	9999
MSh-U:TE	MSh-U:ES	Thin+Hrbx+SeedRose-MSh	0.0100	0.1000	150	999	0	No	0	9999
MSh-U:TE	MSh-U:TE	Drought	0.0056	0.9000	150	999	-999	No	0	9999
MSh-U:TE	MSh-U:TEX	EX-Invasion	0.0050	1.0000	150	999	0	Yes	0	9999
MSh-U:TEX	MSh-A:AL	Thin+Hrbx+SeedRose-MSh	0.0100	0.8000	50	999	0	No	0	9999
MSh-U:TEX	MSh-U:EX	Drought	0.0056	0.1000	50	999	0	No	0	9999
MSh-U:TEX	MSh-U:EX	ReplacementFire	0.0067	1.0000	150	999	0	No	0	9999
MSh-U:TEX	MSh-U:EX	Thin+Hrbx+SeedRose-MSh	0.0100	0.2000	50	999	0	No	0	9999
MSh-U:TEX	MSh-U:SEP	ReplacementFire	0.0067	1.0000	50	149	0	No	0	9999
MSh-U:TEX	MSh-U:TEX	Drought	0.0056	0.9000	50	999	-999	No	0	9999
PJ-A:AL	PJ-A:AL	ReplacementFire	0.0030	1.0000	0	9	-999	No	0	9999
PJ-B:OP	PJ-A:AL	ReplacementFire	0.0050	1.0000	10	29	0	No	0	9999
PJ-C:OP	PJ-A:AL	ReplacementFire	0.0050	1.0000	30	99	0	No	0	9999
PJ-C:OP	PJ-B:OP	Drought	0.0056	0.1000	30	99	0	No	0	9999
PJ-C:OP	PJ-C:OP	Drought	0.0056	0.9000	30	99	-999	No	0	9999
PJ-C:OP	PJ-U:TEX	EX-Invasion	0.0001	1.0000	50	99	0	Yes	0	9999
PJ-D:OP	PJ-A:AL	ReplacementFire	0.0010	1.0000	100	999	0	No	0	9999
PJ-D:OP	PJ-B:OP	Drought	0.0067	0.0300	100	999	0	No	0	9999
PJ-D:OP	PJ-C:OP	Drought	0.0057	0.0700	100	999	0	No	0	9999
PJ-D:OP	PJ-D:OP	Drought	0.0056	0.9000	100	999	-999	No	0	9999
PJ-D:OP	PJ-U:TEX	EX-Invasion	0.0010	1.0000	100	999	0	Yes	0	9999
PJ-U:EX	PJ-A:AL	Hrbx+Seed-PJ	0.0100	0.6000	0	999	0	No	0	9999
PJ-U:EX	PJ-U:EX	Hrbx+Seed-PJ	0.0100	0.4000	0	999	0	No	0	9999
PJ-U:EX	PJ-U:EX	ReplacementFire	0.1000	1.0000	0	999	-999	No	0	9999
PJ-U:TEX	PJ-C:OP	Herbicide-PJ	0.0100	0.6000	30	99	0	Yes	0	9999
PJ-U:TEX	PJ-D:OP	Herbicide-PJ	0.0100	0.6000	100	999	0	Yes	0	9999
PJ-U:TEX	PJ-U:EX	Drought	0.0056	0.1000	100	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
PJ-U:TEX	PJ-U:EX	ReplacementFire	0.0050	1.0000	100	999	0	No	0	9999
PJ-U:TEX	PJ-U:TEX	Drought	0.0056	0.9000	100	999	-999	No	0	9999
PJ-U:TEX	PJ-U:TEX	Herbicide-PJ	0.0100	0.4000	0	999	0	No	0	9999
SWA-A:AL	SWA-A:AL	Flash-Flood	0.1400	1.0000	0	4	-999	No	0	9999
SWA-A:AL	SWA-A:AL	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
SWA-A:AL	SWA-A:AL	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-A:AL	SWA-A:AL	Managed-Herbivory	1.0000	0.0500	2	4	1	No	10	9999
SWA-A:AL	SWA-A:AL	ReplacementFire-Mojave	0.0001	1.0000	0	4	-999	No	3	9999
SWA-A:AL	SWA-A:AL	Utilities	0.0001	0.3000	0	999	-999	No	0	9999
SWA-A:AL	SWA-A:AL	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	No	0	9999
SWA-A:AL	SWA-U:BG	OHV	1.0000	0.0001	0	4	0	No	2	9999
SWA-A:AL	SWA-U:ES	Excessive-Herbivory	1.0000	0.0005	10	10	0	No	10	9999
SWA-A:AL	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	0	4	0	Yes	5	9999
SWA-A:AL	SWA-U:SEP	EX-Invasion	0.0050	1.0000	0	4	0	Yes	0	9999
SWA-A:AL	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-B:CL	SWA-A:AL	Flash-Flood	0.0500	1.0000	5	19	0	No	0	9999
SWA-B:CL	SWA-A:AL	Utilities	0.0001	0.3000	5	999	0	No	0	9999
SWA-B:CL	SWA-B:CL	FuelBreak	0.0100	1.0000	5	999	0	No	0	9999
SWA-B:CL	SWA-B:CL	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-B:CL	SWA-B:CL	Managed-Herbivory	1.0000	0.0500	5	19	1	No	10	9999
SWA-B:CL	SWA-B:CL	ReplacementFire-Mojave	0.0010	1.0000	5	19	0	No	3	9999
SWA-B:CL	SWA-B:CL	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	No	0	9999
SWA-B:CL	SWA-U:BG	OHV	1.0000	0.0001	5	19	0	No	2	9999
SWA-B:CL	SWA-U:ES	Excessive-Herbivory	1.0000	0.0005	10	10	0	No	10	9999
SWA-B:CL	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	5	19	0	Yes	5	9999
SWA-B:CL	SWA-U:SEP	EX-Invasion	0.0050	1.0000	5	19	0	Yes	0	9999
SWA-B:CL	SWA-U:SES	Utilities	0.0001	0.7000	5	999	0	No	0	9999
SWA-C:CL	SWA-A:AL	Flash-Flood	0.0100	1.0000	20	999	-999	No	0	9999
SWA-C:CL	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-C:CL	SWA-B:CL	ReplacementFire-Mojave	0.0010	1.0000	20	999	0	No	3	9999
SWA-C:CL	SWA-C:CL	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
SWA-C:CL	SWA-C:CL	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-C:CL	SWA-C:CL	Managed-Herbivory	1.0000	0.0500	20	999	1	No	10	9999
SWA-C:CL	SWA-C:CL	Weed-Inventory-WAS	0.0100	1.0000	20	999	0	No	0	9999
SWA-C:CL	SWA-U:BG	OHV	1.0000	0.0001	20	999	0	No	2	9999
SWA-C:CL	SWA-U:ES	Excessive-Herbivory	1.0000	0.0005	10	10	0	Yes	10	9999
SWA-C:CL	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	20	999	0	No	5	9999
SWA-C:CL	SWA-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
SWA-C:CL	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-U:BG	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:BG	SWA-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
SWA-U:BG	SWA-U:BG	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:BG	SWA-U:ET	Exotic-Tree-Invasion	0.0050	1.0000	0	999	0	Yes	5	9999
SWA-U:BG	SWA-U:SES	EX-Invasion	0.0050	1.0000	0	999	0	Yes	0	9999
SWA-U:BG	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-U:ES	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:ES	SWA-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
SWA-U:ES	SWA-U:ES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:ES	SWA-U:ES	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-U:ES	SWA-U:ES	ReplacementFire-Mojave	0.0015	1.0000	0	999	0	No	3	9999
SWA-U:ES	SWA-U:ES	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:ES	SWA-U:ET	Exotic-Tree-Invasion	0.0050	1.0000	0	999	0	Yes	5	9999
SWA-U:ES	SWA-U:SES	EX-Invasion	0.0050	1.0000	0	999	0	Yes	0	9999
SWA-U:ES	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-U:ET	SWA-A:AL	Beetle-Mortality	0.2500	1.0000	0	4	0	Yes	0	9999
SWA-U:ET	SWA-A:AL	Exotic-Control-WAS	0.0100	0.9000	0	4	0	No	0	50
SWA-U:ET	SWA-A:AL	Flash-Flood	0.0100	0.0100	0	999	0	No	0	9999
SWA-U:ET	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:ET	SWA-B:CL	Beetle-Mortality	0.2500	1.0000	5	19	0	Yes	0	9999
SWA-U:ET	SWA-B:CL	Exotic-Control-WAS	0.0100	0.9000	5	19	0	No	0	50
SWA-U:ET	SWA-C:CL	Beetle-Mortality	0.2500	1.0000	20	999	0	Yes	0	9999
SWA-U:ET	SWA-C:CL	Exotic-Control-WAS	0.0100	0.9000	20	999	0	No	0	50

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
SWA-U:ET	SWA-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
SWA-U:ET	SWA-U:ET	Excessive-Herbivory	1.0000	0.0010	0	999	3	No	0	9999
SWA-U:ET	SWA-U:ET	Exotic-Control-WAS	0.0100	0.1000	0	999	0	No	0	50
SWA-U:ET	SWA-U:ET	Flash-Flood	0.0100	0.9900	0	999	-999	No	0	9999
SWA-U:ET	SWA-U:ET	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:ET	SWA-U:ET	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-U:ET	SWA-U:ET	Managed-Herbivory	1.0000	0.0500	0	999	1	No	0	9999
SWA-U:ET	SWA-U:ET	ReplacementFire-Mojave	0.0200	1.0000	0	999	-999	No	3	9999
SWA-U:ET	SWA-U:ET	Utilities	0.0001	0.7000	0	999	-999	No	0	9999
SWA-U:SEP	SWA-A:AL	Fingers-of-Death-SWA	0.0100	0.7500	0	4	0	Yes	0	9999
SWA-U:SEP	SWA-A:AL	Flash-Flood	0.0100	0.0100	0	999	0	No	0	9999
SWA-U:SEP	SWA-A:AL	Herbicide-WAS	0.0100	0.5000	0	4	0	Yes	0	9999
SWA-U:SEP	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:SEP	SWA-B:CL	Fingers-of-Death-SWA	0.0100	0.7500	5	19	0	Yes	0	9999
SWA-U:SEP	SWA-B:CL	Herbicide-WAS	0.0100	0.5000	5	19	0	Yes	0	9999
SWA-U:SEP	SWA-C:CL	Fingers-of-Death-SWA	0.0100	0.7500	20	999	0	Yes	0	9999
SWA-U:SEP	SWA-C:CL	Herbicide-WAS	0.0100	0.5000	20	999	0	Yes	0	9999
SWA-U:SEP	SWA-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
SWA-U:SEP	SWA-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	No	10	9999
SWA-U:SEP	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	0	999	0	Yes	5	9999
SWA-U:SEP	SWA-U:SEP	Fingers-of-Death-SWA	0.0100	0.2500	0	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	Flash-Flood	0.0100	0.9900	0	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	Herbicide-WAS	0.0100	0.5000	0	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	ReplacementFire-Mojave	0.0200	1.0000	0	999	-999	No	3	9999
SWA-U:SEP	SWA-U:SEP	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	Yes	0	9999
SWA-U:SEP	SWA-U:SES	Managed-Herbivory	1.0000	0.0500	20	999	0	No	10	9999
SWA-U:SEP	SWA-U:SES	Managed-Herbivory	1.0000	0.0500	0	19	1	No	10	9999
SWA-U:SEP	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-U:SES	SWA-A:AL	Fingers-of-Death-SWA	0.0100	0.7500	0	4	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
SWA-U:SES	SWA-A:AL	Flash-Flood	0.0100	0.0100	0	999	0	No	0	9999
SWA-U:SES	SWA-A:AL	Herbicide-WAS	0.0100	0.5000	0	4	0	Yes	0	9999
SWA-U:SES	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:SES	SWA-B:CL	Fingers-of-Death-SWA	0.0100	0.7500	5	19	0	Yes	0	9999
SWA-U:SES	SWA-B:CL	Herbicide-WAS	0.0100	0.5000	5	19	0	Yes	0	9999
SWA-U:SES	SWA-C:CL	Fingers-of-Death-SWA	0.0100	0.7500	20	999	0	No	0	9999
SWA-U:SES	SWA-C:CL	Herbicide-WAS	0.0100	0.5000	20	999	0	Yes	0	9999
SWA-U:SES	SWA-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
SWA-U:SES	SWA-U:ES	Excessive-Herbivory	1.0000	0.0010	10	10	0	Yes	10	9999
SWA-U:SES	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	0	999	0	Yes	5	9999
SWA-U:SES	SWA-U:SES	Fingers-of-Death-SWA	0.0100	0.2500	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Flash-Flood	0.0100	0.9900	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Herbicide-WAS	0.0100	0.5000	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Managed-Herbivory	1.0000	0.0500	2	999	1	No	10	9999
SWA-U:SES	SWA-U:SES	ReplacementFire-Mojave	0.0500	1.0000	0	999	-999	No	3	9999
SWA-U:SES	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	No	0	9999
WDR-A:AL	WDR-A:AL	Flooding-7yr	0.1300	1.0000	0	4	-999	No	0	9999
WDR-A:AL	WDR-A:AL	Managed-Herbivory	1.0000	0.0500	2	4	-999	No	0	9999
WDR-A:AL	WDR-A:AL	Weed-Inventory	0.0100	1.0000	0	4	0	No	0	9999
WDR-A:AL	WDR-U:DE	Excessive-Herbivory	0.0010	1.0000	0	4	0	Yes	0	9999
WDR-A:AL	WDR-U:EF	Exotic-Forb-Invasion	0.0100	1.0000	0	4	0	No	5	9999
WDR-A:AL	WDR-U:ET	Exotic-Tree-Invasion	0.0100	1.0000	0	4	0	No	5	9999
WDR-A:AL	WDR-U:TEX	EX-Invasion	0.0050	1.0000	0	4	0	Yes	0	9999
WDR-B:CL	WDR-A:AL	Flooding-20yr	0.0500	1.0000	5	19	0	No	0	9999
WDR-B:CL	WDR-B:CL	Managed-Herbivory	1.0000	0.0500	5	19	-1	No	0	9999
WDR-B:CL	WDR-B:CL	Weed-Inventory	0.0100	1.0000	5	19	0	No	0	9999
WDR-B:CL	WDR-U:DE	Excessive-Herbivory	0.0010	1.0000	5	19	0	Yes	0	9999
WDR-B:CL	WDR-U:EF	Exotic-Forb-Invasion	0.0075	1.0000	5	19	0	No	5	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
WDR-B:CL	WDR-U:ET	Exotic-Tree-Invasion	0.0075	1.0000	5	19	0	No	5	9999
WDR-B:CL	WDR-U:TEX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
WDR-C:OP	WDR-A:AL	Flooding-20yr	0.0500	1.0000	1	89	0	No	0	9999
WDR-C:OP	WDR-C:OP	Managed-Herbivory	1.0000	0.0500	1	89	-1	No	0	9999
WDR-C:OP	WDR-U:DE	Excessive-Herbivory	0.0010	1.0000	1	89	0	Yes	0	9999
WDR-C:OP	WDR-U:EF	Exotic-Forb-Invasion	0.0075	1.0000	5	89	0	Yes	5	9999
WDR-C:OP	WDR-U:EF	Exotic-Forb-Invasion	0.0100	1.0000	1	4	0	Yes	5	9999
WDR-C:OP	WDR-U:ET	Exotic-Tree-Invasion	0.0075	1.0000	5	89	0	Yes	5	9999
WDR-C:OP	WDR-U:ET	Exotic-Tree-Invasion	0.0100	1.0000	1	4	0	Yes	5	9999
WDR-C:OP	WDR-U:TEX	EX-Invasion	0.0050	1.0000	1	89	0	Yes	0	9999
WDR-D:CL	WDR-A:AL	Flooding-100yr	0.0100	1.0000	20	89	0	No	0	9999
WDR-D:CL	WDR-C:OP	ReplacementFire	0.0013	1.0000	20	89	0	No	0	9999
WDR-D:CL	WDR-D:CL	Managed-Herbivory	1.0000	0.0500	20	89	1	No	0	9999
WDR-D:CL	WDR-D:CL	Weed-Inventory	0.0100	1.0000	20	89	0	No	0	9999
WDR-D:CL	WDR-U:DE	Excessive-Herbivory	0.0010	1.0000	20	89	0	Yes	0	9999
WDR-D:CL	WDR-U:EF	Exotic-Forb-Invasion	0.0050	1.0000	20	89	0	No	5	9999
WDR-D:CL	WDR-U:ET	Exotic-Tree-Invasion	0.0050	1.0000	20	89	0	No	5	9999
WDR-D:CL	WDR-U:TEX	EX-Invasion	0.0050	1.0000	20	89	0	Yes	0	9999
WDR-E:CL	WDR-A:AL	Flooding-100yr	0.0020	1.0000	90	999	0	No	0	9999
WDR-E:CL	WDR-C:OP	Flooding-100yr	0.0100	1.0000	90	999	0	No	0	9999
WDR-E:CL	WDR-C:OP	ReplacementFire	0.0040	1.0000	90	999	0	No	0	9999
WDR-E:CL	WDR-C:OP	Senescence	0.0200	1.0000	450	999	0	No	0	9999
WDR-E:CL	WDR-E:CL	Managed-Herbivory	1.0000	0.0500	90	999	0	No	0	9999
WDR-E:CL	WDR-E:CL	Weed-Inventory	0.0100	1.0000	90	999	0	No	0	9999
WDR-E:CL	WDR-U:DE	Excessive-Herbivory	1.0000	0.0010	90	999	0	Yes	0	9999
WDR-E:CL	WDR-U:EF	Exotic-Forb-Invasion	0.0050	1.0000	90	999	0	No	5	9999
WDR-E:CL	WDR-U:ET	Exotic-Tree-Invasion	0.0050	1.0000	90	999	0	Yes	5	9999
WDR-E:CL	WDR-U:TEX	EX-Invasion	0.0050	1.0000	90	999	0	Yes	0	9999
WDR-U:DE	WDR-A:AL	Flooding-100yr	0.0100	0.0100	1	999	0	No	0	9999
WDR-U:DE	WDR-A:AL	Floodplain-Restoration	0.0100	0.9000	1	999	0	No	0	9999
WDR-U:DE	WDR-U:DE	Flooding-100yr	0.0100	0.9900	1	999	-999	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
WDR-U:DE	WDR-U:DE	Floodplain-Restoration	0.0100	0.1000	1	999	0	No	0	9999
WDR-U:DE	WDR-U:DE	Weed-Inventory	0.0100	1.0000	0	999	0	No	0	9999
WDR-U:DE	WDR-U:DEF	Exotic-Forb-Invasion	0.0075	1.0000	1	999	0	Yes	5	9999
WDR-U:DE	WDR-U:DET	Exotic-Tree-Invasion	0.0075	1.0000	1	999	0	Yes	5	9999
WDR-U:DEF	WDR-U:DE	Exotic-Forb-Control	0.0100	0.6000	1	999	0	No	0	20
WDR-U:DEF	WDR-U:DEF	Exotic-Forb-Control	0.0100	0.4000	1	999	0	No	0	20
WDR-U:DEF	WDR-U:DEF	Flooding-100yr	0.0100	0.9900	1	999	-999	No	0	9999
WDR-U:DEF	WDR-U:EF	Flooding-100yr	0.0100	0.0100	1	999	0	No	0	9999
WDR-U:DET	WDR-U:DE	Beetle-Mortality	0.2500	0.2500	0	999	0	Yes	0	9999
WDR-U:DET	WDR-U:DE	Exotic-Tree-Control	0.0100	0.8000	1	999	0	No	0	20
WDR-U:DET	WDR-U:DEF	Beetle-Mortality	0.2500	0.7500	0	999	0	Yes	0	9999
WDR-U:DET	WDR-U:DEF	Exotic-Tree-Control	0.0100	0.1000	1	999	0	No	0	20
WDR-U:DET	WDR-U:DET	Exotic-Tree-Control	0.0100	0.1000	1	999	0	No	0	20
WDR-U:DET	WDR-U:DET	Flooding-100yr	0.0100	0.9900	1	999	-999	No	0	9999
WDR-U:DET	WDR-U:DET	ReplacementFire	0.0500	1.0000	5	999	-999	No	0	9999
WDR-U:DET	WDR-U:ET	Flooding-100yr	0.0100	0.0100	1	999	0	No	0	9999
WDR-U:DEX	WDR-A:AL	Flooding-100yr	0.0100	0.0100	0	999	0	No	0	9999
WDR-U:DEX	WDR-U:DEF	Exotic-Forb-Invasion	0.0050	1.0000	0	999	0	Yes	5	9999
WDR-U:DEX	WDR-U:DET	Exotic-Tree-Invasion	0.0050	1.0000	0	999	0	Yes	5	9999
WDR-U:DEX	WDR-U:DEX	Excessive-Herbivory	1.0000	0.0010	0	999	3	No	0	9999
WDR-U:DEX	WDR-U:DEX	Flooding-100yr	0.0100	0.9900	0	999	-999	No	0	9999
WDR-U:DEX	WDR-U:DEX	Managed-Herbivory	1.0000	0.0500	0	999	1	No	0	9999
WDR-U:DEX	WDR-U:DEX	ReplacementFire	0.0500	1.0000	0	999	-999	No	0	9999
WDR-U:DEX	WDR-U:DEX	Weed-Inventory	0.0100	1.0000	0	999	0	No	0	9999
WDR-U:EF	WDR-A:AL	Exotic-Forb-Control	0.0100	0.6000	0	999	0	No	0	20
WDR-U:EF	WDR-U:EF	Exotic-Forb-Control	0.0100	0.4000	0	999	0	No	0	20
WDR-U:EF	WDR-U:EF	Flooding-100yr	0.0100	1.0000	0	999	-999	No	0	9999
WDR-U:ET	WDR-A:AL	Beetle-Mortality	0.2500	1.0000	0	4	0	Yes	0	9999
WDR-U:ET	WDR-A:AL	Exotic-Tree-Control	0.0100	0.8000	0	999	0	No	0	20
WDR-U:ET	WDR-A:AL	Flooding-100yr	0.0100	0.0100	0	999	0	No	0	9999
WDR-U:ET	WDR-B:CL	Beetle-Mortality	0.2500	1.0000	5	19	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
WDR-U:ET	WDR-C:OP	Beetle-Mortality	0.2500	1.0000	0	999	0	Yes	0	9999
WDR-U:ET	WDR-D:CL	Beetle-Mortality	0.2500	1.0000	20	89	0	Yes	0	9999
WDR-U:ET	WDR-E:CL	Beetle-Mortality	0.2500	1.0000	90	999	0	Yes	0	9999
WDR-U:ET	WDR-U:DET	Entrenchment	0.0001	1.0000	0	999	0	Yes	10	9999
WDR-U:ET	WDR-U:EF	Exotic-Tree-Control	0.0100	0.1000	0	999	0	No	0	20
WDR-U:ET	WDR-U:ET	Exotic-Tree-Control	0.0100	0.1000	0	999	0	No	0	20
WDR-U:ET	WDR-U:ET	Flooding-100yr	0.0100	0.9900	0	999	-999	No	0	9999
WDR-U:ET	WDR-U:ET	ReplacementFire	0.0500	1.0000	0	999	-999	No	0	9999
WDR-U:EX	WDR-A:AL	Flooding-100yr	0.0100	0.0100	0	500	-999	No	0	9999
WDR-U:EX	WDR-U:DE	Excessive-Herbivory	1.0000	0.0010	0	500	0	Yes	0	9999
WDR-U:EX	WDR-U:EF	Exotic-Forb-Invasion	0.0075	1.0000	0	500	0	Yes	5	9999
WDR-U:EX	WDR-U:ET	Exotic-Tree-Invasion	0.0075	1.0000	0	500	0	Yes	5	9999
WDR-U:EX	WDR-U:EX	Flooding-100yr	0.0100	0.9900	0	500	-999	No	0	9999
WDR-U:EX	WDR-U:EX	Managed-Herbivory	1.0000	0.0500	2	500	-999	No	0	9999
WDR-U:EX	WDR-U:EX	ReplacementFire	0.0500	1.0000	0	500	-999	No	0	9999
WDR-U:TEX	WDR-A:AL	Flooding-100yr	0.0100	0.0100	20	999	0	No	0	9999
WDR-U:TEX	WDR-A:AL	Hrbx-EX-WDR	0.0100	0.5000	0	4	0	Yes	0	9999
WDR-U:TEX	WDR-B:CL	Hrbx-EX-WDR	0.0100	0.5000	5	19	0	Yes	0	9999
WDR-U:TEX	WDR-D:CL	Hrbx-EX-WDR	0.0100	0.5000	20	89	0	Yes	0	9999
WDR-U:TEX	WDR-E:CL	Hrbx-EX-WDR	0.0100	0.5000	90	999	0	Yes	0	9999
WDR-U:TEX	WDR-U:DE	Excessive-Herbivory	1.0000	0.0001	5	19	0	Yes	0	9999
WDR-U:TEX	WDR-U:EF	Exotic-Forb-Invasion	0.0075	1.0000	5	999	0	Yes	5	9999
WDR-U:TEX	WDR-U:ET	Exotic-Tree-Invasion	0.0075	1.0000	5	999	0	No	5	9999
WDR-U:TEX	WDR-U:EX	Flooding-100yr	0.0100	0.9900	20	999	0	No	0	9999
WDR-U:TEX	WDR-U:EX	Flooding-20yr	0.0500	1.0000	5	19	0	No	0	9999
WDR-U:TEX	WDR-U:EX	ReplacementFire	0.0015	1.0000	5	999	0	No	0	9999
WDR-U:TEX	WDR-U:TEX	Hrbx-EX-WDR	0.0100	0.5000	0	999	0	No	0	9999
WDR-U:TEX	WDR-U:TEX	Managed-Herbivory	1.0000	0.0500	5	999	1	No	0	9999
WDR-U:TEX	WDR-U:TEX	Weed-Inventory	0.0100	1.0000	5	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
Beaver Dam Wash NCA										
DSS-A:OP	DSS-A:OP	NativeHerbivory	0.0050	1.0000	0	2	1	No	0	9999
DSS-A:OP	DSS-A:OP	ReplacementFire	0.0083	1.0000	0	2	-2	No	0	9999
DSS-A:OP	DSS-U:SEP	EX-Invasion	0.0010	1.0000	0	2	0	Yes	0	9999
DSS-B:OP	DSS-A:OP	ReplacementFire	0.0106	1.0000	3	999	0	No	0	9999
DSS-B:OP	DSS-B:OP	Drought	0.0056	1.0000	3	999	-999	No	0	9999
DSS-B:OP	DSS-B:OP	Managed-Herbivory	1.0000	0.0500	3	999	2	No	0	9999
DSS-B:OP	DSS-U:DP	Excessive-Herbivory	0.0010	1.0000	3	999	0	Yes	0	9999
DSS-B:OP	DSS-U:SEP	EX-Invasion	0.0010	1.0000	3	999	0	Yes	0	9999
DSS-U:DP	DSS-U:DP	Drought	0.0056	1.0000	0	999	-999	No	0	9999
DSS-U:DP	DSS-U:DP	ReplacementFire	0.0083	1.0000	0	999	-999	No	0	9999
DSS-U:DP	DSS-U:SEP	EX-Invasion	0.0010	1.0000	0	999	0	Yes	0	9999
DSS-U:SEP	DSS-B:OP	Hrbx+Seed-DSS	0.0100	0.8000	0	999	0	Yes	0	9999
DSS-U:SEP	DSS-U:DP	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	0	9999
DSS-U:SEP	DSS-U:SEP	Drought	0.0056	1.0000	0	999	-999	No	0	9999
DSS-U:SEP	DSS-U:SEP	Hrbx+Seed-DSS	0.0100	0.2000	0	999	0	No	0	9999
DSS-U:SEP	DSS-U:SEP	Managed-Herbivory	1.0000	0.0500	0	999	1	No	0	9999
DSS-U:SEP	DSS-U:SEP	ReplacementFire	0.0106	1.0000	3	999	-999	No	0	9999
DSS-U:SEP	DSS-U:SEP	ReplacementFire	0.0500	1.0000	0	2	-999	No	0	9999
BM-A:AL	BM-A:AL	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-A:AL	BM-A:AL	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-A:AL	BM-A:AL	Managed-Herbivory	1.0000	0.0500	2	199	1	No	0	9999
BM-A:AL	BM-A:AL	ReplacementFire-Mojave	0.0001	1.0000	0	199	-999	No	3	9999
BM-A:AL	BM-B:JT	Joshua-Succession	0.6300	1.0000	198	198	0	No	0	9999
BM-A:AL	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-A:AL	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	0	9999
BM-A:AL	BM-U:EX	EX-Invasion	0.0050	1.0000	0	4	0	Yes	0	9999
BM-A:AL	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-A:AL	BM-U:SEP	EX-Invasion	0.0050	0.5000	5	199	0	Yes	0	9999
BM-A:AL	BM-U:SEPJ	EX-Invasion	0.0050	0.5000	5	999	0	Yes	0	9999
BM-B:JT	BM-A:AL	ReplacementFire-Mojave	0.0005	1.0000	200	999	0	No	3	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-B:JT	BM-B:JT	FuelBreak	0.0100	1.0000	200	999	0	No	0	9999
BM-B:JT	BM-B:JT	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-B:JT	BM-B:JT	Managed-Herbivory	1.0000	0.0500	200	999	3	No	0	9999
BM-B:JT	BM-E:JT	Tree-Invasion	0.0025	1.0000	400	999	0	Yes	0	9999
BM-B:JT	BM-U:BG	OHV	1.0000	0.0001	200	999	0	No	2	9999
BM-B:JT	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	200	999	0	Yes	0	9999
BM-B:JT	BM-U:EX	Utilities	0.0001	1.0000	200	999	0	No	0	9999
BM-B:JT	BM-U:SEPJ	EX-Invasion	0.0050	1.0000	200	999	0	Yes	0	9999
BM-C:OP	BM-A:AL	ReplacementFire-Mojave	0.0005	1.0000	200	999	0	No	3	9999
BM-C:OP	BM-C:OP	FuelBreak	0.0100	1.0000	200	999	0	No	0	9999
BM-C:OP	BM-C:OP	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-C:OP	BM-C:OP	Managed-Herbivory	1.0000	0.0500	200	999	3	No	0	9999
BM-C:OP	BM-D:OP	Tree-Invasion	0.0025	1.0000	400	999	0	Yes	0	9999
BM-C:OP	BM-U:BG	OHV	1.0000	0.0001	200	999	0	No	2	9999
BM-C:OP	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	200	999	0	Yes	0	9999
BM-C:OP	BM-U:EX	Utilities	0.0001	1.0000	200	999	0	No	0	9999
BM-D:OP	BM-A:AL	Drought	0.0056	0.0100	400	999	0	No	0	9999
BM-D:OP	BM-A:AL	ReplacementFire-Mojave	0.0010	1.0000	400	999	0	No	3	9999
BM-D:OP	BM-C:OP	Drought	0.0056	0.9900	400	999	0	No	0	9999
BM-D:OP	BM-D:OP	FuelBreak	0.0100	1.0000	400	999	0	No	0	9999
BM-D:OP	BM-D:OP	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-D:OP	BM-D:OP	Managed-Herbivory	1.0000	0.0500	400	999	3	No	0	9999
BM-D:OP	BM-U:BG	OHV	1.0000	0.0001	400	999	0	No	2	9999
BM-D:OP	BM-U:EX	Utilities	0.0001	1.0000	400	999	0	No	0	9999
BM-D:OP	BM-U:TEX	EX-Invasion	0.0050	1.0000	400	999	0	Yes	0	9999
BM-D:OP	BM-U:TEX	Tree-Encroachment	0.0050	1.0000	600	999	0	No	0	9999
BM-E:JT	BM-A:AL	Drought	0.0056	0.0100	400	999	0	No	0	9999
BM-E:JT	BM-A:AL	ReplacementFire-Mojave	0.0010	1.0000	400	999	0	No	3	9999
BM-E:JT	BM-B:JT	Drought	0.0056	0.9900	400	999	0	No	0	9999
BM-E:JT	BM-E:JT	FuelBreak	0.0100	1.0000	400	999	0	No	0	9999
BM-E:JT	BM-E:JT	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-E:JT	BM-E:JT	Managed-Herbivory	1.0000	0.0500	400	999	3	No	0	9999
BM-E:JT	BM-U:BG	OHV	1.0000	0.0001	400	999	0	No	2	9999
BM-E:JT	BM-U:EX	Utilities	0.0001	1.0000	400	999	0	No	0	9999
BM-E:JT	BM-U:TEX	EX-Invasion	0.0050	1.0000	400	999	0	Yes	0	9999
BM-E:JT	BM-U:TEX	Tree-Encroachment	0.0050	1.0000	600	999	0	No	0	9999
BM-U:BG	BM-U:BG	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-U:BG	BM-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
BM-U:BG	BM-U:EX	EX-Invasion	0.0050	1.0000	0	999	0	No	0	9999
BM-U:BG	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:ES	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:ES	BM-U:ES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:ES	BM-U:ES	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-U:ES	BM-U:ES	ReplacementFire-Mojave	0.0010	1.0000	0	999	-999	No	3	9999
BM-U:ES	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:ES	BM-U:SEP	EX-Invasion	0.0050	0.3700	0	999	0	No	0	9999
BM-U:ES	BM-U:SEPJ	EX-Invasion	0.0050	0.6300	0	999	0	No	0	9999
BM-U:EX	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:EX	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	No	0	9999
BM-U:EX	BM-U:EX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:EX	BM-U:EX	Hrbx+Current-Native-Seed-BM	0.0100	0.9900	0	999	-999	No	0	9999
BM-U:EX	BM-U:EX	Hrbx+Introduced-Seed-BM	0.0100	0.9500	0	999	-999	No	0	9999
BM-U:EX	BM-U:EX	Hrbx+New-Seed-BM	0.0100	0.9500	0	999	0	Yes	0	9999
BM-U:EX	BM-U:EX	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-U:EX	BM-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	1	No	0	9999
BM-U:EX	BM-U:EX	Planting+FOD-BM	0.0100	0.1000	0	999	0	Yes	0	9999
BM-U:EX	BM-U:EX	Planting+Herbicde-BM	0.0100	0.1000	0	999	0	No	0	9999
BM-U:EX	BM-U:EX2B	ReplacementFire-Mojave	0.0500	1.0000	21	999	-999	No	3	9999
BM-U:EX	BM-U:EX2B	ReplacementFire-Mojave	0.1000	1.0000	0	20	-999	No	3	9999
BM-U:EX	BM-U:EX2B	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:EX	BM-U:PL	Planting+FOD-BM	0.0100	0.6950	0	999	0	No	0	9999
BM-U:EX	BM-U:PL	Planting+Herbicde-BM	0.0100	0.4500	0	999	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-U:EX	BM-U:SD	Hrbx+Current-Native-Seed-BM	0.0100	0.0100	0	999	0	Yes	0	9999
BM-U:EX	BM-U:SD	Hrbx+New-Seed-BM	0.0100	0.0500	0	999	0	Yes	0	9999
BM-U:EX	BM-U:SDI	Hrbx+Introduced-Seed-BM	0.0100	0.0500	0	999	0	No	0	9999
BM-U:EX	BM-U:SEP	Non-Joshua-Succession	0.1000	0.3700	20	999	0	No	0	9999
BM-U:EX	BM-U:SEP	Planting+FOD-BM	0.0100	0.0850	0	999	0	No	0	9999
BM-U:EX	BM-U:SEP	Planting+Herbicde-BM	0.0100	0.1700	0	999	0	Yes	0	9999
BM-U:EX	BM-U:SEPJ	Joshua-Succession	0.1000	0.6300	20	999	0	No	0	9999
BM-U:EX	BM-U:SEPJ	Planting+FOD-BM	0.0100	0.1400	0	999	0	No	0	9999
BM-U:EX	BM-U:SEPJ	Planting+Herbicde-BM	0.0100	0.2800	0	999	0	Yes	0	9999
BM-U:EX2B	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:EX2B	BM-U:EX2B	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Hrbx+New-Seed-BM	0.0100	0.9500	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Managed-Herbivory	1.0000	0.0500	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Planting+FOD-BM	0.0100	0.1000	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	Planting+Herbicde-BM	0.0100	0.1000	0	999	0	No	0	9999
BM-U:EX2B	BM-U:EX2B	ReplacementFire-Mojave	0.1000	1.0000	0	999	-999	No	3	9999
BM-U:EX2B	BM-U:PL	Planting+FOD-BM	0.0100	0.6950	0	999	0	No	0	9999
BM-U:EX2B	BM-U:PL	Planting+Herbicde-BM	0.0100	0.4500	0	999	0	No	0	9999
BM-U:EX2B	BM-U:SD	Hrbx+New-Seed-BM	0.0100	0.0500	0	999	0	No	0	9999
BM-U:EX2B	BM-U:SEP	Planting+FOD-BM	0.0100	0.0850	0	999	0	No	0	9999
BM-U:EX2B	BM-U:SEP	Planting+Herbicde-BM	0.0100	0.1700	0	999	0	No	0	9999
BM-U:EX2B	BM-U:SEPJ	Planting+FOD-BM	0.0100	0.1400	0	999	0	No	0	9999
BM-U:EX2B	BM-U:SEPJ	Planting+Herbicde-BM	0.0100	0.2800	0	999	0	No	0	9999
BM-U:PL	BM-A:AL	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
BM-U:PL	BM-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
BM-U:PL	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	2	999	0	Yes	10	9999
BM-U:PL	BM-U:EX	Drought	0.0056	0.1000	0	999	0	No	0	9999
BM-U:PL	BM-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	0	No	10	9999
BM-U:PL	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:PL	BM-U:PL	Drought	0.0056	0.9000	0	999	-999	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-U:PL	BM-U:PL	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-U:PL	BM-U:PL	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BM-U:PL	BM-U:SEP	Seedbank-Emergence	0.2000	0.6800	0	999	0	No	2	9999
BM-U:PL	BM-U:SEPJ	Seedbank-Emergence	0.2000	0.3200	0	999	0	No	2	9999
BM-U:SD	BM-A:AL	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
BM-U:SD	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:SD	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	10	9999
BM-U:SD	BM-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
BM-U:SD	BM-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	0	No	10	9999
BM-U:SD	BM-U:EX	Seedbank-Emergence	0.2000	1.0000	0	999	0	Yes	2	9999
BM-U:SD	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:SD	BM-U:SD	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:SD	BM-U:SD	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-U:SD	BM-U:SD	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BM-U:SD	BM-U:SD	ReplacementFire-Mojave	0.0010	1.0000	0	999	-999	No	3	9999
BM-U:SD	BM-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
BM-U:SDI	BM-A:AL	Natural-Recovery	0.0010	1.0000	20	199	0	Yes	10	9999
BM-U:SDI	BM-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BM-U:SDI	BM-U:ES	Excessive-Herbivory	1.0000	0.0001	0	999	0	Yes	10	9999
BM-U:SDI	BM-U:EX	EX-Invasion	0.0010	1.0000	0	19	0	Yes	0	9999
BM-U:SDI	BM-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:SDI	BM-U:SDI	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:SDI	BM-U:SDI	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-U:SDI	BM-U:SDI	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BM-U:SDI	BM-U:SDI	Managed-Herbivory	1.0000	0.0500	2	999	1	No	10	9999
BM-U:SDI	BM-U:SDI	ReplacementFire-Mojave	0.0001	1.0000	0	999	-999	No	3	9999
BM-U:SDI	BM-U:SEP	EX-Invasion	0.0010	1.0000	20	999	0	Yes	0	9999
BM-U:SDI	BM-U:SEP	Seedbank-Emergence	0.2000	1.0000	0	999	0	No	2	9999
BM-U:SEP	BM-C:OP	Fingers-of-Death-BM	0.0100	0.7500	5	399	0	Yes	0	9999
BM-U:SEP	BM-D:OP	Fingers-of-Death-BM	0.0100	0.7500	400	999	0	Yes	0	9999
BM-U:SEP	BM-U:BG	OHV	1.0000	0.0001	5	999	0	No	2	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-U:SEP	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	5	999	0	Yes	10	9999
BM-U:SEP	BM-U:EX	Drought	0.0056	0.0100	5	999	0	No	0	9999
BM-U:SEP	BM-U:EX	ReplacementFire-Mojave	0.0050	1.0000	200	999	0	No	3	9999
BM-U:SEP	BM-U:EX	Utilities	0.0001	1.0000	200	999	0	No	0	9999
BM-U:SEP	BM-U:EX2B	ReplacementFire-Mojave	0.0050	1.0000	5	199	0	No	3	9999
BM-U:SEP	BM-U:EX2B	Utilities	0.0001	1.0000	0	199	0	No	0	9999
BM-U:SEP	BM-U:PL	Herbicide-BM	0.0100	0.5000	5	15	0	No	1	9999
BM-U:SEP	BM-U:SEP	Drought	0.0056	0.9900	5	999	-999	No	0	9999
BM-U:SEP	BM-U:SEP	Fingers-of-Death-BM	0.0100	0.2500	5	999	0	No	0	9999
BM-U:SEP	BM-U:SEP	FuelBreak	0.0100	1.0000	5	999	0	No	0	9999
BM-U:SEP	BM-U:SEP	Herbicide-BM	0.0100	0.5000	5	15	0	No	1	9999
BM-U:SEP	BM-U:SEP	Law-Inforcement	0.0100	1.0000	5	999	0	No	0	9999
BM-U:SEP	BM-U:SEP	Managed-Herbivory	1.0000	0.0500	5	999	1	No	10	9999
BM-U:SEP	BM-U:TEX	Tree-Invasion	0.0025	1.0000	400	999	0	Yes	0	9999
BM-U:SEPJ	BM-B:JT	Fingers-of-Death-BM	0.0100	0.7500	5	399	0	No	0	9999
BM-U:SEPJ	BM-E:JT	Fingers-of-Death-BM	0.0100	0.7500	400	999	0	Yes	0	9999
BM-U:SEPJ	BM-U:BG	OHV	1.0000	0.0001	5	999	0	No	2	9999
BM-U:SEPJ	BM-U:ES	Excessive-Herbivory	1.0000	0.0010	5	999	0	Yes	10	9999
BM-U:SEPJ	BM-U:EX	Drought	0.0056	0.0100	5	999	0	No	0	9999
BM-U:SEPJ	BM-U:EX	ReplacementFire-Mojave	0.0050	1.0000	200	999	0	No	3	9999
BM-U:SEPJ	BM-U:EX	Utilities	0.0001	1.0000	200	999	0	No	0	9999
BM-U:SEPJ	BM-U:EX2B	ReplacementFire-Mojave	0.0050	1.0000	5	199	0	No	3	9999
BM-U:SEPJ	BM-U:EX2B	Utilities	0.0001	1.0000	0	199	0	No	0	9999
BM-U:SEPJ	BM-U:PL	Herbicide-BM	0.0100	0.5000	5	15	0	No	1	9999
BM-U:SEPJ	BM-U:SEPJ	Drought	0.0056	0.9900	20	999	-999	No	0	9999
BM-U:SEPJ	BM-U:SEPJ	Fingers-of-Death-BM	0.0100	0.2500	5	999	0	No	0	9999
BM-U:SEPJ	BM-U:SEPJ	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
BM-U:SEPJ	BM-U:SEPJ	Herbicide-BM	0.0100	0.5000	5	15	0	No	1	9999
BM-U:SEPJ	BM-U:SEPJ	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BM-U:SEPJ	BM-U:SEPJ	Managed-Herbivory	1.0000	0.0500	20	999	1	No	10	9999
BM-U:SEPJ	BM-U:TEX	Tree-Invasion	0.0025	1.0000	400	999	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BM-U:TEX	BM-U:EX	Drought	0.0056	0.0100	400	999	0	No	0	9999
BM-U:TEX	BM-U:EX	ReplacementFire-Mojave	0.0025	1.0000	400	999	0	No	3	9999
BM-U:TEX	BM-U:SD	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BM-U:TEX	BM-U:SEP	Drought	0.0056	0.0330	400	999	0	No	0	9999
BM-U:TEX	BM-U:SEPJ	Drought	0.0056	0.0570	400	999	0	No	0	9999
BM-U:TEX	BM-U:TEX	Drought	0.0056	0.9000	400	999	-999	No	0	9999
BM-U:TEX	BM-U:TEX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BM-U:TEX	BM-U:TEX	Law-Inforcement	0.0100	1.0000	0	999	0	No	0	9999
BSu-A:AL	BSu-A:AL	Managed-Herbivory	1.0000	0.0500	2	19	1	No	0	9999
BSu-A:AL	BSu-A:AL	ReplacementFire	0.0125	1.0000	0	19	-999	No	0	9999
BSu-A:AL	BSu-U:ES	Excessive-Herbivory	1.0000	0.0010	0	19	0	Yes	0	9999
BSu-B:OP	BSu-A:AL	ReplacementFire	0.0200	1.0000	20	74	0	No	0	9999
BSu-B:OP	BSu-B:OP	Managed-Herbivory	1.0000	0.0500	20	74	1	No	0	9999
BSu-B:OP	BSu-U:ES	Excessive-Herbivory	1.0000	0.0010	20	74	0	Yes	0	9999
BSu-B:OP	BSu-U:SEP	EX-Invasion	0.0050	1.0000	20	74	0	Yes	0	9999
BSu-C:CL	BSu-A:AL	ReplacementFire	0.0200	1.0000	75	999	0	No	0	9999
BSu-C:CL	BSu-B:OP	Drought	0.0060	0.1000	75	999	0	No	0	9999
BSu-C:CL	BSu-C:CL	Drought	0.0056	0.9000	75	999	-999	No	0	9999
BSu-C:CL	BSu-C:CL	Managed-Herbivory	1.0000	0.0500	75	999	1	No	0	9999
BSu-C:CL	BSu-D:OP	Tree-Invasion	0.0050	1.0000	100	999	0	Yes	0	9999
BSu-C:CL	BSu-U:DP	Excessive-Herbivory	1.0000	0.0010	75	999	0	Yes	0	9999
BSu-C:CL	BSu-U:SEP	EX-Invasion	0.0050	1.0000	75	999	0	Yes	0	9999
BSu-D:OP	BSu-A:AL	ReplacementFire	0.0200	1.0000	76	134	0	No	0	9999
BSu-D:OP	BSu-B:OP	Drought	0.0056	0.3000	76	134	0	No	0	9999
BSu-D:OP	BSu-C:CL	Drought	0.0056	0.6000	76	134	0	No	0	9999
BSu-D:OP	BSu-D:OP	Chainsaw-Thinning-BSu	0.0100	1.0000	76	134	-999	No	0	9999
BSu-D:OP	BSu-D:OP	Drought	0.0056	0.1000	76	134	-999	No	0	9999
BSu-D:OP	BSu-D:OP	Excessive-Herbivory	0.0010	0.7500	76	134	3	No	0	9999
BSu-D:OP	BSu-D:OP	Managed-Herbivory	1.0000	0.0500	76	134	1	No	0	9999
BSu-D:OP	BSu-U:DP	Excessive-Herbivory	0.0010	0.2500	86	86	0	Yes	0	9999
BSu-D:OP	BSu-U:SEP	EX-Invasion	0.0050	1.0000	76	134	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BSu-E:CL	BSu-A:AL	Chainsaw-Thinning-BSu	0.0100	1.0000	135	999	0	No	0	9999
BSu-E:CL	BSu-A:AL	ReplacementFire	0.0130	1.0000	135	999	0	No	0	9999
BSu-E:CL	BSu-B:OP	Drought	0.0056	0.1000	135	999	0	No	0	9999
BSu-E:CL	BSu-E:CL	Drought	0.0056	0.9000	135	999	5	No	0	9999
BSu-E:CL	BSu-U:TE	Tree-Encroachment	0.0200	1.0000	250	999	0	Yes	0	9999
BSu-U:DP	BSu-U:DP	Chainsaw-Lopping-BSu	0.0100	1.0000	100	999	-999	No	0	9999
BSu-U:DP	BSu-U:DP	Drought	0.0056	0.9000	75	999	-999	No	0	9999
BSu-U:DP	BSu-U:ES	Drought	0.0056	0.1000	75	999	0	No	0	9999
BSu-U:DP	BSu-U:ES	ReplacementFire	0.0200	1.0000	75	999	0	No	0	9999
BSu-U:DP	BSu-U:SES	EX-Invasion	0.0050	1.0000	75	999	0	Yes	0	9999
BSu-U:DP	BSu-U:TE	Tree-Invasion	0.0050	1.0000	134	999	0	No	0	9999
BSu-U:ES	BSu-A:AL	ReplacementFire	0.0200	0.0100	0	999	0	No	0	9999
BSu-U:ES	BSu-B:OP	Natural-Recovery	0.0010	1.0000	12	49	10	Yes	0	9999
BSu-U:ES	BSu-C:CL	Natural-Recovery	0.0010	1.0000	50	999	10	Yes	0	9999
BSu-U:ES	BSu-U:ES	ReplacementFire	0.0200	0.9900	0	999	0	No	0	9999
BSu-U:EX	BSu-U:EX	Herbicide+Seed-BSu	0.0100	0.2000	0	999	0	No	0	9999
BSu-U:EX	BSu-U:EX	ReplacementFire	0.1000	0.1000	0	999	-999	No	0	9999
BSu-U:EX	BSu-U:SD	Herbicide+Seed-BSu	0.0100	0.8000	0	999	0	No	0	9999
BSu-U:SD	BSu-A:AL	Natural-Recovery	0.0010	1.0000	5	19	0	Yes	0	9999
BSu-U:SD	BSu-B:OP	Natural-Recovery	0.0100	1.0000	20	74	0	Yes	0	9999
BSu-U:SD	BSu-C:CL	Natural-Recovery	0.0500	1.0000	75	999	0	Yes	0	9999
BSu-U:SD	BSu-D:OP	Tree-Invasion	0.0050	1.0000	75	999	0	No	0	9999
BSu-U:SD	BSu-U:ES	Excessive-Herbivory	1.0000	0.0010	75	999	0	Yes	0	9999
BSu-U:SD	BSu-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
BSu-U:SD	BSu-U:SD	Drought	0.0056	1.0000	0	999	-999	No	0	9999
BSu-U:SD	BSu-U:SD	Managed-Herbivory	1.0000	0.0500	2	999	1	No	0	9999
BSu-U:SD	BSu-U:SD	ReplacementFire	0.0125	1.0000	0	19	-999	No	0	9999
BSu-U:SD	BSu-U:SD	ReplacementFire	0.0125	1.0000	135	999	-999	No	0	9999
BSu-U:SD	BSu-U:SD	ReplacementFire	0.0200	1.0000	20	134	-999	No	0	9999
BSu-U:SD	BSu-U:SEP	EX-Invasion	0.0010	1.0000	20	134	0	Yes	0	9999
BSu-U:SD	BSu-U:TEX	EX-Invasion	0.0050	1.0000	135	999	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BSu-U:SEP	BSu-A:AL	Drought	0.0056	0.0100	75	999	0	No	0	9999
BSu-U:SEP	BSu-A:AL	ReplacementFire	0.0400	0.1000	75	999	0	No	0	9999
BSu-U:SEP	BSu-C:CL	Herbicide+Seed-BSu	0.0100	0.9000	75	999	0	No	0	9999
BSu-U:SEP	BSu-C:CL	Natural-Recovery	0.0010	1.0000	75	999	0	Yes	10	9999
BSu-U:SEP	BSu-U:EX	Drought	0.0056	0.0900	75	999	0	No	0	9999
BSu-U:SEP	BSu-U:EX	ReplacementFire	0.0400	0.9000	75	999	0	No	0	9999
BSu-U:SEP	BSu-U:SEP	Chainsaw-Lopping-BSu	0.0100	1.0000	0	999	-999	No	0	9999
BSu-U:SEP	BSu-U:SEP	Drought	0.0056	0.9000	75	999	-999	No	0	9999
BSu-U:SEP	BSu-U:SEP	Herbicide+Seed-BSu	0.0100	0.1000	75	999	0	No	0	9999
BSu-U:SEP	BSu-U:SEP	Managed-Herbivory	1.0000	0.0500	75	99	1	No	0	9999
BSu-U:SEP	BSu-U:SES	Excessive-Herbivory	1.0000	0.0010	75	99	0	Yes	0	9999
BSu-U:SEP	BSu-U:SES	Managed-Herbivory	1.0000	0.0500	100	999	0	No	0	9999
BSu-U:SEP	BSu-U:TEX	Tree-Invasion	0.0050	1.0000	134	999	0	No	0	9999
BSu-U:SES	BSu-U:EX	Drought	0.0056	0.1000	75	999	0	No	0	9999
BSu-U:SES	BSu-U:EX	ReplacementFire	0.0400	1.0000	75	999	0	No	0	9999
BSu-U:SES	BSu-U:SES	Drought	0.0056	0.9000	75	999	-999	No	0	9999
BSu-U:SES	BSu-U:TEX	Tree-Invasion	0.0050	1.0000	134	999	0	Yes	0	9999
BSu-U:TE	BSu-U:ES	Drought	0.0056	0.0500	135	999	0	No	0	9999
BSu-U:TE	BSu-U:ES	ReplacementFire	0.0085	0.4500	135	999	0	No	0	9999
BSu-U:TE	BSu-U:EX	Drought	0.0056	0.0500	135	999	0	No	0	9999
BSu-U:TE	BSu-U:EX	ReplacementFire	0.0085	0.4500	135	999	0	No	0	9999
BSu-U:TE	BSu-U:SES	ReplacementFire	0.0085	0.1000	135	999	0	No	0	9999
BSu-U:TE	BSu-U:TE	Drought	0.0056	0.9000	135	999	-999	No	0	9999
BSu-U:TE	BSu-U:TEX	EX-Invasion	0.0050	1.0000	135	999	0	Yes	0	9999
BSu-U:TEX	BSu-U:EX	Drought	0.0056	0.1000	135	999	0	No	0	9999
BSu-U:TEX	BSu-U:EX	ReplacementFire	0.0085	1.0000	135	999	0	No	0	9999
BSu-U:TEX	BSu-U:EX	Thin+Herbicide+Seed-BSu	0.0100	0.2000	135	999	0	No	0	9999
BSu-U:TEX	BSu-U:SD	Thin+Herbicide+Seed-BSu	0.0100	0.8000	135	999	0	No	0	9999
BSu-U:TEX	BSu-U:TEX	Drought	0.0056	0.9000	0	999	-999	No	0	9999
BT-A:AL	BT-A:AL	FuelBreak	0.0100	1.0000	0	499	0	No	0	9999
BT-A:AL	BT-A:AL	Managed-Herbivory	1.0000	0.0500	2	499	2	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BT-A:AL	BT-A:AL	ReplacementFire-Mojave	0.0001	1.0000	0	499	-999	No	3	9999
BT-A:AL	BT-B:JT	Joshua-Succession	0.5400	1.0000	498	498	0	No	0	9999
BT-A:AL	BT-U:BG	OHV	1.0000	0.0001	0	499	0	No	2	9999
BT-A:AL	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	2	499	0	Yes	0	9999
BT-A:AL	BT-U:EX	EX-Invasion	0.0050	1.0000	0	4	0	Yes	0	9999
BT-A:AL	BT-U:SEP	EX-Invasion	0.0050	0.5000	5	499	0	Yes	0	9999
BT-A:AL	BT-U:SEPJ	EX-Invasion	0.0050	0.5000	5	499	0	Yes	0	9999
BT-B:JT	BT-A:AL	ReplacementFire-Mojave	0.0001	1.0000	500	999	0	No	3	9999
BT-B:JT	BT-B:JT	FuelBreak	0.0100	1.0000	500	999	0	No	0	9999
BT-B:JT	BT-B:JT	Managed-Herbivory	1.0000	0.0500	500	999	2	No	0	9999
BT-B:JT	BT-U:BG	OHV	1.0000	0.0001	500	999	0	No	2	9999
BT-B:JT	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	500	999	0	Yes	0	9999
BT-B:JT	BT-U:EX	Utilities	0.0001	1.0000	500	999	0	No	0	9999
BT-B:JT	BT-U:SEPJ	EX-Invasion	0.0050	1.0000	500	999	0	Yes	0	9999
BT-C:CL	BT-A:AL	ReplacementFire-Mojave	0.0001	1.0000	500	999	0	No	3	9999
BT-C:CL	BT-C:CL	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-C:CL	BT-C:CL	Managed-Herbivory	1.0000	0.0500	500	999	2	No	0	9999
BT-C:CL	BT-U:BG	OHV	1.0000	0.0001	500	999	0	No	2	9999
BT-C:CL	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	500	999	0	Yes	0	9999
BT-C:CL	BT-U:EX	Utilities	0.0001	1.0000	500	999	0	No	0	9999
BT-C:CL	BT-U:SEP	EX-Invasion	0.0050	1.0000	500	999	0	Yes	0	9999
BT-U:BG	BT-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
BT-U:BG	BT-U:EX	EX-Invasion	0.0050	1.0000	0	999	0	No	0	9999
BT-U:BG	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:ES	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:ES	BT-U:ES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-U:ES	BT-U:ES	ReplacementFire-Mojave	0.0010	1.0000	0	999	-999	No	3	9999
BT-U:ES	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:ES	BT-U:SEP	EX-Invasion	0.0050	0.3500	0	999	0	No	0	9999
BT-U:ES	BT-U:SEPJ	EX-Invasion	0.0050	0.6500	0	999	0	No	0	9999
BT-U:EX	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BT-U:EX	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	No	0	9999
BT-U:EX	BT-U:EX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-U:EX	BT-U:EX	Hrbx+Current-Native-Seed-BT	0.0100	0.9900	0	999	-999	No	0	9999
BT-U:EX	BT-U:EX	Hrbx+Introduced-Seed-BT	0.0100	0.9500	0	999	-999	No	0	9999
BT-U:EX	BT-U:EX	Hrbx+New-Seed-BT	0.0100	0.9500	0	999	0	Yes	0	9999
BT-U:EX	BT-U:EX	Managed-Herbivory	1.0000	0.0500	0	999	1	No	0	9999
BT-U:EX	BT-U:EX	Planting+FOD-BT	0.0100	0.1000	0	999	0	No	0	9999
BT-U:EX	BT-U:EX	Planting+Herbicide-BT	0.0100	0.1000	0	999	0	No	0	9999
BT-U:EX	BT-U:EX2B	ReplacementFire-Mojave	0.0500	1.0000	0	999	-999	No	3	9999
BT-U:EX	BT-U:EX2B	Utilities	0.0001	1.0000	0	999	-999	No	0	9999
BT-U:EX	BT-U:PL	Planting+FOD-BT	0.0100	0.6950	0	999	0	No	0	9999
BT-U:EX	BT-U:PL	Planting+Herbicide-BT	0.0100	0.4500	0	999	0	No	0	9999
BT-U:EX	BT-U:SD	Hrbx+Current-Native-Seed-BT	0.0100	0.0100	0	999	0	Yes	0	9999
BT-U:EX	BT-U:SD	Hrbx+New-Seed-BT	0.0100	0.0500	0	999	0	Yes	0	9999
BT-U:EX	BT-U:SDI	Hrbx+Introduced-Seed-BT	0.0100	0.0500	0	999	0	Yes	0	9999
BT-U:EX	BT-U:SEP	Non-Joshua-Succession	0.1000	0.5400	20	999	0	Yes	0	9999
BT-U:EX	BT-U:SEP	Planting+FOD-BT	0.0100	0.1050	0	999	0	No	0	9999
BT-U:EX	BT-U:SEP	Planting+Herbicide-BT	0.0100	0.1800	0	999	0	No	0	9999
BT-U:EX	BT-U:SEPJ	Joshua-Succession	0.1000	0.4600	20	999	0	Yes	0	9999
BT-U:EX	BT-U:SEPJ	Planting+FOD-BT	0.0100	0.1200	0	999	0	No	0	9999
BT-U:EX	BT-U:SEPJ	Planting+Herbicide-BT	0.0100	0.2700	0	999	0	No	0	9999
BT-U:EX2B	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:EX2B	BT-U:EX2B	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-U:EX2B	BT-U:EX2B	Hrbx+New-Seed-BT	0.0100	0.9500	0	999	0	No	0	9999
BT-U:EX2B	BT-U:EX2B	Planting+FOD-BT	0.0100	0.1000	0	999	0	No	0	9999
BT-U:EX2B	BT-U:EX2B	Planting+Herbicide-BT	0.0100	0.1000	0	999	0	No	0	9999
BT-U:EX2B	BT-U:EX2B	ReplacementFire-Mojave	0.1000	1.0000	0	999	-999	No	3	9999
BT-U:EX2B	BT-U:EX2B	Utilities	0.0001	1.0000	0	999	-999	No	0	9999
BT-U:EX2B	BT-U:PL	Planting+FOD-BT	0.0100	0.6950	0	999	0	No	0	9999
BT-U:EX2B	BT-U:PL	Planting+Herbicide-BT	0.0100	0.4500	0	999	0	No	0	9999
BT-U:EX2B	BT-U:SD	Hrbx+New-Seed-BT	0.0100	0.0500	0	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BT-U:EX2B	BT-U:SEP	Planting+FOD-BT	0.0100	0.1050	0	999	0	No	0	9999
BT-U:EX2B	BT-U:SEP	Planting+Herbicide-BT	0.0100	0.1800	0	999	0	No	0	9999
BT-U:EX2B	BT-U:SEPJ	Managed-Herbivory	1.0000	0.0500	0	999	0	No	0	9999
BT-U:EX2B	BT-U:SEPJ	Planting+FOD-BT	0.0100	0.1200	0	999	0	No	0	9999
BT-U:EX2B	BT-U:SEPJ	Planting+Herbicide-BT	0.0100	0.2700	0	999	0	No	0	9999
BT-U:PL	BT-A:AL	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
BT-U:PL	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:PL	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	10	9999
BT-U:PL	BT-U:EX	Drought	0.0056	0.0100	0	999	0	No	0	9999
BT-U:PL	BT-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	-3	No	10	9999
BT-U:PL	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:PL	BT-U:PL	Drought	0.0056	0.9900	0	999	-999	No	0	9999
BT-U:PL	BT-U:PL	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BT-U:PL	BT-U:SEP	Seedbank-Emergence	0.2000	0.4600	0	999	0	No	2	9999
BT-U:PL	BT-U:SEPJ	Seedbank-Emergence	0.2000	0.5400	0	999	0	No	2	9999
BT-U:SD	BT-A:AL	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
BT-U:SD	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:SD	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	10	9999
BT-U:SD	BT-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
BT-U:SD	BT-U:EX	Seedbank-Emergence	0.2000	1.0000	0	999	0	No	2	9999
BT-U:SD	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:SD	BT-U:SD	Drought	0.0056	0.1000	0	999	-999	No	0	9999
BT-U:SD	BT-U:SD	Drought	0.0056	0.9000	0	999	0	No	0	9999
BT-U:SD	BT-U:SD	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-U:SD	BT-U:SD	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BT-U:SD	BT-U:SD	Managed-Herbivory	1.0000	0.0500	2	999	-1	No	10	9999
BT-U:SD	BT-U:SD	ReplacementFire-Mojave	0.0010	1.0000	0	19	-999	No	3	9999
BT-U:SD	BT-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
BT-U:SDI	BT-A:AL	Natural-Recovery	0.0020	1.0000	0	999	0	No	10	9999
BT-U:SDI	BT-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
BT-U:SDI	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	10	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BT-U:SDI	BT-U:EX	EX-Invasion	0.0010	1.0000	0	19	0	Yes	0	9999
BT-U:SDI	BT-U:EX	Seedbank-Emergence	0.2000	1.0000	0	999	0	No	2	9999
BT-U:SDI	BT-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
BT-U:SDI	BT-U:SDI	Drought	0.0056	0.1000	0	999	-999	No	0	9999
BT-U:SDI	BT-U:SDI	Drought	0.0056	0.9000	0	999	0	No	0	9999
BT-U:SDI	BT-U:SDI	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
BT-U:SDI	BT-U:SDI	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
BT-U:SDI	BT-U:SDI	Managed-Herbivory	1.0000	0.0500	2	999	-1	No	10	9999
BT-U:SDI	BT-U:SDI	ReplacementFire-Mojave	0.0001	1.0000	0	999	-999	No	3	9999
BT-U:SDI	BT-U:SEP	EX-Invasion	0.0010	1.0000	20	999	0	No	0	9999
BT-U:SEP	BT-C:CL	Fingers-of-Death-BT	0.0100	0.7500	5	499	0	Yes	0	9999
BT-U:SEP	BT-U:BG	OHV	1.0000	0.0001	5	999	0	No	2	9999
BT-U:SEP	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	5	999	0	Yes	10	9999
BT-U:SEP	BT-U:EX	Drought	0.0056	0.0100	5	999	0	No	0	9999
BT-U:SEP	BT-U:EX	ReplacementFire-Mojave	0.0050	1.0000	500	999	0	No	3	9999
BT-U:SEP	BT-U:EX	Utilities	0.0001	1.0000	500	999	0	No	0	9999
BT-U:SEP	BT-U:EX2B	ReplacementFire-Mojave	0.0050	1.0000	5	499	0	No	3	9999
BT-U:SEP	BT-U:EX2B	Utilities	0.0001	1.0000	0	499	0	No	0	9999
BT-U:SEP	BT-U:PL	Herbicide-BT	0.0100	0.5000	5	15	0	Yes	1	9999
BT-U:SEP	BT-U:SEP	Drought	0.0056	0.9900	5	999	-999	No	0	9999
BT-U:SEP	BT-U:SEP	Fingers-of-Death-BT	0.0100	0.2500	5	999	0	No	0	9999
BT-U:SEP	BT-U:SEP	FuelBreak	0.0100	1.0000	5	999	0	No	0	9999
BT-U:SEP	BT-U:SEP	Herbicide-BT	0.0100	0.5000	5	15	0	Yes	1	9999
BT-U:SEP	BT-U:SEP	Managed-Herbivory	1.0000	0.0500	5	999	2	No	10	9999
BT-U:SEPJ	BT-B:JT	Fingers-of-Death-BT	0.0100	0.7500	5	999	0	Yes	0	9999
BT-U:SEPJ	BT-U:BG	OHV	1.0000	0.0001	5	999	0	No	2	9999
BT-U:SEPJ	BT-U:ES	Excessive-Herbivory	1.0000	0.0010	5	999	0	Yes	10	9999
BT-U:SEPJ	BT-U:EX	Drought	0.0056	0.0100	5	999	0	No	0	9999
BT-U:SEPJ	BT-U:EX	ReplacementFire-Mojave	0.0050	1.0000	500	999	0	No	3	9999
BT-U:SEPJ	BT-U:EX	Utilities	0.0000	1.0000	500	999	0	No	0	9999
BT-U:SEPJ	BT-U:EX2B	ReplacementFire-Mojave	0.0050	1.0000	5	499	0	No	3	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
BT-U:SEPJ	BT-U:EX2B	Utilities	0.0001	1.0000	0	499	0	No	0	9999
BT-U:SEPJ	BT-U:PL	Herbicide-BT	0.0100	0.5000	5	15	0	Yes	1	9999
BT-U:SEPJ	BT-U:SEPJ	Drought	0.0056	0.9900	5	999	-999	No	0	9999
BT-U:SEPJ	BT-U:SEPJ	Fingers-of-Death-BT	0.0100	0.2500	5	999	0	No	0	9999
BT-U:SEPJ	BT-U:SEPJ	FuelBreak	0.0100	1.0000	5	999	0	No	0	9999
BT-U:SEPJ	BT-U:SEPJ	Herbicide-BT	0.0100	0.5000	5	15	0	Yes	1	9999
BT-U:SEPJ	BT-U:SEPJ	Managed-Herbivory	1.0000	0.0500	5	999	2	No	10	9999
CB-A:OP	CB-A:OP	FuelBreak	0.0100	1.0000	0	19	0	No	0	9999
CB-A:OP	CB-A:OP	Managed-Herbivory	1.0000	0.0500	2	19	1	No	0	9999
CB-A:OP	CB-A:OP	ReplacementFire-Mojave	0.0005	1.0000	0	19	-999	No	3	9999
CB-A:OP	CB-B:JT	Joshua-Succession	0.6500	1.0000	18	18	0	No	0	9999
CB-A:OP	CB-U:BG	OHV	1.0000	0.0001	0	19	0	No	2	9999
CB-A:OP	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	0	19	0	Yes	0	9999
CB-A:OP	CB-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	No	0	9999
CB-A:OP	CB-U:EX	Utilities	0.0050	1.0000	0	19	0	No	0	9999
CB-B:JT	CB-A:OP	Drought	0.0056	1.0000	20	399	0	No	0	9999
CB-B:JT	CB-A:OP	ReplacementFire-Mojave	0.0005	1.0000	20	399	0	No	3	9999
CB-B:JT	CB-B:JT	FuelBreak	0.0100	1.0000	20	399	0	No	0	9999
CB-B:JT	CB-B:JT	Managed-Herbivory	1.0000	0.0500	20	399	3	No	0	9999
CB-B:JT	CB-U:BG	OHV	1.0000	0.0001	20	399	0	No	2	9999
CB-B:JT	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	20	399	0	Yes	0	9999
CB-B:JT	CB-U:EX	Utilities	0.0001	1.0000	20	399	0	No	0	9999
CB-B:JT	CB-U:SEPJ	EX-Invasion	0.0050	1.0000	20	399	0	Yes	0	9999
CB-C:OP	CB-A:OP	Drought	0.0056	1.0000	20	399	0	No	0	9999
CB-C:OP	CB-A:OP	ReplacementFire-Mojave	0.0005	1.0000	20	999	0	No	3	9999
CB-C:OP	CB-C:OP	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
CB-C:OP	CB-C:OP	Managed-Herbivory	1.0000	0.0500	20	999	3	No	0	9999
CB-C:OP	CB-U:BG	OHV	1.0000	0.0001	20	999	0	No	2	9999
CB-C:OP	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	20	999	0	Yes	0	9999
CB-C:OP	CB-U:EX	Utilities	0.0001	1.0000	20	999	0	No	0	9999
CB-C:OP	CB-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
CB-D:JT	CB-A:OP	Drought	0.0056	1.0000	200	999	0	No	0	9999
CB-D:JT	CB-A:OP	ReplacementFire-Mojave	0.0010	1.0000	200	999	0	No	3	9999
CB-D:JT	CB-D:JT	FuelBreak	0.0100	1.0000	200	999	0	No	0	9999
CB-D:JT	CB-D:JT	Managed-Herbivory	1.0000	0.0500	200	999	3	No	0	9999
CB-D:JT	CB-U:BG	OHV	1.0000	0.0001	200	999	0	No	2	9999
CB-D:JT	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	200	999	0	Yes	0	9999
CB-D:JT	CB-U:EX	Utilities	0.0001	1.0000	200	999	0	No	0	9999
CB-D:JT	CB-U:SEPJ	EX-Invasion	0.0050	1.0000	200	999	0	Yes	0	9999
CB-U:BG	CB-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
CB-U:BG	CB-U:BG	Utilities	0.0001	1.0000	0	999	0	No	0	9999
CB-U:BG	CB-U:EX	EX-Invasion	0.0050	1.0000	0	999	0	No	0	9999
CB-U:ES	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:ES	CB-U:ES	Drought	0.0056	1.0000	0	999	-999	No	0	9999
CB-U:ES	CB-U:ES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
CB-U:ES	CB-U:ES	ReplacementFire-Mojave	0.0015	1.0000	0	999	-999	No	3	9999
CB-U:ES	CB-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
CB-U:ES	CB-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
CB-U:ES	CB-U:SEP	EX-Invasion	0.0050	0.3500	20	999	0	Yes	0	9999
CB-U:ES	CB-U:SEPJ	EX-Invasion	0.0050	0.6500	20	999	0	Yes	0	9999
CB-U:EX	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:EX	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	No	0	9999
CB-U:EX	CB-U:EX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
CB-U:EX	CB-U:EX	Hrbx+New-Seed-CB	0.0100	0.9500	0	999	0	Yes	0	9999
CB-U:EX	CB-U:EX	Managed-Herbivory	1.0000	0.0500	0	999	1	No	0	9999
CB-U:EX	CB-U:EX	Planting+FOD-CB	0.0100	0.1000	0	999	0	No	0	9999
CB-U:EX	CB-U:EX	Planting+Herbicide-CB	0.0100	0.1000	0	999	0	No	0	9999
CB-U:EX	CB-U:EX2B	ReplacementFire-Mojave	0.0500	1.0000	0	999	-999	No	3	9999
CB-U:EX	CB-U:EX2B	Utilities	0.0001	1.0000	0	999	-999	No	0	9999
CB-U:EX	CB-U:PL	Planting+FOD-CB	0.0100	0.6950	0	999	0	No	0	9999
CB-U:EX	CB-U:PL	Planting+Herbicide-CB	0.0100	0.4500	0	999	0	No	0	9999
CB-U:EX	CB-U:SD	Hrbx+New-Seed-CB	0.0100	0.0500	0	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
CB-U:EX	CB-U:SEP	Non-Joshua-Succession	0.1000	0.3500	20	999	0	Yes	0	9999
CB-U:EX	CB-U:SEP	Planting+FOD-CB	0.0100	0.0750	0	999	0	No	0	9999
CB-U:EX	CB-U:SEP	Planting+Herbicide-CB	0.0100	0.1600	0	999	0	No	0	9999
CB-U:EX	CB-U:SEPJ	Joshua-Succession	0.1000	0.6500	20	999	0	Yes	0	9999
CB-U:EX	CB-U:SEPJ	Planting+FOD-CB	0.0100	0.1500	0	999	0	No	0	9999
CB-U:EX	CB-U:SEPJ	Planting+Herbicide-CB	0.0100	0.2900	0	999	0	No	0	9999
CB-U:EX2B	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:EX2B	CB-U:EX2B	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	Hrbx+New-Seed-CB	0.0100	0.9500	0	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	Managed-Herbivory	1.0000	0.0500	0	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	Planting+FOD-CB	0.0100	0.1000	0	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	Planting+Herbicide-CB	0.0100	0.1000	0	999	0	No	0	9999
CB-U:EX2B	CB-U:EX2B	ReplacementFire-Mojave	0.1000	1.0000	0	999	-999	No	3	9999
CB-U:EX2B	CB-U:EX2B	Utilities	0.0001	1.0000	0	999	-999	No	0	9999
CB-U:EX2B	CB-U:PL	Planting+FOD-CB	0.0100	0.6950	0	999	0	No	0	9999
CB-U:EX2B	CB-U:PL	Planting+Herbicide-CB	0.0100	0.4500	0	999	0	No	0	9999
CB-U:EX2B	CB-U:SD	Hrbx+New-Seed-CB	0.0100	0.0500	0	999	0	No	0	9999
CB-U:EX2B	CB-U:SEP	Planting+FOD-CB	0.0100	0.0750	0	999	0	No	0	9999
CB-U:EX2B	CB-U:SEP	Planting+Herbicide-CB	0.0100	0.1600	0	999	0	No	0	9999
CB-U:EX2B	CB-U:SEPJ	Planting+FOD-CB	0.0100	0.1400	0	999	0	No	0	9999
CB-U:EX2B	CB-U:SEPJ	Planting+Herbicide-CB	0.0100	0.2900	0	999	0	No	0	9999
CB-U:PL	CB-A:OP	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
CB-U:PL	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:PL	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	10	9999
CB-U:PL	CB-U:EX	Drought	0.0056	0.0100	0	999	0	No	0	9999
CB-U:PL	CB-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	-3	No	10	9999
CB-U:PL	CB-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
CB-U:PL	CB-U:PL	Drought	0.0056	0.9900	0	999	-999	No	0	9999
CB-U:PL	CB-U:PL	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
CB-U:PL	CB-U:SEP	Seedbank-Emergence	0.2000	0.3500	0	999	0	No	2	9999
CB-U:PL	CB-U:SEPJ	Seedbank-Emergence	0.2000	0.6500	0	999	0	No	2	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
CB-U:SD	CB-A:OP	Natural-Recovery	0.1000	1.0000	20	999	0	No	10	9999
CB-U:SD	CB-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
CB-U:SD	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	10	9999
CB-U:SD	CB-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
CB-U:SD	CB-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	0	No	10	9999
CB-U:SD	CB-U:EX	Seedbank-Emergence	0.2000	1.0000	0	19	0	No	2	9999
CB-U:SD	CB-U:EX	Utilities	0.0001	1.0000	0	999	0	No	0	9999
CB-U:SD	CB-U:SD	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
CB-U:SD	CB-U:SD	Livestock-Closure	0.0100	1.0000	1	2	0	No	0	9999
CB-U:SD	CB-U:SD	ReplacementFire-Mojave	0.0015	1.0000	0	999	-999	No	3	9999
CB-U:SD	CB-U:SEP	EX-Invasion	0.0050	0.3500	20	999	0	Yes	0	9999
CB-U:SD	CB-U:SEPJ	EX-Invasion	0.0050	0.6500	20	999	0	Yes	0	9999
CB-U:SEP	CB-C:OP	Fingers-of-Death-CB	0.0100	0.7500	20	999	0	Yes	0	9999
CB-U:SEP	CB-U:BG	OHV	1.0000	0.0001	20	999	0	No	2	9999
CB-U:SEP	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	21	999	0	Yes	10	9999
CB-U:SEP	CB-U:EX	Drought	0.0056	1.0000	21	999	0	No	0	9999
CB-U:SEP	CB-U:EX	ReplacementFire-Mojave	0.0015	1.0000	21	999	0	No	3	9999
CB-U:SEP	CB-U:EX	Utilities	0.0001	1.0000	21	999	0	No	0	9999
CB-U:SEP	CB-U:PL	Herbicide-CB	0.0100	0.0500	20	999	0	No	1	9999
CB-U:SEP	CB-U:SEP	Fingers-of-Death-CB	0.0100	0.2500	20	999	0	No	0	9999
CB-U:SEP	CB-U:SEP	FuelBreak	0.0100	1.0000	21	999	0	No	0	9999
CB-U:SEP	CB-U:SEP	Herbicide-CB	0.0100	0.0500	20	999	0	No	1	9999
CB-U:SEP	CB-U:SEP	Managed-Herbivory	1.0000	0.0500	21	999	3	No	10	9999
CB-U:SEPJ	CB-B:JT	Fingers-of-Death-CB	0.0100	0.7500	20	199	0	Yes	0	9999
CB-U:SEPJ	CB-D:JT	Fingers-of-Death-CB	0.0100	0.7500	200	999	0	Yes	0	9999
CB-U:SEPJ	CB-U:BG	OHV	1.0000	0.0001	20	999	0	No	2	9999
CB-U:SEPJ	CB-U:ES	Excessive-Herbivory	1.0000	0.0010	20	999	0	Yes	10	9999
CB-U:SEPJ	CB-U:EX	Drought	0.0056	1.0000	20	999	0	No	0	9999
CB-U:SEPJ	CB-U:EX	ReplacementFire-Mojave	0.0015	1.0000	20	999	0	No	3	9999
CB-U:SEPJ	CB-U:EX	Utilities	0.0001	1.0000	20	999	0	No	0	9999
CB-U:SEPJ	CB-U:PL	Herbicide-CB	0.0100	0.5000	20	999	0	No	1	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
CB-U:SEPJ	CB-U:SEPJ	Fingers-of-Death-CB	0.0100	0.2500	20	199	0	No	0	9999
CB-U:SEPJ	CB-U:SEPJ	Fingers-of-Death-CB	0.0100	0.2500	200	999	0	No	0	9999
CB-U:SEPJ	CB-U:SEPJ	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
CB-U:SEPJ	CB-U:SEPJ	Herbicide-CB	0.0100	0.5000	20	999	0	No	1	9999
CB-U:SEPJ	CB-U:SEPJ	Managed-Herbivory	1.0000	0.0500	20	999	3	No	10	9999
GRL-A:AL	GRL-A:AL	Drought	0.0056	1.0000	0	19	-10	No	0	9999
GRL-A:AL	GRL-A:AL	FuelBreak	0.0100	1.0000	0	19	0	No	0	9999
GRL-A:AL	GRL-A:AL	Managed-Herbivory	1.0000	0.0500	2	19	1	No	0	9999
GRL-A:AL	GRL-A:AL	ReplacementFire-Mojave	0.0015	1.0000	0	19	-999	No	3	9999
GRL-A:AL	GRL-U:DP	Excessive-Herbivory	1.0000	0.0010	0	19	0	Yes	0	9999
GRL-A:AL	GRL-U:EX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
GRL-B:OP	GRL-A:AL	Drought	0.0056	0.1000	20	999	0	No	0	9999
GRL-B:OP	GRL-A:AL	ReplacementFire-Mojave	0.0015	1.0000	20	999	0	No	3	9999
GRL-B:OP	GRL-B:OP	Drought	0.0056	0.9000	20	999	-999	No	0	9999
GRL-B:OP	GRL-B:OP	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
GRL-B:OP	GRL-B:OP	Managed-Herbivory	1.0000	0.0500	20	999	1	No	0	9999
GRL-B:OP	GRL-U:DP	Excessive-Herbivory	1.0000	0.0010	20	999	0	Yes	0	9999
GRL-B:OP	GRL-U:SES	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
GRL-U:DP	GRL-U:DP	Drought	0.0056	1.0000	0	999	-10	No	0	9999
GRL-U:DP	GRL-U:DP	Excessive-Herbivory	1.0000	0.0010	0	999	3	No	0	9999
GRL-U:DP	GRL-U:DP	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
GRL-U:DP	GRL-U:DP	Managed-Herbivory	1.0000	0.0500	2	999	1	No	0	9999
GRL-U:DP	GRL-U:DP	ReplacementFire-Mojave	0.0015	1.0000	0	999	-999	No	3	9999
GRL-U:DP	GRL-U:EEX	EX-Invasion	0.0050	1.0000	0	999	0	Yes	0	9999
GRL-U:EEX	GRL-U:EEX	Drought	0.0056	1.0000	0	999	-10	No	0	9999
GRL-U:EEX	GRL-U:EEX	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
GRL-U:EEX	GRL-U:EEX	Managed-Herbivory	1.0000	0.0500	2	999	1	No	0	9999
GRL-U:EEX	GRL-U:EEX	ReplacementFire-Mojave	0.0015	1.0000	0	999	-999	No	3	9999
GRL-U:EEX	GRL-U:SES	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	0	9999
GRL-U:EX	GRL-U:EEX	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	0	9999
GRL-U:EX	GRL-U:EX	Drought	0.0056	1.0000	0	19	-10	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
GRL-U:EX	GRL-U:EX	FuelBreak	0.0100	1.0000	0	19	0	No	0	9999
GRL-U:EX	GRL-U:EX	Managed-Herbivory	1.0000	0.0500	2	19	1	No	0	9999
GRL-U:EX	GRL-U:EX	ReplacementFire-Mojave	0.0500	1.0000	0	19	-999	No	3	9999
GRL-U:SES	GRL-B:OP	Herbicide-GRL	0.0100	0.6000	0	999	0	No	0	9999
GRL-U:SES	GRL-U:SES	Drought	0.0056	1.0000	20	999	-10	No	0	9999
GRL-U:SES	GRL-U:SES	Excessive-Herbivory	1.0000	0.0010	20	999	3	No	0	9999
GRL-U:SES	GRL-U:SES	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
GRL-U:SES	GRL-U:SES	Herbicide-GRL	0.0100	0.4000	0	999	0	No	0	9999
GRL-U:SES	GRL-U:SES	Managed-Herbivory	1.0000	0.0500	20	999	1	No	0	9999
GRL-U:SES	GRL-U:SES	ReplacementFire-Mojave	0.0100	1.0000	20	999	-999	No	3	9999
MM-A:AL	MM-A:AL	NativeHerbivory	0.0200	1.0000	0	9	-999	No	0	9999
MM-A:AL	MM-A:AL	ReplacementFire	0.0020	1.0000	0	9	-999	No	0	9999
MM-A:AL	MM-A:AL	Wet-Year	0.1500	1.0000	0	999	-1	No	0	9999
MM-B:OP	MM-A:AL	ReplacementFire	0.0070	1.0000	10	29	0	No	0	9999
MM-C:CL	MM-A:AL	ReplacementFire	0.0070	1.0000	60	999	0	No	0	9999
MM-C:CL	MM-U:TEX	EX-Invasion	0.0001	1.0000	60	999	0	Yes	0	9999
MM-U:EX	MM-U:EX	ReplacementFire	0.0500	1.0000	0	999	-999	No	0	9999
MM-U:TEX	MM-U:EX	ReplacementFire	0.0070	1.0000	150	999	0	No	0	9999
MR-A:AL	MR-A:AL	Flooding-7yr	0.1300	1.0000	0	4	-5	No	0	9999
MR-A:AL	MR-A:AL	Managed-Herbivory	1.0000	0.0500	2	4	-5	No	0	9999
MR-A:AL	MR-A:AL	ReplacementFire	0.0010	1.0000	0	999	-999	No	0	9999
MR-A:AL	MR-A:AL	Weed-Inventory-MR	0.2500	1.0000	0	4	0	No	0	9999
MR-A:AL	MR-U:EF	Exotic-Riparian-Invasion-MR	0.0100	1.0000	0	4	0	No	5	9999
MR-A:AL	MR-U:SFE	Excessive-Herbivory	0.0010	1.0000	0	4	0	No	0	9999
MR-B:OP	MR-A:AL	Flooding-20yr	0.0500	1.0000	5	19	0	No	0	9999
MR-B:OP	MR-A:AL	ReplacementFire	0.0010	1.0000	5	19	0	No	0	9999
MR-B:OP	MR-B:OP	Managed-Herbivory	1.0000	0.0500	5	19	-1	No	0	9999
MR-B:OP	MR-B:OP	Weed-Inventory-MR	0.0100	1.0000	5	19	0	No	0	9999
MR-B:OP	MR-U:EF	Exotic-Riparian-Invasion-MR	0.0100	1.0000	5	19	0	No	5	9999
MR-B:OP	MR-U:SFE	Excessive-Herbivory	0.0010	1.0000	5	19	0	No	0	9999
MR-C:CL	MR-A:AL	Flooding-100yr	0.0100	1.0000	20	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
MR-C:CL	MR-A:AL	ReplacementFire	0.0010	1.0000	20	999	0	No	0	9999
MR-C:CL	MR-C:CL	Managed-Herbivory	1.0000	0.0500	20	999	1	No	0	9999
MR-C:CL	MR-C:CL	Weed-Inventory-MR	0.0100	1.0000	20	999	0	No	0	9999
MR-C:CL	MR-U:EF	Exotic-Riparian-Invasion-MR	0.0100	1.0000	20	999	0	No	5	9999
MR-C:CL	MR-U:SFE	Excessive-Herbivory	0.0010	1.0000	20	999	0	No	0	9999
MR-U:DE	MR-A:AL	Flooding-100yr	0.0100	0.0100	0	999	0	No	0	9999
MR-U:DE	MR-A:AL	Floodplain-Recovery	0.0010	1.0000	0	999	0	No	10	9999
MR-U:DE	MR-A:AL	Floodplain-Restoration	0.0100	1.0000	0	999	0	No	0	9999
MR-U:DE	MR-U:DE	Flooding-100yr	0.0100	0.9900	0	999	-999	No	0	9999
MR-U:DE	MR-U:DE	ReplacementFire	0.0200	1.0000	0	999	-999	No	0	9999
MR-U:EF	MR-B:OP	Exotic-Control-MR	0.6000	1.0000	0	999	0	No	0	20
MR-U:EF	MR-U:EF	Exotic-Control-MR	0.4000	1.0000	0	999	0	No	0	20
MR-U:EF	MR-U:EF	ReplacementFire	0.0001	1.0000	0	999	-999	No	0	9999
MR-U:SFE	MR-A:AL	Flooding-100yr	0.0100	0.0100	0	999	0	No	0	9999
MR-U:SFE	MR-U:DE	Excessive-Herbivory	1.0000	0.0010	0	999	0	No	0	9999
MR-U:SFE	MR-U:EF	Exotic-Riparian-Invasion-MR	0.3300	1.0000	0	999	0	No	5	9999
MR-U:SFE	MR-U:SFE	Flooding-100yr	0.0100	0.9900	20	999	-999	No	0	9999
MR-U:SFE	MR-U:SFE	ReplacementFire	0.0010	1.0000	0	999	-999	No	0	9999
MR-U:SFE	MR-U:SFE	Weed-Inventory-MR	0.0100	1.0000	0	999	0	No	0	9999
MSD-A:AL	MSD-A:AL	Managed-Herbivory	1.0000	0.0500	2	4	1	No	0	9999
MSD-A:AL	MSD-A:AL	Very-Wet-Year	0.0100	1.0000	0	4	-4	No	0	9999
MSD-B:OP	MSD-A:AL	Managed-Herbivory	1.0000	0.0500	5	999	0	No	0	9999
MSD-B:OP	MSD-A:AL	ReplacementFire	0.0001	1.0000	5	999	0	No	0	9999
MSD-B:OP	MSD-A:AL	Very-Wet-Year	0.0180	1.0000	5	999	0	No	0	9999
MSD-B:OP	MSD-C:OP	Drought	0.0056	1.0000	5	999	0	No	0	9999
MSD-B:OP	MSD-U:SES	EX-Invasion	0.0050	1.0000	5	999	0	Yes	0	9999
MSD-C:OP	MSD-A:AL	Very-Wet-Year	0.0500	1.0000	10	59	0	No	0	9999
MSD-C:OP	MSD-C:OP	Drought	0.0056	1.0000	10	59	-999	No	0	9999
MSD-C:OP	MSD-U:SES	EX-Invasion	0.0050	1.0000	10	59	0	Yes	0	9999
MSD-U:EX	MSD-U:EX	ReplacementFire	0.1000	1.0000	0	999	-999	No	0	9999
MSD-U:SD	MSD-A:AL	Natural-Recovery	0.0010	1.0000	0	4	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
MSD-U:SD	MSD-B:OP	Natural-Recovery	0.0050	1.0000	5	999	0	Yes	0	9999
MSD-U:SD	MSD-U:EX	EX-Invasion	0.0050	1.0000	0	4	0	No	0	9999
MSD-U:SD	MSD-U:SD	Drought	0.0056	1.0000	0	4	-999	No	0	9999
MSD-U:SD	MSD-U:SD	Drought	0.0056	1.0000	5	999	-1	No	0	9999
MSD-U:SD	MSD-U:SD	Managed-Herbivory	1.0000	0.0500	3	999	1	No	0	9999
MSD-U:SD	MSD-U:SD	Very-Wet-Year	0.0180	1.0000	0	999	-999	No	0	9999
MSD-U:SD	MSD-U:SES	EX-Invasion	0.0050	1.0000	5	999	0	No	0	9999
MSD-U:SES	MSD-U:EX	ReplacementFire	0.0250	1.0000	5	999	0	No	0	9999
MSD-U:SES	MSD-U:EX	Very-Wet-Year	0.0500	1.0000	5	999	0	No	0	9999
MSh-A:AL	MSh-A:AL	Managed-Herbivory	1.0000	0.0500	2	5	-999	No	0	9999
MSh-A:AL	MSh-A:AL	NativeHerbivory	1.0000	0.0200	0	999	-1	No	0	9999
MSh-A:AL	MSh-A:AL	Wet-Year	0.1500	1.0000	0	5	-1	No	0	9999
MSh-A:AL	MSh-U:ES	Excessive-Herbivory	0.0010	1.0000	0	5	0	Yes	0	9999
MSh-A:AL	MSh-U:EX	EX-Invasion	0.0025	1.0000	0	5	0	Yes	0	9999
MSh-B:CL	MSh-A:AL	ReplacementFire	0.0140	1.0000	6	19	0	No	0	9999
MSh-B:CL	MSh-B:CL	Managed-Herbivory	1.0000	0.0500	6	19	1	No	0	9999
MSh-B:CL	MSh-U:ES	Excessive-Herbivory	0.0010	1.0000	5	19	0	Yes	0	9999
MSh-B:CL	MSh-U:SEP	EX-Invasion	0.0025	1.0000	20	49	0	Yes	0	9999
MSh-C:CL	MSh-A:AL	ReplacementFire	0.0140	1.0000	20	999	0	No	0	9999
MSh-C:CL	MSh-C:CL	Managed-Herbivory	1.0000	0.0500	20	999	1	No	0	9999
MSh-C:CL	MSh-D:OP	Tree-Invasion	0.0010	1.0000	50	99	0	No	0	9999
MSh-C:CL	MSh-D:OP	Tree-Invasion	0.0050	1.0000	99	999	0	No	0	9999
MSh-C:CL	MSh-U:ES	Excessive-Herbivory	1.0000	0.0010	20	999	0	Yes	0	9999
MSh-C:CL	MSh-U:SEP	EX-Invasion	0.0025	1.0000	20	999	0	Yes	0	9999
MSh-D:OP	MSh-A:AL	Chainsaw-Thinning-MSh	0.0100	0.2000	50	999	0	No	0	9999
MSh-D:OP	MSh-A:AL	ReplacementFire	0.0067	1.0000	50	999	0	No	0	9999
MSh-D:OP	MSh-B:CL	Chainsaw-Thinning-MSh	0.0100	0.8000	50	999	0	No	0	9999
MSh-D:OP	MSh-C:CL	Drought	0.0056	0.1000	50	999	0	No	0	9999
MSh-D:OP	MSh-D:OP	Drought	0.0056	0.9000	50	999	-999	No	0	9999
MSh-D:OP	MSh-U:TE	Tree-Encroachment	0.0067	1.0000	150	999	0	Yes	0	9999
MSh-D:OP	MSh-U:TEX	EX-Invasion	0.0025	1.0000	50	999	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
MSh-U:ES	MSh-U:ES	Managed-Herbivory	1.0000	0.0500	0	999	0	No	0	9999
MSh-U:ES	MSh-U:ES	ReplacementFire	0.0140	1.0000	0	999	-999	No	0	9999
MSh-U:EX	MSh-A:AL	Herbicide+SeedRose-MSh	0.0100	0.5000	0	999	0	No	0	9999
MSh-U:EX	MSh-U:EX	Herbicide+SeedRose-MSh	0.0100	0.5000	0	999	0	No	0	9999
MSh-U:EX	MSh-U:EX	Managed-Herbivory	1.0000	0.0500	2	999	0	No	0	9999
MSh-U:EX	MSh-U:EX	ReplacementFire	0.1000	1.0000	0	999	-999	No	0	9999
MSh-U:EX	MSh-U:EX	Wet-Year	0.1500	1.0000	0	5	-5	No	0	9999
MSh-U:SEP	MSh-B:CL	Hrbx+SeedGrass-MSh	0.0100	0.7000	0	999	0	Yes	0	9999
MSh-U:SEP	MSh-U:EX	ReplacementFire	0.0250	1.0000	6	300	0	No	0	9999
MSh-U:SEP	MSh-U:SEP	Excessive-Herbivory	1.0000	0.0010	6	999	3	No	0	9999
MSh-U:SEP	MSh-U:SEP	Hrbx+SeedGrass-MSh	0.0100	0.3000	6	999	0	No	0	9999
MSh-U:SEP	MSh-U:SEP	Managed-Herbivory	1.0000	0.0500	6	999	1	No	0	9999
MSh-U:SEP	MSh-U:TEX	Tree-Invasion	0.0010	1.0000	50	99	0	No	0	9999
MSh-U:SEP	MSh-U:TEX	Tree-Invasion	0.0050	1.0000	100	999	0	No	0	9999
MSh-U:TE	MSh-A:AL	Thin+Hrbx+SeedRose-MSh	0.0100	0.9000	150	999	0	No	0	9999
MSh-U:TE	MSh-U:ES	Drought	0.0056	0.1000	150	999	0	No	0	9999
MSh-U:TE	MSh-U:ES	ReplacementFire	0.0067	1.0000	150	999	0	No	0	9999
MSh-U:TE	MSh-U:ES	Thin+Hrbx+SeedRose-MSh	0.0100	0.1000	150	999	0	No	0	9999
MSh-U:TE	MSh-U:TE	Drought	0.0056	0.9000	150	999	-999	No	0	9999
MSh-U:TE	MSh-U:TEX	EX-Invasion	0.0050	1.0000	150	999	0	Yes	0	9999
MSh-U:TEX	MSh-A:AL	Thin+Hrbx+SeedRose-MSh	0.0100	0.8000	50	999	0	No	0	9999
MSh-U:TEX	MSh-U:EX	Drought	0.0056	0.1000	50	999	0	No	0	9999
MSh-U:TEX	MSh-U:EX	ReplacementFire	0.0067	1.0000	150	999	0	No	0	9999
MSh-U:TEX	MSh-U:EX	Thin+Hrbx+SeedRose-MSh	0.0100	0.2000	50	999	0	No	0	9999
MSh-U:TEX	MSh-U:SEP	ReplacementFire	0.0067	1.0000	50	149	0	No	0	9999
MSh-U:TEX	MSh-U:TEX	Drought	0.0056	0.9000	50	999	-999	No	0	9999
PJ-A:AL	PJ-A:AL	ReplacementFire	0.0030	1.0000	0	9	-999	No	0	9999
PJ-B:OP	PJ-A:AL	ReplacementFire	0.0050	1.0000	10	29	0	No	0	9999
PJ-C:OP	PJ-A:AL	ReplacementFire	0.0050	1.0000	30	99	0	No	0	9999
PJ-C:OP	PJ-B:OP	Drought	0.0056	0.1000	30	99	0	No	0	9999
PJ-C:OP	PJ-C:OP	Drought	0.0056	0.9000	30	99	-999	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
PJ-C:OP	PJ-U:TEX	EX-Invasion	0.0001	1.0000	50	99	0	Yes	0	9999
PJ-D:OP	PJ-A:AL	ReplacementFire	0.0010	1.0000	100	999	0	No	0	9999
PJ-D:OP	PJ-B:OP	Drought	0.0067	0.0300	100	999	0	No	0	9999
PJ-D:OP	PJ-C:OP	Drought	0.0057	0.0700	100	999	0	No	0	9999
PJ-D:OP	PJ-D:OP	Drought	0.0056	0.9000	100	999	-999	No	0	9999
PJ-D:OP	PJ-U:TEX	EX-Invasion	0.0010	1.0000	100	999	0	Yes	0	9999
PJ-U:EX	PJ-A:AL	Hrbx+Seed-PJ	0.0100	0.6000	0	999	0	No	0	9999
PJ-U:EX	PJ-U:EX	Hrbx+Seed-PJ	0.0100	0.4000	0	999	0	No	0	9999
PJ-U:EX	PJ-U:EX	ReplacementFire	0.1000	1.0000	0	999	-999	No	0	9999
PJ-U:TEX	PJ-C:OP	Herbicide-PJ	0.0100	0.6000	30	99	0	Yes	0	9999
PJ-U:TEX	PJ-D:OP	Herbicide-PJ	0.0100	0.6000	100	999	0	Yes	0	9999
PJ-U:TEX	PJ-U:EX	Drought	0.0056	0.1000	100	999	0	No	0	9999
PJ-U:TEX	PJ-U:EX	ReplacementFire	0.0050	1.0000	100	999	0	No	0	9999
PJ-U:TEX	PJ-U:TEX	Drought	0.0056	0.9000	100	999	-999	No	0	9999
PJ-U:TEX	PJ-U:TEX	Herbicide-PJ	0.0100	0.4000	0	999	0	No	0	9999
SWA-A:AL	SWA-A:AL	Flash-Flood	0.1400	1.0000	0	4	-999	No	0	9999
SWA-A:AL	SWA-A:AL	FuelBreak	0.0100	1.0000	0	4	0	No	0	9999
SWA-A:AL	SWA-A:AL	Livestock-Closure	0.0100	1.0000	1	4	0	No	0	9999
SWA-A:AL	SWA-A:AL	Managed-Herbivory	1.0000	0.0500	2	4	1	No	10	9999
SWA-A:AL	SWA-A:AL	ReplacementFire-Mojave	0.0001	1.0000	0	4	-999	No	3	9999
SWA-A:AL	SWA-A:AL	Utilities	0.0001	0.3000	0	4	-999	No	0	9999
SWA-A:AL	SWA-A:AL	Weed-Inventory-WAS	0.0100	1.0000	0	4	0	No	0	9999
SWA-A:AL	SWA-U:BG	OHV	1.0000	0.0001	0	4	0	No	2	9999
SWA-A:AL	SWA-U:ES	Excessive-Herbivory	1.0000	0.0005	0	4	0	No	10	9999
SWA-A:AL	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	0	4	0	Yes	5	9999
SWA-A:AL	SWA-U:SEP	EX-Invasion	0.0050	1.0000	0	4	0	Yes	0	9999
SWA-A:AL	SWA-U:SES	Utilities	0.0001	0.7000	0	4	0	No	0	9999
SWA-B:CL	SWA-A:AL	Flash-Flood	0.0500	1.0000	5	19	0	No	0	9999
SWA-B:CL	SWA-A:AL	Utilities	0.0001	0.3000	5	19	0	No	0	9999
SWA-B:CL	SWA-B:CL	FuelBreak	0.0100	1.0000	5	19	0	No	0	9999
SWA-B:CL	SWA-B:CL	Livestock-Closure	0.0100	1.0000	1	19	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
SWA-B:CL	SWA-B:CL	Managed-Herbivory	1.0000	0.0500	5	19	1	No	10	9999
SWA-B:CL	SWA-B:CL	ReplacementFire-Mojave	0.0010	1.0000	5	19	0	No	3	9999
SWA-B:CL	SWA-B:CL	Weed-Inventory-WAS	0.0100	1.0000	5	19	0	No	0	9999
SWA-B:CL	SWA-U:BG	OHV	1.0000	0.0001	5	19	0	No	2	9999
SWA-B:CL	SWA-U:ES	Excessive-Herbivory	1.0000	0.0005	5	19	0	No	10	9999
SWA-B:CL	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	5	19	0	Yes	5	9999
SWA-B:CL	SWA-U:SEP	EX-Invasion	0.0050	1.0000	5	19	0	Yes	0	9999
SWA-B:CL	SWA-U:SES	Utilities	0.0001	0.7000	5	999	0	No	0	9999
SWA-C:CL	SWA-A:AL	Flash-Flood	0.0100	1.0000	20	999	0	No	0	9999
SWA-C:CL	SWA-A:AL	Utilities	0.0001	0.3000	20	999	0	No	0	9999
SWA-C:CL	SWA-B:CL	ReplacementFire-Mojave	0.0010	1.0000	20	999	0	No	3	9999
SWA-C:CL	SWA-C:CL	FuelBreak	0.0100	1.0000	20	999	0	No	0	9999
SWA-C:CL	SWA-C:CL	Livestock-Closure	0.0100	1.0000	20	999	0	No	0	9999
SWA-C:CL	SWA-C:CL	Managed-Herbivory	1.0000	0.0500	20	999	1	No	10	9999
SWA-C:CL	SWA-C:CL	Weed-Inventory-WAS	0.0100	1.0000	20	999	0	No	0	9999
SWA-C:CL	SWA-U:BG	OHV	1.0000	0.0001	20	999	0	No	2	9999
SWA-C:CL	SWA-U:ES	Excessive-Herbivory	1.0000	0.0005	20	999	0	Yes	10	9999
SWA-C:CL	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	20	999	0	No	5	9999
SWA-C:CL	SWA-U:SEP	EX-Invasion	0.0050	1.0000	20	999	0	Yes	0	9999
SWA-C:CL	SWA-U:SES	Utilities	0.0001	0.7000	20	999	0	No	0	9999
SWA-U:BG	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:BG	SWA-U:BG	OHV	1.0000	0.0001	0	999	-999	No	2	9999
SWA-U:BG	SWA-U:BG	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:BG	SWA-U:ET	Exotic-Tree-Invasion	0.0050	1.0000	0	999	0	Yes	5	9999
SWA-U:BG	SWA-U:SES	EX-Invasion	0.0050	1.0000	0	999	0	Yes	0	9999
SWA-U:BG	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-U:ES	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:ES	SWA-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
SWA-U:ES	SWA-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	3	No	10	9999
SWA-U:ES	SWA-U:ES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:ES	SWA-U:ES	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
SWA-U:ES	SWA-U:ES	Managed-Herbivory	1.0000	0.0500	0	999	1	No	10	9999
SWA-U:ES	SWA-U:ES	ReplacementFire-Mojave	0.0015	1.0000	0	999	0	No	3	9999
SWA-U:ES	SWA-U:ES	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:ES	SWA-U:ET	Exotic-Tree-Invasion	0.0050	1.0000	0	999	0	Yes	5	9999
SWA-U:ES	SWA-U:SES	EX-Invasion	0.0050	1.0000	0	999	0	Yes	0	9999
SWA-U:ES	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-U:ET	SWA-A:AL	Beetle-Mortality	0.2500	1.0000	0	4	0	Yes	0	9999
SWA-U:ET	SWA-A:AL	Exotic-Control-WAS	0.0100	0.9000	0	4	0	No	0	50
SWA-U:ET	SWA-A:AL	Flash-Flood	0.0100	0.0100	0	999	0	No	0	9999
SWA-U:ET	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:ET	SWA-B:CL	Beetle-Mortality	0.2500	1.0000	5	19	0	Yes	0	9999
SWA-U:ET	SWA-B:CL	Exotic-Control-WAS	0.0100	0.9000	5	19	0	No	0	50
SWA-U:ET	SWA-C:CL	Beetle-Mortality	0.2500	1.0000	20	999	0	Yes	0	9999
SWA-U:ET	SWA-C:CL	Exotic-Control-WAS	0.0100	0.9000	20	999	0	No	0	50
SWA-U:ET	SWA-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
SWA-U:ET	SWA-U:ET	Excessive-Herbivory	1.0000	0.0010	0	999	3	No	10	9999
SWA-U:ET	SWA-U:ET	Exotic-Control-WAS	0.0100	0.1000	0	999	0	No	0	50
SWA-U:ET	SWA-U:ET	Flash-Flood	0.0100	0.9900	0	999	-999	No	0	9999
SWA-U:ET	SWA-U:ET	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:ET	SWA-U:ET	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-U:ET	SWA-U:ET	Managed-Herbivory	1.0000	0.0500	0	999	1	No	10	9999
SWA-U:ET	SWA-U:ET	ReplacementFire-Mojave	0.0200	1.0000	0	999	-999	No	3	9999
SWA-U:ET	SWA-U:ET	Utilities	0.0001	0.7000	0	999	-999	No	0	9999
SWA-U:SEP	SWA-A:AL	Fingers-of-Death-SWA	0.0100	0.7500	0	4	0	Yes	0	9999
SWA-U:SEP	SWA-A:AL	Flash-Flood	0.0100	0.0100	0	999	0	No	0	9999
SWA-U:SEP	SWA-A:AL	Herbicide-WAS	0.0100	0.5000	0	4	0	Yes	0	9999
SWA-U:SEP	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:SEP	SWA-B:CL	Fingers-of-Death-SWA	0.0100	0.7500	5	19	0	Yes	0	9999
SWA-U:SEP	SWA-B:CL	Herbicide-WAS	0.0100	0.5000	5	19	0	Yes	0	9999
SWA-U:SEP	SWA-C:CL	Fingers-of-Death-SWA	0.0100	0.7500	20	999	0	Yes	0	9999
SWA-U:SEP	SWA-C:CL	Herbicide-WAS	0.0100	0.5000	20	999	0	Yes	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
SWA-U:SEP	SWA-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
SWA-U:SEP	SWA-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	No	10	9999
SWA-U:SEP	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	0	999	0	Yes	5	9999
SWA-U:SEP	SWA-U:SEP	Fingers-of-Death-SWA	0.0100	0.2500	0	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	Flash-Flood	0.0100	0.9900	0	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	Herbicide-WAS	0.0100	0.5000	0	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-U:SEP	SWA-U:SEP	ReplacementFire-Mojave	0.0200	1.0000	0	999	-999	No	3	9999
SWA-U:SEP	SWA-U:SEP	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	Yes	0	9999
SWA-U:SEP	SWA-U:SES	Managed-Herbivory	1.0000	0.0500	20	999	0	No	10	9999
SWA-U:SEP	SWA-U:SES	Managed-Herbivory	1.0000	0.0500	0	19	1	No	10	9999
SWA-U:SEP	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-U:SES	SWA-A:AL	Fingers-of-Death-SWA	0.0100	0.7500	0	4	0	Yes	0	9999
SWA-U:SES	SWA-A:AL	Flash-Flood	0.0100	0.0100	0	999	0	No	0	9999
SWA-U:SES	SWA-A:AL	Herbicide-WAS	0.0100	0.5000	0	4	0	Yes	0	9999
SWA-U:SES	SWA-A:AL	Utilities	0.0001	0.3000	0	999	0	No	0	9999
SWA-U:SES	SWA-B:CL	Herbicide-WAS	0.0100	0.5000	5	19	0	Yes	0	9999
SWA-U:SES	SWA-C:CL	Fingers-of-Death-SWA	0.0100	0.7500	5	19	0	Yes	0	9999
SWA-U:SES	SWA-C:CL	Fingers-of-Death-SWA	0.0100	0.7500	20	999	0	No	0	9999
SWA-U:SES	SWA-C:CL	Herbicide-WAS	0.0100	0.5000	20	999	0	Yes	0	9999
SWA-U:SES	SWA-U:BG	OHV	1.0000	0.0001	0	999	0	No	2	9999
SWA-U:SES	SWA-U:ES	Excessive-Herbivory	1.0000	0.0010	0	999	0	Yes	10	9999
SWA-U:SES	SWA-U:ET	Exotic-Tree-Invasion	0.0001	1.0000	0	999	0	Yes	5	9999
SWA-U:SES	SWA-U:SES	Fingers-of-Death-SWA	0.0100	0.2500	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Flash-Flood	0.0100	0.9900	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	FuelBreak	0.0100	1.0000	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Herbicide-WAS	0.0100	0.5000	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Livestock-Closure	0.0100	1.0000	1	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Managed-Herbivory	1.0000	0.0500	2	999	1	No	10	9999
SWA-U:SES	SWA-U:SES	ReplacementFire-Mojave	0.0500	1.0000	0	999	-999	No	3	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
SWA-U:SES	SWA-U:SES	Utilities	0.0001	0.7000	0	999	0	No	0	9999
SWA-U:SES	SWA-U:SES	Weed-Inventory-WAS	0.0100	1.0000	0	999	0	No	0	9999
WDR-A:AL	WDR-A:AL	Flooding-7yr	0.1300	1.0000	0	4	-999	No	0	9999
WDR-A:AL	WDR-A:AL	Managed-Herbivory	1.0000	0.0500	2	4	-999	No	0	9999
WDR-A:AL	WDR-A:AL	Weed-Inventory	0.0100	1.0000	0	4	0	No	0	9999
WDR-A:AL	WDR-U:DE	Excessive-Herbivory	1.0000	0.0010	0	4	0	Yes	0	9999
WDR-A:AL	WDR-U:EF	Exotic-Forb-Invasion	0.0100	1.0000	0	4	0	No	5	9999
WDR-A:AL	WDR-U:ET	Exotic-Tree-Invasion	0.0100	1.0000	0	4	0	No	5	9999
WDR-A:AL	WDR-U:TEX	EX-Invasion	0.0050	1.0000	0	4	0	Yes	0	9999
WDR-B:CL	WDR-A:AL	Flooding-20yr	0.0500	1.0000	5	19	0	No	0	9999
WDR-B:CL	WDR-B:CL	Managed-Herbivory	1.0000	0.0500	5	19	-1	No	0	9999
WDR-B:CL	WDR-B:CL	Weed-Inventory	0.0100	1.0000	5	19	0	No	0	9999
WDR-B:CL	WDR-U:DE	Excessive-Herbivory	1.0000	0.0010	5	19	0	Yes	0	9999
WDR-B:CL	WDR-U:EF	Exotic-Forb-Invasion	0.0075	1.0000	5	19	0	No	5	9999
WDR-B:CL	WDR-U:ET	Exotic-Tree-Invasion	0.0075	1.0000	5	19	0	No	5	9999
WDR-B:CL	WDR-U:TEX	EX-Invasion	0.0050	1.0000	0	19	0	Yes	0	9999
WDR-C:OP	WDR-A:AL	Flooding-20yr	0.0500	1.0000	1	89	0	No	0	9999
WDR-C:OP	WDR-C:OP	Managed-Herbivory	1.0000	0.0500	1	89	-1	No	0	9999
WDR-C:OP	WDR-U:DE	Excessive-Herbivory	1.0000	0.0010	1	89	0	Yes	0	9999
WDR-C:OP	WDR-U:EF	Exotic-Forb-Invasion	0.0075	1.0000	5	89	0	Yes	5	9999
WDR-C:OP	WDR-U:EF	Exotic-Forb-Invasion	0.0100	1.0000	1	4	0	Yes	5	9999
WDR-C:OP	WDR-U:ET	Exotic-Tree-Invasion	0.0075	1.0000	5	89	0	Yes	5	9999
WDR-C:OP	WDR-U:ET	Exotic-Tree-Invasion	0.0100	1.0000	1	4	0	Yes	5	9999
WDR-C:OP	WDR-U:TEX	EX-Invasion	0.0050	1.0000	1	89	0	Yes	0	9999
WDR-D:CL	WDR-A:AL	Flooding-100yr	0.0100	1.0000	20	89	0	No	0	9999
WDR-D:CL	WDR-C:OP	ReplacementFire	0.0013	1.0000	20	89	0	No	0	9999
WDR-D:CL	WDR-D:CL	Managed-Herbivory	1.0000	0.0500	20	89	1	No	0	9999
WDR-D:CL	WDR-D:CL	Weed-Inventory	0.0100	1.0000	20	89	0	No	0	9999
WDR-D:CL	WDR-U:DE	Excessive-Herbivory	1.0000	0.0010	20	89	0	Yes	0	9999
WDR-D:CL	WDR-U:EF	Exotic-Forb-Invasion	0.0050	1.0000	20	89	0	No	5	9999
WDR-D:CL	WDR-U:ET	Exotic-Tree-Invasion	0.0050	1.0000	20	89	0	No	5	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
WDR-D:CL	WDR-U:TEX	EX-Invasion	0.0050	1.0000	20	89	0	Yes	0	9999
WDR-E:CL	WDR-A:AL	Flooding-100yr	0.0020	1.0000	90	999	0	No	0	9999
WDR-E:CL	WDR-C:OP	Flooding-100yr	0.0100	1.0000	90	999	0	No	0	9999
WDR-E:CL	WDR-C:OP	ReplacementFire	0.0040	1.0000	90	999	0	No	0	9999
WDR-E:CL	WDR-C:OP	Senescence	0.0200	1.0000	450	999	0	No	0	9999
WDR-E:CL	WDR-E:CL	Managed-Herbivory	1.0000	0.0500	90	999	0	No	0	9999
WDR-E:CL	WDR-E:CL	Weed-Inventory	0.0100	1.0000	90	999	0	No	0	9999
WDR-E:CL	WDR-U:DE	Excessive-Herbivory	1.0000	0.0010	90	999	0	Yes	0	9999
WDR-E:CL	WDR-U:EF	Exotic-Forb-Invasion	0.0050	1.0000	90	999	0	No	5	9999
WDR-E:CL	WDR-U:ET	Exotic-Tree-Invasion	0.0050	1.0000	90	999	0	Yes	5	9999
WDR-E:CL	WDR-U:TEX	EX-Invasion	0.0050	1.0000	90	999	0	Yes	0	9999
WDR-U:DE	WDR-A:AL	Flooding-100yr	0.0100	0.0100	1	999	0	No	0	9999
WDR-U:DE	WDR-A:AL	Floodplain-Restoration	0.0100	0.9000	1	999	0	No	0	9999
WDR-U:DE	WDR-U:DE	Flooding-100yr	0.0100	0.9900	1	999	-999	No	0	9999
WDR-U:DE	WDR-U:DE	Floodplain-Restoration	0.0100	0.1000	1	999	0	No	0	9999
WDR-U:DE	WDR-U:DE	Weed-Inventory	0.0100	1.0000	0	999	0	No	0	9999
WDR-U:DE	WDR-U:DEF	Exotic-Forb-Invasion	0.0075	1.0000	1	999	0	Yes	5	9999
WDR-U:DE	WDR-U:DET	Exotic-Tree-Invasion	0.0075	1.0000	1	999	0	Yes	5	9999
WDR-U:DEF	WDR-U:DE	Exotic-Forb-Control	0.0100	0.6000	1	999	0	No	0	20
WDR-U:DEF	WDR-U:DEF	Exotic-Forb-Control	0.0100	0.4000	1	999	0	No	0	20
WDR-U:DEF	WDR-U:DEF	Flooding-100yr	0.0100	0.9900	1	999	-999	No	0	9999
WDR-U:DEF	WDR-U:EF	Flooding-100yr	0.0100	0.0100	1	999	0	No	0	9999
WDR-U:DET	WDR-U:DE	Beetle-Mortality	0.2500	0.2500	0	999	0	Yes	0	9999
WDR-U:DET	WDR-U:DE	Exotic-Tree-Control	0.0100	0.8000	1	999	0	No	0	20
WDR-U:DET	WDR-U:DEF	Beetle-Mortality	0.2500	0.7500	0	999	0	Yes	0	9999
WDR-U:DET	WDR-U:DEF	Exotic-Tree-Control	0.0100	0.1000	1	999	0	No	0	20
WDR-U:DET	WDR-U:DET	Exotic-Tree-Control	0.0100	0.1000	1	999	0	No	0	20
WDR-U:DET	WDR-U:DET	Flooding-100yr	0.0100	0.9900	1	999	-999	No	0	9999
WDR-U:DET	WDR-U:DET	ReplacementFire	0.0500	1.0000	5	999	-999	No	0	9999
WDR-U:DET	WDR-U:ET	Flooding-100yr	0.0100	0.0100	1	999	0	No	0	9999
WDR-U:DEX	WDR-A:AL	Flooding-100yr	0.0100	0.0100	0	999	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
WDR-U:DEX	WDR-U:DEF	Exotic-Forb-Invasion	0.0050	1.0000	0	999	0	Yes	5	9999
WDR-U:DEX	WDR-U:DET	Exotic-Tree-Invasion	0.0050	1.0000	0	999	0	Yes	5	9999
WDR-U:DEX	WDR-U:DEX	Excessive-Herbivory	1.0000	0.0010	0	999	3	No	0	9999
WDR-U:DEX	WDR-U:DEX	Flooding-100yr	0.0100	0.9900	0	999	-999	No	0	9999
WDR-U:DEX	WDR-U:DEX	Managed-Herbivory	1.0000	0.0500	0	999	1	No	0	9999
WDR-U:DEX	WDR-U:DEX	ReplacementFire	0.0500	1.0000	0	999	-999	No	0	9999
WDR-U:DEX	WDR-U:DEX	Weed-Inventory	0.0100	1.0000	0	999	0	No	0	9999
WDR-U:EF	WDR-A:AL	Exotic-Forb-Control	0.0100	0.6000	0	999	0	No	0	20
WDR-U:EF	WDR-U:EF	Exotic-Forb-Control	0.0100	0.4000	0	999	0	No	0	20
WDR-U:EF	WDR-U:EF	Flooding-100yr	0.0100	1.0000	0	999	-999	No	0	9999
WDR-U:ET	WDR-A:AL	Beetle-Mortality	0.2500	1.0000	0	4	0	Yes	0	9999
WDR-U:ET	WDR-A:AL	Exotic-Tree-Control	0.0100	0.8000	0	999	0	No	0	20
WDR-U:ET	WDR-A:AL	Flooding-100yr	0.0100	0.0100	0	999	0	No	0	9999
WDR-U:ET	WDR-B:CL	Beetle-Mortality	0.2500	1.0000	5	19	0	Yes	0	9999
WDR-U:ET	WDR-C:OP	Beetle-Mortality	0.2500	1.0000	0	89	0	Yes	0	9999
WDR-U:ET	WDR-D:CL	Beetle-Mortality	0.2500	1.0000	20	89	0	Yes	0	9999
WDR-U:ET	WDR-E:CL	Beetle-Mortality	0.2500	1.0000	90	999	0	Yes	0	9999
WDR-U:ET	WDR-U:DET	Entrenchment	0.0001	1.0000	0	999	0	Yes	10	9999
WDR-U:ET	WDR-U:EF	Exotic-Tree-Control	0.0100	0.1000	0	999	0	No	0	20
WDR-U:ET	WDR-U:ET	Exotic-Tree-Control	0.0100	0.1000	0	999	0	No	0	20
WDR-U:ET	WDR-U:ET	Flooding-100yr	0.0100	0.9900	0	999	-999	No	0	9999
WDR-U:ET	WDR-U:ET	ReplacementFire	0.0500	1.0000	0	999	-999	No	0	9999
WDR-U:EX	WDR-A:AL	Flooding-100yr	0.0100	0.0100	0	500	-999	No	0	9999
WDR-U:EX	WDR-U:DE	Excessive-Herbivory	1.0000	0.0010	0	500	0	Yes	0	9999
WDR-U:EX	WDR-U:EF	Exotic-Forb-Invasion	0.0075	1.0000	0	500	0	Yes	5	9999
WDR-U:EX	WDR-U:ET	Exotic-Tree-Invasion	0.0075	1.0000	0	500	0	Yes	5	9999
WDR-U:EX	WDR-U:EX	Flooding-100yr	0.0100	0.9900	0	500	-999	No	0	9999
WDR-U:EX	WDR-U:EX	Managed-Herbivory	1.0000	0.0500	0	500	-999	No	0	9999
WDR-U:EX	WDR-U:EX	ReplacementFire	0.0500	1.0000	0	500	-999	No	0	9999
WDR-U:TEX	WDR-A:AL	Flooding-100yr	0.0100	0.0100	20	999	0	No	0	9999
WDR-U:TEX	WDR-A:AL	Hrbx-EX-WDR	0.0100	0.5000	0	5	0	No	0	9999

From Class	To Class	Transition Type	Prob	Propn	Start Age	End Age	Rel Age	Keep Age	Min TST	Max TST
WDR-U:TEX	WDR-B:CL	Hrbx-EX-WDR	0.0100	0.5000	5	19	0	No	0	9999
WDR-U:TEX	WDR-D:CL	Hrbx-EX-WDR	0.0100	0.5000	20	89	0	No	0	9999
WDR-U:TEX	WDR-E:CL	Hrbx-EX-WDR	0.0100	0.5000	90	999	0	No	0	9999
WDR-U:TEX	WDR-U:DE	Excessive-Herbivory	1.0000	0.0010	5	19	0	Yes	0	9999
WDR-U:TEX	WDR-U:EF	Exotic-Forb-Invasion	0.0075	1.0000	5	999	0	Yes	5	9999
WDR-U:TEX	WDR-U:ET	Exotic-Tree-Invasion	0.0075	1.0000	5	999	0	No	5	9999
WDR-U:TEX	WDR-U:EX	Flooding-100yr	0.0100	0.9900	20	999	0	No	0	9999
WDR-U:TEX	WDR-U:EX	Flooding-20yr	0.0500	1.0000	5	19	0	No	0	9999
WDR-U:TEX	WDR-U:EX	ReplacementFire	0.0015	1.0000	5	999	0	No	0	9999
WDR-U:TEX	WDR-U:TEX	Hrbx-EX-WDR	0.0100	0.5000	0	999	0	No	0	9999
WDR-U:TEX	WDR-U:TEX	Managed-Herbivory	1.0000	0.0500	5	999	1	No	0	9999
WDR-U:TEX	WDR-U:TEX	Weed-Inventory	0.0100	1.0000	5	999	0	No	0	9999

Appendix 4. Temporal Multipliers

Fire Activity

Federal data were available for fire activity between 1980 and 2009 for both NCAs. Data from the Federal Fire Occurrence Website were downloaded for the whole western U.S.A. and time series of fire size from 1980 to 2009 were extracted from "clipped" NCAs with ARC GIS 10. Five time series of fire activity were used as replicates for all scenarios. The Red Cliffs and Beaver Dam Wash time series were each 29 years long; time series for 50 years were created by re-sampling the original fire series data (the original 29-year data sequence was not used in any replicate) using the yearly total area burned divided by the temporal average of total area burned. All fire activity was assumed replacement fire.

The 10 time series (i.e., 5 replicates × 2 landscapes) were uploaded into PATH. For strictly management reasons, we used the same variability time series for two different parameters: Mojave replacement fire and (upper elevation) replacement fire. Each yearly value in a replicate temporal multiplier multiplied the average wildfire rate in the models for a specific time step. All replicates had several peaks of fire activity with the fourth replicate being the least active (Figure 4-1).

Upland Variability

Remaining upland temporal multipliers were climate related: drought-induced mortality, annual grass invasion rate, and tree invasion rate. The Palmer Drought Severity Index (PDSI; Heddinghaus and Sabol 1991) was used for all multipliers. PDSI is a long-term drought measure because it incorporates the cumulative influence of past monthly observations (Heddinghaus and Sabol 1991). PDSI values are available from 1895 to current for the four climatic regions of Nevada and Utah. The Mojave Desert is in climate division #4. PDSI values starting in 1935 to 2009 were extracted and this original 75-year time series was resampled five times times for 50 years to obtain a total of five replicates. Negative PDSI values indicate drought, whereas positive ones represent wetter than average years. Severe droughts and very wet periods, respectively, have PDSI values <-3 and >3. Taylor and Beaty (2005) showed that the PDSI 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. 2006). 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, *in press*).

We assumed that more severe droughts cause increased mortality, whereas wetter conditions suppress mortality. Because PDSI can be negative, therefore incompatible with VDDT, we chose a negative exponential function to create positive values that increased exponentially with smaller (more negative) PDSI values:

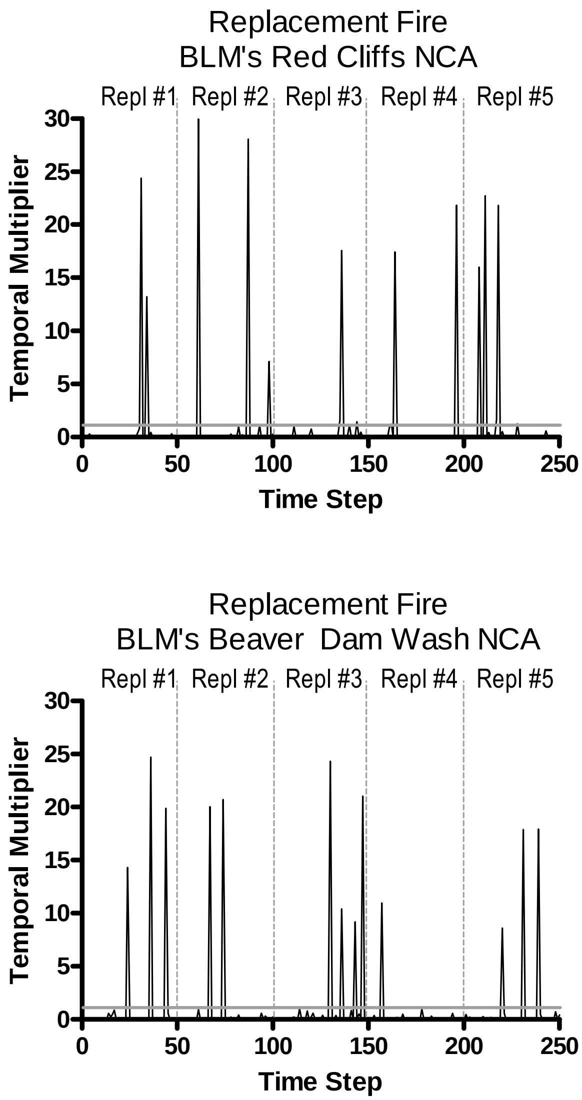
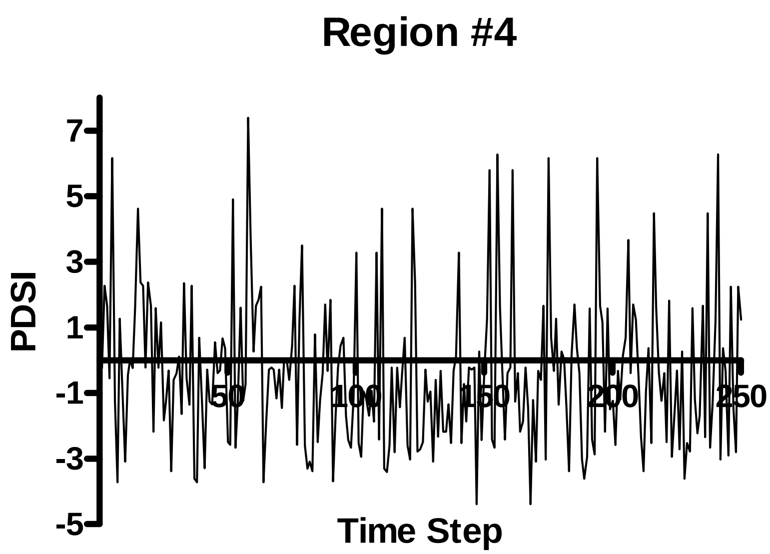


Figure 4-1. Five replicates of temporal probability multipliers for fire activity. Each replicate is numbered and represented by 50-year period. The horizontal gray line for temporal multiplier = 1 represents the "no-change" or neutral parameter line.

$$\text{Temporal multiplier for drought mortality} = 0.6\times e^{-0.6\times \text{PDSI}}$$

The parameters of this function were chosen such that PDSI values close to -3 were slightly greater than 3 (actually, 3.63) and that very severe droughts with PDSI as high as -5.2 translated into slightly more than doubling of the temporal multipliers (13.8). Another consideration was that a mild drought characterized by a PDSI of -1 would about equal to a neutral temporal multiplier value of 1. Figure 4-2 demonstrates the relationship between PDSI and the temporal multiplier for climatic division #4.



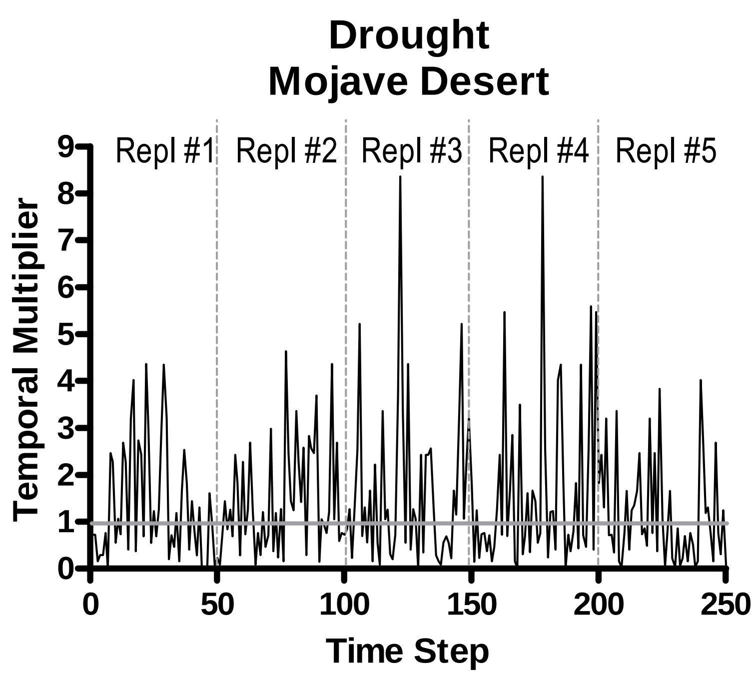


Figure 4-2. Palmer drought severity index (PDSI) time series (top) and calculated drought temporal multipliers (bottom) for the fourth climatic divisions of Nevada and Utah. Five replicates (Repl) are shown each per 50-year period. The gray line for PDSI = 0 represented average drought conditions, whereas the gray line for the drought temporal multiplier = 1 represented the "no-change" or neutral parameter line.

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. This implies that PDSI was directly related to the variability of these invasion rates:

Annual grass invasion (Figure 4-3 top)

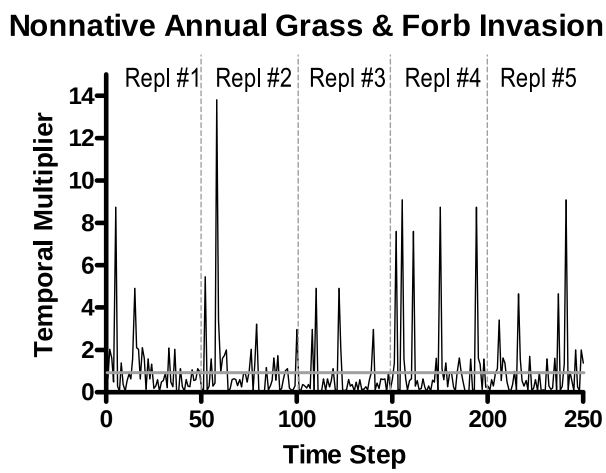
PDSI > 0, temporal multiplier = $(0.75 \times e^{0.75 \times PDSI})^{0.5}$

PDSI ≤ 0, temporal multiplier = $0.75 \times e^{0.75 \times PDSI}$

Tree invasion (Figure 4-3 bottom)

PDSI > 0, temporal multiplier = $(0.2 \times e^{0.8 \times PDSI})^{0.5}$

PDSI ≤ 0, temporal multiplier = $0.2 \times e^{0.8 \times PDSI}$



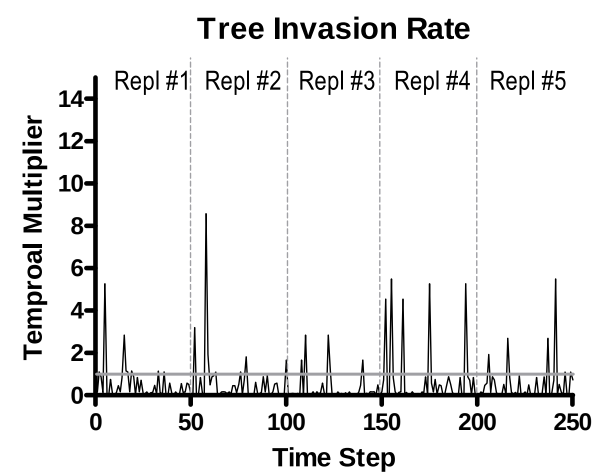


Figure 4-3. Temporal multipliers of annual grass invasion and tree invasion for the fourth climatic division of Nevada and Utah. Five replicates (Repl) are shown each per 50-year period. The gray line for the drought temporal multiplier = 1 represented the "no-change" or neutral parameter line.

Riparian Variability

Montane, warm desert 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 Santa Clara River at Gunlock, Utah, measured between 1970 and 2010 (US Geological Survey: # USGS 09409880 SANTA CLARA RIVER AT GUNLOCK, UT). We created five replicates of 50 years each by resampling the original time series using random numbers and MS Excel®'s vlookup function. Each resampled peak discharge values were divided by the temporal average discharge of that gage, thus generating a dimensionless time series of peak flow with an average of one (i.e., the temporal multiplier).

Peak flow data from the Santa Clara 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). The 7-year flood events encompass the full time series of peak flow divided by the temporal average (Figure 4-4). The 20-year flood event for the Santa Clara River at Gunlock was determined to correspond to a temporal multiplier of 3.062, whereas the threshold for 100-year event was 7.8399 (Natural Channel Design, Inc. 2005: Table 2.2).

Flash flooding was obtained from USGS peak flow data at Beaver Dam, Arizona (USGS 09414900 BEAVER DAM WASH AT BEAVER DAM, AZ), from 1998 to 2010. Most of Beaver Dam Wash is dry and flows are frequently null, except during major events. The same dimensionless transformation used for peak flow in the Santa Clara River was used here. The original time series was resampled because it contained only one major flood event and practically no flow for other years (Figure 4-4).

Annual discharge from the Santa Clara River at Gunlock was used to determine exotic forb and exotic tree invasion rates. For simplicity, exotic-species invasion was identical for three related temporal multipliers: exotic invasion (mostly saltcedar) in the montane riparian ecological system, and exotic-forb invasion and exotic-tree invasion in the warm desert riparian ecological system. The exotic-invasion disturbance generally encompasses forbs and trees, whereas the disturbance was split by forb and tree species in the Mojave Desert. 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 PATH/VDDT models was, therefore, multiplied by the annual flow temporal multiplier. The temporal multipliers were obtained exactly as done for peak discharge, except annual discharge was used. Data are shown in Figure 4-5.

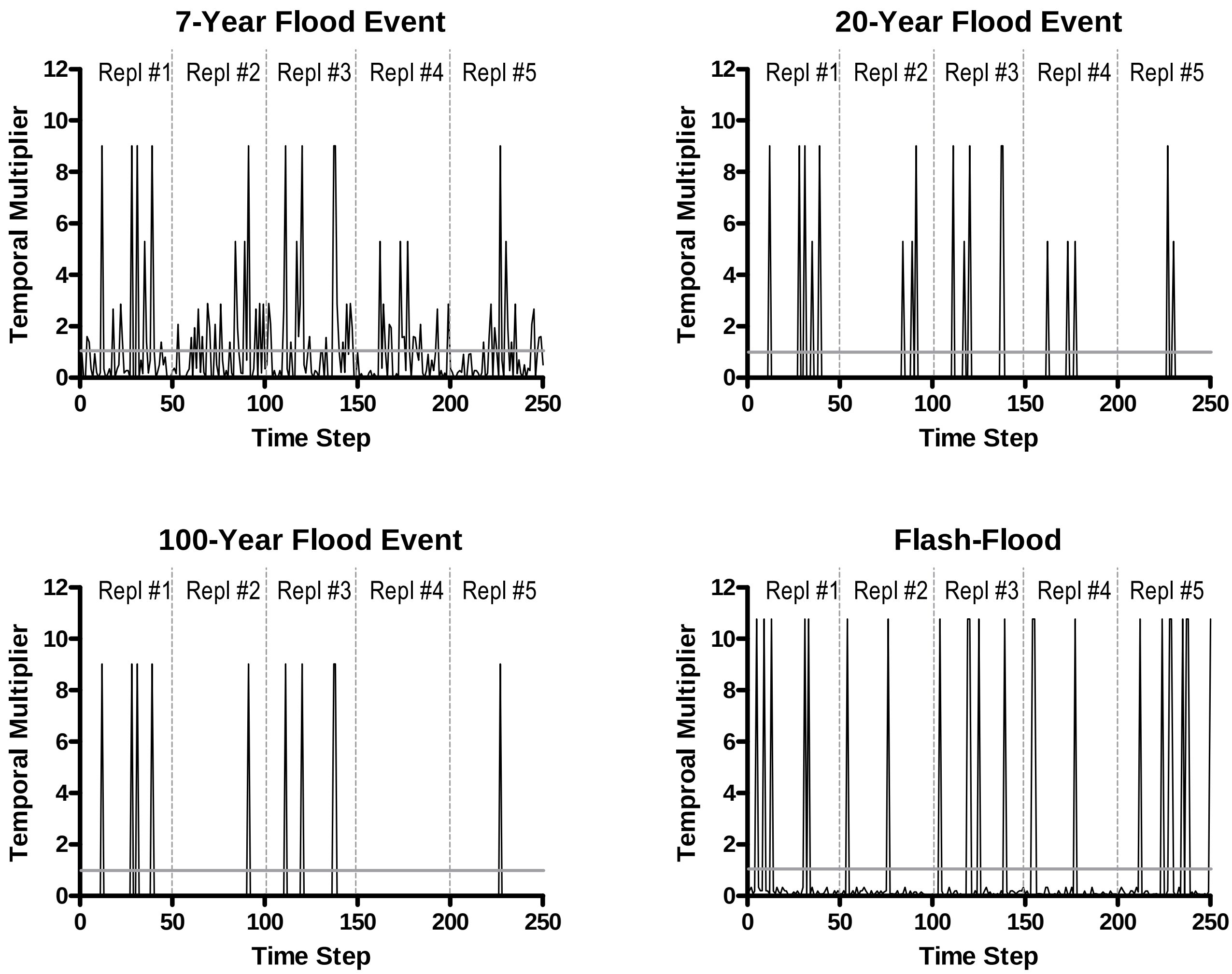
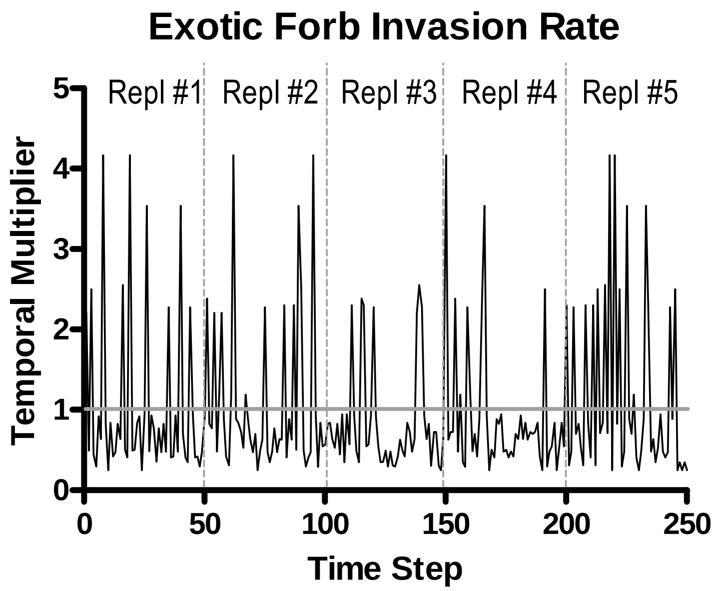


Figure 4-4. Riparian temporal multipliers for 7-year, 20-year, 100-year flood events, and flash flooding. For the 20-year and 100-year flood events all values below their threshold are zero. Data from U.S. Geological Survey gage obtained from the Santa Clara River at Gunlock, UT, for 7-year, 20-year, and 100-year flood events. Flash flooding data were from the U.S. Geological Survey gage on the Beaver Dam Wash at Beaver Dam, Arizona. The horizontal gray line for temporal multiplier = 1 represents the "no-change" or neutral parameter line.



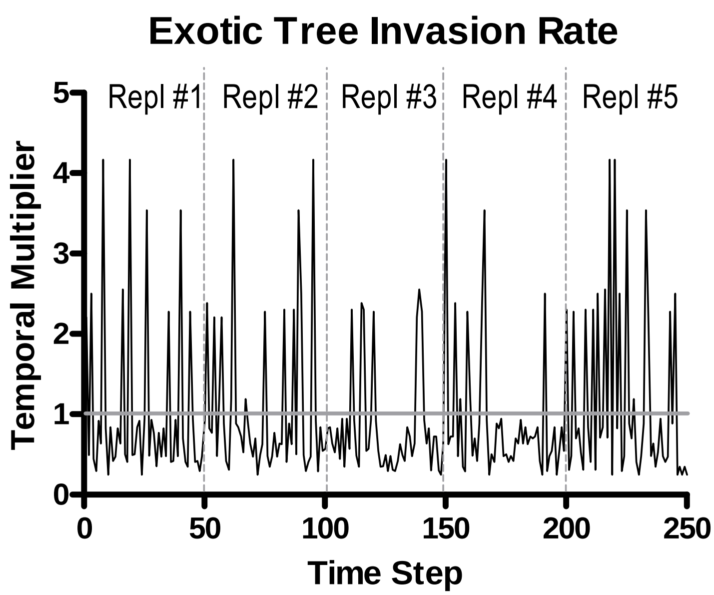


Figure 4-5. Riparian temporal multipliers for exotic forb invasion and exotic tree invasion. Annual discharge data from U.S. Geological Survey gage obtained from the Santa Clara River at Gunlock, UT. The horizontal gray line for temporal multiplier = 1 represents the "no-change" or neutral parameter line.

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Appendix 5. Management actions and cost by ecological systems.

Ecological System	Management Action in Model	Management Action Description	From Class	To Class	Cost/ Acre	Success Rate	Comment
Multiple Systems: Blackbrush- mesic and thermic, and Cresotebush- White Bursage, Desert Washes, Warm-Season Grassland	Fuel breaks	Aerial spraying to create 250 feet wide fuel breaks along roads, rights-of-ways, and boundaries (all that are in several BpS) to maintain the SEP/SEPJ class; Reduces the frequency of fires for 3 years.	ALL	ALL	$ 11	3 years less fire activity	Reapply every wet year of good exotic annual species productivity (i.e., about 7 years with El Nino cycle): $80/acre but spreadout over every 7 years. Arizona Strip BLM uses 8oz vs 4-6oz for St George BLM.
Multiple Systems of Beaver Dam Wash NCA	Law-enforcement	Reduces bare ground creation caused by OHV in BDW only.	ALL	ALL	$0.8	90%	Law enforcement only affects OHV and in BDW; too inefficient to model large acres of law enforcement with PATH, therefore, we reduced OHV rate to 5% with static transition multiplier. Salary of one law enforcement person maybe 1/3 FTE: $50K divided by 64K acres $0.80/acre
Multiple Systems: Blackbrush- mesic and thermic, Cresotebush- White Bursage, Desert Wash	Livestock-Closure	Beaver Dam Wash only; Reduction of stocking rate in Desert Washes and 10-year closure of plantings and seedings in blackbrush and creosotebush-white bursage	All in Desert Washes and seedings and plantings	All classes, except BG	$ 11	10 yrs no grazing for selected pixels	This is modeled as a reduction of stocking rate, however, closing the allotment, if chosen, is different (No-Grazing-only scenario) would be better done with static transition multiplier setting Managed-Herbivory = 0 and Excessive-Herbivory = 0.
Big Sagebrush Steppe	Herbicide+Seed	Control cheatgrass and Erodium and broadcast seed or harrow on some plateaus	EX, SEP	A, C (respectiv ely)	$ 250	80% & 90%	
Big Sagebrush Steppe	Thin+Herbicide+ Seed	Chainsaw invading PJ, apply herbicide to control exotic annuals, and seed native species	TEX, TE	SD	$ 350	80%	

Ecological System	Management Action in Model	Management Action Description	From Class	To Class	Cost/ Acre	Success Rate	Comment
Blackbrush- mesic	Herbicide+Current Native Species Seeding	Aerial spraying Plateau on non-native annuals followed by native seeding with mechanical covering	EX	SD	$ 1,000	1%	Not used due to low success rate of current quality of native seed and granivory; Success rate assumes no grazing
Blackbrush- mesic	Herbicide+Mixed Introduced and Native Species Seeding	Aerial spraying Plateau on non-native annuals followed by introduced and native species seeding with mechanical covering	EX	SDI	$ 450	5%	Not used as most of BLM's Beaver Dam Wash is below the elevation suitable ofr forage koshia (~3500 feet): need to track success fo forage koshia with low preciipitation. Can still have grazing with introduced species; $200 seed; 5 applications of herbicide over 10 yrs.
Blackbrush- mesic and thermic, and Cresotebush- White Bursage	Herbicide+ New Native cultivar Seeding	Aerial spraying Plateau on non-native annuals followed by new native species cultivar seeding, including seedballing (ball of clay with seeds that prevents granivory)	EX	SD	$ 150	5%	In experimental development. Seed new native cultivar after 20 years of development. The new seed mix would incorporate new proven technologies such as "seedballing" and seed coating. Seedballing. Simulations assumed that the new seed mix would include all new technological development. Cost: $100 lb native/10 lbs acre, plus application costs.
Blackbrush- mesic	Carbon addition	Add sugar or wood chips to soil	EX	SD	TBD	TBD	Not used: Supplemental treatment to seeding, or perhaps standalone, to reduce nitrogen availability to exotic species by stimulating bacterial and fungal uptake of nitrogen during carbon processing
Blackbrush - mesic	Chainsaw-Lopping	Thin juniper and pinyon in late class	TEX	SEP	$ 70	100%	Not used. Release blackbrush by removing trees in Red Cliffs were a large amount of shrubland has been lost.

Ecological System	Management Action in Model	Management Action Description	From Class	To Class	Cost/ Acre	Success Rate	Comment
Blackbrush- mesic and thermic, and Cresotebush- White Bursage	Herbicide+Planting	From Scott Abella's: Aerial spraying of Plateau on non-native annuals and plant containerized desert shrubs and forbs (but not blackbrush) with gel caps included in potting soil.	EX	PL, SEP, SEPJ	$ 650	90%	In experimental development: commercial scaling up needs to be demonstrated. Main pathway is to Planting state, but then slower succession pathway to SEP or SEPJ if herbicide fails. Seedbank emergence of exotics after 2-3 years in the Planting state will also cause a transition to SEP or SEPJ. Six dollars for plant, gel cap and labor; 100 plants per acre; add $50/acre for brome control.
Blackbrush- mesic and thermic, and Cresotebush- White Bursage	BFOD+Planting	From Scott Abella's: Application of BFOD fungi on non-native annuals and plant containerized desert shrubs and forbs (but not blackbrush) with gel caps included in potting soil.	EX	PL, SEP, SEPJ	$ 650	90%	In experimental development: commercial scaling up needs to be demonstrated. Main pathway is to Planting state, but then slower succession pathway to SEP or SEPJ if herbicide fails. Seedbank emergence of exotics after 2-3 years in the Planting state will also cause a transition to SEP or SEPJ. Six dollars for plant, gel cap and labor; 100 plants per acre; add $50/acre for brome control.
Blackbrush- mesic and thermic, and Cresotebush- White Bursage	BFOD - BM, BT, CB, & WAS	Apply the BFOD fungi to kill exotic annual species	SES & SEP	A,B,C	$ 300	25% to 75%	In experimental development: Patent filed for fungi. Expect fungi to be ready for commercial release in 5 years. Curent research estimates success rate of 75% at killing seed, but simulations tested success artes at 25%, 50%, and 75%. Mode of application (liquid or granular) undecided and in feasibility research.
Desert Sand Sagebrush	Herbicide+Seed	Seed with native perennial grasses after application of Plateau to control exotic annual species; had 80% back with 10 years	SEP	B	$ 250	80%	For SEP, the cover of exotic annual species is not high and not considered high risk; quick recovery

Ecological System	Management Action in Model	Management Action Description	From Class	To Class	Cost/ Acre	Success Rate	Comment
Desert Wash	Herbicide-WAS	Aerial spraying Plateau on non-native annuals	SES & SEP	A, B, or C	$ 25	50%	Lasts for 2 years because of seedbank emergence and invasion; must be done every 3-5 years
Desert Wash	BFOD-WAS	Apply the BFOD fungi to kill exotic annual species	SES & SEP	A,B,C	$ 300	25% to 75%	In experimental development: Patent filed for fungi. Expect fungi to be ready for commercial release in 5 years. Curent research estimates success rate of 75% at killing seed, but simulations tested success artes at 25%, 50%, and 75%. Mode of application (liquid or granular) undecided and in feasibility research.
Desert Wash	Exotic-Control-WAS	Cut tamarisk and immediately apply Garlon to stumps	ET	A,B,C	$ 200	90%	If biocontrol beetle doesn't kill enough tamarisk
Montane Riparian	Exotic Control	Cut tamarisk and immediately apply Garlon to stumps.			$ 200	90%	If biocontrol beetle doesn't kill enough tamarisk
Mountain Shrub	Herbicide+Seed Rose	Application of Plateau (perhaps by ATV) to control cheatgrass and Erodium in burned areas, followed by seeding of cliffrose during drier years.	EX	A	$ 100	70%	Rehabilitation of mine sites and degraded range with seeded cliffrose is a common and successful practice. Cliffrose has a greater germination success during drought years and wet years can set back reestablishment after fire. Cliffrose seedlings do not tolerate plant competition. Ability to reprouts varies a lot by ecotype and uncommon, but seeding is successful and seed caching by rodents contributes to success.
Mountain Shrub	Herbicide+Seed Grass	Application of Plateau (perhaps by ATV or spot treatment) to control cheatgrass and Erodium in SEP, followed by seeding of grass species during wet years.	SEP	B	$ 250	70%	Cliffrose may come back from seedbank; however cheatgrass competes strongly against seedlings.
Pinyon-Juniper	Herbicide	Spot treatment of brome with Plateau under canopy of mature trees.	TEX	C, D	$ 75	60%	Very difficult to spray and and applied by hand.

Ecological System	Management Action in Model	Management Action Description	From Class	To Class	Cost/ Acre	Success Rate	Comment
Pinyon-Juniper	Herbicide+Seed	Aerial application of herbicide to control annual exotic species (Bromus & Erodium) in burned areas followed by aerial seeding in burned areas	EX	A	$ 250	60%	Need to consider constraints on aerial application over Red Cliffs wilderness.
Warm Desert Riparian	Weed Inventory	Periodic inventory of invasive weeds / tamarisk. Assumes spot treatment of small patches and tamarisk, and identifies a need to return to control larger trees and patches.	ALL, except ET, EF, DEF, DET	ALL	$ 55		Visit every 3-5 years
Warm Desert Riparian	Exotic Tree Control	Cut tamarisk and immediately apply Garlon to stumps: replant native shrubs/trees and seed native forbs if needed.	ET, DET	A	$ 200	90%	If the beetle doesn't do the job
Warm Desert Riparian	Herbicide-EX	Spot treatment of Plateau to control exotic annual species (Bromus and Erodium) under mature riparian vegetation	TEX	A, B, D, E	$ 50	50%	Spot treatment mostly along Beaver Dam Wash.
Warm Desert Riparian	Exotic Forb Control	Control exotic forbs (Knapweed spp., tall whitetop, others) with herbicide	EF, DEF	A	$ 150	60%	
Warm Season Grassland	Herbicide+Seed	Spray exotic annual species and seed in grass species (Galleta and others) to increase grass cover	EEX	A	$ 250	40%	Literature reports difficulty of seeding galleta grass.
Warm Season Grassland	BFOD	Spot treatment of BFOD fungi in SES.	SES	B	$ 300	75%	In experimental development: Patent filed for fungi. Expect fungi to be ready for commercial release in 5 years. Already high cover of Galleta grass.
Warm Season Grassland	BFOD + Seed	Apply BFOD fungi on exotic annual species and seed in grass species (Galleta and others) to increase grass cover	EEX	A	$ 600	63%	In experimental development: Patent filed for fungi. Expect fungi to be ready for commercial release in 5 years. Literature reports difficulty of seeding Galleta grass.

Appendix 6. Current acres by vegetation class, natural range of variability (NRV) and ecological departure (ED) calculations for ecological systems of the Red Cliffs and Beaver Dam Wash NCAs.

Red Cliffs NCA																
Ecol System ↓	Class→	A	B	C	D	E	EEX	EF	ET	EX	SEP	SEPJ	SES	TE	TEX	Total
Big Sagebrush Steppe-upland	Current acres	0	0	0	0	0				2408	505			148		3061
	NRV %	30	47	20	1	2	0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	0	0				79	17		0	5		101
	Ecol Departure															100
Blackbrush-mesic	Current acres	0	0	0	0					6750	10510					17260
	NRV	11	0	73	16		0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	0					39	61					100
	Ecol Departure															100
Blackbrush-thermic	Current acres	0	0	0						583	4422					5005
	NRV	5	0	95			0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0			0	0	0	12	88	0	0	0	0	100
	Ecol Departure															100
Creosotebush-White Bursage	Current acres	0	0	0	0					1661	1382					3043
	NRV	8	0	92	0		0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	0					55	45					100
	Ecol Departure															100
Desert Sand Sagebrush	Current acres	0	0								1586					1586
	NRV	2	98				0	0	0	0	0	0	0	0	0	100
	Current % area	0	0								100					100
	Ecol Departure															100
Montane Riparian	Current acres	0.02	0	0.33				39.5								40
	NRV	10	19	71			0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	1				99								100
	Ecol Departure															99
Mountain Mahogany	Current acres															
	NRV															
	Current % area															
	Ecol Departure															

Red Cliffs NCA																
Ecol System ↓	**Class→**	**A**	**B**	**C**	**D**	**E**	**EEX**	**EF**	**ET**	**EX**	**SEP**	**SEPJ**	**SES**	**TE**	**TEX**	**Total**
Mountain Shrub	**Current acres**	0	0	0	0					2.7	0.3			1.2		4.2
	NRV	7	15	63	14		0	0	0	0	0	0	0	0	0	99
	Current % area	0	0	0	0					64	7			29		100
	Ecol Departure															100
Pinyon-Juniper	**Current acres**	0	0	0	0										3719	3719
	NRV	2	3	13	82		0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	0										100	100
	Ecol Departure															100
Warm Desert Riparian	**Current acres**	0	0	0	0	0			34						126	160
	NRV	10	19	8	40	23	0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	0	0			21						79	100
	Ecol Departure															100
Warm Desert Riparian-Wash	**Current acres**	171	0	0									231			402
	NRV	10	18	72			0	0	0	0	0	0	0	0	0	100
	Current % area	43	0	0									57			100
	Ecol Departure															90
Warm-Season Grassland	**Current acres**	0	0				3			7			108			118
	NRV	4	96				0	0	0	0	0	0	0	0	0	100
	Current % area	0	0				3			6			91			100
	Ecol Departure															100

Beaver Dam Wash NCA																
Ecol System ↓	Class→	A	B	C	D	E	EEX	EF	ET	EX	SEP	SEPJ	SES	TE	TEX	Total
Big Sagebrush Steppe-upland	Current acres	0	0	0	0	0				12			2			14
	NRV	30	47	20	1	2	0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	0	0	0	0	0	83	0	0	17	0	0	100
	Ecol Departure															100
Blackbrush-mesic	Current acres	0	0	0	0	0				24629	3364	5629			6	33628
	NRV	10	39	35	8	8	0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	0	0	0	0	0	73	10	17	0	0	0	100
	Ecol Departure															100
Blackbrush-thermic	Current acres	0	0	0						1211	1133	1309				3653
	NRV	5	48	47			0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0			0	0	0	33	31	36	0	0	0	100
	Ecol Departure															100
Creosotebush-White Bursage	Current acres	0	0	0	0					1960	7024	13057				22041
	NRV	9	36	38	17		0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	0		0	0	0	9	32	59	0	0	0	100
	Ecol Departure															100
Desert Sand Sagebrush	Current acres															
	NRV															
	Current % area															
	Ecol Departure															
Montane Riparian	Current acres															
	NRV															
	Current % area															
	Ecol Departure															
Mountain Mahogany	Current acres	0.1	0	0.4												0.5
	NRV	6	10	84			0	0	0	0	0	0	0	0	0	100
	Current % area	20	0	80			0	0	0	0	0	0	0	0	0	100
	Ecol Departure															14
Mountain Shrub	Current acres	0	0	0	0					143						143
	NRV	7	15	63	14		0	0	0	0	0	0	0	0	0	99
	Current % area	0	0	0	0		0	0	0	100	0	0	0	0	0	100
	Ecol Departure															100

Beaver Dam Wash NCA																
Ecol System ↓	**Class→**	**A**	**B**	**C**	**D**	**E**	**EEX**	**EF**	**ET**	**EX**	**SEP**	**SEPJ**	**SES**	**TE**	**TEX**	**Total**
Pinyon-Juniper	**Current acres**	0	0	0	16					220					34	270
	NRV	2	3	13	82		0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	6		0	0	0	82	0	0	0	0	13	101
	Ecol Departure															94
Warm Desert Riparian	**Current acres**	0	0	0	0	0			4						110	114
	NRV	10	19	8	40	23	0	0	0	0	0	0	0	0	0	100
	Current % area	0	0	0	0	0	0	0	4	0	0	0	0	0	96	100
	Ecol Departure															100
Warm Desert Riparian-Wash	**Current acres**	2646	0	0									699			3345
	NRV	10	18	72			0	0	0	0	0	0	0	0	0	100
	Current % area	79	0	0			0	0	0	0	0	0	21	0	0	100
	Ecol Departure															90
Warm-Season Grassland	**Current acres**															
	NRV															
	Current % area															
	Ecol Departure															

Appendix 7. MINIMUM MANAGEMENT scenario areas (percent) by vegetation class for ecological systems of the Red Cliffs and Beaver Dam Wash NCAs.

Red Cliffs NCA					
Ecological System × Vegetation class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	1%	0%	1%	0%	1%
BSu-B:OP: 0%	0%	2%	1%	1%	1%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	1%	1%	1%	0%	1%
BSu-U:EX: 0%	94%	93%	95%	87%	94%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	6%	0%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	2%	2%	2%	3%	2%
BSu-U:TEX: 0%	1%	2%	1%	3%	1%
BM-A:AL: 0%	0%	0%	0%	0%	0%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	3%	2%	3%	1%	3%
BM-U:EX2B: 0%	73%	64%	76%	35%	67%
BM-U:PL: 0%	0%	0%	0%	0%	0%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	23%	33%	21%	63%	29%
BM-U:SEPJ: 0%	0%	0%	0%	0%	0%
BM-U:TEX: 0%	1%	1%	1%	2%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	3%	2%	3%	1%	3%
BT-U:EX2B: 0%	73%	63%	76%	35%	66%
BT-U:PL: 0%	0%	0%	0%	0%	0%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	24%	35%	21%	64%	30%
BT-U:SEPJ: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	3%	16%	5%	20%	8%
CB-U:EX2B: 0%	37%	26%	38%	20%	26%
CB-U:PL: 0%	0%	0%	0%	0%	0%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	60%	58%	57%	60%	65%
CB-U:SEPJ: 0%	0%	0%	0%	0%	0%
DSS-A:OP: 0%	0%	0%	0%	0%	0%
DSS-B:OP: 0%	0%	0%	0%	0%	0%
DSS-U:DP: 0%	0%	0%	0%	0%	0%
DSS-U:SEP: 0%	100%	100%	100%	100%	100%
MR-A:AL: 0%	0%	0%	0%	0%	0%
MR-B:OP: 0%	0%	0%	0%	0%	0%
MR-C:CL: 0%	0%	0%	0%	0%	0%
MR-U:DE: 0%	0%	0%	0%	0%	0%
MR-U:EF: 0%	100%	100%	100%	100%	100%
MR-U:SFE: 0%	0%	0%	0%	0%	0%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	33%	0%	0%	25%	25%
MSh-U:EX: 0%	0%	0%	50%	0%	25%
MSh-U:SEP: 0%	67%	75%	25%	75%	50%
MSh-U:TE: 0%	0%	25%	25%	0%	0%
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	0%	0%	0%
PJ-D:OP: 0%	0%	0%	0%	0%	0%
PJ-U:EX: 0%	24%	20%	26%	10%	19%
PJ-U:TEX: 0%	76%	80%	74%	90%	81%
SWA-A:AL: 0%	1%	0%	1%	0%	14%
SWA-B:CL: 0%	20%	0%	15%	1%	12%
SWA-C:CL: 0%	11%	29%	19%	31%	7%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
SWA-U:SEP: 0%	10%	13%	8%	11%	10%
SWA-U:SES: 0%	58%	57%	57%	57%	57%
WDR-A:AL: 0%	0%	3%	1%	0%	2%
WDR-B:CL: 0%	13%	8%	15%	3%	7%
WDR-C:OP: 0%	4%	7%	6%	8%	11%
WDR-D:CL: 0%	7%	4%	3%	7%	9%
WDR-E:CL: 0%	7%	3%	4%	10%	7%
WDR-U:DE: 0%	0%	0%	0%	0%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	28%	34%	30%	31%	30%
WDR-U:ET: 0%	1%	1%	2%	1%	0%
WDR-U:EX: 0%	0%	0%	4%	0%	0%
WDR-U:TEX: 0%	41%	40%	35%	41%	34%
GRL-A:AL: 0%	0%	0%	0%	0%	0%
GRL-B:OP: 0%	0%	0%	0%	0%	0%
GRL-U:DP: 0%	0%	0%	0%	0%	0%
GRL-U:EEX: 0%	3%	3%	3%	3%	3%
GRL-U:EX: 0%	0%	0%	0%	0%	1%
GRL-U:SES: 0%	97%	97%	97%	97%	96%

Beaver Dam Wash NCA					
Ecological System × Vegetation class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	89%	100%	100%	89%	100%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	11%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%
BSu-U:TEX: 0%	11%	0%	0%	0%	0%
BM-A:AL: 0%	0%	0%	0%	0%	0%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	1%	1%	1%	1%	1%
BM-U:EX2B: 0%	32%	30%	34%	27%	27%
BM-U:PL: 0%	0%	0%	0%	0%	0%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	24%	25%	24%	26%	26%
BM-U:SEPJ: 0%	41%	42%	40%	45%	44%
BM-U:TEX: 0%	1%	1%	0%	1%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	1%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	3%	3%	2%	1%	3%
BT-U:EX2B: 0%	14%	5%	17%	2%	9%
BT-U:PL: 0%	0%	0%	0%	0%	0%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	33%	35%	33%	41%	37%
BT-U:SEPJ: 0%	49%	56%	48%	55%	51%
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	1%	0%	1%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	3%	18%	5%	22%	8%
CB-U:EX2B: 0%	33%	19%	37%	6%	23%
CB-U:PL: 0%	0%	0%	0%	0%	0%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	22%	22%	20%	26%	24%
CB-U:SEPJ: 0%	41%	41%	37%	46%	45%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	28%	2%	79%	1%	29%
MSh-U:SEP: 0%	72%	98%	21%	99%	71%
MSh-U:TE: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	1%	0%	1%	1%	1%
PJ-C:OP: 0%	0%	0%	0%	1%	0%
PJ-D:OP: 0%	5%	5%	5%	4%	5%
PJ-U:EX: 0%	84%	85%	84%	82%	85%
PJ-U:TEX: 0%	10%	10%	11%	12%	9%
SWA-A:AL: 0%	1%	0%	1%	0%	26%
SWA-B:CL: 0%	27%	2%	25%	1%	19%
SWA-C:CL: 0%	33%	57%	41%	56%	17%
SWA-U:BG: 0%	0%	1%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	4%	5%	3%	7%	7%
SWA-U:SES: 0%	34%	35%	28%	36%	31%
WDR-A:AL: 0%	4%	10%	6%	4%	6%
WDR-B:CL: 0%	0%	0%	1%	1%	0%
WDR-C:OP: 0%	4%	6%	1%	3%	4%
WDR-D:CL: 0%	0%	0%	0%	0%	0%
WDR-E:CL: 0%	1%	0%	0%	0%	1%
WDR-U:DE: 0%	0%	4%	1%	3%	0%
WDR-U:DEF: 0%	1%	1%	1%	3%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	19%	14%	24%	6%	24%
WDR-U:ET: 0%	0%	1%	1%	0%	0%
WDR-U:EX: 0%	19%	7%	13%	1%	7%
WDR-U:TEX: 0%	50%	57%	51%	79%	58%

Appendix 8. MAXIMUM MANAGEMENT scenario 50-year area results (percent) by vegetation class for ecological systems of Red Cliffs and Beaver Dam Wash NCA, Utah.

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	1%	6%	1%	2%	3%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	14%	8%	15%	9%	13%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	3%	1%	0%	1%	2%
BSu-U:SD: 0%	80%	84%	83%	86%	81%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	1%	1%	1%	1%	1%
BSu-U:TEX: 0%	1%	1%	0%	1%	0%
BM-A:AL: 0%	3%	3%	3%	2%	3%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	1%	0%	0%	1%
BM-U:EX2B: 0%	0%	18%	1%	0%	13%
BM-U:PL: 0%	2%	7%	1%	3%	1%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	94%	69%	95%	93%	82%
BM-U:SEPJ: 0%	0%	0%	0%	0%	0%
BM-U:TEX: 0%	2%	2%	1%	1%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	1%	1%	0%	1%	1%
BT-U:EX2B: 0%	0%	9%	1%	2%	14%
BT-U:PL: 0%	2%	10%	2%	6%	2%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	97%	79%	97%	90%	83%
BT-U:SEPJ: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	3%	0%	1%	1%	2%
CB-U:EX2B: 0%	0%	0%	0%	0%	0%
CB-U:PL: 0%	4%	3%	3%	3%	4%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	93%	96%	97%	95%	94%
CB-U:SEPJ: 0%	0%	0%	0%	0%	0%
DSS-A:OP: 0%	0%	0%	0%	0%	3%
DSS-B:OP: 0%	40%	41%	41%	40%	37%
DSS-U:DP: 0%	0%	0%	0%	0%	0%
DSS-U:SEP: 0%	60%	59%	59%	60%	60%
MM-A:AL: 0%	0%	0%	0%	0%	0%
MM-B:OP: 0%	0%	0%	0%	0%	0%
MM-C:CL: 0%	0%	0%	0%	0%	0%
MM-U:EX: 0%	0%	0%	0%	0%	0%
MM-U:TEX: 0%	0%	0%	0%	0%	0%
MR-A:AL: 0%	0%	2%	50%	0%	2%
MR-B:OP: 0%	62%	36%	24%	58%	34%
MR-C:CL: 0%	32%	62%	18%	40%	60%
MR-U:DE: 0%	0%	0%	0%	0%	0%
MR-U:EF: 0%	6%	0%	8%	2%	4%
MR-U:SFE: 0%	0%	0%	0%	0%	0%
MSh-A:AL: 0%	0%	20%	0%	0%	0%
MSh-B:CL: 0%	60%	60%	20%	75%	50%
MSh-C:CL: 0%	20%	0%	60%	25%	50%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	0%	0%	0%	0%	0%
MSh-U:SEP: 0%	0%	0%	0%	0%	0%
MSh-U:TE: 0%	20%	20%	20%	0%	0%
PJ-A:AL: 0%	2%	2%	1%	1%	1%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	3%	3%	3%	3%	3%
PJ-D:OP: 0%	28%	28%	30%	29%	29%
PJ-U:EX: 0%	1%	6%	1%	4%	4%
PJ-U:TEX: 0%	67%	60%	64%	62%	63%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
SWA-A:AL: 0%	4%	2%	40%	1%	0%
SWA-B:CL: 0%	42%	31%	6%	42%	29%
SWA-C:CL: 0%	45%	64%	51%	52%	70%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	3%	2%	1%	2%	0%
SWA-U:SES: 0%	6%	2%	2%	3%	1%
WDR-A:AL: 0%	3%	2%	20%	4%	6%
WDR-B:CL: 0%	9%	13%	4%	10%	9%
WDR-C:OP: 0%	8%	9%	5%	6%	8%
WDR-D:CL: 0%	7%	10%	4%	8%	9%
WDR-E:CL: 0%	56%	48%	49%	59%	52%
WDR-U:DE: 0%	0%	0%	0%	0%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	0%	1%	1%	1%	3%
WDR-U:ET: 0%	0%	0%	1%	1%	2%
WDR-U:EX: 0%	1%	1%	4%	0%	0%
WDR-U:TEX: 0%	17%	15%	12%	12%	11%
GRL-A:AL: 0%	4%	5%	5%	4%	5%
GRL-B:OP: 0%	93%	93%	87%	95%	90%
GRL-U:DP: 0%	0%	0%	0%	0%	0%
GRL-U:EEX: 0%	0%	1%	0%	0%	1%
GRL-U:EX: 0%	0%	0%	0%	0%	0%
GRL-U:SES: 0%	3%	1%	7%	1%	4%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	90%	90%	100%	90%	100%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	10%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-U:TEX: 0%	10%	10%	0%	0%	0%
BM-A:AL: 0%	2%	2%	2%	1%	2%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	0%	0%	0%	0%
BM-U:EX2B: 0%	0%	0%	1%	0%	0%
BM-U:PL: 0%	2%	0%	3%	0%	1%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	40%	41%	39%	40%	40%
BM-U:SEPJ: 0%	55%	56%	54%	57%	56%
BM-U:TEX: 0%	1%	1%	1%	1%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	0%	0%	0%	0%	0%
BT-U:EX2B: 0%	0%	0%	0%	0%	0%
BT-U:PL: 0%	2%	0%	3%	0%	1%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	46%	47%	45%	45%	46%
BT-U:SEPJ: 0%	52%	53%	51%	55%	53%
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	0%	1%	2%	2%	0%
CB-U:EX2B: 0%	0%	0%	0%	0%	0%
CB-U:PL: 0%	1%	3%	4%	4%	2%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	35%	35%	33%	33%	35%
CB-U:SEPJ: 0%	64%	62%	61%	60%	63%
MSh-A:AL: 0%	7%	0%	27%	1%	6%
MSh-B:CL: 0%	42%	3%	20%	3%	30%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
MSh-C:CL: 0%	35%	74%	26%	78%	38%
MSh-D:OP: 0%	15%	22%	26%	17%	25%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	0%	0%	0%	0%	0%
MSh-U:SEP: 0%	0%	1%	1%	0%	0%
MSh-U:TE: 0%	0%	0%	0%	0%	0%
PJ-A:AL: 0%	9%	1%	16%	1%	2%
PJ-B:OP: 0%	21%	12%	15%	3%	17%
PJ-C:OP: 0%	56%	72%	53%	80%	67%
PJ-D:OP: 0%	5%	5%	6%	5%	5%
PJ-U:EX: 0%	0%	0%	1%	0%	0%
PJ-U:TEX: 0%	10%	10%	9%	12%	9%
SWA-A:AL: 0%	1%	0%	1%	0%	11%
SWA-B:CL: 0%	14%	1%	13%	1%	23%
SWA-C:CL: 0%	85%	97%	85%	97%	64%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	1%	2%	1%	1%	1%
SWA-U:SES: 0%	0%	0%	0%	0%	0%
WDR-A:AL: 0%	0%	5%	3%	0%	3%
WDR-B:CL: 0%	51%	18%	25%	8%	15%
WDR-C:OP: 0%	12%	15%	15%	3%	11%
WDR-D:CL: 0%	7%	8%	14%	19%	21%
WDR-E:CL: 0%	23%	47%	36%	64%	47%
WDR-U:DE: 0%	4%	5%	5%	3%	3%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	3%	1%	1%	3%	0%
WDR-U:ET: 0%	0%	0%	0%	0%	0%
WDR-U:EX: 0%	0%	0%	0%	0%	0%
WDR-U:TEX: 0%	0%	0%	1%	0%	1%

Appendix 9. STREAMLINED MANAGEMENT scenario areas (percent) by vegetation class for ecological systems of the Red Cliffs and Beaver Dam Wash NCAs.

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	14%	1%	12%	0%	7%
BSu-B:OP: 0%	6%	18%	9%	14%	13%
BSu-C:CL: 0%	4%	5%	2%	11%	6%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	0%	0%	0%	0%	0%
BSu-U:SD: 0%	76%	74%	76%	73%	73%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	0%	0%	0%	1%	0%
BSu-U:TEX: 0%	0%	0%	0%	1%	0%
BM-A:AL: 0%	2%	2%	2%	1%	2%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	0%	0%	0%	0%
BM-U:EX2B: 0%	1%	0%	7%	0%	1%
BM-U:PL: 0%	9%	0%	9%	0%	2%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	87%	95%	80%	95%	93%
BM-U:SEPJ: 0%	0%	0%	0%	0%	0%
BM-U:TEX: 0%	2%	2%	1%	3%	2%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	4%	1%	3%	0%	2%
BT-U:EX2B: 0%	0%	0%	4%	0%	1%
BT-U:PL: 0%	12%	2%	12%	1%	5%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	84%	97%	81%	99%	92%
BT-U:SEPJ: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	0%	2%	4%	5%	0%
CB-U:EX2B: 0%	0%	0%	0%	0%	0%
CB-U:PL: 0%	1%	3%	2%	3%	2%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	99%	95%	94%	91%	97%
CB-U:SEPJ: 0%	0%	0%	0%	0%	0%
DSS-A:OP: 0%	0%	0%	0%	0%	0%
DSS-B:OP: 0%	100%	100%	100%	100%	100%
DSS-U:DP: 0%	0%	0%	0%	0%	0%
DSS-U:SEP: 0%	0%	0%	0%	0%	0%
MR-A:AL: 0%	0%	4%	2%	0%	0%
MR-B:OP: 0%	56%	18%	46%	6%	16%
MR-C:CL: 0%	42%	74%	48%	92%	84%
MR-U:DE: 0%	0%	0%	0%	0%	0%
MR-U:EF: 0%	2%	4%	4%	2%	0%
MR-U:SFE: 0%	0%	0%	0%	0%	0%
MSh-A:AL: 0%	0%	0%	0%	20%	0%
MSh-B:CL: 0%	40%	0%	50%	0%	20%
MSh-C:CL: 0%	20%	80%	50%	60%	40%
MSh-D:OP: 0%	20%	0%	0%	20%	20%
MSh-U:ES: 0%	20%	0%	0%	0%	0%
MSh-U:EX: 0%	0%	0%	0%	0%	0%
MSh-U:SEP: 0%	0%	0%	0%	0%	0%
MSh-U:TE: 0%	0%	20%	0%	0%	20%
PJ-A:AL: 0%	4%	0%	7%	0%	1%
PJ-B:OP: 0%	9%	11%	10%	5%	11%
PJ-C:OP: 0%	15%	19%	16%	18%	15%
PJ-D:OP: 0%	61%	61%	57%	62%	64%
PJ-U:EX: 0%	0%	0%	0%	0%	0%
PJ-U:TEX: 0%	10%	8%	10%	15%	9%
SWA-A:AL: 0%	2%	0%	1%	0%	20%
SWA-B:CL: 0%	16%	2%	19%	3%	29%
SWA-C:CL: 0%	80%	96%	80%	91%	49%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
SWA-U:SEP: 0%	1%	2%	0%	4%	2%
SWA-U:SES: 0%	0%	0%	0%	1%	0%
WDR-A:AL: 0%	1%	12%	5%	1%	2%
WDR-B:CL: 0%	46%	18%	40%	7%	14%
WDR-C:OP: 0%	9%	12%	11%	9%	14%
WDR-D:CL: 0%	16%	17%	14%	23%	31%
WDR-E:CL: 0%	25%	38%	24%	57%	33%
WDR-U:DE: 0%	0%	0%	0%	0%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	3%	2%	6%	2%	2%
WDR-U:ET: 0%	1%	0%	1%	1%	0%
WDR-U:EX: 0%	0%	0%	0%	0%	0%
WDR-U:TEX: 0%	0%	2%	1%	1%	3%
GRL-A:AL: 0%	0%	2%	1%	2%	1%
GRL-B:OP: 0%	100%	97%	98%	96%	98%
GRL-U:DP: 0%	0%	0%	0%	0%	0%
GRL-U:EEX: 0%	0%	0%	0%	0%	1%
GRL-U:EX: 0%	0%	0%	0%	0%	0%
GRL-U:SES: 0%	0%	2%	2%	2%	1%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	89%	100%	89%	100%	100%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%
BSu-U:TEX: 0%	11%	0%	11%	0%	0%
BM-A:AL: 0%	1%	1%	2%	1%	1%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	0%	0%	0%	0%
BM-U:EX2B: 0%	0%	0%	2%	0%	0%
BM-U:PL: 0%	2%	0%	3%	0%	1%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	40%	41%	38%	40%	40%
BM-U:SEPJ: 0%	56%	57%	54%	58%	57%
BM-U:TEX: 0%	1%	1%	1%	1%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	0%	0%	0%	0%	0%
BT-U:EX2B: 0%	0%	0%	0%	0%	0%
BT-U:PL: 0%	2%	0%	3%	0%	1%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	45%	47%	44%	46%	46%
BT-U:SEPJ: 0%	53%	52%	52%	53%	53%
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	0%	1%	2%	2%	0%
CB-U:EX2B: 0%	0%	0%	0%	0%	0%
CB-U:PL: 0%	2%	3%	4%	4%	2%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	35%	34%	33%	34%	34%
CB-U:SEPJ: 0%	63%	63%	60%	60%	63%
MSh-A:AL: 0%	9%	1%	25%	0%	1%
MSh-B:CL: 0%	40%	1%	21%	1%	29%
MSh-C:CL: 0%	33%	75%	32%	83%	45%
MSh-D:OP: 0%	17%	22%	22%	16%	24%
MSh-U:ES: 0%	0%	0%	0%	0%	1%
MSh-U:EX: 0%	0%	0%	0%	0%	0%
MSh-U:SEP: 0%	0%	2%	0%	0%	0%
MSh-U:TE: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
PJ-A:AL: 0%	9%	2%	10%	1%	2%
PJ-B:OP: 0%	16%	10%	15%	1%	19%
PJ-C:OP: 0%	60%	73%	62%	82%	64%
PJ-D:OP: 0%	5%	6%	4%	5%	5%
PJ-U:EX: 0%	0%	0%	0%	1%	0%
PJ-U:TEX: 0%	10%	9%	9%	11%	10%
SWA-A:AL: 0%	1%	0%	1%	0%	12%
SWA-B:CL: 0%	14%	2%	13%	1%	21%
SWA-C:CL: 0%	85%	96%	85%	97%	66%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	1%	1%	1%	1%	2%
SWA-U:SES: 0%	0%	0%	0%	0%	0%
WDR-A:AL: 0%	0%	5%	3%	0%	3%
WDR-B:CL: 0%	51%	18%	25%	8%	15%
WDR-C:OP: 0%	12%	15%	15%	3%	11%
WDR-D:CL: 0%	7%	8%	14%	19%	21%
WDR-E:CL: 0%	23%	47%	36%	64%	47%
WDR-U:DE: 0%	4%	5%	5%	3%	3%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	3%	1%	1%	3%	0%
WDR-U:ET: 0%	0%	0%	0%	0%	0%
WDR-U:EX: 0%	0%	0%	0%	0%	0%
WDR-U:TEX: 0%	0%	0%	1%	0%	1%

Appendix 10. PLANTING AND HERBICIDE-ONLY MANAGEMENT scenario areas (percent) by vegetation class for ecological systems of the Red Cliffs and Beaver Dam Wash NCAs.

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	1%	0%	1%	0%	1%
BSu-B:OP: 0%	0%	2%	1%	1%	1%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	1%	0%	1%	0%	1%
BSu-U:EX: 0%	95%	93%	94%	87%	93%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	1%	0%	7%	1%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	2%	3%	2%	3%	2%
BSu-U:TEX: 0%	1%	2%	1%	3%	1%
BM-A:AL: 0%	3%	3%	3%	1%	2%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	0%	2%	0%	0%
BM-U:EX2B: 0%	0%	1%	27%	0%	1%
BM-U:PL: 0%	20%	1%	19%	1%	7%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	74%	93%	49%	95%	88%
BM-U:SEPJ: 0%	0%	0%	0%	0%	0%
BM-U:TEX: 0%	2%	2%	1%	3%	2%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	7%	2%	8%	1%	4%
BT-U:EX2B: 0%	0%	1%	5%	0%	1%
BT-U:PL: 0%	31%	6%	37%	2%	17%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	62%	91%	50%	96%	78%
BT-U:SEPJ: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	0%	0%	4%	2%	0%
CB-U:EX2B: 0%	0%	0%	1%	0%	0%
CB-U:PL: 0%	2%	2%	4%	3%	2%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	98%	97%	91%	94%	98%
CB-U:SEPJ: 0%	0%	0%	0%	0%	0%
DSS-A:OP: 0%	0%	0%	0%	0%	0%
DSS-B:OP: 0%	0%	0%	0%	0%	0%
DSS-U:DP: 0%	0%	0%	0%	0%	0%
DSS-U:SEP: 0%	100%	100%	100%	100%	100%
MR-A:AL: 0%	0%	0%	0%	0%	0%
MR-B:OP: 0%	0%	0%	0%	0%	0%
MR-C:CL: 0%	0%	0%	0%	0%	0%
MR-U:DE: 0%	0%	0%	0%	0%	0%
MR-U:EF: 0%	100%	100%	100%	100%	100%
MR-U:SFE: 0%	0%	0%	0%	0%	0%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	25%	0%	0%	0%	0%
MSh-U:EX: 0%	50%	0%	25%	0%	0%
MSh-U:SEP: 0%	25%	75%	50%	75%	75%
MSh-U:TE: 0%	0%	25%	25%	25%	25%
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	0%	0%	0%
PJ-D:OP: 0%	0%	0%	0%	0%	0%
PJ-U:EX: 0%	22%	21%	24%	9%	19%
PJ-U:TEX: 0%	78%	79%	76%	91%	81%
SWA-A:AL: 0%	0%	0%	0%	0%	15%
SWA-B:CL: 0%	23%	2%	16%	1%	11%
SWA-C:CL: 0%	9%	29%	20%	29%	9%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
SWA-U:SEP: 0%	11%	13%	7%	12%	9%
SWA-U:SES: 0%	56%	57%	56%	57%	56%
WDR-A:AL: 0%	0%	3%	1%	0%	2%
WDR-B:CL: 0%	13%	8%	15%	3%	7%
WDR-C:OP: 0%	4%	7%	6%	8%	11%
WDR-D:CL: 0%	7%	4%	3%	7%	9%
WDR-E:CL: 0%	7%	3%	4%	10%	7%
WDR-U:DE: 0%	0%	0%	0%	0%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	28%	34%	30%	31%	30%
WDR-U:ET: 0%	1%	1%	2%	1%	0%
WDR-U:EX: 0%	0%	0%	4%	0%	0%
WDR-U:TEX: 0%	41%	40%	35%	41%	34%
GRL-A:AL: 0%	0%	0%	0%	0%	0%
GRL-B:OP: 0%	0%	0%	0%	0%	0%
GRL-U:DP: 0%	0%	0%	0%	0%	0%
GRL-U:EEX: 0%	3%	3%	3%	3%	3%
GRL-U:EX: 0%	0%	0%	0%	0%	0%
GRL-U:SES: 0%	97%	97%	97%	97%	97%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	100%	100%	100%	89%	100%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	11%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%
BSu-U:TEX: 0%	0%	0%	0%	0%	0%
BM-A:AL: 0%	2%	2%	2%	1%	2%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	0%	1%	0%	0%
BM-U:EX2B: 0%	0%	0%	2%	0%	0%
BM-U:PL: 0%	3%	0%	5%	0%	1%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	40%	41%	37%	41%	40%
BM-U:SEPJ: 0%	54%	56%	53%	56%	56%
BM-U:TEX: 0%	1%	1%	1%	1%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	0%	0%	1%	0%	0%
BT-U:EX2B: 0%	0%	0%	1%	0%	0%
BT-U:PL: 0%	3%	0%	4%	0%	1%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	44%	45%	42%	45%	46%
BT-U:SEPJ: 0%	53%	55%	51%	54%	53%
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	0%	1%	1%	2%	0%
CB-U:EX2B: 0%	0%	0%	0%	0%	0%
CB-U:PL: 0%	1%	2%	5%	4%	1%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	35%	34%	33%	34%	35%
CB-U:SEPJ: 0%	63%	63%	61%	60%	63%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	24%	2%	73%	1%	30%
MSh-U:SEP: 0%	76%	98%	27%	99%	70%
MSh-U:TE: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	0%	1%	0%
PJ-D:OP: 0%	6%	3%	6%	5%	5%
PJ-U:EX: 0%	83%	85%	85%	82%	85%
PJ-U:TEX: 0%	11%	11%	9%	12%	9%
SWA-A:AL: 0%	1%	0%	1%	0%	26%
SWA-B:CL: 0%	27%	1%	26%	1%	20%
SWA-C:CL: 0%	33%	56%	41%	55%	16%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	4%	6%	4%	6%	6%
SWA-U:SES: 0%	35%	36%	29%	37%	32%
WDR-A:AL: 0%	0%	1%	1%	0%	3%
WDR-B:CL: 0%	18%	1%	8%	1%	1%
WDR-C:OP: 0%	5%	5%	3%	3%	8%
WDR-D:CL: 0%	3%	1%	1%	4%	7%
WDR-E:CL: 0%	0%	1%	0%	0%	0%
WDR-U:DE: 0%	3%	0%	1%	1%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	36%	40%	32%	30%	40%
WDR-U:ET: 0%	0%	0%	4%	0%	0%
WDR-U:EX: 0%	0%	0%	7%	0%	0%
WDR-U:TEX: 0%	36%	49%	42%	60%	41%

Appendix 11. **PLANTING AND HERBICIDE & LIVESTOCK CLOSURE-ONLY MANAGEMENT scenario areas (percent) by vegetation class for ecological systems of the Beaver Dam Wash NCA.**

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	100%	100%	100%	100%	100%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%
BSu-U:TEX: 0%	0%	0%	0%	0%	0%
BM-A:AL: 0%	2%	2%	2%	1%	2%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	0%	0%	0%	0%
BM-U:EX2B: 0%	0%	0%	1%	0%	0%
BM-U:PL: 0%	3%	0%	5%	0%	1%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	40%	41%	39%	41%	41%
BM-U:SEPJ: 0%	54%	56%	52%	56%	55%
BM-U:TEX: 0%	1%	1%	1%	1%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	0%	0%	0%	0%	0%
BT-U:EX2B: 0%	0%	0%	1%	0%	0%
BT-U:PL: 0%	4%	0%	5%	0%	1%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	44%	45%	41%	45%	45%
BT-U:SEPJ: 0%	52%	54%	53%	55%	54%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	0%	1%	1%	1%	0%
CB-U:EX2B: 0%	0%	0%	0%	0%	0%
CB-U:PL: 0%	2%	3%	6%	4%	2%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	35%	35%	33%	34%	35%
CB-U:SEPJ: 0%	63%	62%	60%	60%	63%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	26%	5%	78%	1%	17%
MSh-U:SEP: 0%	74%	95%	22%	99%	83%
MSh-U:TE: 0%	0%	0%	0%	0%	0%
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	1%	1%	1%
PJ-D:OP: 0%	5%	6%	5%	5%	5%
PJ-U:EX: 0%	85%	86%	85%	84%	83%
PJ-U:TEX: 0%	10%	8%	9%	10%	12%
SWA-A:AL: 0%	0%	0%	0%	0%	9%
SWA-B:CL: 0%	10%	1%	10%	1%	15%
SWA-C:CL: 0%	60%	67%	62%	65%	46%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	9%	11%	7%	13%	10%
SWA-U:SES: 0%	21%	21%	21%	21%	21%
WDR-A:AL: 0%	0%	1%	1%	0%	3%
WDR-B:CL: 0%	18%	1%	8%	1%	1%
WDR-C:OP: 0%	5%	5%	3%	3%	8%
WDR-D:CL: 0%	3%	1%	1%	4%	7%
WDR-E:CL: 0%	0%	1%	0%	0%	0%
WDR-U:DE: 0%	3%	0%	1%	1%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	36%	40%	32%	30%	40%
WDR-U:ET: 0%	0%	0%	4%	0%	0%
WDR-U:EX: 0%	0%	0%	7%	0%	0%
WDR-U:TEX: 0%	36%	49%	42%	60%	41%

Appendix 12. FUEL-BREAK-ONLY MANAGEMENT scenario areas (percent) by vegetation class for ecological systems of the Red Cliffs and Beaver Dam Wash NCAs.

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	1%	0%	1%	0%	1%
BSu-B:OP: 0%	0%	2%	1%	1%	1%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	1%	1%	1%	0%	1%
BSu-U:EX: 0%	94%	93%	94%	87%	93%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	6%	1%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	2%	2%	2%	3%	2%
BSu-U:TEX: 0%	2%	2%	1%	3%	1%
BM-A:AL: 0%	0%	0%	0%	0%	0%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	3%	1%	3%	1%	3%
BM-U:EX2B: 0%	59%	52%	62%	23%	51%
BM-U:PL: 0%	0%	0%	0%	0%	0%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	37%	44%	34%	73%	44%
BM-U:SEPJ: 0%	0%	0%	0%	0%	0%
BM-U:TEX: 0%	2%	2%	1%	3%	2%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	3%	2%	3%	1%	3%
BT-U:EX2B: 0%	57%	42%	61%	18%	46%
BT-U:PL: 0%	0%	0%	0%	0%	0%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	41%	56%	36%	81%	50%
BT-U:SEPJ: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	9%	19%	11%	22%	12%
CB-U:EX2B: 0%	18%	11%	21%	9%	13%
CB-U:PL: 0%	0%	0%	0%	0%	0%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	73%	70%	69%	69%	76%
CB-U:SEPJ: 0%	0%	0%	0%	0%	0%
DSS-A:OP: 0%	0%	0%	0%	0%	0%
DSS-B:OP: 0%	0%	0%	0%	0%	0%
DSS-U:DP: 0%	0%	0%	0%	0%	0%
DSS-U:SEP: 0%	100%	100%	100%	100%	100%
MR-A:AL: 0%	0%	0%	0%	0%	0%
MR-B:OP: 0%	0%	0%	0%	0%	0%
MR-C:CL: 0%	0%	0%	0%	0%	0%
MR-U:DE: 0%	0%	0%	0%	0%	0%
MR-U:EF: 0%	100%	100%	100%	100%	100%
MR-U:SFE: 0%	0%	0%	0%	0%	0%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	25%	0%	0%	0%	0%
MSh-U:EX: 0%	0%	25%	50%	0%	0%
MSh-U:SEP: 0%	75%	50%	25%	75%	100%
MSh-U:TE: 0%	0%	25%	25%	25%	0%
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	0%	0%	0%
PJ-D:OP: 0%	0%	0%	0%	0%	0%
PJ-U:EX: 0%	23%	19%	25%	9%	20%
PJ-U:TEX: 0%	77%	81%	75%	91%	80%
SWA-A:AL: 0%	1%	0%	1%	0%	16%
SWA-B:CL: 0%	16%	1%	14%	1%	8%
SWA-C:CL: 0%	17%	31%	20%	32%	11%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
SWA-U:SEP: 0%	9%	11%	7%	10%	10%
SWA-U:SES: 0%	57%	57%	57%	57%	56%
WDR-A:AL: 0%	0%	3%	1%	0%	2%
WDR-B:CL: 0%	13%	8%	15%	3%	7%
WDR-C:OP: 0%	4%	7%	6%	8%	11%
WDR-D:CL: 0%	7%	4%	3%	7%	9%
WDR-E:CL: 0%	7%	3%	4%	10%	7%
WDR-U:DE: 0%	0%	0%	0%	0%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	28%	34%	30%	31%	30%
WDR-U:ET: 0%	1%	1%	2%	1%	0%
WDR-U:EX: 0%	0%	0%	4%	0%	0%
WDR-U:TEX: 0%	41%	40%	35%	41%	34%
GRL-A:AL: 0%	0%	0%	0%	0%	0%
GRL-B:OP: 0%	0%	0%	0%	0%	0%
GRL-U:DP: 0%	0%	0%	0%	0%	0%
GRL-U:EEX: 0%	3%	3%	3%	3%	3%
GRL-U:EX: 0%	0%	0%	0%	0%	0%
GRL-U:SES: 0%	97%	97%	97%	97%	97%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	100%	100%	100%	100%	89%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%
BSu-U:TEX: 0%	0%	0%	0%	0%	11%
BM-A:AL: 0%	0%	0%	0%	0%	0%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	1%	1%	1%	1%	1%
BM-U:EX2B: 0%	20%	19%	22%	15%	18%
BM-U:PL: 0%	0%	0%	0%	0%	0%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	29%	31%	28%	31%	30%
BM-U:SEPJ: 0%	48%	49%	48%	52%	50%
BM-U:TEX: 0%	1%	1%	0%	1%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	3%	2%	3%	1%	3%
BT-U:EX2B: 0%	8%	2%	10%	1%	4%
BT-U:PL: 0%	0%	0%	0%	0%	0%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	40%	43%	39%	44%	41%
BT-U:SEPJ: 0%	49%	53%	48%	54%	52%
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	8%	19%	10%	23%	10%
CB-U:EX2B: 0%	22%	11%	24%	3%	14%
CB-U:PL: 0%	0%	0%	0%	0%	0%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	24%	25%	23%	26%	26%
CB-U:SEPJ: 0%	46%	45%	43%	48%	49%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	19%	2%	72%	1%	26%
MSh-U:SEP: 0%	81%	98%	28%	99%	74%
MSh-U:TE: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
PJ-A:AL: 0%	1%	0%	0%	0%	1%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	0%	0%	0%
PJ-D:OP: 0%	5%	6%	4%	6%	5%
PJ-U:EX: 0%	83%	84%	85%	84%	83%
PJ-U:TEX: 0%	12%	10%	11%	10%	11%
SWA-A:AL: 0%	1%	0%	1%	0%	27%
SWA-B:CL: 0%	23%	2%	24%	1%	20%
SWA-C:CL: 0%	38%	59%	42%	56%	14%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	5%	4%	4%	7%	7%
SWA-U:SES: 0%	34%	35%	29%	35%	33%
WDR-A:AL: 0%	1%	4%	1%	1%	1%
WDR-B:CL: 0%	18%	8%	11%	8%	5%
WDR-C:OP: 0%	3%	1%	4%	5%	11%
WDR-D:CL: 0%	1%	3%	7%	11%	4%
WDR-E:CL: 0%	0%	0%	0%	1%	0%
WDR-U:DE: 0%	3%	0%	1%	0%	1%
WDR-U:DEF: 0%	1%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	1%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	40%	34%	25%	21%	37%
WDR-U:ET: 0%	0%	3%	1%	1%	1%
WDR-U:EX: 0%	0%	0%	12%	0%	0%
WDR-U:TEX: 0%	33%	47%	36%	51%	38%

Appendix 13. BFOD WITH 75% SUCCESS RATE MANAGEMENT scenario areas (percent) by vegetation class for ecological systems of the Red Cliffs and Beaver Dam Wash NCAs.

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	1%	0%	1%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	1%	1%	1%	0%	1%
BSu-U:EX: 0%	95%	94%	96%	87%	95%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	1%	0%
BSu-U:SES: 0%	0%	0%	0%	6%	1%
BSu-U:TE: 0%	2%	2%	2%	3%	2%
BSu-U:TEX: 0%	1%	1%	1%	2%	1%
BM-A:AL: 0%	3%	1%	3%	0%	2%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	69%	61%	66%	76%	68%
BM-D:OP: 0%	18%	15%	16%	15%	19%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	2%	1%	0%	0%
BM-U:EX2B: 0%	0%	6%	2%	0%	0%
BM-U:PL: 0%	3%	6%	5%	0%	3%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	2%	2%	2%	0%	1%
BM-U:SEPJ: 0%	0%	0%	0%	0%	0%
BM-U:TEX: 0%	5%	7%	5%	9%	6%
BT-A:AL: 0%	1%	0%	1%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	96%	78%	98%	94%	93%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	1%	4%	0%	1%	1%
BT-U:EX2B: 0%	0%	0%	0%	0%	0%
BT-U:PL: 0%	1%	15%	0%	3%	3%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	1%	3%	1%	2%	2%
BT-U:SEPJ: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	6%	6%	8%	8%	5%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	93%	91%	91%	90%	93%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	1%	0%	0%
CB-U:EX: 0%	0%	0%	0%	0%	0%
CB-U:EX2B: 0%	0%	0%	0%	0%	0%
CB-U:PL: 0%	0%	0%	0%	1%	0%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	0%	2%	0%	1%	1%
CB-U:SEPJ: 0%	0%	0%	0%	0%	0%
DSS-A:OP: 0%	0%	0%	0%	0%	0%
DSS-B:OP: 0%	100%	100%	100%	100%	99%
DSS-U:DP: 0%	0%	0%	0%	0%	0%
DSS-U:SEP: 0%	0%	0%	0%	0%	0%
MR-A:AL: 0%	0%	0%	0%	0%	0%
MR-B:OP: 0%	0%	0%	0%	0%	0%
MR-C:CL: 0%	0%	0%	0%	0%	0%
MR-U:DE: 0%	0%	0%	0%	0%	0%
MR-U:EF: 0%	100%	100%	100%	100%	100%
MR-U:SFE: 0%	0%	0%	0%	0%	0%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	25%	0%	25%
MSh-U:EX: 0%	75%	75%	75%	67%	75%
MSh-U:SEP: 0%	0%	0%	0%	0%	0%
MSh-U:TE: 0%	25%	25%	0%	33%	0%
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	0%	0%	0%
PJ-D:OP: 0%	0%	0%	0%	0%	0%
PJ-U:EX: 0%	23%	21%	25%	10%	19%
PJ-U:TEX: 0%	77%	79%	75%	90%	81%
SWA-A:AL: 0%	2%	0%	2%	1%	38%
SWA-B:CL: 0%	35%	2%	27%	3%	27%
SWA-C:CL: 0%	63%	97%	70%	96%	33%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
SWA-U:SEP: 0%	1%	1%	1%	1%	1%
SWA-U:SES: 0%	0%	0%	0%	0%	0%
WDR-A:AL: 0%	1%	4%	1%	1%	1%
WDR-B:CL: 0%	9%	11%	10%	3%	8%
WDR-C:OP: 0%	6%	6%	7%	6%	11%
WDR-D:CL: 0%	2%	3%	3%	7%	6%
WDR-E:CL: 0%	8%	6%	2%	9%	4%
WDR-U:DE: 0%	3%	1%	1%	2%	2%
WDR-U:DEF: 0%	0%	1%	0%	0%	1%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	28%	30%	25%	25%	30%
WDR-U:ET: 0%	1%	0%	2%	2%	1%
WDR-U:EX: 0%	3%	1%	6%	0%	0%
WDR-U:TEX: 0%	40%	38%	44%	46%	38%
GRL-A:AL: 0%	7%	0%	8%	4%	4%
GRL-B:OP: 0%	81%	90%	84%	79%	75%
GRL-U:DP: 0%	0%	0%	0%	0%	0%
GRL-U:EEX: 0%	0%	0%	0%	0%	0%
GRL-U:EX: 0%	0%	0%	0%	0%	1%
GRL-U:SES: 0%	13%	10%	7%	17%	20%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	100%	100%	100%	89%	100%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	11%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%
BSu-U:TEX: 0%	0%	0%	0%	0%	0%
BM-A:AL: 0%	2%	1%	3%	0%	2%
BM-B:JT: 0%	49%	48%	49%	48%	48%
BM-C:OP: 0%	38%	41%	39%	42%	39%
BM-D:OP: 0%	3%	2%	3%	3%	3%
BM-E:JT: 0%	5%	4%	4%	4%	5%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	0%	0%	0%	0%
BM-U:EX2B: 0%	0%	0%	0%	0%	0%
BM-U:PL: 0%	0%	0%	0%	0%	0%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	0%	0%	0%	0%	0%
BM-U:SEPJ: 0%	0%	1%	0%	0%	1%
BM-U:TEX: 0%	2%	3%	2%	3%	2%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	52%	49%	53%	52%	53%
BT-C:CL: 0%	33%	32%	34%	32%	30%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	0%	1%	0%	0%	0%
BT-U:EX2B: 0%	0%	3%	0%	0%	0%
BT-U:PL: 0%	1%	1%	1%	0%	1%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	13%	13%	10%	15%	15%
BT-U:SEPJ: 0%	0%	1%	1%	0%	1%
CB-A:OP: 0%	6%	9%	11%	11%	6%
CB-B:JT: 0%	20%	18%	19%	17%	17%
CB-C:OP: 0%	32%	31%	32%	30%	31%
CB-D:JT: 0%	33%	32%	31%	30%	34%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	1%	2%	1%	1%	0%
CB-U:EX2B: 0%	2%	1%	2%	0%	0%
CB-U:PL: 0%	2%	2%	2%	2%	2%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	1%	2%	1%	3%	4%
CB-U:SEPJ: 0%	2%	3%	1%	5%	6%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	28%	2%	72%	1%	23%
MSh-U:SEP: 0%	72%	98%	28%	99%	77%
MSh-U:TE: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
PJ-A:AL: 0%	0%	0%	1%	0%	0%
PJ-B:OP: 0%	1%	0%	1%	0%	0%
PJ-C:OP: 0%	0%	0%	0%	0%	0%
PJ-D:OP: 0%	5%	5%	5%	6%	6%
PJ-U:EX: 0%	83%	85%	84%	84%	83%
PJ-U:TEX: 0%	12%	9%	10%	10%	11%
SWA-A:AL: 0%	1%	0%	3%	0%	40%
SWA-B:CL: 0%	52%	3%	38%	2%	29%
SWA-C:CL: 0%	47%	95%	59%	97%	30%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	0%	1%	0%	0%	1%
SWA-U:SES: 0%	0%	0%	0%	0%	0%
WDR-A:AL: 0%	0%	4%	0%	0%	0%
WDR-B:CL: 0%	14%	14%	8%	3%	7%
WDR-C:OP: 0%	10%	4%	5%	8%	7%
WDR-D:CL: 0%	0%	3%	3%	1%	10%
WDR-E:CL: 0%	0%	0%	0%	3%	1%
WDR-U:DE: 0%	0%	0%	0%	0%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	25%	36%	38%	29%	30%
WDR-U:ET: 0%	0%	0%	1%	1%	0%
WDR-U:EX: 0%	0%	0%	7%	0%	0%
WDR-U:TEX: 0%	52%	40%	37%	55%	45%

Appendix 14. BFOD WITH 50% SUCCESS RATE MANAGEMENT scenario areas (percent) by vegetation class for ecological systems of the Red Cliffs and Beaver Dam Wash NCAs.

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	1%	0%	1%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	1%	1%	1%	0%	1%
BSu-U:EX: 0%	96%	94%	96%	87%	95%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	1%	0%
BSu-U:SES: 0%	0%	1%	0%	6%	1%
BSu-U:TE: 0%	2%	3%	2%	3%	2%
BSu-U:TEX: 0%	1%	1%	0%	2%	1%
BM-A:AL: 0%	2%	1%	2%	0%	1%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	56%	57%	54%	69%	54%
BM-D:OP: 0%	18%	15%	16%	15%	18%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	1%	2%	1%	0%	2%
BM-U:EX2B: 0%	12%	12%	16%	0%	13%
BM-U:PL: 0%	4%	4%	3%	0%	4%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	3%	3%	3%	9%	3%
BM-U:SEPJ: 0%	0%	0%	0%	0%	0%
BM-U:TEX: 0%	5%	6%	4%	7%	5%
BT-A:AL: 0%	1%	0%	1%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	96%	94%	98%	98%	96%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	1%	1%	0%	0%	0%
BT-U:EX2B: 0%	0%	0%	0%	0%	0%
BT-U:PL: 0%	2%	3%	0%	0%	1%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	1%	2%	1%	1%	2%
BT-U:SEPJ: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	5%	7%	9%	8%	5%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	94%	90%	90%	90%	93%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	0%	0%	0%	0%	0%
CB-U:EX2B: 0%	0%	0%	0%	0%	0%
CB-U:PL: 0%	0%	0%	0%	0%	0%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	0%	2%	1%	1%	2%
CB-U:SEPJ: 0%	0%	0%	0%	0%	0%
DSS-A:OP: 0%	0%	0%	0%	0%	0%
DSS-B:OP: 0%	72%	68%	74%	70%	70%
DSS-U:DP: 0%	0%	0%	0%	0%	0%
DSS-U:SEP: 0%	28%	32%	26%	30%	30%
MR-A:AL: 0%	0%	0%	0%	0%	0%
MR-B:OP: 0%	0%	0%	0%	0%	0%
MR-C:CL: 0%	0%	0%	0%	0%	0%
MR-U:DE: 0%	0%	0%	0%	0%	0%
MR-U:EF: 0%	100%	100%	100%	100%	100%
MR-U:SFE: 0%	0%	0%	0%	0%	0%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	25%	50%	25%
MSh-U:EX: 0%	0%	0%	25%	0%	25%
MSh-U:SEP: 0%	100%	75%	50%	50%	50%
MSh-U:TE: 0%	0%	25%	0%	0%	0%
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	0%	0%	0%
PJ-D:OP: 0%	0%	0%	0%	0%	0%
PJ-U:EX: 0%	22%	20%	25%	10%	20%
PJ-U:TEX: 0%	78%	80%	75%	90%	80%
SWA-A:AL: 0%	1%	0%	2%	1%	38%
SWA-B:CL: 0%	33%	3%	32%	3%	23%
SWA-C:CL: 0%	66%	94%	65%	96%	36%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
SWA-U:SEP: 0%	0%	2%	1%	0%	2%
SWA-U:SES: 0%	0%	0%	0%	0%	0%
WDR-A:AL: 0%	1%	4%	1%	1%	1%
WDR-B:CL: 0%	9%	11%	10%	3%	8%
WDR-C:OP: 0%	6%	6%	7%	6%	11%
WDR-D:CL: 0%	2%	3%	3%	7%	6%
WDR-E:CL: 0%	8%	6%	2%	9%	4%
WDR-U:DE: 0%	3%	1%	1%	2%	2%
WDR-U:DEF: 0%	0%	1%	0%	0%	1%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	28%	30%	25%	25%	30%
WDR-U:ET: 0%	1%	0%	2%	2%	1%
WDR-U:EX: 0%	3%	1%	6%	0%	0%
WDR-U:TEX: 0%	40%	38%	44%	46%	38%
GRL-A:AL: 0%	9%	1%	5%	1%	3%
GRL-B:OP: 0%	81%	84%	84%	81%	81%
GRL-U:DP: 0%	0%	0%	0%	0%	0%
GRL-U:EEX: 0%	0%	0%	0%	0%	0%
GRL-U:EX: 0%	1%	0%	1%	1%	1%
GRL-U:SES: 0%	10%	15%	10%	16%	14%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	100%	100%	100%	89%	100%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%
BSu-U:TEX: 0%	0%	0%	0%	11%	0%
BM-A:AL: 0%	2%	0%	2%	0%	1%
BM-B:JT: 0%	44%	45%	45%	43%	43%
BM-C:OP: 0%	31%	33%	32%	32%	31%
BM-D:OP: 0%	3%	3%	2%	2%	3%
BM-E:JT: 0%	4%	4%	4%	4%	5%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	0%	0%	0%	0%
BM-U:EX2B: 0%	0%	0%	0%	0%	0%
BM-U:PL: 0%	1%	0%	1%	0%	0%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	5%	5%	5%	6%	6%
BM-U:SEPJ: 0%	8%	8%	6%	10%	9%
BM-U:TEX: 0%	2%	2%	2%	3%	2%
BT-A:AL: 0%	0%	0%	1%	0%	0%
BT-B:JT: 0%	53%	55%	51%	54%	52%
BT-C:CL: 0%	32%	28%	33%	30%	30%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	0%	1%	1%	0%	1%
BT-U:EX2B: 0%	0%	0%	2%	0%	0%
BT-U:PL: 0%	1%	1%	1%	0%	1%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	14%	14%	11%	15%	16%
BT-U:SEPJ: 0%	0%	1%	1%	0%	1%
CB-A:OP: 0%	4%	5%	7%	7%	4%
CB-B:JT: 0%	12%	11%	11%	10%	11%
CB-C:OP: 0%	21%	21%	21%	20%	20%
CB-D:JT: 0%	24%	23%	23%	21%	24%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	2%	7%	2%	7%	3%
CB-U:EX2B: 0%	9%	3%	11%	1%	3%
CB-U:PL: 0%	1%	1%	1%	1%	1%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	9%	10%	8%	11%	12%
CB-U:SEPJ: 0%	18%	19%	15%	21%	21%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	30%	1%	74%	0%	17%
MSh-U:SEP: 0%	70%	99%	26%	100%	83%
MSh-U:TE: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	0%	0%	0%	0%	1%
PJ-C:OP: 0%	1%	0%	0%	0%	0%
PJ-D:OP: 0%	3%	6%	6%	6%	5%
PJ-U:EX: 0%	85%	85%	85%	83%	83%
PJ-U:TEX: 0%	10%	9%	9%	11%	12%
SWA-A:AL: 0%	2%	0%	3%	0%	35%
SWA-B:CL: 0%	40%	2%	34%	2%	28%
SWA-C:CL: 0%	50%	87%	63%	84%	29%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	3%	3%	1%	6%	4%
SWA-U:SES: 0%	5%	7%	0%	8%	3%
WDR-A:AL: 0%	0%	1%	1%	0%	3%
WDR-B:CL: 0%	18%	1%	8%	1%	1%
WDR-C:OP: 0%	5%	5%	3%	3%	8%
WDR-D:CL: 0%	3%	1%	1%	4%	7%
WDR-E:CL: 0%	0%	1%	0%	0%	0%
WDR-U:DE: 0%	3%	0%	1%	1%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	36%	40%	32%	30%	40%
WDR-U:ET: 0%	0%	0%	4%	0%	0%
WDR-U:EX: 0%	0%	0%	7%	0%	0%
WDR-U:TEX: 0%	36%	49%	42%	60%	41%

Appendix 15. BFOD WITH 25% SUCCESS RATE MANAGEMENT scenario areas (percent) by vegetation class for ecological systems of the Red Cliffs and Beaver Dam Wash NCAs.

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	1%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	1%	0%	1%	0%	1%
BSu-U:EX: 0%	96%	95%	96%	88%	95%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	1%	0%
BSu-U:SES: 0%	0%	1%	0%	6%	1%
BSu-U:TE: 0%	2%	2%	2%	3%	2%
BSu-U:TEX: 0%	1%	1%	1%	2%	1%
BM-A:AL: 0%	1%	0%	1%	0%	1%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	27%	29%	27%	34%	28%
BM-D:OP: 0%	15%	11%	13%	7%	14%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	2%	2%	1%	0%	2%
BM-U:EX2B: 0%	39%	19%	44%	0%	32%
BM-U:PL: 0%	2%	2%	2%	0%	2%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	11%	32%	9%	53%	19%
BM-U:SEPJ: 0%	0%	0%	0%	0%	0%
BM-U:TEX: 0%	3%	4%	3%	5%	4%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	96%	96%	95%	98%	94%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	1%	1%	1%	0%	1%
BT-U:EX2B: 0%	0%	0%	0%	0%	0%
BT-U:PL: 0%	2%	1%	2%	0%	2%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	1%	2%	2%	1%	3%
BT-U:SEPJ: 0%	0%	0%	0%	0%	0%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	5%	6%	9%	8%	5%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	94%	91%	90%	89%	93%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	1%	0%	0%	1%	0%
CB-U:EX: 0%	0%	0%	0%	0%	0%
CB-U:EX2B: 0%	0%	0%	0%	0%	0%
CB-U:PL: 0%	0%	0%	0%	1%	0%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	1%	2%	1%	2%	1%
CB-U:SEPJ: 0%	0%	0%	0%	0%	0%
DSS-A:OP: 0%	0%	0%	0%	0%	0%
DSS-B:OP: 0%	37%	34%	37%	35%	34%
DSS-U:DP: 0%	0%	0%	0%	0%	0%
DSS-U:SEP: 0%	63%	66%	63%	64%	66%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	33%	0%	0%	0%
MSh-U:EX: 0%	67%	0%	50%	0%	0%
MSh-U:SEP: 0%	33%	67%	25%	67%	50%
MSh-U:TE: 0%	0%	0%	25%	33%	50%
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	0%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	0%	0%	0%
PJ-D:OP: 0%	0%	0%	0%	0%	0%
PJ-U:EX: 0%	22%	20%	24%	10%	19%
PJ-U:TEX: 0%	78%	80%	76%	90%	81%
SWA-A:AL: 0%	2%	1%	1%	0%	37%
SWA-B:CL: 0%	35%	4%	30%	3%	28%
SWA-C:CL: 0%	63%	94%	69%	95%	33%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	1%	1%	0%	2%	1%
SWA-U:SES: 0%	0%	0%	0%	0%	0%
WDR-A:AL: 0%	1%	4%	1%	1%	1%
WDR-B:CL: 0%	9%	11%	10%	3%	8%
WDR-C:OP: 0%	6%	6%	7%	6%	11%
WDR-D:CL: 0%	2%	3%	3%	7%	6%

Red Cliffs NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
WDR-E:CL: 0%	8%	6%	2%	9%	4%
WDR-U:DE: 0%	3%	1%	1%	2%	2%
WDR-U:DEF: 0%	0%	1%	0%	0%	1%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	28%	30%	25%	25%	30%
WDR-U:ET: 0%	1%	0%	2%	2%	1%
WDR-U:EX: 0%	3%	1%	6%	0%	0%
WDR-U:TEX: 0%	40%	38%	44%	46%	38%
GRL-A:AL: 0%	6%	1%	5%	1%	2%
GRL-B:OP: 0%	59%	66%	68%	60%	64%
GRL-U:DP: 0%	0%	1%	0%	0%	0%
GRL-U:EEX: 0%	0%	0%	1%	1%	0%
GRL-U:EX: 0%	0%	0%	1%	1%	1%
GRL-U:SES: 0%	35%	32%	25%	37%	32%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	100%	100%	100%	89%	100%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	11%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%
BSu-U:TEX: 0%	0%	0%	0%	0%	0%
BM-A:AL: 0%	1%	0%	1%	0%	0%
BM-B:JT: 0%	23%	23%	23%	22%	21%
BM-C:OP: 0%	15%	15%	15%	15%	15%
BM-D:OP: 0%	1%	1%	1%	1%	1%
BM-E:JT: 0%	2%	2%	2%	2%	2%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	0%	0%	1%	0%	0%
BM-U:EX2B: 0%	1%	0%	3%	0%	0%
BM-U:PL: 0%	1%	0%	1%	0%	0%
BM-U:SD: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	21%	23%	20%	22%	22%
BM-U:SEPJ: 0%	33%	34%	32%	34%	35%
BM-U:TEX: 0%	1%	1%	1%	2%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	40%	40%	41%	40%	37%
BT-C:CL: 0%	29%	26%	27%	26%	24%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	1%	0%	2%	0%	1%
BT-U:EX2B: 0%	5%	0%	6%	0%	3%
BT-U:PL: 0%	0%	0%	0%	0%	0%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	16%	21%	15%	22%	22%
BT-U:SEPJ: 0%	9%	11%	8%	12%	13%
CB-A:OP: 0%	2%	3%	4%	3%	2%
CB-B:JT: 0%	6%	5%	6%	5%	5%
CB-C:OP: 0%	11%	10%	11%	10%	10%
CB-D:JT: 0%	12%	12%	12%	11%	12%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	2%	10%	4%	12%	5%
CB-U:EX2B: 0%	13%	5%	16%	2%	5%
CB-U:PL: 0%	1%	1%	0%	1%	1%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	18%	19%	16%	20%	21%
CB-U:SEPJ: 0%	34%	35%	31%	37%	39%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	23%	2%	73%	1%	17%
MSh-U:SEP: 0%	77%	98%	27%	99%	83%
MSh-U:TE: 0%	0%	0%	0%	0%	0%
PJ-A:AL: 0%	0%	0%	0%	0%	0%
PJ-B:OP: 0%	1%	0%	0%	0%	0%
PJ-C:OP: 0%	0%	0%	1%	1%	0%
PJ-D:OP: 0%	5%	6%	5%	5%	6%
PJ-U:EX: 0%	84%	84%	85%	84%	86%
PJ-U:TEX: 0%	10%	10%	10%	10%	8%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
SWA-A:AL: 0%	1%	0%	2%	0%	30%
SWA-B:CL: 0%	32%	2%	30%	2%	24%
SWA-C:CL: 0%	41%	75%	51%	68%	23%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	5%	4%	3%	7%	6%
SWA-U:SES: 0%	22%	19%	13%	24%	17%
WDR-A:AL: 0%	3%	3%	0%	3%	0%
WDR-B:CL: 0%	14%	3%	5%	0%	4%
WDR-C:OP: 0%	4%	5%	1%	7%	7%
WDR-D:CL: 0%	0%	3%	1%	3%	3%
WDR-E:CL: 0%	0%	0%	0%	0%	0%
WDR-U:DE: 0%	0%	0%	0%	3%	0%
WDR-U:DEF: 0%	0%	1%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	40%	38%	37%	29%	42%
WDR-U:ET: 0%	0%	0%	3%	0%	0%
WDR-U:EX: 0%	3%	0%	5%	0%	0%
WDR-U:TEX: 0%	37%	47%	47%	56%	44%

Appendix 16. NO-GRAZING-ONLY MANAGEMENT scenario areas (percent) by vegetation class for ecological systems of the Beaver Dam Wash NCA.

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
BSu-A:AL: 0%	0%	0%	0%	0%	0%
BSu-B:OP: 0%	0%	0%	0%	0%	0%
BSu-C:CL: 0%	0%	0%	0%	0%	0%
BSu-D:OP: 0%	0%	0%	0%	0%	0%
BSu-E:CL: 0%	0%	0%	0%	0%	0%
BSu-U:DP: 0%	0%	0%	0%	0%	0%
BSu-U:ES: 0%	0%	0%	0%	0%	0%
BSu-U:EX: 0%	100%	100%	100%	100%	100%
BSu-U:SD: 0%	0%	0%	0%	0%	0%
BSu-U:SEP: 0%	0%	0%	0%	0%	0%
BSu-U:SES: 0%	0%	0%	0%	0%	0%
BSu-U:TE: 0%	0%	0%	0%	0%	0%
BSu-U:TEX: 0%	0%	0%	0%	0%	0%
BM-A:AL: 0%	0%	0%	0%	0%	0%
BM-B:JT: 0%	0%	0%	0%	0%	0%
BM-C:OP: 0%	0%	0%	0%	0%	0%
BM-D:OP: 0%	0%	0%	0%	0%	0%
BM-E:JT: 0%	0%	0%	0%	0%	0%
BM-U:BG: 0%	0%	0%	0%	0%	0%
BM-U:ES: 0%	0%	0%	0%	0%	0%
BM-U:EX: 0%	1%	1%	1%	1%	1%
BM-U:EX2B: 0%	33%	31%	34%	27%	28%
BM-U:PL: 0%	0%	0%	0%	0%	0%
BM-U:SD: 0%	0%	0%	0%	0%	0%
BM-U:SDI: 0%	0%	0%	0%	0%	0%
BM-U:SEP: 0%	24%	25%	24%	26%	26%
BM-U:SEPJ: 0%	41%	42%	41%	45%	44%
BM-U:TEX: 0%	1%	1%	0%	1%	1%
BT-A:AL: 0%	0%	0%	0%	0%	0%
BT-B:JT: 0%	0%	0%	0%	0%	0%
BT-C:CL: 0%	0%	0%	0%	0%	0%
BT-U:BG: 0%	0%	0%	0%	0%	0%
BT-U:ES: 0%	0%	0%	0%	0%	0%
BT-U:EX: 0%	3%	2%	3%	1%	4%
BT-U:EX2B: 0%	30%	22%	31%	14%	23%
BT-U:PL: 0%	0%	0%	0%	0%	0%
BT-U:SD: 0%	0%	0%	0%	0%	0%
BT-U:SDI: 0%	0%	0%	0%	0%	0%
BT-U:SEP: 0%	32%	37%	32%	41%	35%
BT-U:SEPJ: 0%	36%	39%	35%	44%	38%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
CB-A:OP: 0%	0%	0%	0%	0%	0%
CB-B:JT: 0%	0%	0%	0%	0%	0%
CB-C:OP: 0%	0%	0%	0%	0%	0%
CB-D:JT: 0%	0%	0%	0%	0%	0%
CB-U:BG: 0%	0%	0%	0%	0%	0%
CB-U:ES: 0%	0%	0%	0%	0%	0%
CB-U:EX: 0%	3%	17%	5%	23%	8%
CB-U:EX2B: 0%	34%	19%	37%	6%	23%
CB-U:PL: 0%	0%	0%	0%	0%	0%
CB-U:SD: 0%	0%	0%	0%	0%	0%
CB-U:SDI: 0%	0%	0%	0%	0%	0%
CB-U:SEP: 0%	22%	22%	21%	24%	24%
CB-U:SEPJ: 0%	41%	41%	37%	46%	45%
MSh-A:AL: 0%	0%	0%	0%	0%	0%
MSh-B:CL: 0%	0%	0%	0%	0%	0%
MSh-C:CL: 0%	0%	0%	0%	0%	0%
MSh-D:OP: 0%	0%	0%	0%	0%	0%
MSh-U:ES: 0%	0%	0%	0%	0%	0%
MSh-U:EX: 0%	24%	1%	75%	1%	25%
MSh-U:SEP: 0%	76%	99%	25%	99%	75%
MSh-U:TE: 0%	0%	0%	0%	0%	0%
PJ-A:AL: 0%	0%	0%	1%	0%	0%
PJ-B:OP: 0%	1%	0%	0%	0%	0%
PJ-C:OP: 0%	1%	1%	0%	1%	1%
PJ-D:OP: 0%	4%	5%	5%	5%	5%
PJ-U:EX: 0%	85%	85%	85%	83%	85%
PJ-U:TEX: 0%	9%	9%	10%	11%	10%
SWA-A:AL: 0%	1%	0%	1%	0%	26%
SWA-B:CL: 0%	37%	2%	29%	2%	19%
SWA-C:CL: 0%	24%	59%	36%	55%	15%
SWA-U:BG: 0%	0%	0%	0%	0%	0%
SWA-U:ES: 0%	0%	0%	0%	0%	0%
SWA-U:ET: 0%	0%	0%	0%	0%	0%
SWA-U:SEP: 0%	17%	18%	12%	22%	19%
SWA-U:SES: 0%	21%	21%	21%	21%	21%
WDR-A:AL: 0%	0%	4%	0%	0%	0%
WDR-B:CL: 0%	14%	14%	8%	3%	7%
WDR-C:OP: 0%	10%	4%	5%	8%	7%
WDR-D:CL: 0%	0%	3%	3%	1%	10%
WDR-E:CL: 0%	0%	0%	0%	3%	1%
WDR-U:DE: 0%	0%	0%	0%	0%	0%
WDR-U:DEF: 0%	0%	0%	0%	0%	0%
WDR-U:DET: 0%	0%	0%	0%	0%	0%

Beaver Dam Wash NCA					
Ecological System × Vegetation Class	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**
WDR-U:DEX: 0%	0%	0%	0%	0%	0%
WDR-U:EF: 0%	25%	36%	38%	29%	30%
WDR-U:ET: 0%	0%	0%	1%	1%	0%
WDR-U:EX: 0%	0%	0%	7%	0%	0%
WDR-U:TEX: 0%	52%	40%	37%	55%	45%