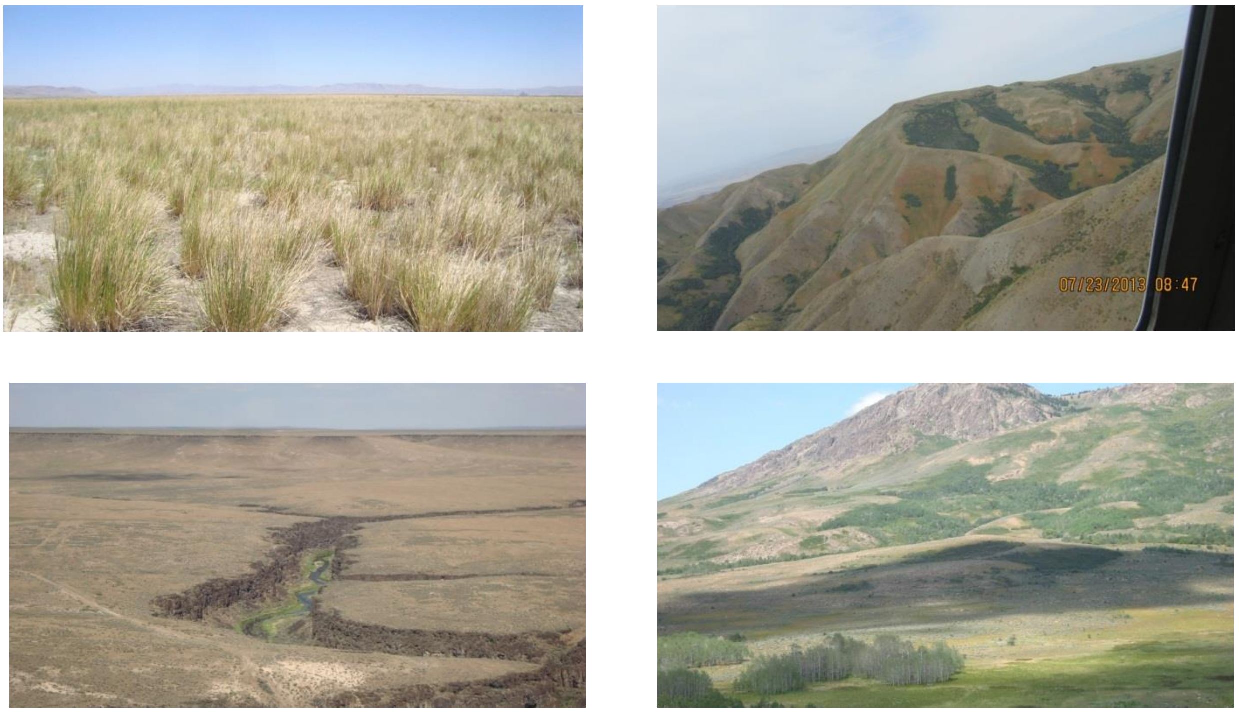
Sage-grouse Conservation Forecasting for
Newmont Mining Corporation's IL and TS-Horseshoe Ranches

DRAFT Report for Newmont Mining Corporation; Elko, NV



Clockwise from top left: Basin wildrye bottomland in Boulder Valley; North Tuscarora Range; Bull Run Basin; and South Fork of the Owyhee River, Louis Provencher 2013, © The Nature Conservancy

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Executive Summary

Introduction

As a result of discussions and concept development activities with The Nature Conservancy (TNC) that began in 2011, Newmont Mining Corporation (Newmont) entered into a formal partnership with TNC in April 2013. Further into the partnership, TNC and Newmont established a Consulting Services Agreement to apply the Landscape Conservation Forecasting ™ process – including satellite imagery, remote sensing, predictive ecological models, and cost-benefit assessments– to two large landscapes within Northern Nevada. These areas, the IL Ranch and the TS and Horseshoe Ranches are owned and operated by Elko Land and Livestock Company (ELLCo), a wholly owned subsidiary of Newmont. These ranches comprise a portion of the lands owned by Newmont and ELLCo in Nevada. The agreement provided that:

- "The Nature Conservancy will apply advanced conservation planning methodologies to produce a greater sage-grouse (GSG) conservation and habitat restoration plan (Plan) for roughly 1.2 million acres of fee-owned and federal lands that are managed by Newmont and ELLCo in Nevada.
- The recommendations will inform the stewardship actions that Newmont may subsequently take on their lands to improve critical ecosystem functionality.
- The Plan will also demonstrate a scientifically defensible methodology and set of metrics for measuring and predicting changes in habitat conditions for sage grouse (and other species of concern, namely mule deer and golden eagle)."

Process and Methods

The Landscape Conservation Forecasting™ process for Newmont consisted of seven primary steps:

1. Develop maps of potential vegetation types, termed ecological systems or biophysical settings, and of current vegetation classes within each system, by conducting remote sensing of satellite imagery.
2. Refine computerized predictive state-and-transition ecological models for the ecological systems by updating TNC's Great Basin "library" of models, or by creating new models.
3. Determine current condition of ecological systems using the metric of Unified Ecological Departure (i.e. dis-similarity between current vegetation and vegetation projected projected under reference conditions with minor adjustments for introduced species seedings and pastures). Conditions ranges from 0-100% departed from the "Natural Range of Variation" and divided into three categories: low departure (0-33% departed), moderate departure (34-66% departed), and high departure (67-100% departed).

4. Determine current suitability of habitat for Greater Sage-grouse using the metric of Functional Acres and calculating habitat suitability for golden eagle and mule deer as species representative of overall ecosystem health.
5. Use the computerized ecological models to forecast anticipated future condition of ecological systems, and of habitat suitability for the three species, under a MINIMUM MANAGEMENT scenario (analogous to the "no-action" alternative of NEPA).
6. Use the computerized ecological models to forecast anticipated future condition of ecological systems, and of habitat suitability for the three species, under alternative "active" management scenarios (suites of specific actions or treatments). While all active scenarios aggressively deployed fuel breaks and more widely distributed water sources for livestock and wildlife, two active management scenarios were retained to (a) only maximize sage-grouse habitat suitability (MAX GSG HS MANAGEMENT) or (b) focused on improving ecological system condition (i.e., reducing Unified Ecological departure) even if some actions would not benefit, or even be detrimental for the short-term, to sage-grouse (BEST UED MANAGEMENT).
7. Use Return On Investment (ROI) analyses to assess which actions for which ecological systems yield the most advantageous ("bang for the buck") results for the systems and the three species' habitats.

Disscussion

Key conclusions of the Landscape Conservation Forecasting™ assessment for Newmont's IL Ranch and TS-Horseshoe Ranches are summarized below:

1. The IL Ranch and TS-Horseshoe Ranches, encompassing, respectively, 485,732 acres (196,569 ha) and 521,085 acres (210,876 ha), are ecologically different project areas of north-central Nevada as the former lies within the southern Columbia Plateau ecoregion within the GRSG Management Zone IV and the latter occupies the northern Great Basin ecoregion in GRSG Management Zone III.
2. Sixteen and 19 ecological systems, respectively, were identified in the IL Ranch and TS-Horseshoe Ranches, and they and their component vegetation classes were mapped at 5-m resolution via interpretation of RapidEye satellite imagery. Big sagebrush on upland soils and montane sagebrush steppe were the dominant ecological systems on each property. On theTS-Horseshoe Ranches, the Humboldt River floodplain supports low elevation mesic, saline, and sodic plant communities, which are not found on the IL Ranch.
3. At present, many ecological systems in the IL Ranch are in fair to poor condition, as indicated by high values of the metric of unified ecological departure (UED) (i.e. conditions are highly departed from reference/pre-European settlement conditions), although this metric allows for a limited area of introduced-species seedings without

penalty to the metric. Seven systems were highly departed from reference conditions, six moderately departed, and three showed low departure from reference conditions. Systems at lower levels of unified ecological departure were found at higher elevations and were not widespread.

4. The current condition of ecological systems of the TS-Horseshoe Ranch ranged from 11 in high departure, six at moderate departure, and one at low departure from reference conditions according to the metric unified ecological departure.
5. For the IL Ranch after 30 years of MINIMUM MANAGEMENT (no proactive management actions), UED increased in basin wildrye-montane, montane riparian, montane sagebrush steppe-subalpine, and wet meadow-montane. A few systems were stable, though remained highly departed from reference conditions: aspen woodland, aspen-mixed conifer, and low sagebrush. The big sagebrush-upland system naturally recovered (i.e., lower UED) as reference classes through the actions of various disturbances.
6. For the TS-Horseshoe Ranches after 30 years of MINIMUM MANAGEMENT, UED significantly increased in greasewood, montane sagebrush steppe-upland, saline meadow, wet meadow bottomland, and wet meadow-montane. A few systems remained highly departed from reference conditions, but not further deteriorating: both basin wildrye systems, big sagebrush-semidesert, and big sagebrush-upland with trees.
7. The areas of highest sage-grouse habitat suitability were generally at higher elevations where standing sagebrush dominated vegetation structure when leks were within 10 km of any location. Mapped areas of highest habitat suitability as measured by vital rates or λ were generally the same for the current and 30-year MINIMUM MANAGEMENT scenario habitat suitability for sage-grouse; however, local changes in λ for the MINIMUM MANAGEMENT scenario were observed in formerly burned areas where mixed non-native annual species and perennial native grass species matured into a shrub phase usable as nesting habitat on both ranches. Despite similarities, habitat suitability temporally increased on the TS-Horseshoe Ranch due to recovery from fire and significantly decreased on the IL Ranch due to fires and Aroga moth outbreaks in the minimum management scenario.
8. Mule deer and golden eagle habitat suitability were largely unchanged over 30 years as resource selection functions were dominated by geomorphic, soil, topographic, and established migration corridor attributes, which do not change. For mule deer, mountainous terrain in proximity of migration corridors showed the highest habitat suitability, whereas location of deep soil supporting abundant jackrabbit populations, vegetation supporting alternative prey, locations of food subsidies from livestock birthing and Interstate highway roadkill were determinant for golden eagle habitat suitability.
9. Eight and 10 ecological systems, respectively, were selected for detailed modeling analyses for the IL Ranch and TS-Horseshoe Ranches based on their size, current and

likely future condition (degree of ecological departure), importance to sage-grouse, and/or other features of importance to Newmont and the BLM.

10. Two management scenarios were chosen that emphasized management actions designed to either increase sage-grouse habitat suitability only in the ecological systems used by sage-grouse (MAX GSG HS MANAGEMENT scenario) or decreased unified ecological departure of all systems that were either sufficiently departed or had classes that needed special attention (BEST UED MANAGEMENT scenario). The two scenarios were proposed because several range improvements targeting degraded sagebrush conflicted with increasing sage-grouse habitat suitability in the 30-year time horizon (as per the demographic model). Both scenarios employed fuel breaks (beyond the BLM's existing or proposed fuel breaks) to protect sage-grouse nesting habitat and deployed a more distributed livestock watering system in the Owyhee Allotment.

11. Management scenario Return-On-Investment was examined on two scales: by ecological system using UED and by landscape using species habitat suitability. ROIs summarize a lot of information because they revealed (a) whether an active scenario was worth doing compared to the MINIMUM MANAGEMENT scenario (i.e., scenario's ROI > 0) and (b) if one active scenario was more effective than other active scenarios at improving metrics because ROIs are significantly different.

12. Looking at the larger scale of species habitat suitability (not UED by ecological system), no active management scenario was capable of significantly increasing sage-grouse functional acres compared to the MINIMUM MANAGEMENT scenario on the IL Ranch (average of -50 functional acres lost in the MAX GSG HS MANAGEMENT scenario and an average of 149 functional acres gained with the BEST UED MANAGEMENT scenario). The IL Ranch's vegetation was in relatively good ecological condition with few recent fires, and few areas dominated by non-native annual species; therefore, actively improving generally mature sagebrush and wet meadow communities for the benefit of sage-grouse would be difficult. The value of management on the IL Ranch is in avoiding the loss of good habitat to very large fires.

    The functional acres of the active management scenarios were greater than those of the MINIMUM MANAGEMENT scenario on the 20th year in the IL Ranch; however, these difference vanished in the next 10 years. Despite fuel breaks causing less fire, major fire activity in the last decade for seven out of ten replicates, coupled with Aroga moth thinning of mature sagebrush in the Owyhee Plateau, are believed to have sufficiently transformed sage-grouse nesting habitat into early-succession sagebrush. These processes also chipped away at habitat suitability over the 30 years of the simulations in all scenarios. Early-succession sagebrush cannot be used for nesting and would decrease nest success up to a distance of 2 km. The early-succession vegetation classes would not have enough time to mature by year 30 to contribute to nesting habitat.

    On the TS-Horseshoe Ranch, habitat suitability and functional acres increased rapidly with time in all scenarios because of the maturation of higher elevation early-succession classes in sagebrush systems caused by pre-mapping fires. It is also important to note that a large fraction of the TS-Horseshoe Ranch is non-habitat for sage-grouse. The BEST UED MANAGEMENT scenario caused the significantly highest habitat suitability by year 30 (average of 2,255 functional acres gained), but ROIs showed that the higher cost of the BEST UED MANAGEMENT scenario may not be worth its habitat suitability benefits compared to MAX GSG HS MANAGEMENT scenario, which yielded an average of 1,028 functional acres.

While sage-grouse did not strongly benefit from active management, mule deer habitat improved most with the MAX GSG HS MANAGEMENT scenario on both ranches despite that this metric was highly determined by physical factors not responsive to vegetation management. Mule deer would benefit from the restoration of the non-native annual species classes into mature shrublands (browse and thermal cover) in proximity of migratory corridors, but it is not clear why less restoration activity in the MAX GSG HS MANAGEMENT compared to the BEST UED MANAGEMENT scenario would result in higher habitat suitability.

Golden eagle habitat suitability improved most under the BEST UED MANAGEMENT scenario, and more so in the TS-Horseshoe Ranch than the IL Ranch. Improvement of alternative prey habitat outside of the deep soil communities was thought to be the main reason for habitat improvement, because more actions causing sagebrush and riparian system improvements were conducted in the BEST UED MANAGEMENT scenario than the MAX GSG HS MANAGEMENT scenario.

13. Looking at the scale of ecological systems, active management scenarios often significantly reduced UED compared to the MINIMUM MANAGEMENT scenario. When both active scenarios were implemented for the same ecological system on the IL Ranch, the BEST UED MANAGEMENT scenario's ROI was significantly higher in three of six systems (basin wildrye-montane, big sagebrush upland, and montane riparian), higher for the MAX GSG HS MANAGEMENT scenario in montane sagebrush steppe, and not different between active scenarios in low sagebrush and wet meadow-montane. For these two last systems, implementation rates were very similar for both scenarios.

    One important result is that the implementation of any active scenario did not change UED for the largest system, big sagebrush upland without trees, on the IL Ranch, which means that ROIs statistically overlapped with zero (negative ROI for MAX GSG HS MANAGEMENT scenario) or were weak and highly variable (positive ROI for BEST UED MANAGEMENT scenario yielding a 1% improvement in UED). Little change was observed in big sagebrush upland because management actions primarily created mixed introduced and native species seedings, which are uncharacteristic vegetation classes. The small proportion of these classes was below the acceptable management threshold for seedings, and, therefore, did not result in an increase in UED, but, conversely, did not reduce UED. On the IL Ranch's BLM lands, the greatest benefits of each active management scenarios were the reduction of 3,000 acres of the non-native annual species class and 700 acres of exotic forbs (mostly thistles). Additionally, only the BEST

UED Management scenario restored the shrub with non-native annual species class (U:SAP) to a mixed introduced and native species seeding class. The cumulative costs were also substantially different between these scenarios: $2,824,034 for Best UED Management scenario compared to $757,178 for the MAX GSG HS Management scenario. Public and Newmont managers, therefore, need to carefully consider the costs for a rather marginal reduction in UED and non-significant effect on sage-grouse habitat suitability in the IL Ranch.

Both aspen systems were only treated in the Best UED Management scenario to prevent the permanent loss of aspen clones. Although ROIs were zero, thus actions were not worth doing compared to the Minimum Management scenario, the actions reduced small areas of target classes and accomplished a very narrow goal. Managers should pursue restoration of these systems regardless of UED benefits.

14. Five ecological systems only received actions specified in the Best UED Management scenario for the TS-Horseshoe Ranches: aspen woodland, basin wildrye-bottomland, big sagebrush-semidesert, saline meadow, and wet meadow bottomland. Low and zero ROIs, respectively, did not justify actions in the basin wildrye-bottomland and big sagebrush-semidesert systems. Among the five other systems where both active management scenarios were simulated, ROIs were higher in the Best UED Management scenario in three systems (basin wildrye-montane, montane riparian, and wet meadow-montane) and statistically equal between active scenarios for the big sagebrush upland with trees and montane sagebrush steppe systems. Overall, the Best UED Management scenario appeared to be the best choice for most ecological systems with ROIs greater than zero and for wildlife habitat suitability on the TS-Horseshoe Ranch.

15. Spatial simulation maps of the 30 future years identified areas of most probable disturbance events or implementation of the more commonly used management actions. A few significant observations emerged from these maps.

    a. Modeled fuel breaks worked better in the IL Ranch than TS-Horseshoe Ranch. Less fire and smaller fires occurred with fuel breaks than without. More fuel breaks could be placed on the IL Ranch because of the flat topography of the Owyhee Allotment and IL Meadow pastures, whereas placing fuel breaks was not feasible in the rugged Tuscarora Range where the best sage-grouse habitat was found. Fuel break effects were simulated using a new option in ST-Sim that prevented the priority placement of large fires when sufficient space was in short supply. Fuel break effects did not include a reduction of the overall fire rate, which could be implemented with additional effort, as a result of staging fire suppression crews and equipment to hold fire lines at fuel breaks. TNC believes holding fires at fuel breaks by ground crews appear less probable on the IL Ranch due to its remoteness, especially in the Owyhee Allotment, although it is conceivable for the TS-Horseshoe Ranches, which is close to Carlin, Battle Mountain, and Elko.

b. Aroga moth outbreaks were more widespread than anticipated. Although outbreaks resulted in complete shrub thinning to the early-succession class for only 25% of events compared to 75% of events leading to partial thinning (i.e., remaining standing sagebrush), outbreaks remained a dominant and natural determinant of sage-grouse nest site selection, nest success, and per capita population growth rate (λ). In the absence of fire due to active fire exclusion, Aroga moth outbreaks become the dominant stand replacing disturbance in northern Nevada landscapes dominated by mature semidesert and upland sagebrush.

   Results suggested that both fire and Aroga moth outbreaks may have counteracted management actions designed to accelerate sagebrush maturation in areas that burned before mapping. In particular, these results challenge the need of placing supplemental salt blocks to improve resilience in the Owyhee Allotment where Aroga moth populations appear, and are predicted, to be most effective at defoliating sagebrush. The thinning of sagebrush near salt blocks would only add to the reduction of nest site selection and nest success already caused by Aroga moth and fire.

c. The areas of highest habitat suitability are frequently at higher elevations (Tuscarora Range, Independence Range, and Bull Run Range). These areas contribute disproportionately more to sage-grouse habitat suitability and functional acres if leks are within 10 km; therefore, restoration actions in those areas can make a large difference for habitat suitability if one or two vital rates (chick survival, female survival, nest-site selection or nest success) are dragging down the entire habitat suitability. Paradoxically, these areas are the steepest and most inaccessible to restoration equipment. As a result, simulated implementation was rarely accomplished in the mountains.

   Critical actions to restore sage-grouse habitat (for example, herbicide-Plateau+seed used in the non-native annual species class) were instead deployed by ST-Sim on the toes and alluvial benches of the steep mountain ranges where slope was ≤15% on both ranches and on the flatter areas that formerly burned in the central part of the IL Ranch. These areas can contribute large functional acres if management scenarios are carefully placed to uplift one or two failing vital rates using a dynamic spatial constraint multiplier process. The simulated results of this report incorporated a different dynamic spatial constraint multiplier process preventing accidental sagebrush thinning in high suitability areas. We do not currently have the ability to run more than one dynamic spatial multiplier process, therefore we would need to either combine the two levels of constraints (i.e., not thin sagebrush in highly suitable areas and uplift vital rates where it makes the greatest difference) or select just one of the two processes for simulation improvements. For example, restoration of incised and shrub-encroached wet meadows of Four-mile Creek and seeding mixed introduced and native species (including planting sagebrush plugs) in the non-native annual species vegetation class up to 2 km east and north-east of Four-mile Creek might be very strategic as an individual project, given analysis warrants this conclusion. This example, however, requires that we dissociate the functional acres achieved from a single project from the variation in functional acres for the entire landscape.

16. Managers may select management actions and treatment areas based upon additional factors beyond ROI values. Such additional factors could include availability of financial resources, public-safety concerns, regulatory constraints, and other multiple-use or societal objectives.

Introduction

Project Background and Agreement

Management of sagebrush-dominated landscapes has received increased attention since Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) was first determined to be warranted of protection, but precluded by other higher priorities under the Endangered Species Act (ESA, USFWS 2010). The September 2015 decision to not list the species as endangered has not diminished the need for continued conservation actions. Managing for sage-grouse while multiple uses and economic activities move forward is challenging because ecological and regulatory processes, and ownership exist at different scales in the extensive landscapes that support sagebrush obligate or dependent species (Table 1).

Table 1. Multiple spatial and temporal scales as influenced by ecology, land ownership, and regulatory framework

	Spatial Scale		Temporal Scale	
	Landscape	Local	Multi-decadal	Sub-decadal
Sagebrush-dependent wildlife dispersal	X			X
Sagebrush-dependent wildlife limiting habitat		X	X	
Dominant stand-replacing ecological disturbances	X		X	
Ecological recovery from historic intense livestock grazing	X		X	
Deeded ranch ownership (with wildlife limiting habitat)		X	X	
Public Land Management Policy/Regulation	X		X	X
Grazing systems	X			X

Many sagebrush-dependent species and natural disturbances operate over large spatial scales. Important sagebrush-dependent species have seasonal requirements and dispersal that cause animals to cross ownerships and jurisdictions. Movement of studied wildlife species has been shown to be predictable and strongly hardwired regardless of land ownership patterns (Sawyer et al. 2013). While sagebrush-dependent species can be wide-ranging, water and mesic ecological systems critical to wildlife are frequently situated on small deeded land parcels belonging to cattle ranches that also hold large public grazing allotments. These small mesic systems, therefore, are often resource bottlenecks for wildlife. For example, it is not unusual that a ranch will hold claim to 81 ha (200 acres) of deeded land tied to water rights and 80,937 ha (200,000 acres) of public grazing allotments; therefore, a private-to-public 1: 1,000 ratio is not uncommon.

In the western sagebrush country, the landscapes are increasingly impacted by larger fires and widespread invasion of non-native annual species that modify plant species composition and fire regimes (Suring et al. 2005, Miller et al. 2011). Although it is known that non-native fine fuels increase the likelihood of ignition and spread of fire (Whisenant 1990, Pyke et al. 2015), it is also recognized that a legacy of public land management producing a continuous and homogenous canopy of shrubs containing volatile compounds will also support fire burning over large areas (e.g., large higher elevation parts of Nevada and Idaho's Murphy Fire Complex). Uncharacteristically larger fires and non-native plant species invasions ultimately affect the demography of highly visible species, such as sage-grouse and mule deer. Other widespread more regionalized processes also affect ecological systems and their dependent species in these large landscapes, for example: single-leaf pinyon and/or Utah juniper encroachment of sagebrush shrublands south of the Columbia Plateau rim, Aroga moth outbreaks in northern Nevada, livestock and wild horse grazing, and regional severe drought mortality of shrubs and trees. All of these major disturbances have long time scales in terms of return intervals, time until an area is transformed by the disturbance (e.g., tree encroachment and livestock grazing; Blackburn and Tueller 1970), or time until a disturbed area is sufficiently recovered to be used by key wildlife species. In arid lands, plant species responses to disturbances and grazing are slow as the native species are primarily perennial and slow growing. For instance, native grasses may take at least five years to significantly increase after tree removal in black sagebrush in eastern Nevada (Provencher and Thomson 2014; Baughman et al. 2010) and comparable responses have been observed in Oregon's basin big sagebrush after western juniper removal (Bates et al. 2005). Similarly, native grass abundance may not change for decades after livestock is removed from already degraded range as species need to recolonize sites where non-palatable species dominate and herbaceous seed sources are scarce (Curtin 2002, Courtois et al. 2004).

The mismatch in scale between the species' needs and land ownership patterns is an important detail in the Intermountain West because the standards for enforcement of the federal law on endangered species management (ESA 1973; 16 U.S.C. § 1531 et seq.) vary between public and private lands, and wildlife species in the arid west depend disproportionally more on the mesic vegetation of deeded lands than the very large lands held in public trust. Although the USFWS Endangered Species Act applies to public and private lands, private land owners are not subject to the review process for proposed actions imposed by the National Environmental Policy Act (NEPA 1970) under which ESA regulations are considered. Therefore, ranch owners can conduct actions on their lands that would not be conducted on public lands, or conducted only after years of review. In the case of sage-grouse, which is not listed, land management actions that are incompatible with sage-grouse could have future and irreversible conservation consequences that would contribute to the species' status should it be eventually listed. Conversely, ranchers can design grazing systems that minimize impacts to wildlife (e.g. Swanson et al. 2015) and even be used to consume non-native plant species (Schmelzer et al. 2014).

Large landscapes, multiple scales for ecological and social processes, jurisdictional "discrepancies", tracking the condition of natural resources, and financial realities are some of the complex challenges that must be accounted for which quantitative models can handle with efficiency and resulting solutions. Different stakeholders will ask different management questions about large landscapes because of their ownership status, regulatory control, financial interests, and conservation interests. The quantitative tools that help answer conservation questions in most landscapes with realistic ownership, regulatory, and financial constraints are few (Low et al. 2010). State-and-transition simulation models (STSM) and associated development software were developed to answer range and forest management questions as those described above (Daniel and Frid 2012; Provencher et al. 2015).

As a result of discussions and concept development activities with The Nature Conservancy (TNC) that began in 2011, Newmont Mining Corporation (Newmont) entered into a formal partnership with TNC in April 2013. Further into the partnership, TNC and Newmont established a Consulting Services Agreement to apply the Landscape Conservation Forecasting ™ process – including satellite imagery, remote sensing, predictive ecological models, and cost-benefit assessments– to two large landscapes within Northern Nevada. These areas, the IL Ranch and the TS and Horseshoe Ranches are owned and operated by Elko Land and Livestock Company (ELLCo), a wholly owned subsidiary of Newmont. These ranches comprise a portion of the lands owned by Newmont and ELLCo in Nevada. The agreement provided that:

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- The recommendations will inform the stewardship actions that Newmont may subsequently take on their lands to improve critical ecosystem functionality.
- The Plan will also demonstrate a scientifically defensible methodology and set of metrics for measuring and predicting changes in habitat conditions for sage grouse (and other species of concern, namely mule deer and golden eagle)."

Project Area

The IL Ranch and TS-Horseshoe Ranches project areas are located in Elko, Humboldt, Eureka, and Lander Counties in northern Nevada (Figure 1). The project areas encompass, respectively, about 485,732 acres (196,569 ha) and 521,085 acres (210,876 ha) for the IL Ranch the TS-Horse Ranch. Whereas the IL Ranch is largely undeveloped lands in the southern Columbia Plateau ecoregion and in sage-grouse Management Zone IV, the TS-Horseshoe Ranches, about 50 miles (80 km) to the south of the IL Ranch, contains significant industrial and municipal infrastructure and is situated in the northern Great Basin ecoregion and in sage-grouse Management Zone III. The IL Ranch is bordered to the north by the Idaho state line and contains the Owyhee Allotment of the Bureau of Land Management. The TS-Horseshoe Ranches are bisected by

Interstate 80 between Carlin and Argenta and contains Boulder Valley, part of Crescent Valley, the southern Tuscarora Range, and mines of the Carlin Trend.

The majority of the area of the IL Ranch is located on the Owyhee Plateau, which is mostly flat, volcanic, and supports only few sources of surface water outside of the South Fork of the Owyhee River. The smaller eastern portion of the IL Ranch climbs into the slopes of the northern Independence Range and the southern tip of the Bull Run Mountains. Both ranges are north-south trending.

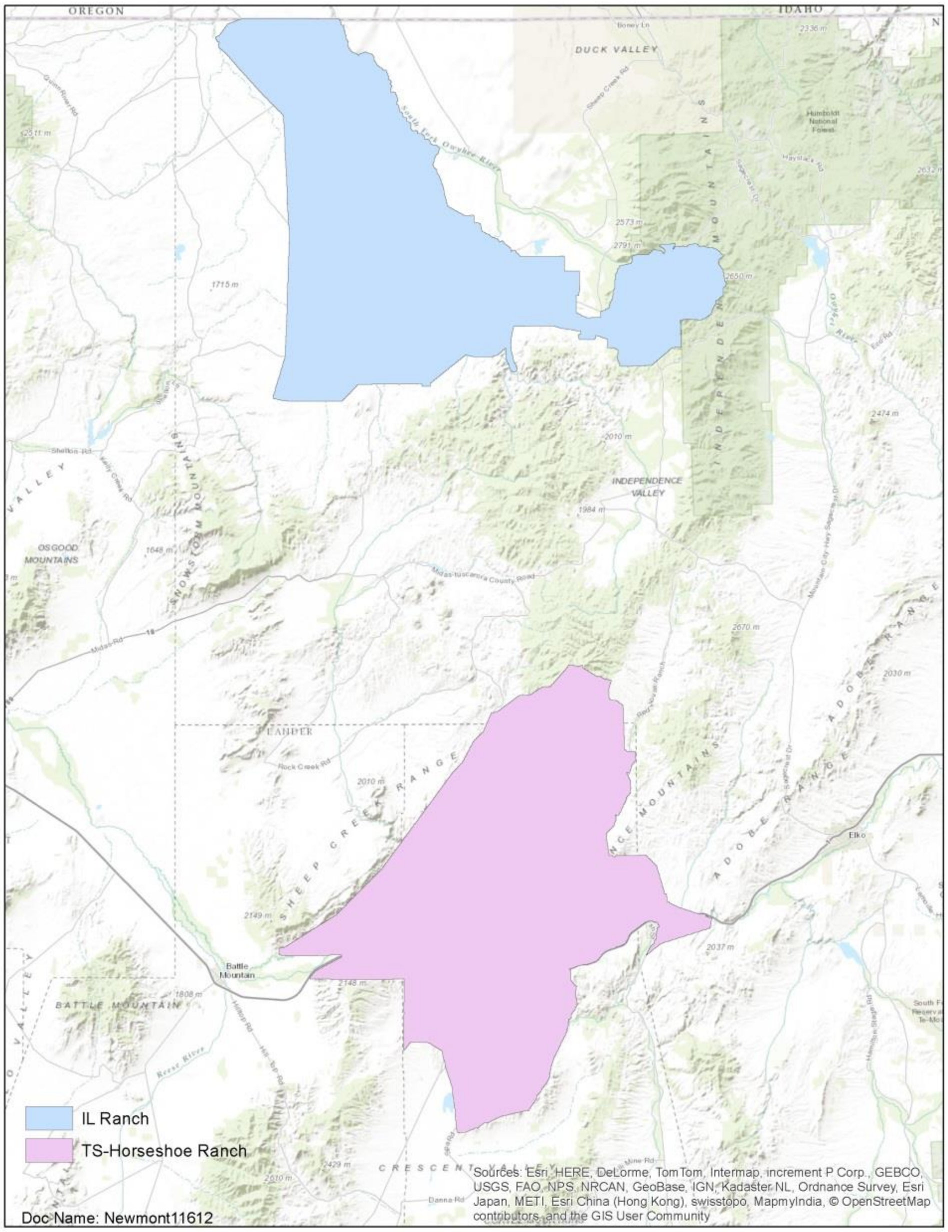


Figure 1. The Il Ranch and TS-Horseshoe Ranches Project Areas in northern Nevada.

The TS-Horseshoe Ranches are a more typical Great Basin landscape with north-south trending ranges (Tuscarora Range) with the Humboldt River traversing the project area from east to west. The geology is primarily volcanic. The project area also includes the large triangular and flat Boulder Valley, which is hydrologically connected to the Humboldt River below the Sheep Creek Range and Argenta Rim on the west side.

The IL Ranch's vegetation is dominated by vast expanses of Wyoming big sagebrush on upland soils of the Owyhee Plateau that rapidly grade into steep slopes of mountain big sagebrush (*A. tridentata* spp. *vaseyana*) in the eastern mountain ranges. Low sagebrush (*A. arbuscula*) is patchily distributed across the project area. Unlike many ranges in the Great Basin, singleleaf pinyon (*Pinus monphylla*) and Utah juniper (*Juniperus osteosperma*) are absent. Willow dominated creeks, strips of basin wildrye, wet meadows, patches of mountain shrubs, aspen woodland, aspen-subalpine fir, subalpine grasslands, and subalpine woodlands distinguish the eastern mountain ranges. BLM's Owyhee allotment also contains vernal lakes that are a mix of grasslands, silver sagebrush, and salt flats where many greater sage-grouse leks are found.

The TS-Horseshoe Ranches' vegetation are more clearly zonal with sodic and saline communities closer to the Humboldt River and in Crescent Valley, and the gradient of salt desert to big sagebrush shrublands distributed from middle and upper elevations. Boulder Valley also contains extensive herbaceous communities of moist floodplain, bottomland basin wildrye, and saline meadows that were probably more abundant and mesic before water diversions dried the historic Argenta Marsh in the mid-1950s. Again, pinyon and Utah juniper are absent, except for a few occurrences in the southeastern portion of the project area. Aspen woodlands and patches of mountain shrub are infrequent, but more common in the northern reaches on the steep slopes of the Tuscarora Range.

Sage-grouse is found in both landscapes, but the population is smaller for the TS-Horseshoe Ranch. The size of the population and location of leks are under-studied for the IL Ranch due to the remoteness of the Owyhee allotment. Both landscapes contain critical mule deer migration corridors and wintering grounds. Creeks of the TS-Horseshoe Ranches, especially Maggie Creek and tributaries, support Lahontan cutthroat trout populations, whereas creeks of the IL Ranch are within the historic habitat of redband trout and contained in the greater Owyhee River drainage flowing to the Pacific Ocean.

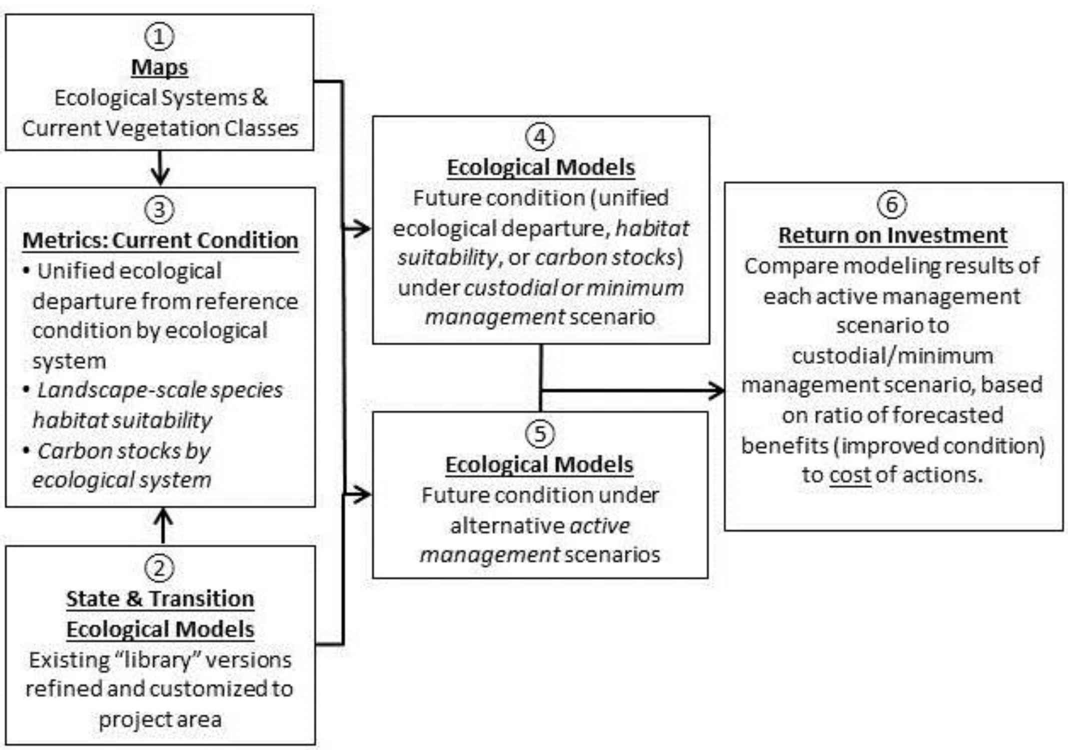
Process and Methods

The LCF™ process for the IL and TS-Horseshoe Ranches consisted of six primary steps:

1. Develop maps of potential vegetation types, termed ecological systems, and of current vegetation classes within each system, by conducting remote sensing of satellite imagery including extensive ground-truthing.

2. Refine computerized predictive state-and-transition ecological models for the ecological systems by updating TNC's Great Basin "library" of models, or by creating new models.
3. Determine current condition of ecological systems using the metric of Unified Ecological Departure: the dis-similarity between current vegetation and vegetation expected under reference conditions adjusted for management considerations. Estimate the reference condition for each ecological system, which is the vegetation class distribution representing either the pre-settlement condition or a currently naturally functioning system without even minor human influences (e.g., no exotic species). Determine current suitability of habitat for sage-grouse using demographically-based metrics of habitat suitability and Functional Acres (currency of mitigation estimated using pixel-based habitat suitability). Determine habitat suitability and Functional Acres for mule deer and golden eagle using heuristic resource selection functions based on expert opinion and the scientific literature.
4. Use the computerized ecological models (2nd step) to forecast anticipated future condition of ecological systems, and of habitat suitability for the sage-grouse, mule deer, and golden eagle, under minimum management (analogous to the "no-action" alternative of NEPA).
5. Use the computerized ecological models (2nd step) to forecast anticipated future condition of ecological systems, and of habitat suitability for the three species, under alternative "active" management scenarios (suites of specific actions or treatments).
6. Use Ecological Return On Investment (ROI) analyses to assess which actions (i) for which ecological systems yield the most advantageous ("bang for the buck") results for the systems and (ii) for sage-grouse habitat suitability.

A diagram that displays the relationship of these six components to each other is presented below, and the timeline of the project appears in Table 2 on the following page.



Timeline of IL Ranch and TS-Horseshoe Ranches LCF™ project.

	2013				2014				2015				2016			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Admin. set-up																
Remote sensing						IL & HS-TS										
Accuracy assessment																
Modeling & workshops		Veg. Descrip. work.			Model review work.				1st manag. work.		2nd manag. work.					
Final Report																
Outreach to regulators																

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

Stakeholder and Expert Workshop Contributions

The Newmont LCF process included four expert workshops that (i) provided transparency to the LCF™ process in the context of Newmont's sage-grouse conservation, (ii) elicited valuable feedback and new information from experts for model improvement, and (iii) attempted to increase buy-in from various agencies and other stakeholders. All workshops were held in Elko over a two-year period.

The four workshops were about:

1. The expert review of ecological system and their vegetation class descriptions. This is the first workshop and the first activity in the entire LCF™ process. The description is necessary for remote sensing interpretation, especially in the field, and determines entirely the composition of the state-and-transition simulation models.
2. The expert review of the state-and-transition simulation models is, by far, the most technical workshop because it is about a large number of model assumptions, vegetation dynamics powered by succession and disturbances, and spatial constraints and parameters. Originally the model review workshop was envisioned as a 2-day event when models were simpler and often non-spatial. More recently with spatial dynamics, more complex representation of grazing systems, and wildlife habitat suitability components, model review has become more in-depth, complex, and requires at least three days.
3. The first management workshop is critical to managers because it serves three key purposes: (1) Review the ecological and vegetation class maps created from high-resolution remote sensing; (2) proposing overarching land management objectives; and

(3) defining land management scenarios that will be simulated to achieve management objectives.

4. The main purpose of the second management workshop, is to review draft simulation results from land management scenarios defined in the first management workshop and fine-tune implementation rates of management actions.

Newmont selected workshop participants based on their:

1. Responsibility for Elko Land and Livestock's ranch management;
2. Working knowledge of the ranches' vegetation;
3. Expertise on northern Great Basin ecological disturbances, range restoration, and grazing systems;
4. Responsibility for management of public grazing allotments on the IL and TS-Horseshoe Ranches; and
5. Regulatory authority over sage-grouse and other wildlife management.

Vegetation Mapping

The fundamental elements of vegetation mapping are the distributions of:

1. Ecological systems
2. Current vegetation classes within each ecological system.

Ecological systems, also known as biophysical settings (Rollins 2009, LANDFIRE 2010; Low et al. 2010), are dominant *potential* vegetation types expected in the physical environment (geology-soil-landform-climate) under "natural" disturbance regimes. Thus ecological systems are fundamentally abiotic units, NOT units of current vegetation. Each ecological system supports (expresses) a particular kind of dominant vegetation, and is named by its dominant vegetation. Ecological systems are essentially single or grouped ecological sites from the Natural Resource Conservation Service (NRCS) soil surveys. The NRCS defines an ecological site as "a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation." (*National Forestry Manual*, www.nrcs.usda.gov/technical/ECS/forest/2002_nfm_complete.pdf). Unfortunately, order III soil surveys are too coarse to allow unambiguous mapping of ecological systems at each map pixel.

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

- Successional stages – early to mid to late.
- Vegetation canopy – open versus closed.
- Reference (native) versus Uncharacteristic vegetation or site characteristics – defined later in the subsection titled **Predictive Ecological Models**.

It is important to understand that a vegetation class label or attribute is ***meaningless*** unless it is associated with an ecological system. A customized process was used to map the project areas' ecological systems, and their component vegetation classes, as described below.

Definition and Description of Vegetation Prior to Mapping

Draft descriptions for the each of the IL Ranch and TS-Horseshoe Ranches were compiled of ecological systems and their component vegetation classes that were believed to occur on the IL Ranch and TS-Horseshoe Ranches, based on an inventory of ecological sites from the different NRCS soil surveys, and vegetation descriptions from different sites in the Great Basin and Columbia Plateau (Appendices 1-A and 1-B). The crosswalk to NRCS ecological sites is found in Appendix 2. These brief descriptions were reviewed by local experts during a June 13-14, 2013, workshop, and were then revised and used in the field for remote sensing interpretation. Adjustments to the vegetation descriptions continued throughout remote sensing and subsequent modeling.

Remote Sensing Analysis and Ground-Truthing

Spatial Solutions, Inc. was contracted by TNC to conduct vegetation mapping via interpretation of satellite imagery of the project area, which started on July 3, 2013. Discussions were held between Spatial Solutions, TNC, and Newmont's Project Manager to agree upon specific sets of RapidEye satellite imagery (5×5-m pixels of multispectral imagery) that would be acquired for mapping. Remote sensing was conducted from new RapidEye 5-m resolution multi-spectral satellite imagery captured on June 22, 2013, for the northern Independence Range and June 26, 2013, for the rest of the IL Ranch to the west, and on June 28, 2013, for the TS-Horseshoe Ranches. Moreover, freely available 1-m resolution NAIP imagery was used to assist interpretation of the 5-m multi-spectral imagery. The imagery was clipped to the boundary defined by the Newmont Project Manager, and then buffered outward by 100 m. Private inholdings were part of the imagery, but private inholdings not belonging to Newmont were excluded from field surveys and mapping.

TNC sent descriptions of ecological systems and vegetation classes (see above) to Spatial Solutions. Spatial Solutions used these data to develop an unsupervised[1] vegetation classification of the selected satellite imagery, which was to be ground-truthed via fieldwork in July 3-13 and October 23-26, and 31, 2013 for the IL Ranch, July 17-26 and October 27-30, 2013 for the TS-Horseshoe Ranches. A chartered helicopter was used to allow project specialists

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[1] In unsupervised classification, the image processing software classifies an image based on natural groupings of the spectral properties of the pixels, without the analyst specifying how to classify any portion of the image. This is in contrast to supervised classification, in which the analyst defines "training sites" – areas in the map that are known to be representative of a particular land cover type – for each land cover type of interest to guide the assignment of classes to each pixel.

efficient transport and access to remote sites in order to to interpret vegetation of the IL Ranch on July 11 and October 25-26, 2013 and July 14 and October 28-29, 2013 for the TS-Horseshoe Ranches.

Spatial Solutions used the software Imagine® from Leica Geosystems to conduct an iterative unsupervised classification of 5x5-m RapidEye imagery for the two landscapes. The unsupervised classification of the satellite imagery was used to interpret rasters and is described in Provencher et al. (2008, 2009) and Low et al. (2010). Draft raster layers were created of ecological systems and current vegetation classes with similar spectral characteristics (combinations of blue, green, red, and near infrared reflectance).

The goal of this field work was to visit all unique spectral class signatures (i.e., representing all of the systems and classes present) and document their vegetation and site features via rapid ("cruising") observations obtained from driving (either stopping or cruising), hiking, and helicopter flying. Each rapid road/hiking observation point included the identity of the ecological system and its vegetation class, and two geo-referenced photographs (landscape context and site) for use in future analysis. Additional comments about vegetation and topography were added to the data if time allowed. In past projects, formal training plots were visited, where the cover values of dominant species and cover types were recorded, which were supplemented with rapid observations. Over time, a high ratio of rapid observations to formal training plots was eventually replaced by rapid observations only: A large number (e.g., 10,000) of rapid geo-referenced observations is far more valuable than a small number of formal training plots (e.g., 60-100 at most) given the short duration of field surveys. The IL Ranch was covered by 6,069 observations and 2,673 photographs, and the TS-Horseshoe Ranches generated 7,744 observations and 3,752 photographs. The portability of ruggedized computers, with GPS reception and Imagine® software running live, enabled the two field workers to map vegetation accurately by simply going within the boundary of spectral signatures, or by viewing them from a distance with binoculars (or the air) in more difficult terrain.

A draft geo-layer of ecological systems and vegetation classes was spot-verified, and more observations were collected from data-poor areas, during a second field trip. The primary activity of the first field trip was to provide the vast majority of road, helicopter, and hiking observations. About 10 days were spent in each landscape during the first field trip. The second field trip was focused on areas that we were unable to access during the first field trip, as well from areas already visited where more data were needed.

This final field trip allowed Spatial Solutions to complete final maps of ecological systems and their current vegetation classes, which were delivered to TNC in April 21, 2014, for the IL Ranch and June 19, 2014, for the TS-Horseshoe Ranches. Upon receipt of the ecological system and vegetation class classification rasters, the first step was to cross-walk Spatial Solutions' field coding to the ones used in the state-and-transition models. The classification rasters originally had landcover systems and classes coded together in one field; however, ST-Sim is unable to utilize these same codes. Therefore, the first step was to crosswalk to a usable data format. In

GIS, we added five new fields to the attribute table: SYS_NAME, SYS_CODE, CLA_NAME, CLA_CODE, and SYSxCLA. Attributes were filled in the corresponding information, including corrections or reinterpretation of Spatial Solutions classification if names did not exist in the STSMs. We converted a shapefile of roads into raster format and combined it with the 'clean' 5-m raster.

The second step was to resample (i.e., make coarser) the 5-m resolution of RapidEye to a more manageable resolution as the 5-m spatial resolution resulted in too many pixels for ST-Sim simulations and habitat suitability estimation software to keep in computer memory and to process in a reasonable timeframe. A multi-step resampling, therefore, was necessary. We determined that 60-m was an acceptable resolution that retained characteristics of the landscape while reducing data processing.

We implemented a rule-based approach of resampling to ensure that small, but ecological systems either important to sage-grouse use or for non-native species management such as wet meadows would not be absorbed into the surrounding pixels during the resampling process. A set of priority rules was developed in order to determine how the different ecological systems (numerical code) and classes (name code; see Appendix 1-A) would be retained from 5-m to the final 60-m raster:

1. Preserve pixels of water (1004)
2. Preserve pixels of aspen (1011 and 1061) in all vegetation classes at the expense of wet meadows (11450) and montane riparian (11540); furthermore, depleted aspen classes (U:Depleted, see Appendix 1_A for all descriptions) are preserved over all other vegetation classes.
3. Preserve pixels of wet meadow-montane (11450) and wet meadow-bottomland (11452) at the expense of upland system pixels. Within these systems, classes with exotic forbs (U-EF) have higher retention priority than hummocked classes (U-HU), which both have higher retention priority than all other classes.
4. Preserve pixels of montane riparian (11540), Owyhee River riparian (11542), moist floodplain (11541), and Wetland (11543) at the expense of uplands system pixels. Within these systems, classes were assigned a decreasing retention priority as follow: inset floodplain invaded by exotic forbs and trees (U-inset:EFT) > non-inset classes invaded by exotic forbs and trees (U:EFT) > other incised classes > other inset classes > early-succession willow (1-Early:Willow) > mid-succession willow (2-Mid:Willow; only in moist floodplain) > late-succession willow (3-Late:Willow) > early-succession cottonwood (1-Early:Cottonwood) > mid-succession cottonwood (2-Mid:Cottonwood) > late-succession cottonwood (3-Late:Cottonwood), and others.
5. Preserve pixels of basin wildrye-montane (10801), basin wildrye-bottomland (10803), and saline meadow (11451) at the expense of other upland systems, but not mesic systems. Furthermore, within these systems, give a higher retention priority to the following classes in decreasing order of importance: Exotic forbs (U:EF) > pastures (U-Pas) > non-native annual species (U-AS) > Early-succession (1-Early:Open).
6. Preserve pixels of lower montane-valley grassland (1139) at the expense of upland systems, but not montane wet meadows (11450). Furthermore, give higher priority to classes invaded by exotic forbs (U-EF) over all other classes.
7. Preserve pixels subalpine-upland grassland (1140) at the expense of surrounding upland pixels (mostly montane sagebrush steppe (11260), but not montane wet meadows (11450) and montane riparian (11540) pixels.

8. Preserve pixels of limber pine (1020) at expense of surrounding ‘dry’ pixels, but not mesic pixels.
9. Among upland sagebrush systems (10800 and 10790, 11260, 11261, 1106, 10801), preserve pixels in the following decreasing order of retention priority: non-native annual species (U-AS) > shrubs with non-native annual species (U-SA) > shrubs with non-native annual species and native perennial species (U-SAP) > non-native annual species and native perennial grass (U-ASPG) > late-succession sagebrush with dense shrub cover (4,5-Late:Dense) > early-succession sagebrush (1-Early:All) > early-succession of basin wildrye-montane (1-Early:Open).
10. Preserve pixels of greasewood invaded by exotic forbs (U:EF) over other remaining pixels.
11. The remaining pixels are subject to the implementation of the majority rule of ARC GIS.

To reduce the time it takes to process the raster into a usable format we used Python scripting which utilized code to direct ArcGIS 10.2.2, which also minimized human entry errors. A Python script (Appendix 3) was used to implement the following steps.

1. Generate a 5-m raster with the cross-walked ST-SIM codes.
2. Implement a table of ranked ecological systems and classes paired with the updated raster including roads.
3. Priority classes which had a ranking greater than 0 were extracted and block statistics (maximum) were performed with a 60-m window. This was then resampled at a 60-m resolution.
4. The entire raster (including the systems with a ranking greater than 0) was then resampled at a 60-m resolution using majority filter.
5. The resampled priority classes were then mosaicked onto the resampled entire landscape. This new raster was then output into a final 60-m raster.

In the IL Ranch study area, roads were stamped in at the end of the processing, whereas roads were stamped in before the first step in the Python script for the TS-Horseshoe Ranches. The resulting systems and classes raster layers provided the base rasters for the model.

The last iteration in the final draft map of current vegetation classes was used to calculate draft unified ecological departure scores (defined farther below) and sage-grouse habitat suitability. The final vegetation maps and ecological departure scores were reviewed at the project’s first “management” workshop held February 25-27, 2014.

A number of difficulties were encountered during remote sensing. The following challenges resolved using the following solutions:

1. The most difficult mapping was at lower elevation in the flatter part of the salt desert scrub communities on the TS-Horseshoe Ranches. Mapping was difficult because soil reflectance overpowered light reflected by vegetation and/or very large areas were burned and retained no standing shrub vegetation. Moreover, a few feet of difference in elevation and slight soil changes often completely changed vegetation types. There were two distinct challenges: identifying lower elevation ecological systems in thoroughly burned areas, predominantly in Crescent Valley, and separation of ecological systems in the very complex Humboldt River floodplain of Boulder Valley. In both cases,

considerable field observations were required.

  a. In Crescent Valley, especially, and the eastern rim of Boulder Valley, fires have removed <u>all</u> standing woody vegetation over tens of thousands of acres. The transitions between greasewood, mixed salt desert, and big sagebrush semi-desert systems cannot be observed from the standing non-native annual species (e.g. cheatgrass and halogeton) dominating the vegetation. We found as a rule of thumb that greasewood rarely burned such that the presence of greasewood probably indicated where it was located before the fire. The greatest difficulties, therefore, were to determine if greasewood was directly adjacent to big sagebrush semi-desert or if greasewood was situated between mixed salt desert and big sagebrush semi-desert, if the former was present. We resolved these difficulties by using the ecological site boundaries of the NRCS soil survey if its map units did not lump these different systems (often lumped in order III surveys) and by walking the most likely ecotone locations and identifying occasional downed woody and charred skeletons of Wyoming big sagebrush or shadscale, are diagnostic between big sagebrush semi-desert and mixed salt desert, respectively. Due to the approach we used, the boundary between mixed salt desert and big sagebrush semi-desert is probable, albeit approximate.
  b. In Boulder Valley, distinguishing among the moist floodplain, saline meadows, greasewood, degraded basin wildrye bottomland, and big sagebrush semi-desert is spectrally difficult due to soil reflectance and very time-consuming because ecological systems were inter-mingled in a complex manner due to the geological meandering of the Humboldt River. The two easiest of these four difficult systems was basin wildrye bottomland and saline meadows because the abundant grass reflected more infrared. Basin wildrye when in its grass phase exhibits an infra-red signature and texture due to the tall grass that is distinctive, however, degraded basin wildrye that has been converted to bare ground due to heavy livestock grazing is difficult to map because it can be confused for degraded mixed salt desert or big sagebrush semi-desert. Greasewood flats were distinct due to their very white and high soil reflectance, except where they blended into saline meadows where greasewood and basin big sagebrush plants have slightly encroached during dry periods. The challenge with these systems is the fine geomorphic pattern that has caused ecological systems to appear as if looking down into a plate of spaghetti. Mapping of these features took more time than mapping anything else in the TS-Horseshoe Ranches despite an abundance of driving, hiking, and helicopter observations.

2. It can be difficult to separate the widespread big sagebrush upland (i.e., Wyoming big sagebrush upland) from the montane sagebrush steppe (the primary indicator species is mountain big sagebrush) at their ecotone, especially if the area burned. Our first approach at separating the two systems was to determine the elevation of the ecotonal transition while driving roads and trails climbing in elevation and using that elevation as the first approximation for splitting these two systems in other areas not visited. If the ecotonal

transition could not be positively identified in other areas due to lack of field observations and fire, an arbitrary cutoff at 6,500 feet of elevation was used. Both of these approaches failed in the Bull Run Basin of the IL Ranch as the topography of the basin at the juncture of the Bull Run Mountains and Independence Range acts as a rainfall catchment; therefore, precipitation was >14 inches as recorded by NRCS (i.e., appropriate for mountain big sagebrush) at elevations more typical for Wyoming big sagebrush upland (5,500 to 6,500 ft.). We found more Wyoming big sagebrush than mountain big sagebrush in this area and initially classified it as big sagebrush upland. At the insistence of NRCS, we later reclassified the big sagebrush upland to montane sagebrush steppe upstream at the junction of Deep Creek and County Road 728.

3. During higher elevation survey days we found that mountain shrub communities dominated by *Prunus virginiana* (chokecherry) frequently surround aspen woodland like a "donut" (the hole of donut being filled by aspen). Spectrally, aspen is as bright as chokecherry in the infrared, although the imagery's texture is different. This feature was mostly visible from the helicopter or looking at opposite steep mountain slopes with binoculars. We separated aspen woodland from mountain shrub in these cases but it would not have been inappropriate to subsume the mountain shrubs into aspen communities.

4. Mountain shrub is difficult to tease apart from montane sagebrush steppe. The cause of this difficulty is that mountain shrub species are naturally found in montane sagebrush steppe communities, sometimes in high cover. This makes the field identification of mountain shrub ambiguous. We resolved to adopt a clearer description of mountain shrub communities that required >10% mountain shrub species and <10% of big sagebrush species cover when unburned.

5. On the IL Ranch, the burned areas of big sagebrush upland in the southern part of the Owyhee allotment were not spectrally distinct from the unburned adjacent areas that were also big sagebrush upland. This was a current vegetation class problem that was apparently caused by the high native grass cover in both burned and unburned areas that overwhelmed the spectral contribution of Wyoming big sagebrush. The solution to resolving the lack of clear separation was to visit as many burn boundaries as possible from roads and, especially, by helicopter where we could fly the boundary.

Ecological Systems – Natural Range of Variability

In order to calculate current or future condition ("health") of each ecological system, using a process described farther below, it is first necessary to define the Natural Range of Variability (NRV) for each system. NRV is the relative amount (percentage) of each vegetation class that, based on previously developed models, would be projected to occur in an ecological system under its *reference* condition. For this analysis, reference condition is defined as vegetation that would occur under natural disturbance regimes and current climate and absent species introduced post European Settlement (Hann and Bunnell 2001; Provencher et al. 2007, 2008; Rollins 2009).

The NRV is obtained by simulating state-and-transition models for 500 to 1,000 years using the software ST-Sim within the Syncrosim platform (www.apexrms.com, www.syncrosim.org; Daniel and Frid 2012). The underlying state-and-transition models were modified models from previous TNC projects completed with the BLM Cedar City Field Office (Tuhy et al. 2015), Dixie National Forest (Tuhy et al. 2014), Great Basin National Park (Provencher et al. 2013), and NDOW's Revised Wildlife Action Plan (Wildlife Action Plan Team 2012).

The initial condition of vegetation used to determine NRV is a modified version of the initial condition measured on the landscape. For the NRV initial conditions, all classes with vegetation that is ascribed to post-European settlement are changed to a "reference" condition of relevant structure. For example, acreages defined as an established wet meadow with exotic forbs would be considered simply an established wet meadow. While it is highly unlikely that theyse conditions may be achievable, NRF is an important tool for comparison of current and future conditions. NRV is used to as a baseline in order to compare current and future vegetation and not meant to be the goal of any proposed management scenarios, which are determined by land managers. Additionally, given the extent of degradation, limited resources, and societal context complete return to NRV is unlikely in simulated or real landscapes. The NRV (reference) percentages of vegetation classes for each ecological system in each landscape are listed below in Table 2.

Table 2. Natural Range of Variability (%) for ecological systems of the IL Ranch and TS-Horseshoe Ranches. Numbers 1 to 6 indicate the succession position of a reference class.

Vegetation Type	State Class	NRV (%)
Aspen Woodland	1-Early:Closed	8
	2-Mid:Closed	26
	3-Late:Closed	38
	4-Late:Open	27
Aspen-Mixed Conifer	1-Early:All	9
	2-Mid:Closed	40
	3-Mid:Closed	31
	4-Late:Open	15
	5-Late:Closed	5
Basin Wildrye-bottomland	1-Early:Open	24
	2-Mid:Closed	68
	3-Late:Open	8
Basin Wildrye-montane	1-Early:Open	19
	2-Mid:Closed	66
	4-Late:Open	15

Big Sagebrush-semidesert	1-Early:All	20
	2-Mid:Open	50
	3-Late:Closed	29
	4-Late:Dense	1
Big Sagebrush-upland no trees	1-Early:All	22
	2-Mid:Open	50
	3-Late:Closed	27
	4-Late:Dense	1
Big Sagebrush-upland+trees	1-Early:All	21
	2-Mid:Open	51
	3-Late:Closed	27
	4-Late:Dense	1
	5-Late:Open	0
	6-Late:Dense	0
Curl-leaf Mountain Mahogany	1-Early:All	8
	2-Mid:Open	12
	3-Mid:Closed	14
	4-Late:Open	26
	5-Late:Closed	39
Desert Wash	1-Early:All	9
	2-Mid:Closed	22
	3-Late:Closed	69
Four-Wing Saltbush	1-Early:Open	9
	2-Mid:Open	22
	3-Late:Closed	69
Greasewood	1-Early:All	1
	3-Late:Closed	99
Juniper Woodland	1-Early:Open	2
	2-Mid:Open	6
	3-Mid:Open	25
	4-Late:Open	67
Limber Pine Woodland	1-Early:All	10
	2-Mid:Open	12
	3-Late:Open	78
Low Sagebrush	1-Early:All	10
	2-Mid:Open	37
	3-Late:Closed	53
Low Sagebrush Steppe	1-Early:All	22
	2-Mid:Open	57
	3-Late:Closed	21
Lower Montane-Valley Grassland	1-Early:All	29
	2-Mid:Open	70

	4-Late:Closed	1
Mixed Salt Desert	1-Early:All	9
	3-Late:Open	75
	4-Late:Open	16
Moist Floodplain	1-Early:Cottonwood	0
	1-Early:Willow	9
	2-Mid:Cottonwood	0
	2-Mid:Willow	17
	3-Late:Cottonwood	1
	3-Late:Willow	73
	PointBar:Bare Ground	1
Montane Riparian	1-Early:Cottonwood	0
	1-Early:Willow	33
	2-Mid:Cottonwood	0
	3-Late:Cottonwood	0
	3-Late:Willow	66
	PointBar:Bare Ground	1
Montane Sagebrush Steppe	1-Early:All	25
	2-Mid:Open	48
	3-Late:Closed	26
	4-Late:Dense	1
Montane Sagebrush Steppe-Subalpine	1-Early:All	22
	2-Mid:Open	24
	3-Late:Closed	48
	4-Late:Dense	1
	5-Late:Open	4
	6-Late:Closed	1
Mountain Shrub	1-Early:All	8
	2-Mid:Open	75
	3-Late:Closed	17
Owyhee River Riparian	1-Early:Cottonwood	17
	1-Early:Willow	0
	2-Mid:Cottonwood	0
	2-Mid:Willow	28
	3-Late:Cottonwood	0
	3-Late:Willow	55
	PointBar:Bare Ground	1
Saline Meadow	1-Early:Open	0
	2-Mid:Closed	73

	3-Late:Open	27
Subalpine-Upper Montane Grassland	1-Early:All	29
	2-Mid:Closed	26
	3-Late:Open	45
Wet Meadow-bottomland	1-Early:Open	2
	2-Mid:Closed	97
	3-Late:Open	1
Wet Meadow-Montane	1-Early:Open	8
	2-Mid:Closed	91
	3-Late:Open	0
	Wallow:Bare Ground	1
Wetland	1-Early:All	1
	3-Late:All	98
	WATER:Water	1

Predictive Ecological Models

The LCF^{TM} process includes the simulation of management scenarios using state-and-transition predictive models for each ecological system (reviewed in Daniel and Frid 2012 and Provencher et al. 2015). A state-and-transition model is a discrete, box-and-arrow representation of the continuous variation in vegetation composition and structure of an ecological system (Bestelmeyer et al. 2004). Examples of state-and-transition models are shown in Forbis et al. (2006) for mountain big sagebrush from eastern Nevada and in Provencher et al. (2015) for Wyoming big sagebrush upland gravelly loam in Utah and buffelgrass (*Cenchus ciliaris*) in Arizona. Different boxes in the model belong either to: (a) different *states*, or (b) different *phases* within a state. States are formally defined in rangeland literature (Bestelmeyer et al. 2004) as: persistent vegetation and soils per potential ecological sites that can be represented in a diagram with two or more boxes (phases of the same state). Different states are separated by "thresholds." A threshold implies that substantial management action would be required to restore ecosystem structure and function. Unlike thresholds, relatively reversible changes (e.g., fire, flooding, drought, insect outbreaks, and others) operate between phases within a state.

Predictive models for ecological systems include several different types of vegetation classes: reference and uncharacteristic. The classes of pre-settlement vegetation defined by the NRV are considered to be each ecological system's core succession *reference* classes. At their core, therefore, all models have the reference condition represented by some variation around the A-B-C-D-E reference classes originally developed by LANDFIRE (see Table 3; Rollins 2009). The A-E classes typically represent succession, usually from herbaceous vegetation to increasing woody species dominance, either shrubs or trees. Said another way, the A-E classes are different (successional) *phases* within a single reference *state*.

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

(1) Disturbances beyond what would be considered "natural," whether caused by human actions or not; examples include invasion/dominance by non-native grasses, depleted understories of shrublands, incised/entrenched riparian areas, etc.; or

(2) Purposeful actions by land managers to manipulate or alter vegetation to meet specific management objectives, such as seedings with non-native species to provide forage for livestock and wildlife.

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

1. Vegetation succession (the passage of time), which is deterministic modeled;
2. Disturbances that can be represented by:
   i. Natural ecological processes, such as fire or flooding;
   ii. Uncharacteristic disturbances, such as annual grass invasion or livestock grazing; and
   iii. Active management treatments, such as mechanical thinning or prescribed fire.

To develop the predictive ecological models used in this project, existing state-and-transition simulation models in the TNC library were revised to reflect decisions regarding the project's ecological systems and vegetation classes that were made in the first workshop (see Table 2). Models were constructed and run using the modeling software ST-Sim, a product of ApexRMS, Ltd (www.apexrms.com, www.syncrosim.org; Daniel and Frid 2012). A complete list of model parameter values (probabilistic transitions) appears in Appendix 4.

In past LCF™ projects, non-spatial modeling was generally conducted because there were no explicit spatial questions that justified the increased difficulty of spatial modeling. Because we report here on species habitat suitability, where a species' fitness depends on the proximity of landscape features, spatial modeling was required. Also, representation of the grazing systems as expressed by Newmont required defining the spatial distribution of livestock and wild horses by allotments and pastures, and the distance from water sources.

In addition to building the spatial model, extra rasters were created to support simulations. Many additional geospatial rasters were prepared for use in the model for different purposes such as restricting treatments, identifying slopes and locations of grazing pastures (Table 3). Unless noted each layer was generated for both IL and TS-Horseshoe Ranches.

Table 3. Rasters created to support spatial simulations

Purpose	Spatial layer	Origin
Identifies the age of the different vegetation classes.	Succession Age	Spatial Solutions remote sensing
Identifies the vegetation classes per ecological system	Classes	Spatial Solutions remote sensing
Identifies the ecological systems	Systems	Spatial Solutions remote sensing
Identifies the grazing rates of cattle on the IL ranches in early season and even years.[1]	Early Season Even Year Grazing Pastures	BLM, Newmont, and TNC
Identifies the grazing rates of cattle on the IL ranch in early season and odd years. [1]	Early Season Odd Year Grazing Pastures	BLM
Identifies the grazing rates of cattle on the IL ranch in late season and even years. [1]	Late Season Even Year Grazing Pastures	BLM
Identifies the grazing rates of cattle on the IL ranch in late season and odd years. [1]	Late Season Odd Year Grazing Pastures	BLM
Identifies the grazing rates of cattle on the TS-Horseshoe Ranches in early season in 2014 and 2015	Early Season 2014-2015 Grazing Pastures	BLM
Identifies the grazing rates of cattle on the TS-Horseshoe Ranches in late season in 2014 and 2015. [1]	Late Season 2014-2015 Grazing Pastures	BLM
Identifies the grazing rates of cattle on the TS-Horseshoe Ranches in late season in 2016 and on. [1]	Late Season 2016-x Grazing Pastures	BLM
Identifies the grazing rates of cattle on the TS-Horseshoe Ranches in early season in 2016 and on. [1]	Early Season 2016-x Grazing Pastures	BLM
Identifies the probability of cattle grazing on slopes.	Grazing on Slopes	DEM downloaded from EPA website
Identifies the horse management area in the IL Ranch.	Horse Management Areas	BLM
Identifies potential fuel breaks that could be implemented to minimize catastrophic fires on the landscape.	Fuel Breaks	BLM, Newmont, and TNC
Identifies a 2 km buffer around sage grouse leks.	Leks	NDOW
Identifies areas with the greatest probability of being traveled through by mule deer.	Mule Deer Resistance	NDOW, DEM, and Landcover Vegetation Cover
Identifies areas of slopes of greater than 15%, which restricts mechanical grazing treatments.	Slopes >15 degrees	DEM downloaded from EPA website
To identify areas with the greatest probability for grazing by cows in the Spring and Fall based on the distance to water.	Distance to Water in Spring and Fall for Cows	Calculated from water sources provided by Newmont

Identifies areas with the greatest probability for grazing by cows in summer based on the distance from water.	Distance to Water in Summer for Cows	Calculated from water sources provided by Newmont
Identifies areas with the greatest probability for grazing by horses in summer based on the distance from water.	Distance to Water in Summer for Horses	Calculated from water sources provided by Newmont
Identifies areas where a potential fence could be erected to exclude grazing from Owyhee River riparian areas.	Owyhee Fence	Derived from aerial imagery

[1] Note that grazing plans were only coarsely mapped for all properties. Actual grazing prescriptions on the ranches involve greater rotation within allotments.

ST-Sim allows for spatial modelling using the using rasters of ecological systems, their vegetation classes, and land ownership as inputs. When current condition rasters are coupled with the state-and-transition models supplied to ST-Sim simulation of spatially explicit results are possible. From the simulated rasters, we can estimate future spatial metrics for our species of interest. In order to create alternative future rasters of vegetation, ST-Sim's spatial modeling additional data are required to more realistically model ecological processes, such as fire. There are six types of data needed: Size distribution, spread distribution, patch prioritization, spatial multipliers, direction multipliers, adjacency multipliers, and dynamic habitat suitability.

The first set of additional spatial data consists of the spatial frequency distributions for all natural and management disturbances (i.e. probabilistic transitions) (Appendix 4). These distributions define the percentage of occurrence for a disturbance of a certain size (area; Table 4). For example, based on federal fire occurrence data from 1980 to 2012 and the Monitoring Trends in Burn Severity (MTBS) data from 1984 to 2012 for each landscape, we determined that 20% of fires were less than 1 acre, 22% of fires were between 1+ and 10 acres, 28% were between 10+ and 100 acres, 17% between 100+ and 1,000 acres, 11% were between 1,000+ and 10,000 acres, 1.9% were between 10,000+ and 100,000 acres, and 0.1% were between 100,000+ and 500,000 acres.

Table 4. Percent occurrence of ecological and management probabilistic transitions (i.e. disturbance) for various acreage sizes. For management actions, the size distribution indicates the minimum and maximum areas of implementation for any one event (e.g., contractor application) as it is often not possible for a contractor to profitably apply a treatment below a certain area and application too large may not be feasible in one year.

	Acreage												
Probabilistic Transition	**1**	**10**	**50**	**100**	**200**	**500**	**1,000**	**1,500**	**5,000**	**10,000**	**50,000**	**100,000**	**500,000**
AllFire	20	22		28			17			11		1.9	0.1
Aroga-Outbreak	90			10									
AS-Invasion	99	1											
Avalanches				100									
Chainsaw-Thinning		0					100						
Competition	100												
Entrenchment		100											
Exotic-Control				100									
Exotic-Invasion	90	10											
Fence	0		100										
Flooding						100							
Floodplain-Recovery	100												
Herbicide-Plateau+Native-Seed					0				100				
Herbicide-Plateau+Seed					0					100			
Inexpensive Floodplain-Restoration			100										
Insect/Disease	90	10											
LosingClone	90	10											
Masticate+Plateau+NativeSeed					0			100					
Severe Drought				95							5		
Spike+Plateau+Seed				100									
Supplemental-Salt-Block	100												
Thin+2-4D+Seed									100				
Thin+Native-Seed									100				
Thin+Seed									100				
Thin-Plateau-Seed									100				
Weed-Inventory+Spot-Treat									100				

The spread distribution applied only to the spread of non-native annual grasses (i.e., cheatgrass), exotic forb species, and native trees into shrublands (i.e. pinyon-juniper encroachment) from an infested source pixel into nearby or distant pixels. Note, however, that ST-Sim also creates a few random invasion events beyond the distances specified by the spread distribution. For annual grasses, 99.9% of dispersal was within 5 m of a pixel (which was 70 x 70 m calculated from pixel centers), and the remaining 0.1% was within 30 m. For exotic forbs, the frequencies and distances were, respectively, 99.9% and 0.1% for 1 m and 30 m. For pinyon or juniper encroachment into shrublands, the frequencies and distances were, respectively, 99.99% and 0.01% for 10 m and 30 m. Model results were most sensitive to the spread distribution specifications. A slight increase in the spread distance profoundly increase the area invaded by the end of the simulation.

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

Spatial multiplier rasters are used either to enhance or to constrain natural or managed disturbances. We used three types of spatial multipliers that control the locations of (i) livestock and wild horse grazing, (ii) dynamic management actions, and (iii) static fuel breaks.

Figure 2A. Grazed pastures in odd and even years for early-season (before July 1st) (A. and B.), the Horse Management Area for the IL Ranch (C.), and late-season (after June 30th) grazing (D. and E.). For cattle grazing, teal is grazed areas, while brown is rested.

Spatial rasters limited early-season and late-season cattle grazing to certain pastures within allotments on odd (2015, 2017, and so on) and even (2016, 2018, and so on) years on both ranches and constrained wild horse grazing to the northern part of the Owyhee allotment (Figures 2A and B). Note that grazing use was different in 2014 and 2015 due to voluntary drought management. Furthermore, grazing intensity was controlled by the distance from water sources that varied between the summer (late-season grazing when moisture is generally not in the vegetation) and all others seasons (early-grazing season when moisture is present in the vegetation) (Table 6; Figures 3A and B).

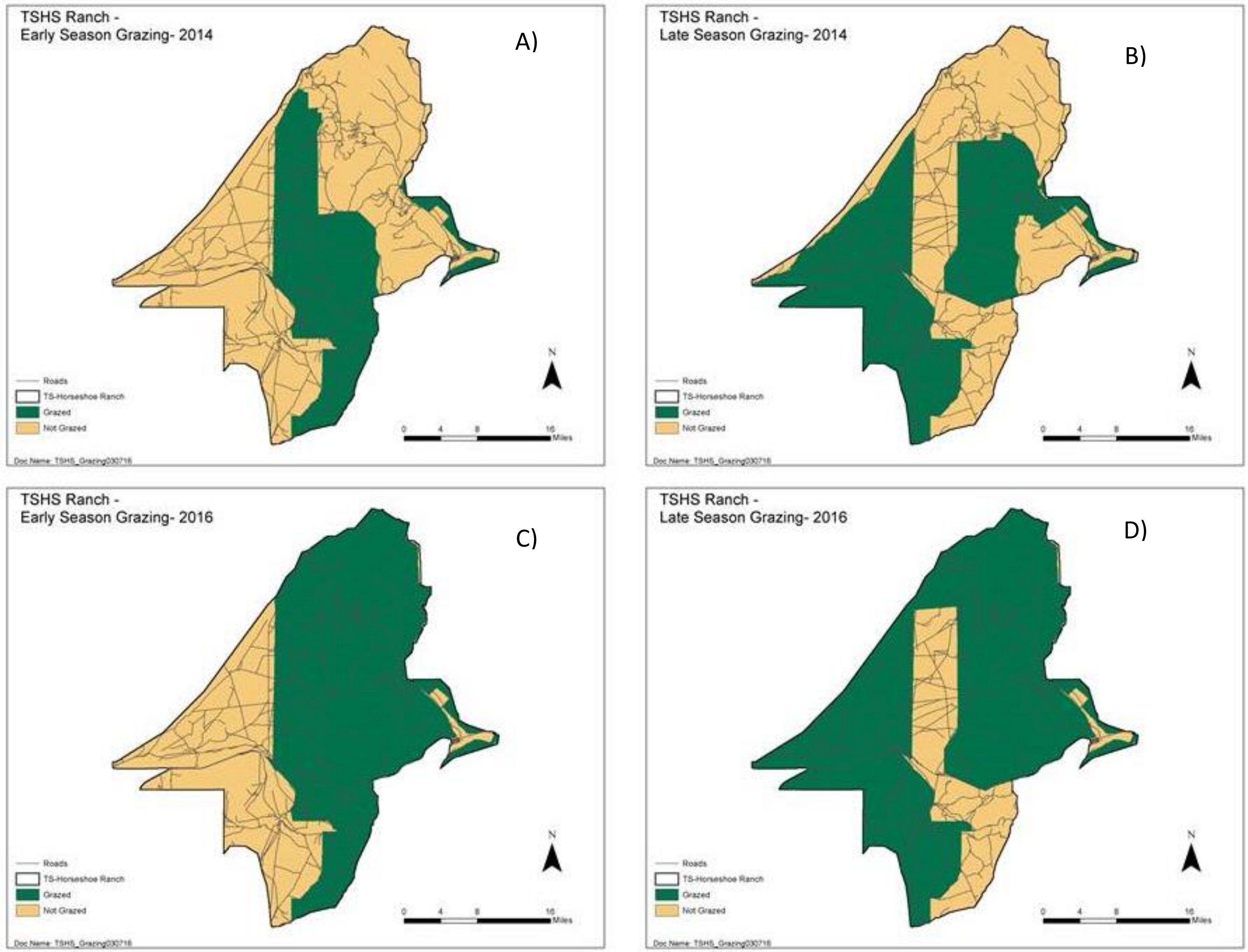


Figure 2B. Grazed pastures in odd and even years for early-season (before July 1st) and late-season (after June 30th) grazing from 2014 to 2015 (A. and B.) and after 2015 for the TS-Horseshoe Ranches (C. and D)

Table 5. Effect of distance from a water source on the grazing rate of cattle and wild horse used in the ST-Sim transition pathways. Distances effects were modified from Holchek et al. (2011).

Cattle		
Distance (mi)	Summer Grazing Spatial Multiplier	Spring & Fall Grazing Spatial Multiplier
0.0 to 0.5	1.0	1.0
>0.5 to 1.0	0.9	1.0
>1.0 to 1.5	0.5	0.8
>1.5 to 2	0.1	0.5
>2.0 to 2.25	0.05	0.3
>2.25 to 2.5	0.0	0.3
>2.5 to 3.0	0.0	0.1
>3.0 to 4.0	0.0	0.03
>4.0	0.0	0.0
Wild Horses		
Distance (mi)	Summer Grazing Spatial Multiplier	
0.0 to 0.25	1.25	Not used
>0.25 to 1.2	1.2	Not used
>1.2 to 1.25	0.65	Not used
>1.25 to 6.5	0.35	Not used
>6.5 to 9.0	0.21	Not used
>9.0	0.0	Not used

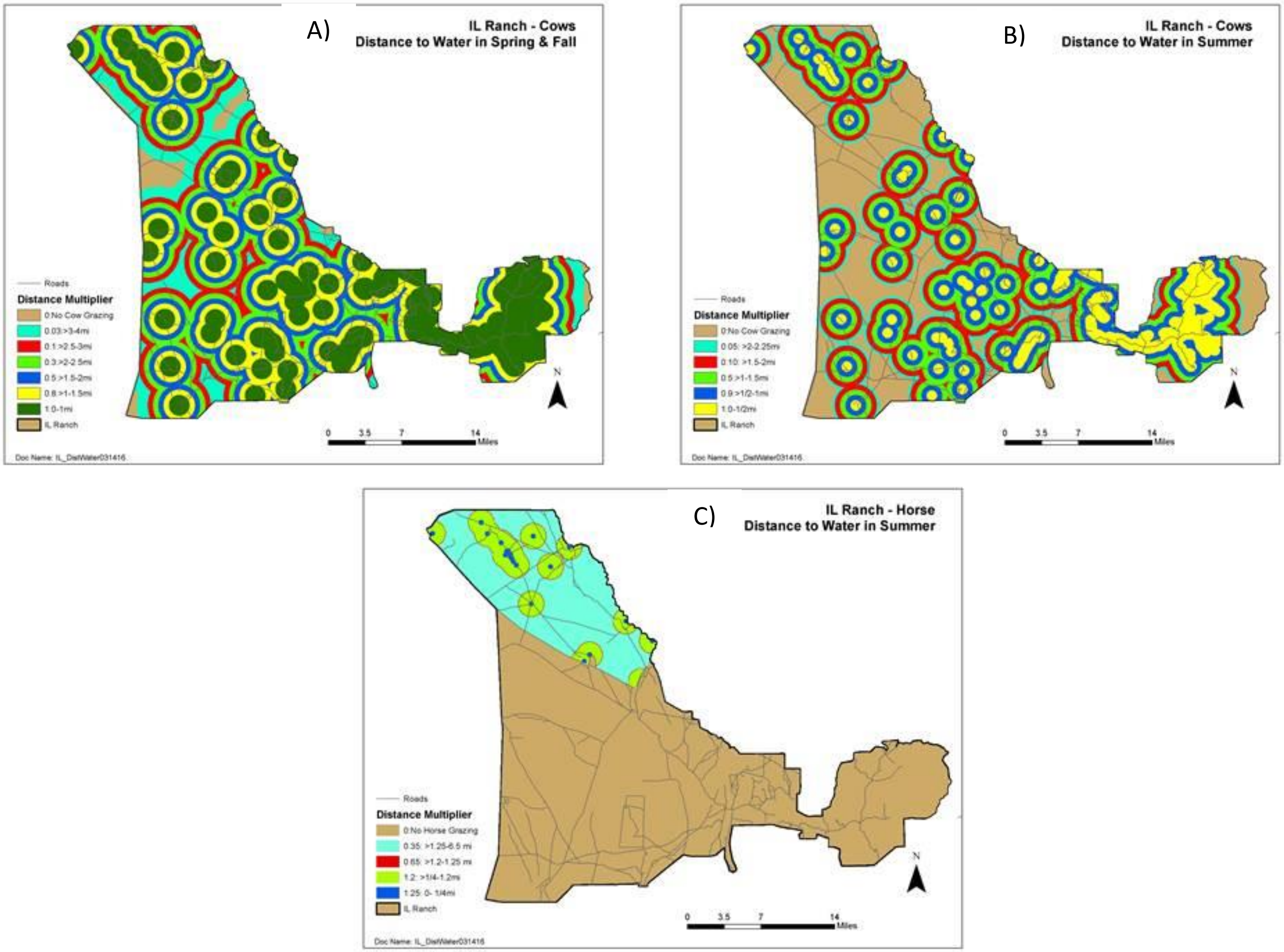


Figure 3A. Effect of distance to water source on ST-Sim's grazing rates for early-season (before July 1st) (A.) and late-season (after June 30th) grazing (B.), and for the Horse Management Area for the IL Ranch (C.).

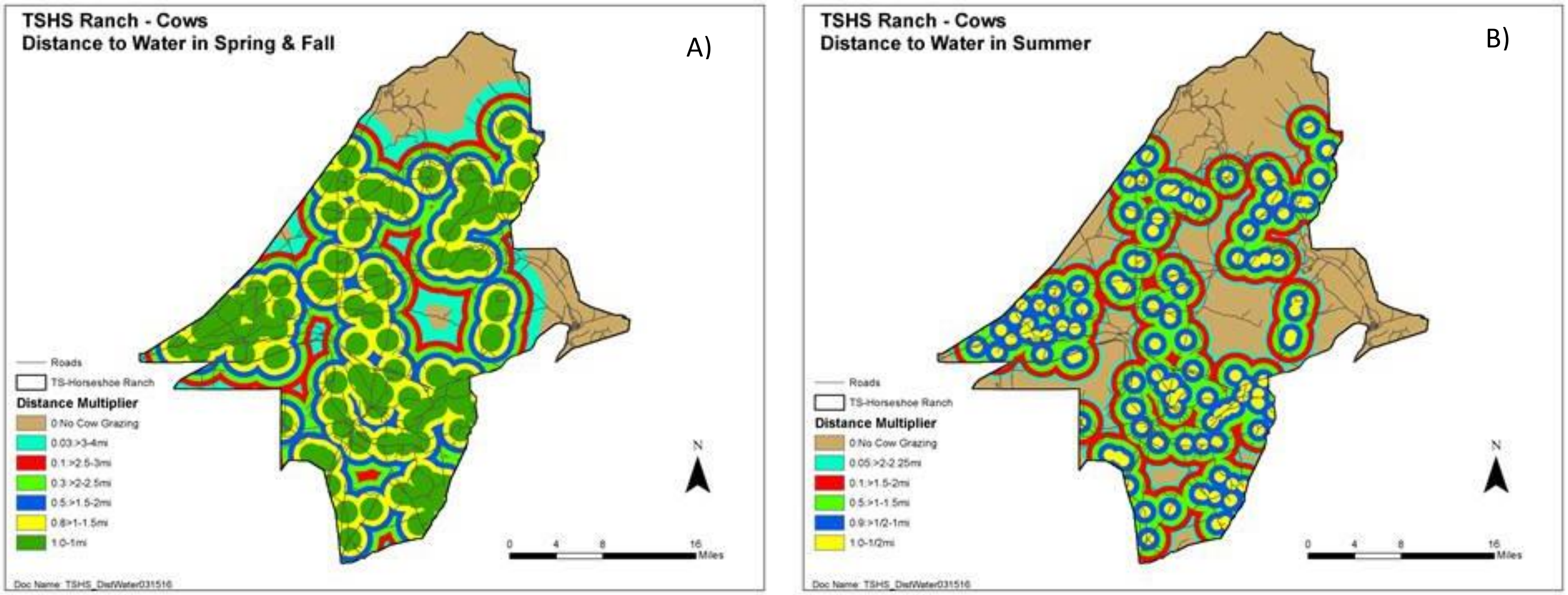


Figure 3B. Effect of distance to water source on ST-Sim's grazing rates for early-season (before July 1st) (A.) and late-season (after June 30th) grazing (B.), for the TS-Horseshoe Ranches.

The second type of spatial rasters prevented actions (a) that remove or thin sagebrush cover from being implemented (in the simulations) within 2,000 m of any lek in both landscapes, (b) in areas where the slope is >15% and, therefore, incompatible with rangeland seeders, tractors, mowers, and herbicide sprayers, but compatible with masticators as they can be used on slopes up to 30%, and (c) in basin wildrye systems of the IL Ranch due to deep canyon walls of the South Fork of the Owyhee River or at sites usually inundated at the Desert Ranch reservoir (Figures 4A and B). Within 2 km of leks, actions that remove rabbitbrush or restore wet meadows were allowed as these management treatments did not reduce sagebrush cover for greater sage-grouse nesting. One exception to the exclusion around leks was an action that created very small gaps in otherwise closed canopies of sagebrush. This was done to increase landscape heterogeneity and system resilience. This action was only permitted on the IL Ranch as the TS-Horseshoe Ranches have burned resulting in the loss of much of the sagebrush canopy. In reality, these gaps could be created by positioning supplemental salt blocks for a few months that attract cattle, which crush shrubs and release herbaceous vegetation.

The third type of raster included static fuel breaks for each landscape that were based on existing BLM fuel breaks and additional ones we inserted in probable areas near, and mostly upwind, of critical quality sage-grouse habitat (Figure 5). The value of pixels in the fuel breaks was 0.001 (i.e., the rate of replacement fire was suppressed by multiplying by 0.001), which translate into a very poorly permeable barrier to fire, whereas the value of pixels outside the fuel breaks was one, which means no change to the rates for fire in ST-Sim. An absolute fuel break (i.e. pixels of 0) was not used as fire is known to jump fuel breaks under extreme weather (Maestas et al. 2016)

Figure 4A. Areas of exclusion for management actions for the Il Ranch. A) Basin wildrye exclusion zone B) areas within 2 km of leks, and C) areas with slopes greater than 15%.

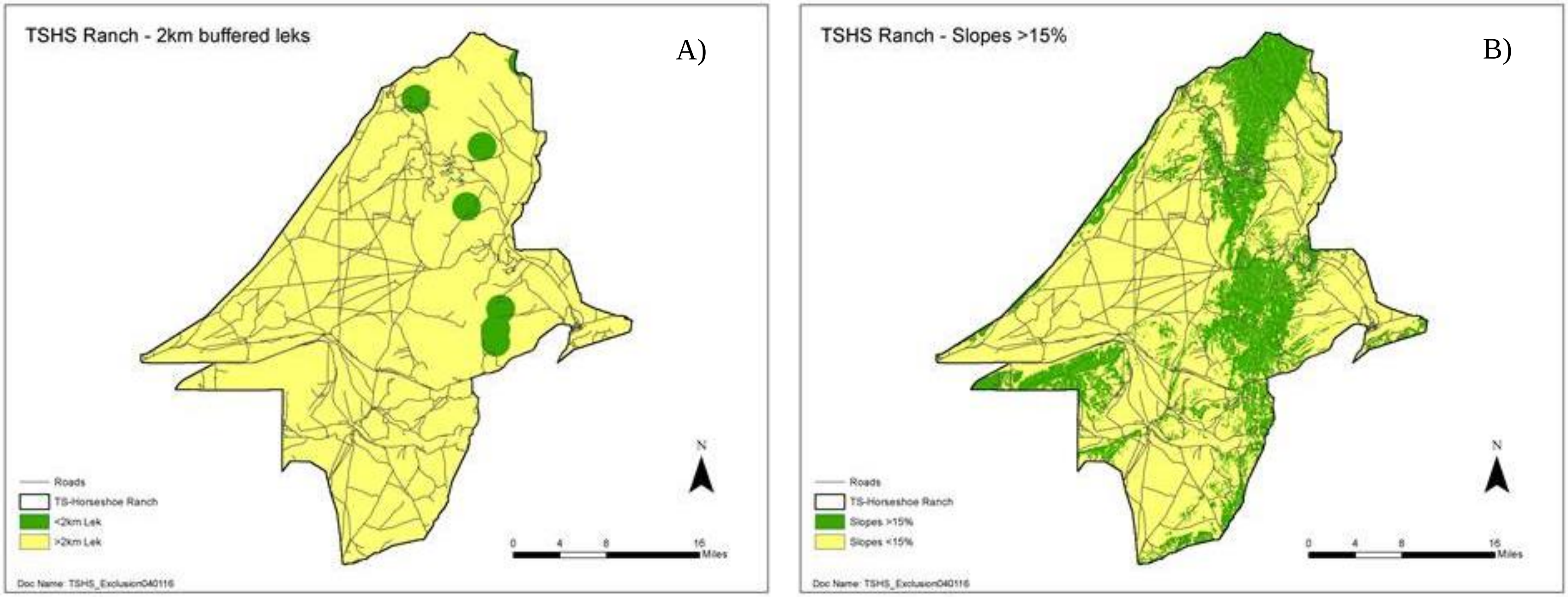
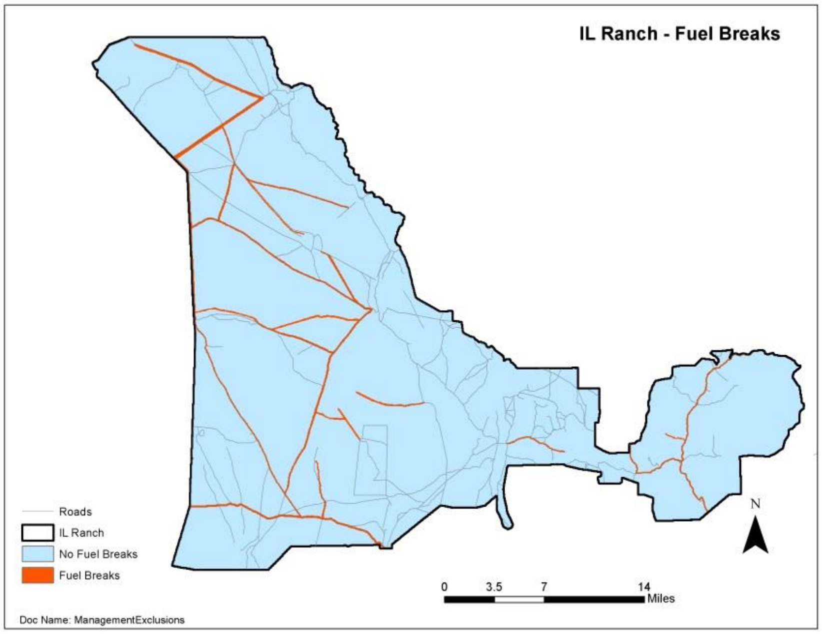


Figure 4B. Areas of exclusion for management actions for the TS-Horseshoe Ranches. A) Areas within 2 km of leks and B) areas with slopes greater than 15%.

Direction multipliers governed the non-uniform direction of fire spread, primarily following southwest to northeast prevailing winds (i.e., 45 degrees). Table 6 shows the degree and the multiplicative factor of fire spread. For example, for every one pixel of fire spreading in the 270^{o} (west) direction, fire spreads 7 pixels in the 45^{o} (northeast) direction. The distribution was determined by trial and error while coarsely approximating true fire shapes for the area.



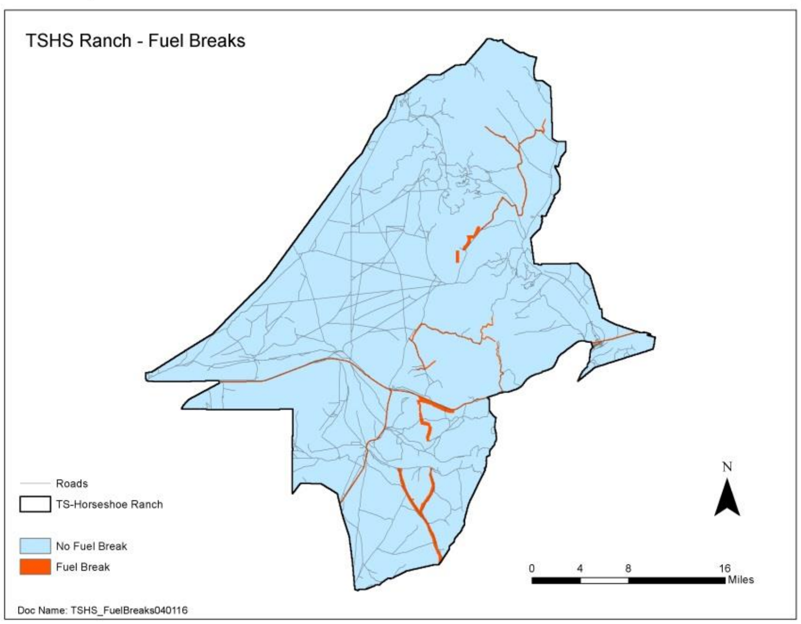


Figure 5. Simulated fuel breaks on the IL Ranch and TS-Horseshoe Ranches. Fuel breaks are at least 60 m wide and include original BLM fuel breaks and additional hypothetical ones to achieve protection of greater sage-grouse habitat.

Table 6. Direction multipliers for fire spread of all types.

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

Adjacency Multipliers allow simulations to modify the rate of implementation of disturbances based on the average condition of pixels around a focal pixel as determined by a circular moving window for a fixed radius. This option was used for only one disturbance: the placement of supplemental salt blocks within 2 km of a lek. Because sage-grouse's nest-site selection and nest success, respectively, decrease with the proportion of early-succession vegetation classes within 1,000 m and 2,000 m of a pixel (see below *Habitat Suitability for Greater Sage-Grouse)*, the simulation was constrained to not place a supplemental salt block adjacent (60-m radius) to a pixel already defined as an early-succession vegetation classes. If the proportion of early-succession vegetation classes was, respectively, <0.45, 0.45 or >0.45, a salt block could be placed in the pixel 100%, 75%, and 0% of times.

The last spatial option used to constrain simulations was dynamic habitat suitability, which was added to the ST-Sim software specifically for this project. Dynamic habitat suitability functions by periodically sending the simulation's transition group table (group of disturbances) and rasters of ecological systems and vegetation classes to R (R Core Team, 2014) to calculate sage-grouse habitat suitability (see below *Habitat Suitability for Greater Sage-Grouse)*. For a given year, the R script returns a binary (0, 1) raster to ST-Sim representing the areas where some management actions (identified by the transition group table) cannot be applied (value = 0) or applied without constraints (value =1). The binary values of the raster were determined by being (i) zero for pixels whose value equaled or exceeded one standard deviation above the average (i.e., the highest habitat suitability, where actions are unlikely to improve habitat) and (ii) one in areas less than one standard deviation above the average habitat suitability (i.e., sagebrush cover might be treated to improve future habitat suitability). The frequency for refreshing the binary raster was every 5 years (including year 0).

Accounting for Temporal Variability in Disturbances and Climate

The basic ST-Sim state-and-transition models incorporate by default stochastic disturbance rates that vary around a mean value for a particular disturbance associated with each vegetation class of each ecological system. This variability is simply caused by the drawing of random numbers to satisfy certain disturbance rates. 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. However, in real-world conditions the disturbance rates are likely to vary appreciably over time, and more than that provided by ST-Sim's default variability. To simulate strong yearly variability for fire activity, climate-induced mortality and non-native species fertilization, insect and disease outbreaks, non-native species invasion rates, tree encroachment rate, loss of herbaceous understory, and flooding, *temporal multipliers* were incorporated in the model-run replicates. Due to the extremely episodic nature of weather, fire, and flooding in the Great Basin, temporal multipliers have profound effects on model-run results (reporting variables). For example, a very large area suitable for sage-grouse nesting could burn during a major fire year which would then trigger major restoration actions to recover lost habitat suitability over decades.

A temporal multiplier is a number in a yearly time series that multiplies a base disturbance rate in the state-and-transition models. For example, in a given year, a temporal multiplier of one implies no change in a disturbance rate, whereas a multiplier of zero is a complete suppression of the disturbance rate, and a multiplier of three triples the disturbance rate. In this example, if your original disturbance rate is $0.01 \cdot year^{-1}$ or 100-year mean fire return interval, a multiplier of zero would completely suppress fire in a given year and a multiplier of three would mean, $3 \times 0.01 \cdot year^{-1} = 0.03 \cdot year^{-1}$, or a 33-year mean fire return interval. A tripling of a fire rate means an approximate tripling of the area burned because the rate, a temporal measure, allocates virtual pixels chosen (i.e., an area) per year. Temporal multipliers can be obtained from data, statistical projections, mechanistic equations, and heuristic (i.e., curve fitting) equations. A more detailed explanation of temporal multipliers is presented in Appendix 5 and Provencher et al. (2015).

Management Objectives, Actions, and Scenarios

Management objectives ultimately determine how the ST-Sim database will be structured as management scenarios whose actions (i.e., implemented treatments) are designed to reach stated objectives. Newmont with the assistance of TNC worked on three interrelated tasks toward achieving these purposes:

1) Development of a set of more-specific guiding *management objectives* consistent with Newmont and ELLCos corporate mission and goals, and BLM's multiple-use management;
2) Development of various alternative *management scenarios*, i.e., combinations of management actions that have a similar theme; and
3) Definition of comprehensive set of *management actions* per ecological system and per scenario, also known as a strategy, that Newmont and BLM can implement.

At workshops, participants reviewed proposed Newmont management objectives and scenarios, which played an important role defining the type, cost and outcomes of management actions at the project's second and third workshops. These management objectives are listed in the box below.

LCF™ Management Objectives for the IL Ranch and TS-Horseshoe Ranches

	Private Lands	Shared	Public Lands
General	▪ Continuation and enhancement of an economically and ecologically sustainable rangeland livestock enterprise. ▪ Access to land to meet Business Plan needs regardless of GSG or other species' ESA regulatory status.	▪ Maintain or improve overall ecological condition of the major native vegetation types (ecological systems) in the project areas. ▪ Decrease fuel loads, or maintain target fuel loads, to reduce wildfire hazard to land resources and to human infrastructure in and around the project area. ▪ Prevent expansion, and reduce the extent if possible, of "high-risk" vegetation classes in the project areas – vegetation that are difficult or expensive to treat successfully, such as invasive annual grasses. ▪ Jointly maintain or enhance the quality of GSG, mule deer, and golden eagle habitat. – BLM also considers other species of special concern.	
IL	▪ Identify private land opportunities to be managed for GSG conservation credits. ▪ Explore joint private-public funding to manage ecological sites to reference conditions to the extent possible on public and private lands. ▪ Maintain ecological sites that are currently in a desired community phase of the reference state by applying treatments/management that prevent crossing of thresholds and rejuvenate the plant community.	▪ Manage ecological sites to provide for age class diversity or multiple community phases for the reference condition, thus providing habitat for focal species and special status species, as well as modifying fuel loading on the landscape. ▪ Explore joint private-public funding to manage ecological sites to desired or reference conditions to the extent	▪ Jointly maintain or enhance the quality of GSG, mule deer, and golden eagle habitat on public lands. ▪ Restore currently degraded or impaired ecological systems that would provide

	▪ Create a landscape of the various community phases of the full spectrum of Great Bain Ecological Sites that are present on the ranch at the watershed, allotment, and/or pasture level. ▪ Implement restoration pathways to return altered states to a desired state or reference state (if appropriate and possible) or a near-reference state with ecological functions operating at near reference state levels. ▪ If the technology or funding does not yet exist for returning altered states to desired or reference state conditions, then rehabilitate the altered states to some level of functioning ecological condition (e.g. perennial grass seeding).	possible on public and private lands.	the highest return on investment.
TS-HS	▪ Partition landscape between areas of ecological sites with potential to provide GSG habitat *vs.* ecological sites with no potential to support GSG habitat. ▪ Identify private land opportunities to be managed for GSG conservation credits. ▪ Explore joint private-public funding to manage ecological sites to desired or reference conditions to the extent possible on public and private lands. ▪ Maintain ecological sites that are currently in a desired community phase of the reference state by applying treatments/management that prevent crossing of thresholds and rejuvenate the plant community. ▪ Create a landscape of the various community phases of the full spectrum of Great Bain Ecological Sites that are present on the ranch at the watershed, allotment, and/or pasture level.	▪ Manage ecological sites to provide for age class diversity or multiple community phases for the reference condition, thus providing habitat for focal species and special status species, as well as modifying fuel loading on the landscape. ▪ Explore joint private-public funding to manage ecological sites to desired or reference conditions to the extent possible on public and private lands	▪ Evaluate potential land areas for special wildlife habitat improvements on public lands. ▪ Restore currently degraded or impaired ecological systems that would provide the highest return on investment. ▪ If applicable, maintain or enhance the quality of GSG, mule deer, and golden eagle habitats.

	▪ Implement restoration pathways to return altered states to a desired state or reference state (if appropriate and possible) or a near-reference state with ecological functions operating at near reference state levels. ▪ If the technology or funding does not yet exist for returning altered states to desired or reference state conditions, then rehabilitate the altered states to some level of functioning ecological condition (e.g. perennial grass seeding)		

Management Scenarios

Management scenarios represent common "themes" for grouping individual management actions, so that the effectiveness of sets-of-actions can be better compared within and across ecological systems. Scenarios are comparable to alternatives proposed in agency planning documents or project-specific National Environmental Policy Act (NEPA) analyses. Based on past experience in eastern California, Nevada, and western Utah, and several trial-and-error iterations of "single-action scenarios," Newmont and TNC settled on three management scenarios: Minimum management, Maximum GSG Habitat Suitability (pure sage-grouse habitat improvements), Highest Return-On-Investment for lowest Unified Ecological Departure (generalized range management for increased ecological condition) (Table 7).

Table 7. Descriptions of management scenarios for both the IL Ranch and TS-Horseshoe Ranches.

Management Scenarios
Minimum
This is a control scenario that includes only natural disturbances, unmanaged non-native species invasion, fire suppression management, and current livestock grazing where it is permitted. Fire suppression by agencies was simulated by reducing natural, reference fire return intervals by 90%, while maintaining stated fire return intervals for uncharacteristic vegetation classes, using time series that reflect current fire events from the immediate and nearby areas (temporal multiplier). Fire event data were obtained from the Federal Fire Occurrence Website and the Monitoring Trends in Burn Severity website. In essence, this scenario can be considered as a no-treatment control, but it does not always exactly represent current management.
Maximum GSG Habitat Suitability (hereafter: Max GSG HS management)
This scenario allocates limited funds to actions that only increase short- and long-term GSG habitat suitability as calculated by University of Nevada, Reno's demographic model by replacing vegetation classes that negatively contribute to habitat suitability with classes that positively contribute, sometimes after decades, to habitat suitability. This scenario assumes a landowner (Newmont/ELLCo) treatment budget of \$250,000 per year (for the first 10 years), the Bureau of Land Management (at most \$350,000·year^{-1}), and, for the IL Ranch only, the US Forest Service (at most \$5,000·year^{-1}). The scenario includes (i) enhanced landscape fuel breaks seeded with introduced species and forbs that includes BLM's fuel break design and (ii) an expanded livestock watering system to areas lacking water (IL Ranch only).
Highest Return-on-Investment for lowest Unified Ecological Departure (hereafter: Best UED management)
This standard LCF™ scenario was identified interactively by managers and stakeholders at the workshop to counter-balance the single-species focus of the Maximum GSG Credit Creation scenario that can result in neglecting proper range management. It aims to reduce unified ecological departure and/or specific "problem" high risk classes per focal ecological system within the constraints of anticipated (realistic) Newmont and agency budgets (see above) and regulatory requirements. Basically, this scenario seeks a set of actions that produces the highest return on investment, or ratio of benefit (improvement in condition) to affordable cost even it results in actions that may target vegetation classes that currently contribute positively to GSG habitat suitability. As above, this scenario includes an expanded fuel break layout and watering system (IL Ranch only).

The Max GSG HS Management and Best UED Management scenarios are referred to collectively as Active Management scenarios, because they are comprised of specific management actions, in contrast to the Minimum Management scenario which contains no proactive management actions.

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

Management Actions

Project participants identified various management actions (also termed treatments) toward achieving the management objectives for the two project areas and their ecological systems. The effectiveness of actions was tested using the predictive ecological models through a trial-and-error process. All management actions were fundamentally designed to: (i) improve GSG habitat suitability within a 30-year simulation or (ii) improve the condition of focal ecological systems that are currently or will become substantially departed from reference conditions (defined below under **Metrics for Assessing of Current Condition**).

Initial sets of management actions were developed by participants in the project's model review workshop and first management workshop. Each management action has a cost-per-acre figure associated with it, using various published sources as well as the local experience of agency staff and stakeholders (Appendix 6).

TNC then conducted computer runs of the state-and-transition models to test and refine suites of actions for each of the selected ecological systems over a 30-year time horizon. A group of actions per system is also called a strategy. These models included a "failure rate" for many management actions to reflect that some actions only partially succeed at restoring a vegetation class, mirroring restoration in practice on the landscape. Several alternative management actions and levels of treatment were tested to develop successful scenarios (see below). This process of "successive approximation" created a robust set of actions that in many cases reduced unified ecological departure, specifically by reducing amounts of high risk vegetation classes, while seeking to minimize cost.

Reporting Variables

The scenarios from Table 7 were simulated for each ecological system for 30 years using ST-Sim state-and-transition modeling software. Ten model replicates were run for each scenario to capture extremes in processes such as fire activity, drought, Aroga moth outbreaks. For ecological systems, the main reporting variable (output) for each simulation was the future-condition measure of unified ecological departure. For the three species, reporting variables were habitat suitability and functional area of sage-grouse and habitat suitability for mule deer and golden eagle for each landscape. Sage-grouse habitat suitability was based on the University of Nevada, Reno demographic model, whereas only resource selection functions proposed by experts and found in the literature were used for mule deer and golden eagle.

Other measures were reported including acres actually treated and the 30-year total cost of treatments.

Ecological Systems

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

Traditional Ecological Departure

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

(1) The amount (percentage) of each vegetation classes expected under reference conditions (NRV, Table 3); and

(2) The amount (percentage) of each vegetation classes that is currently present on the landscape.

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

Traditional ecological departure is scored on a scale of 0% to 100% departure from NRV: Zero percent represents NRV itself (no departure), while 100% represents total departure. In other words, a higher the number indicates increasingly greater 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; Rollins 2009). An example of the calculation of traditional ecological departure, and assignment to the corresponding ecological departure class, is shown in Table 8.

Table 8. Example of calculation of traditional 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 ac
Current % by class in project area	0.1	6.6	49.0	5.6	0.2	38.5	100%
Minimum of NRV % or Current %	0.1	6.6	15.0	5.6	0.2	0	27.5%
Ecological Departure (%)[2]							72.5%
Ecological Departure Class[3]							3

1. Standard LANDFIRE coding: A = early-development; B = mid-development, closed; C = mid-development, open; D = late-development, open; E = late-development, closed; and U = uncharacteristic.
2. Ecological Departure (ED) = 100% – $\sum_{i=1}^{n} \min\{Current_i, NRV_i\}$
3. Ecological Departure Class: 1 for 0% ≤ ED ≤ 33%; 2 for 34% ≤ ED ≤ 66%; 3 for 67% ≤ ED ≤ 100%.

Undesirability of Certain Uncharacteristic Classes

Not all uncharacteristic (non-reference) vegetation classes are equal: Some uncharacteristic classes create heightened challenges because their presence represents significant ecological degradation or unacceptably high levels of hazard to public safety, and their restoration is either very difficult (ecologically) or very expensive, or both. Such classes are particularly undesirable, and in this LCF™ project they are identified with the label "high risk vegetation classes" (HRVC). HRVCs are defined as uncharacteristic vegetation classes that meet at least one of the three following criteria:

(1) ≥5% cover of invasive non-native species,

(2) very expensive to restore, or

(3) a direct pathway to one of these classes (invaded or very expensive to restore).

In past LCF™ projects, TNC and partners used percent-area of HRVCs as a second measure of current condition for ecological systems, alongside traditional ecological departure. This project does not report amounts of HRVCs separately, though these undesirable classes do figure prominently into the measure of unified ecological departure, explained below. In ST-Sim's Ecological Departure menu, the value of HRVC is termed "Undesirability" and recommended to range from 0 (neutral uncharacteristic class, such as dominated by rabbitbrush) to 2 (very bad such as invaded by Russian knapweed) (Table 9).

Table 9. Level of undesirability (0 to 2) of uncharacteristic classes. If an uncharacteristic class is not listed, it is assumed that its undesirability level is zero. For full description of classes, see Appendix 1-A.

Ecological System	Undesirability Level
Aspen Woodland	
U:ASP->MSS	2
U:Depleted	1
Aspen-Mixed Conifer	
U:ASM->SF	2
Basin Wildrye-bottomland	
U:Annual Spp	1
U:Depleted	1
U:Exotic Forbs	2
Basin Wildrye-montane	
U:Annual Spp	1
U:Depleted	1
U:Exotic Forbs	2
Big Sagebrush-semidesert	
U:Annual Spp	1
U:Depleted	1
U:Exotic Forbs	2
U:SA-Closed	1
U:SA-Dense	1
Big Sagebrush-upland no trees	
U:Annual Spp	1
U:Depleted	1
U:Exotic Forbs	2
U:SA-Closed	1
U:SA-Dense	1
Big Sagebrush-upland+trees	
U:Annual Spp	1
U:Depleted	1
U:Exotic Forbs	2
U:SA-Closed	1
U:SA-Dense	1
U:TEA	1
Channel	
Channel:Exotic Forb&Tree	2
Curl-leaf Mountain Mahogany	
U:Annual Spp	1
Desert Wash	
U:Bare Ground	1
U:Exotic Forb&Tree	2
U:SA	1
Four-Wing Saltbush	
U:Annual Spp	1
U:Exotic Forbs	2
Greasewood	
U:Annual Spp	1
U:Exotic Forbs	2
U:SA	1
Juniper Woodland	
U:Annual Spp	1
U:Exotic Forbs	2
U:Tree Ann Spp	1
Low Sagebrush	

U:Annual Spp	1
U:Depleted	1
U:Exotic Forbs	2
U:SA	1
Lower Montane-Valley Grassland	
U:ASPG	1
U:Bare Ground	1
U:Depleted	1
U:Exotic Forb-ARCA	2
U:Exotic Forbs	2
U:SA	1
U:SE-Early	1
U:SE-Late	1
Mixed Salt Desert	
U:Annual Spp	1
U:Exotic Forbs	2
U:SA	1
Moist Floodplain	
U:Annual Spp	1
U:Desertified	1
U:Exotic Forb&Tree	2
U:Incised-EFT	2
U:SAP	1
Montane Riparian	
U:Annual Spp	1
U:Desertified	1
U:Exotic Forb&Tree	2
U:Incised-EFT	2
U:Inset-EFT	2
U:Inset-HU	1
U:Inset-SFE	1
U:Pasture	1
U:SAP	1
Montane Sagebrush Steppe	
U:Annual Spp	1
U:Depleted	1
U:Exotic Forbs	2
U:SA-Closed	1
U:SA-Dense	1
U:SAP-Closed	1
Montane Sagebrush Steppe-Subalpine	
U:Annual Spp	1
U:ASPG	0
U:Depleted	1
U:Exotic Forbs	2
U:TEA	1
Mountain Shrub	
U:Depleted	1
U:SAP	1
U:TEA	1
Owyhee River Riparian	
U:Annual Spp	1
U:Desertified	1
U:Exotic Forb&Tree	2
U:Incised-EFT	2
U:Inset-A	1
U:Inset-B	1
U:Inset-EFT	2

U:Inset-HU	1
U:Inset-SFE	1
U:SAP	1
Saline Meadow	
U:Annual Spp	1
U:Exotic Forbs	1
Wet Meadow-bottomland	
U:Annual Spp	1
U:Desertified	1
U:Exotic Forbs	2
U:Hummocked	1
U:Incised-EFT	2
U:SA	1
U:Shrb-Frb Encr	1
Wet Meadow-Montane	
U:Annual Spp	1
U:Desertified	1
U:Exotic Forbs	2
U:Hummocked	1
U:Incised-EFT	2
U:Pasture	1
U:SAP	1
U:Shrb-Frb Encr	1
U:Unpalat. Forb	1
Wetland	
U:Exotic Forb&Tree	2
U:Hummocked	1

Allowable Thresholds of Certain Uncharacteristic Classes

Some uncharacteristic classes have been expressly created by managers toward the meeting of management objectives. Classes of this type do not represent significant ecological degradation (e.g. severe soil loss) or high levels of public-safety hazard (e.g. copious fuel buildups). Moreover, they often benefit wildlife. Classic examples of such classes are seedings with non-native introduced species such as crested wheatgrass, where a complement of native shrubs, forbs and grasses is still present. These classes are acceptable or "allowable" in moderation – i.e., in amounts up to an agreed-upon threshold for each one. Allowable classes included irrigated pastures in more mesic systems, native species seedings, and seeding containing in whole or part introduced species (e.g., crested wheatgrass and forage kochia). Newmont managers and experts defined the threshold of allowable uncharacteristic classes at 10% for non-native seeded classes within each ecological system. Devotion of scarce management/restoration funds to "fixing" sub-threshold amounts of these allowable (but still uncharacteristic) classes has minimal priority – far lower than projects that focus on treating highly undesirable vegetation classes.

The identification of these harmless or benign uncharacteristic classes is relatively new to the LCF^{TM} process. They are formally labeled by "Threshold Percent" in the ST-Sim Ecological Departure menu and could be called Allowable Uncharacteristic Classes (Table 10). Their presence contributes to the new integrated measure of condition known as unified ecological departure, described in the following section.

Table 10. Percent threshold of class area per ecological system below which no ecological departure accumulates and above which ecological departure accrues normally. Among seeded classes, the total threshold of 10% is distributed following the same distribution as in the NRV of reference classes.

Ecological System/Class	Threshold Percent
Basin Wildrye-bottomland	
U:Pasture	1
U:SDI	10
U:Seeded Native	10
Basin Wildrye-montane	
U:Pasture	50
U:Seeded Native	30
Big Sagebrush-semidesert	
U:SDI-A	2.9
U:SDI-B	4.5
U:SDI-C	2.5
U:SDI-D	0.1
Big Sagebrush-upland no trees	
U:SDI-A	3.1
U:SDI-B	4.4
U:SDI-C	2.4
U:SDI-D	0.1
Big Sagebrush-upland+trees	
U:SDI-A	3
U:SDI-B	4.6
U:SDI-C	2.3
U:SDI-D	0.1
Four-Wing Saltbush	
U:Seeded Native	10
Greasewood	
U:Pasture	2
U:SDI	10
Low Sagebrush	
U:SDI-A	1
U:SDI-B	3.7
U:SDI-C	5.3
Mixed Salt Desert	
U:SDI	10
U:Seeded Native	10
Montane Sagebrush Steppe	
U:SDI-A	4.4
U:SDI-B	2.3
U:SDI-C	0.2
Wet Meadow-Montane	
U:Pasture	4

Unified Ecological Departure

Unified ecological departure gives a more realistic accounting of ecological condition or health than traditional ecological departure as it incorporates ecological departure, high risk vegetation classes, and threshold percentage of allowable classes. Importantly, the concept of UED also solves a double-counting problem where the same class was counted twice in ED and again under HRVC when incorporated in the calculation of Return On Investment measure for ecological systems (defined later). The technical description of unified ecological departure appears in Appendix 7.

Unified ecological departure is the primary metric of both current and future condition for each ecological system (not for the landscape as we reported later for species) in this report. However, in describing condition of ecological systems in the **Findings** section farther below, amounts of high risk classes are highlighted as the "problems" that largely drive the selection of treatment actions. The modeled results of applying those treatments are then shown as predicted reductions (in most cases) of those problem classes. This highlighting of high risk classes may be useful to managers, because the single UED measure can mask specific identities of high risk classes in an ecological system. As previously mentioned, UED is a metric used to inform management decisions and does not imply an expectation that all systems will/can be returned to NRV. However, UED allows users to assess the level of degradation within systems as well as identify systems were ecological processes may be altered from natural or desired condition.

Habitat Suitability for Species

In addition to unified ecological departure, effectiveness of management scenarios was analyzed using habitat suitability for three species: greater sage-grouse, mule deer, and golden eagle. While the concern for the sage-grouse is apparent, mule deer and golden eagle were chosen as focal species for several reasons. First, while not sagebrush obligates, as is the case for sage-grouse, mule deer and golden eagles are locally dependent on sagebrush communities. These species can be used as case studies to understand the impact of single species focused management (here sage-grouse) on other species. For example, mule deer are known to prefer younger seral sites and greater shrub diversity, so management prioritized on maintenance of later seral intact sagebrush for sage-grouse may impact habitat suitability for mule deer. This analysis can, in turn, help managers make decisions on actions that can help conserve and protect habitat for the ~350 other sagebrush obligate or near-obligate species that can have similar habitat needs.

Habitat suitability for sage-grouse was empirically derived from a 9-year study conducted in Eureka County, NV (hereafter Eureka Co. data); heuristic resource selection functions were developed for mule deer and golden eagle as data for the Newmont properties for these species are lacking. Habitat suitability for all three species was determined for current vegetation and the simulated 30-year vegetation.

Habitat Suitability for Greater Sage-Grouse

Data on sage-grouse demography were collected as part of a long-term research program on greater sage-grouse ecology from 2003-2012 in Eureka County, Nevada (Falcon-Gondor study area; see Gibson et al. 2013, Kane et al. *in prep*). The field data from that project were used to quantitatively describe the habitat requirements for four demographic parameters (i.e. life history stages): nest site selection (NSS), nest success (NS), chick survival (CS), and female survival (Appendix 8, Tables 8-1 and 8-2). While winter is an important season for sage-grouse, we did not include winter habitat suitability because mortality tends to be low during that season (J. Sedinger, pers. comm.). Additionally, within the Eureka Co. study winter habitat was not limited, so it did not greatly impact demographic rates (J. Sedinger, pers. comm.). The four demographic parameters are defined as such:

1. Nest Site Selection (NSS): probability of an individual successfully initiating a nest. It is a function of elevation, slope, distance from the nearest lek, proportion of sagebrush classes surrounding a given pixel, and interactions among these variables. High NSS would be found at pixels that are at mid-elevations, moderate slopes, close to a lek, and have high sagebrush cover in the surrounding area.
2. Nest Success (NS): probability that at least one chick will hatch from the nest and survive until brood rearing age and includes the likelihood that a female will initiate a new nest if her first one fails. This variable is a function of the proportion of grassland surrounding a pixel and the cover of non-sagebrush shrubs. Pixels with high NS would be those with low levels of grasslands in the surrounding area and have high non-sagebrush shrub cover.
3. Chick Survival (CS): probability that at least one chick from the brood will survive through the 6-week late brood rearing season. First, average daily distance moved was calculated as the distance from a potential nest site to the nearest pixel classified as late brood habitat. This variable was then used to calculate the weekly survival rates of the brood across brood rearing. Finally, CS was the product of the 6 weekly survival rates. High CS values were calculated for pixels close to brood rearing habitat (Appendix 8, Table 8-2). The final CS values were estimated using a weighted CS that penalizes pixels that are in nearest to degraded late brood habitat.
4. Female Survival (FS): probability that a female will survive. Calculated based on monthly survival rates within the four seasons. Additionally, FS is dependent on NS and CS. Both NS and CS illustrate the trade-off that exists between reproductive success and female survival. This means areas where a female is more likely to successfully produce a nest or brood are areas of depressed female survival

In addition to outputs from simulations other environmental spatial data were gathered for the calculation of the four demographic parameters. Rasters of slope and elevation were obtained from a National Elevation Dataset Digital Elevation Model (NED DEM; USGS). Lek locations were made available by the Nevada Department of Wildlife (NDOW). Eight new geo-referenced and filmed leks, which were discovered by the IL Ranch manager and BLM staff in 2015, were added to the analysis. All rasters were standardized by subtracting the rasters mean and dividing by its standard deviation (unless otherwise noted), to obtain a raster with mean 0 and a standard deviation 1. Rasters were standardized to allow for comparison between the Newmont properties and the Eureka Co. dataset. We used the following general form of logistic regression equation with the corresponding coefficients and beta values to build our spatial models (Hosmer and Lemeshow 1989):

$$S= e^{((\beta 0 + \beta 1X1+\beta 2X2 +\ldots+ \beta nXn)/ (1 + \exp (\beta 0 + \beta 1X1 + \beta 2X2 +\ldots+ \beta nXn))}$$

where β_0 is the model intercept, β_i are the logistic regression coefficients (Appendix 8 Table 8-4), and X_i are the measured covariates.

The demographic parameters were used to model the per capita population growth rate (λ) as a function of the spatial variation in sage-grouse demographic parameters to predict contributions of specific habitats to regional population dynamics (Kane et al. *in prep*). This process allows for the direct link between a pixel's demographic parameter values and its expected impact on sage-grouse population. The calculation of λ (or Lambda) incorporates the fecundity and annual survival of females and the relative impact of NSS, NS, CS, and FS. Fecundity was estimated from the Eureka Co. data and assumed constant throughout the study period. It is important to note that λ is effectively weighted toward the lower values among the demographic parameters. For example, a pixel with relatively high values for NSS but low CS will have a lower λ as CS is given more weight at that pixel.

Once λ was calculated for each pixel at the two properties, a single functional acre score was computed for each property. Functional area (expressed as functional acres by managers, although units could also be hectares) is the sum over all pixels in a landscape of the product of the area of each pixel by the overall habitat suitability (scaled 0 to 1) of that pixel. It can also be calculated as the area of a pixel (all the same in a grid) multiplied by the sum of the overall habitat suitability (scaled 0 to 1) of each pixel in the landscape. By definition, functional area is always equal to or smaller than the size of the landscape. Functional area is calculated as:

$$\sum_{i} \frac{Area\ of\ pixel * \lambda_i}{2}$$

where A = area of pixel (units in acres for this application), λ_I is the λ for a pixel, and λ_{max} is the maximum λ found. To keep results from different replicates and scenarios comparable, λ_{max} was set at 2.0. This meant that $\lambda_i / \lambda_{max} = 0.5$ corresponds to a stable rate of $\lambda_I = 1$.

Resource Selection Functions for Mule Deer

Heuristic resource selection functions (RSFs) for mule deer were developed with help from researchers at UNR and biologists at NDOW, since movement data were not available across the two Newmont properties. In addition to consultation with these experts, all equations were vetted at the first and second workshops in Elko, NV. RSFs were categorized into 4 categories: summer, winter, topography, and migration (see Appendix 8 for detailed description of RSF described below).

For summer, five RSFs were calculated:

1. Summer elevation: mule deer prefer higher elevation, due to thermoregulation demand.
2. Distance to moist habitats: calculated as the distance between a pixel and the nearest pixel classified as moist habitat; mule deer prefer to be closer to moist habitats.
3. Distance to water source: calculated as the distance between a pixel and the nearest water source; mule deer prefer to be closer to water for drinking.
4. Proportion of early seral classes: calculated as the proportion of early seral pixels within a 2,000m radius; mule deer prefer higher proportion of early seral classes.
5. Proportion of tree classes: calculated as the proportion of tree classes within a 2,000m radius; mule deer prefer higher proportion of tree classes in order to shade themselves during the warmest portion of the day.

As the importance of these variables is not uniform, a single summer RSF was calculated by multiplying the RSF by a weight and adding the weighted results (Appendix 8 Table A8-9).

For winter, 4 RSFs were calculated:

1. Winter elevation: mule deer prefer lower elevation due to thermoregulation demands.
2. Shrub diversity: calculated as the Shannon diversity index of different shrub classes within the 2,000m radius; mule deer prefer higher shrub diversity.
3. Age diversity: calculated as the Shannon diversity index of different age classes within the 2,000m radius; mule deer prefer higher age diversity.
4. Proportion of tree classes: calculated as the proportion of tree classes within a 2,000m radius; mule deer prefer higher proportion of tree classes in order to protect themselves from wind and precipitation during winter.

As with summer, RSFs for winter were weighted before a single winter RSF was calculated (Appendix 8 Table A8-10).

Topography was described by a single variable, Topographic Ruggedness Index (TRI):

1. TRI: calculated as the mean of differences in elevation between a pixel and surrounding pixels

Mule deer populations are known to have high fidelity to migratory routes between winter and summer habitat. In order to model mule deer migration, mapped migratory corridors were used to create a single RSF:

1. Migratory resistance: calculated as the distance of a pixel from the migration corridor, mule deer prefer to be closer to the traditional migratory corridor

For the final RSF, the Simpson's Evenness Index was calculated using the final summer, final winter, TRI, and migratory resistance RSFs.

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

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

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

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

Resource Selection Functions for Golden Eagle

Heuristic RSFs for golden eagles were developed with help from biologists at USFW, NDOW, and Great Basin Ecology, Inc. The RSFs were also vetted at the first and second workshops in Elko, NV. Three RSFs were chosen to create a final habitat suitability layer:

1. Distance from potential nest sites: calculated as the distance from modelled cliff faces and old growth pinyon pine classes; golden eagles prefer to be closer to nest sites.
2. Proportion of deep soiled classes: calculated as the proportion of deep soiled classes within a 3750m radius; this variable was used to approximate the abundance of black tailed jackrabbits (*Lepus californicus*), which are the primary prey for golden eagles within the Intermountain West.
3. Alternative prey: this was an average of several RSFs to model the presence of food sources.
   3.1. Proportion of alternative mammal habitat: calculated as the proportion of reference and some non-reference classes within a 3750m radius; models the availability of non-lagomorph prey.
   3.2. Distance to calving grounds: calculated as the distance of pixel to early grazing pastures where calving occurs; golden eagles are known to scavenge on afterbirth in calving areas.
   3.3. Distance from roads: calculated as the distance to the nearest road; models the availability of roadkill.
   3.4. Distance to chukar habitat: calculated as the distance of a pixel to designated chukar habitat; recent field observations have indicated that chukar are an important alternative prey in central Nevada.

As with mule deer, the final habitat suitability score was calculated using the Simpson's Evenness Index among variables for distance from potential nest sites, proportion of deep soil classes, and alternative prey. Note that due to large home ranges of golden eagles, artificial "edge effects" are observed for golden eagle habitat analysis. These effects occur where mapped data is adjacent or near unmapped data, such as holes in the mapped or areas beyond the mapped project area.

Ecological Return-On-Investment Analysis

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

The predicted *benefit* is the amount of improvement in unified ecological departure that a scenario provides after 30 years, relative to the unified ecological departure that is predicted to occur after 30 years of MINIMUM MANAGEMENT. Said another way, the benefit is the difference between the future UED score of an active management scenario and the future UED score of "no action" management. The baseline used to calculate improvement in condition is the UED score of the MINIMUM MANAGEMENT scenario after 30 years, NOT the UED score as it is at the current time.

To calculate the ROI for an active management scenario, its predicted benefit is divided by the total 30-year cost of its management actions (treatments), and that result is multiplied by the area (acreage) of the ecological system being modeled. The formula for ROI of an active management scenario in the i_{th} ecological system thus appears as follows:

$$\mathrm{ROI}_i = \frac{(\mathrm{UED}_{\mathrm{MINIMUM},i} - \mathrm{UED}_{\mathrm{ACTIVE},i}) \times \mathrm{Acres}_{\mathrm{ACTIVE},i}}{\mathrm{TotalCost}_{\mathrm{ACTIVE},i}}$$

where 0% ≤ UED ≤ 100% and TotalCost is the cumulative 30-year cost of implementing an active scenario in the i_{th} ecological system.

For species habitat suitability (HS, where 0 ≤ HS ≤ 1) multiplied by 100 for conversion to a percentage, ecological ROI is calculated by species *i* (SPP_i) as shown below.

$$\mathrm{ROI}_{\mathrm{SPP}_i} = \frac{100 \times (\mathrm{HS}_{\mathrm{ACTIVE},\mathrm{SPP}_i} - \mathrm{HS}_{\mathrm{MINIMUM},\mathrm{SPP}_i})}{\mathrm{TotalCost}_{\mathrm{ACTIVE},\ \mathrm{SPP}_i}}$$

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, or among scenarios in a given landscape for the benefit of a species of special concern. Of course, managers may also select final scenarios, actions or treatment areas based upon a variety of additional factors, such as availability of financial resources, regulatory constraints, and other multiple-use or societal objectives.

Findings

Ecological Systems

Sixteen and 19 ecological systems, respectively, were mapped in the IL Ranch (Table 11A and Figure 6) and TS-Horseshoe Ranches (Tables 11B and Figure 7). Specific acreage figures for each ecological system in the two Project Areas appear in Tables 3A and 3B.

The largest system was big sagebrush on upland soils (i.e., Wyoming big sagebrush; big sagebrush without trees on 82% of the IL Ranch; big sagebrush with trees on 38% of the TS-Horseshoe Ranches). On the IL Ranch, big sagebrush on upland soils was very dominant on the large Owyhee grazing Allotment (Figure 6). The next largest system was montane sagebrush steppe at 7.7% of the IL Ranch and big sagebrush semi-desert on 16% of the TS-Horseshoe Ranches.

On the IL Ranch, the next group of ecological systems ranging from 2+ to 1% of the area is aspen woodland, basin wildrye-montane, low sagebrush, mountain shrub, and wet meadow-montane. About 10 systems, occupied less than 1% of the area of the IL Ranch. Among these 10 systems, a few are critical to sage-grouse habitat suitability.

For the TS-Horseshoe Ranches, the third largest system was greasewood at 9.7% of the area, followed by a group of systems composed of ranging from 2-5+% basin wildrye-bottomland, basin wildrye-montane, low sagebrush, mixed salt desert, moist floodplain, and montane sagebrush steppe. Several mesic and wet systems, such as aspen woodland and wet meadows, each represented <1% of the TS-Horseshoe Ranches project area.

Table 11A. Ecological systems by ownership (acres) of the IL Ranch based on June 22 and 26, 2013, 5-m RapidEye satellite imagery. Imagery includes a 100-m buffer around the project area.

Ecological System	BLM	Private	USFS
Aspen Woodland	578	2,450	2,630
Aspen-Mixed Conifer	4	208	303
Barren	692	109	29
Basin Wildrye-montane	6,348	4,930	0
Big Sagebrush-upland no trees	384,668	13,992	0
Curl-leaf Mountain Mahogany	0	2	0
Developed	51	171	0
Limber Pine Woodland	239	37	0
Low Sagebrush	4,386	2,032	491
Low Sagebrush Steppe	0	12	18
Lower Montane-Valley Grassland	4,322	0	0
Montane Riparian	483	2,341	410
Montane Sagebrush Steppe	8,611	20,289	8,665
Montane Sagebrush Steppe-Subalpine	0	77	257
Mountain Shrub	2,736	3,744	2,024

Owyhee River Riparian	454	312	0
Subalpine-Upper Montane Grassland	0	6	22
Water	2	98	0
Wet Meadow-Montane	1,207	4,913	42
SUB-TOTAL	**414,780**	**55,722**	**14,892**
TOTAL		**485,731**	

Figure 6. Ecological systems of the IL Ranch.

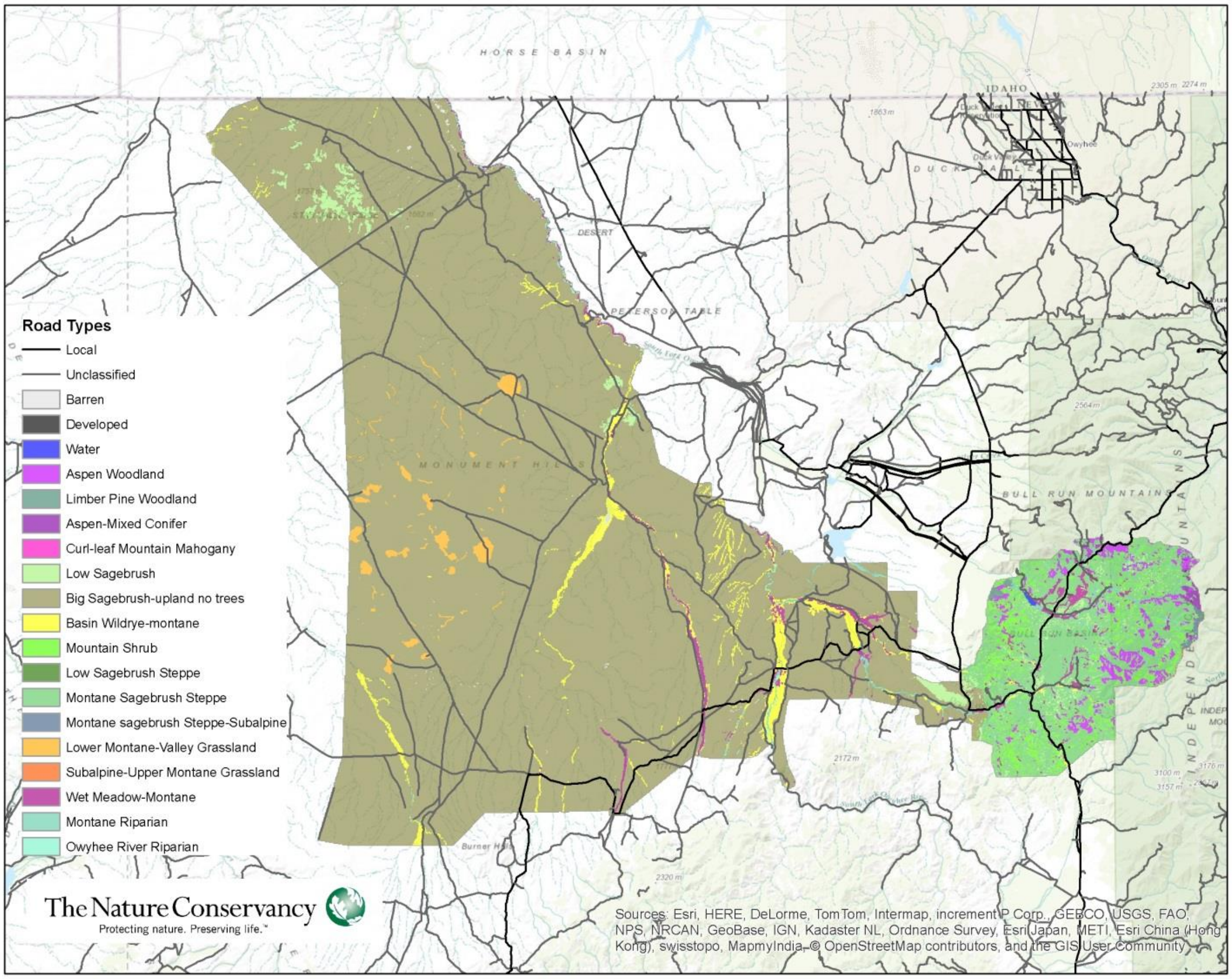


Table 11B. Ecological systems by ownership (acres) of the TS-Horseshoe Ranches based on June 28, 2013, 5-m RapidEye satellite imagery. Imagery includes a 100-m buffer around the project area.

Ecological System	BLM	BOR[1]	Private
Agriculture	3	0	4,916
Aspen Woodland	1,141	0	949
Barren	1,223	0	2,702
Basin Wildrye-bottomland	110	201	30,898
Basin Wildrye-montane	10,313	0	20,547
Big Sagebrush-semidesert	22,040	27	64,012
Big Sagebrush-upland+trees	82,680	1	111,836
Channel	3	0	24
Desert Wash	0	0	7
Developed	62	0	2,380
Four-Wing Saltbush	4	0	0
Greasewood	5,858	77	44,494
Juniper Woodland	4	0	5
Low Sagebrush	6,459	0	5,904
Mine	5,390	0	18,436
Mixed Salt Desert	11,394	0	12,348
Moist Floodplain	310	164	15,938
Montane Riparian	506	0	2,127
Montane Sagebrush Steppe	11,788	0	8,826
Mountain Shrub	1,148	0	809
Saline Meadow	413	85	7,309
Water	0	0	65
Wet Meadow-bottomland	4		425
Wet Meadow-Montane	575	0	1,928
Wetland	0	0	2,219
SUB-TOTAL	**161,426**	**553**	**359,104**
TOTAL		**521,085**	

[1]At the time of remote sensing, this land was under the jurisdiction of BOR, but had since been relinquished.

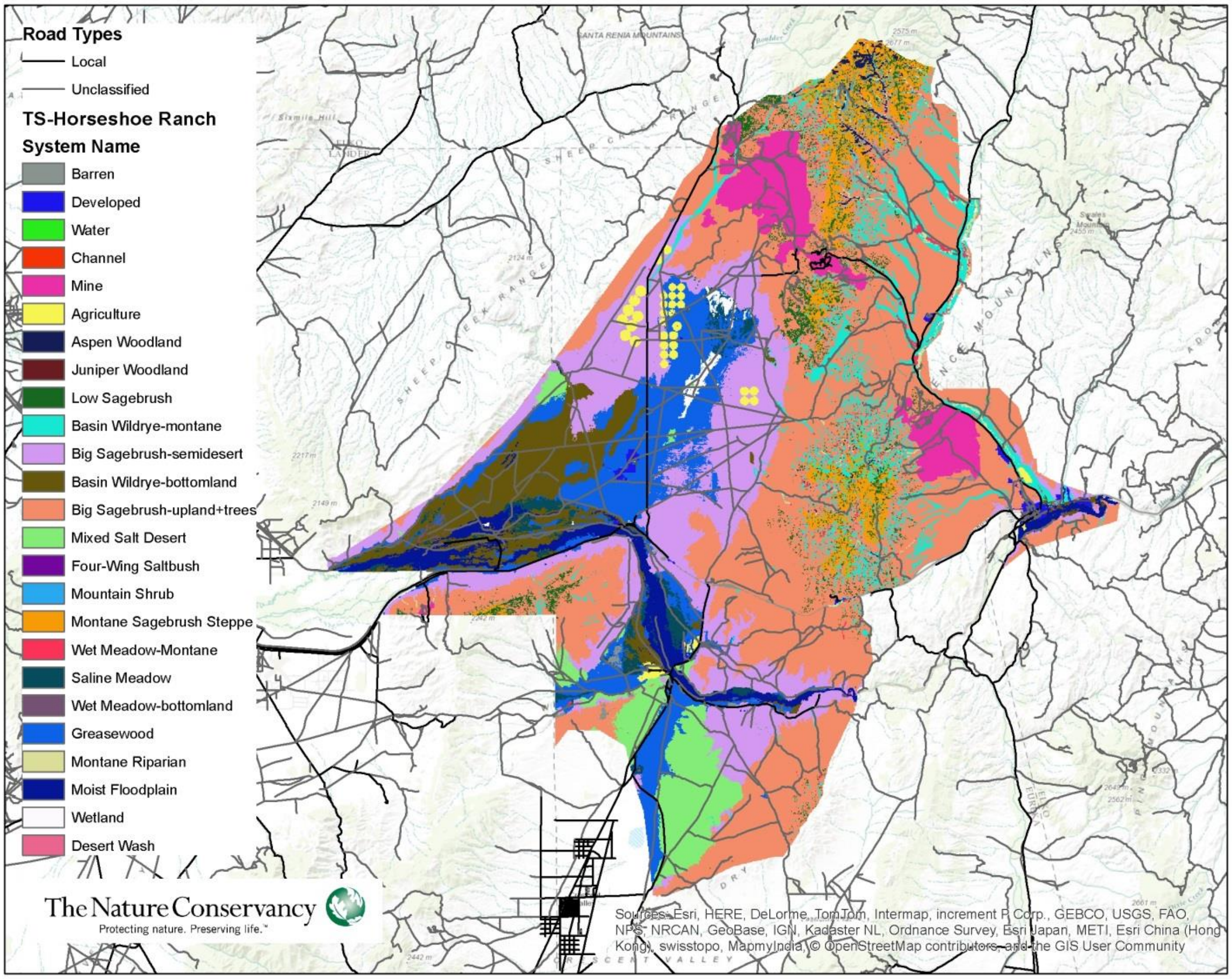


Figure 7. Ecological systems of the TS-Horseshoe Ranches.

Current Condition

<u>Ecological Systems: Unified Ecological Departure</u>

Current values of unified ecological departure for ecological systems in the IL Ranch and TS-Horseshoe Ranches project areas appear in Tables 12A and 12B. The first observation is that overall UED for the IL Ranch is lower (Table 12A) than that of the TS-Horseshoe Ranches (i.e., less red; Table 12B). Whereas many systems were 100% departed on the TS-Horseshoe Ranches, the same systems were less departed on the IL Ranch. Big sagebrush without trees on upland soils representing 82% of the project area, the largest system of the IL Ranch, was only moderately departed at 47%, whereas big sagebrush with trees on upland soils, the most comparable system at the TS-Horseshoe Ranches, was highly departed (91%) from desired conditions. Three ecological systems in the IL Ranch showed low departure from desired conditions: low sagebrush steppe, montane sagebrush steppe-subalpine, and mountain shrub. Two ecological systems in the TS-Horseshoe Ranches showed low departure: Low sagebrush and wet meadow-bottomland. All of these systems were small, thus the UED measure could be biased due to large-scale disturbances causing disproportionate large vegetation class shifts. At the other end of departure, seven ecological systems, which were small, were highly departed on the IL Ranch, whereas 13 systems ranked as highly departed on the TS-Horseshoe Ranches. These latter systems were small to large in area.

Three factors explain the variation in UED. (1) Large areas of the TS-Horseshoe Ranches burned repeatedly and are invaded by non-native annual species; as a result, many systems are over-represented by early-succession vegetation classes dominated by non-native annual species. (2) Much less fire has been experienced on the IL Ranch, but the invasion of *Bromus tectorum* in some areas of standing sagebrush and the lack or very low cover of native perennial grasses in localized sagebrush shrublands are important causes of increased departure. (3) In some systems more unique to the lower elevations of the TS-Horseshoe Ranches, moister systems experience high UED because of exotic forbs present over large areas.

Table 12A. Current unified ecological departure in all ecological systems in the IL Ranch project area. Systems shaded turquoise are those selected for management analyses.

Ecological Systems	2014 UED
Aspen Woodland	**58**
Aspen-Mixed Conifer	**74**
Basin Wildrye-montane	**73**
Big Sagebrush-upland no trees	**47**
Curl-leaf Mountain Mahogany	**88**
Limber Pine Woodland	**88**
Low Sagebrush	**49**
Low Sagebrush Steppe	**25**
Lower Montane-Valley Grassland	**100**

Montane Riparian	58
Montane Sagebrush Steppe	38
Montane Sagebrush Steppe-Subalpine	33
Mountain Shrub	20
Owyhee River Riparian	100
Subalpine-Upper Montane Grassland	71
Wet Meadow-Montane	35

Table 12B. Current unified ecological departure in all ecological systems in the TS-Horseshoe Ranches project area. Systems shaded turquoise are those selected for management analyses.

Ecological System	2014 UED
Aspen Woodland	47
Basin Wildrye-bottomland	100
Basin Wildrye-montane	100
Big Sagebrush-semidesert	100
Big Sagebrush-upland+trees	91
Desert Wash	91
Four-Wing Saltbush	100
Greasewood	85
Juniper Woodland	84
Low Sagebrush	31
Mixed Salt Desert	100
Moist Floodplain	100
Montane Riparian	91
Montane Sagebrush Steppe	57
Mountain Shrub	38
Saline Meadow	67
Wet Meadow-bottomland	43
Wet Meadow-Montane	41
Wetland	100

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

Greater Sage-Grouse: Habitat Suitability

Higher sage-grouse nest site selection (values approaching 99%) occurred in areas closer to lek and with more consistent mature sagebrush cover (i.e., greener areas on Figure 8). Many areas with adequate shrub cover had low nest site selection values because they were far from known leks, such as the north-western portion where the western allotment boundary turns towards the northwest. Areas of highest nest site selection where the eastern part and the base and in the Independence Range and Bull Run Mountains, the large central portion of the Owyhee allotment, and the very northern portion of the Owyhee allotment, and a smaller area between the Bull Run Mountains and the IL Ranch headquarters (i.e., north of the IL Meadows through which Deep Creek flows). The southern portion of the Owyhee allotments continuing towards the IL Ranch headquarters was unsuitable because of past fires having removed sagebrush cover and too much distance to closest leks.

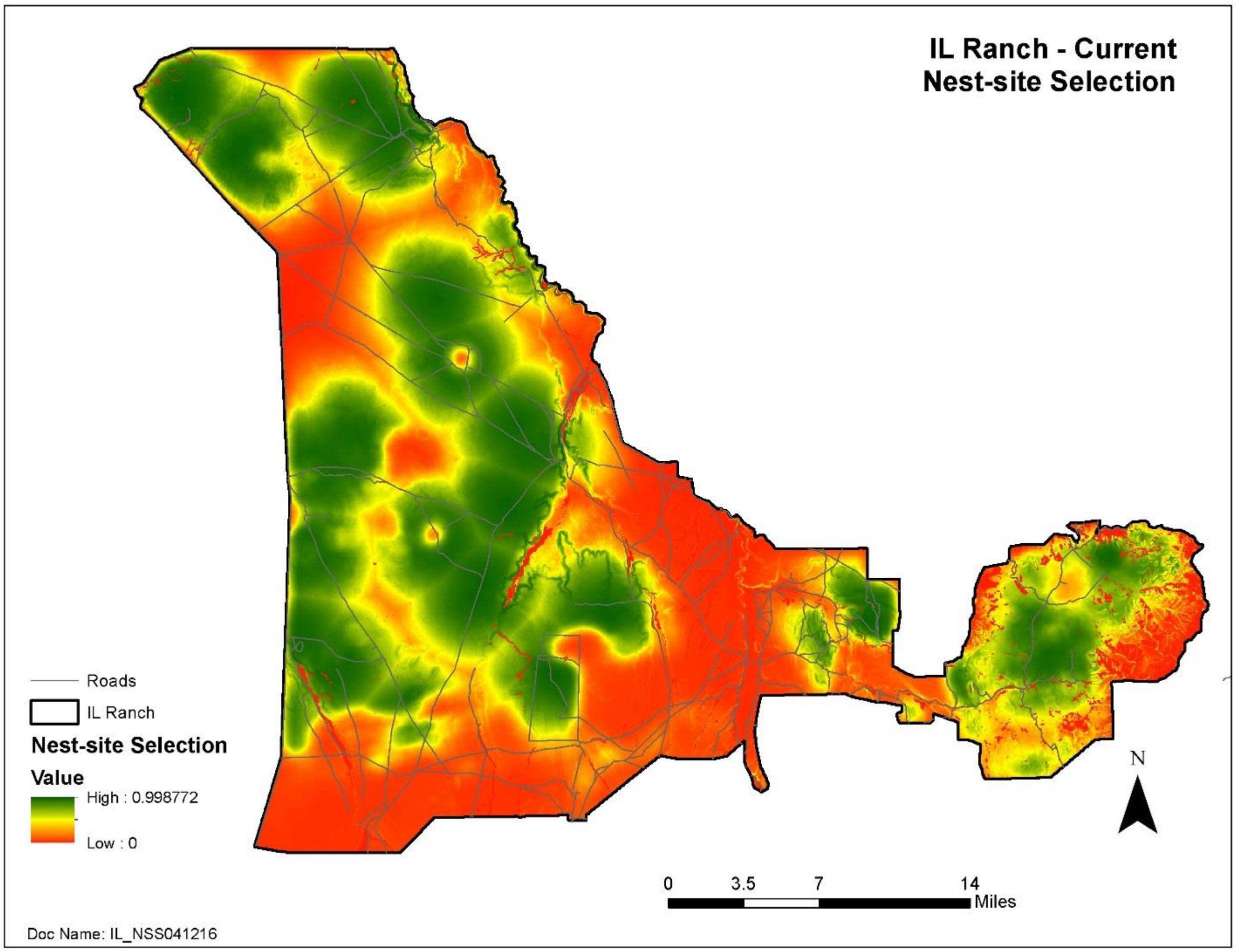


Figure 8. Spatial distribution of nest site selection values for sage-grouse in the IL Ranch project area based on 2013 RapidEye satellite imagery.

Nest success never reached more than 87% (Figure 9). Although many areas achieved moderate nest success, lower nest success was clearer associated with early succession vegetation classes with low shrub cover, often where fire occurred as in western part of the ranch or in areas of high heterogeneity of ecological systems not used by sage-grouse for nesting (for examples, aspen, montane riparian, and wet meadow) adjacent to highly suitable nesting combinations of ecological systems and vegetation classes (for example, late-succession mountain shrub) as observed in the eastern portion dominated by mountain range with a strong elevational gradient.

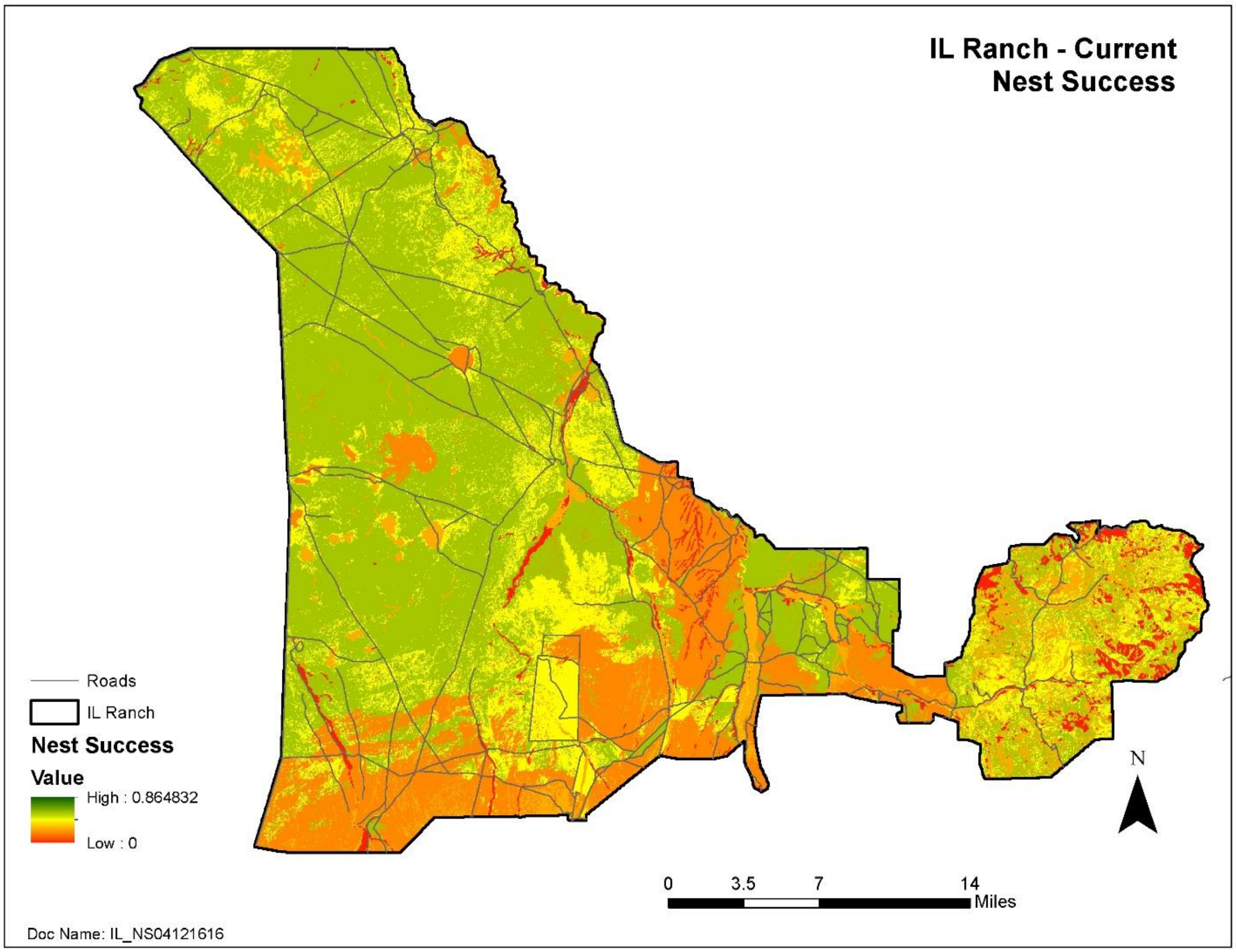


Figure 9. Spatial distribution of nest success values for sage-grouse in the IL Ranch project area based on 2013 RapidEye satellite imagery.

Female success closely resembles a blend of nest site selection, mostly, and nest success, which reflects how the vital rate was calculated (Figure 10). Highest values approaching 91% were found in the large central portion of the Owyhee Allotment, eastern part of Star Ridge pasture, around the IL Meadows, and the eastern Mountain area.

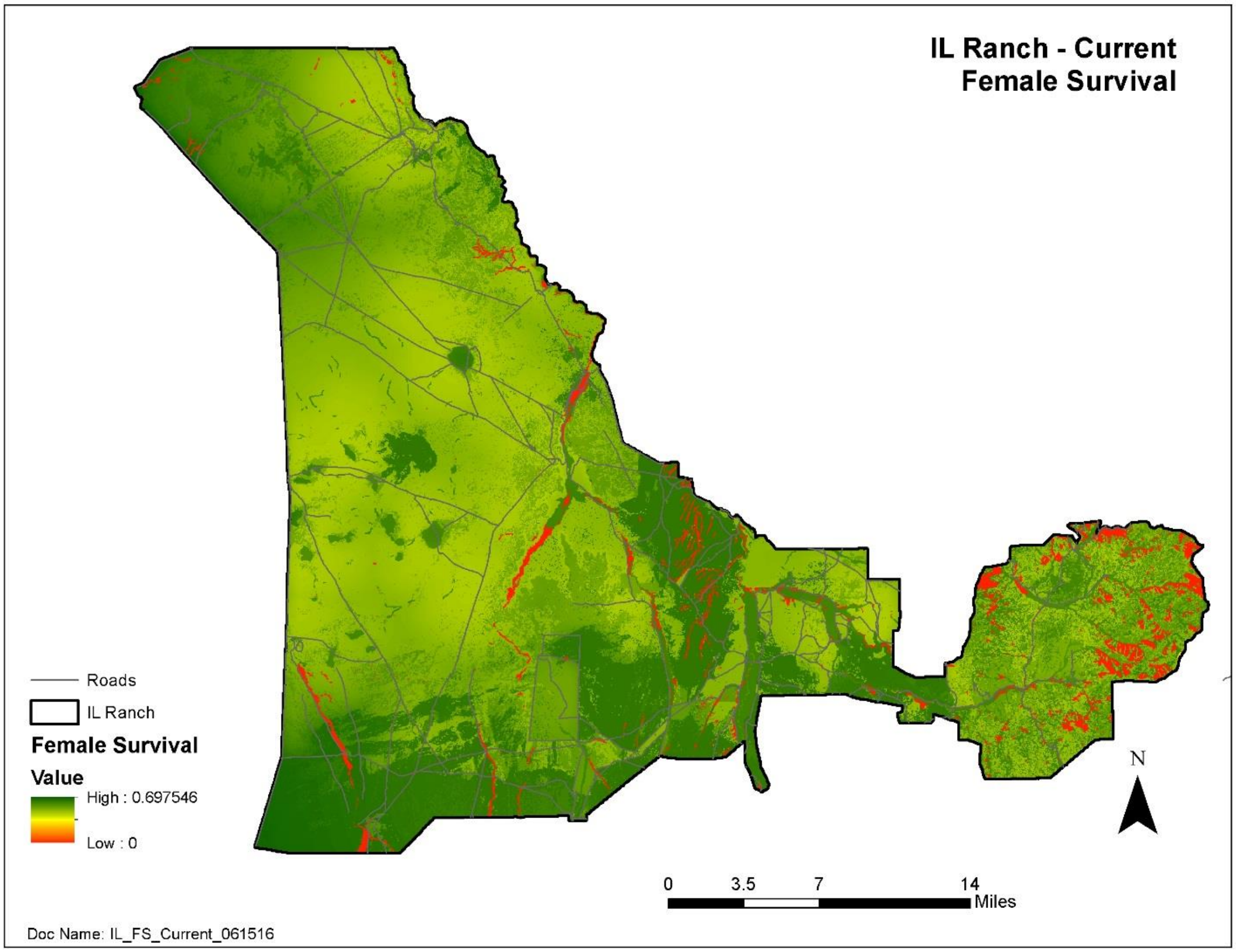


Figure 10. Spatial distribution of female success values for sage-grouse in the IL Ranch project area based on 2013 RapidEye satellite imagery.

Chick survival was highest (never exceeding 50%) in the eastern portion of the IL Ranch where the Independence Range supports the highest concentration of wet meadows, montane sagebrush steppe, and subalpine-upper montane grasslands (Figure 11). Chick survival decreased from east to west and the highest areas of chick survival were strictly associated with wet or irrigated meadows of Deep Creek and the South Fork of the Owyhee River, other wet meadows (for example, Four-mile Creek), and lower montane valley grasslands (i.e., vernal pools where many leks are situated).

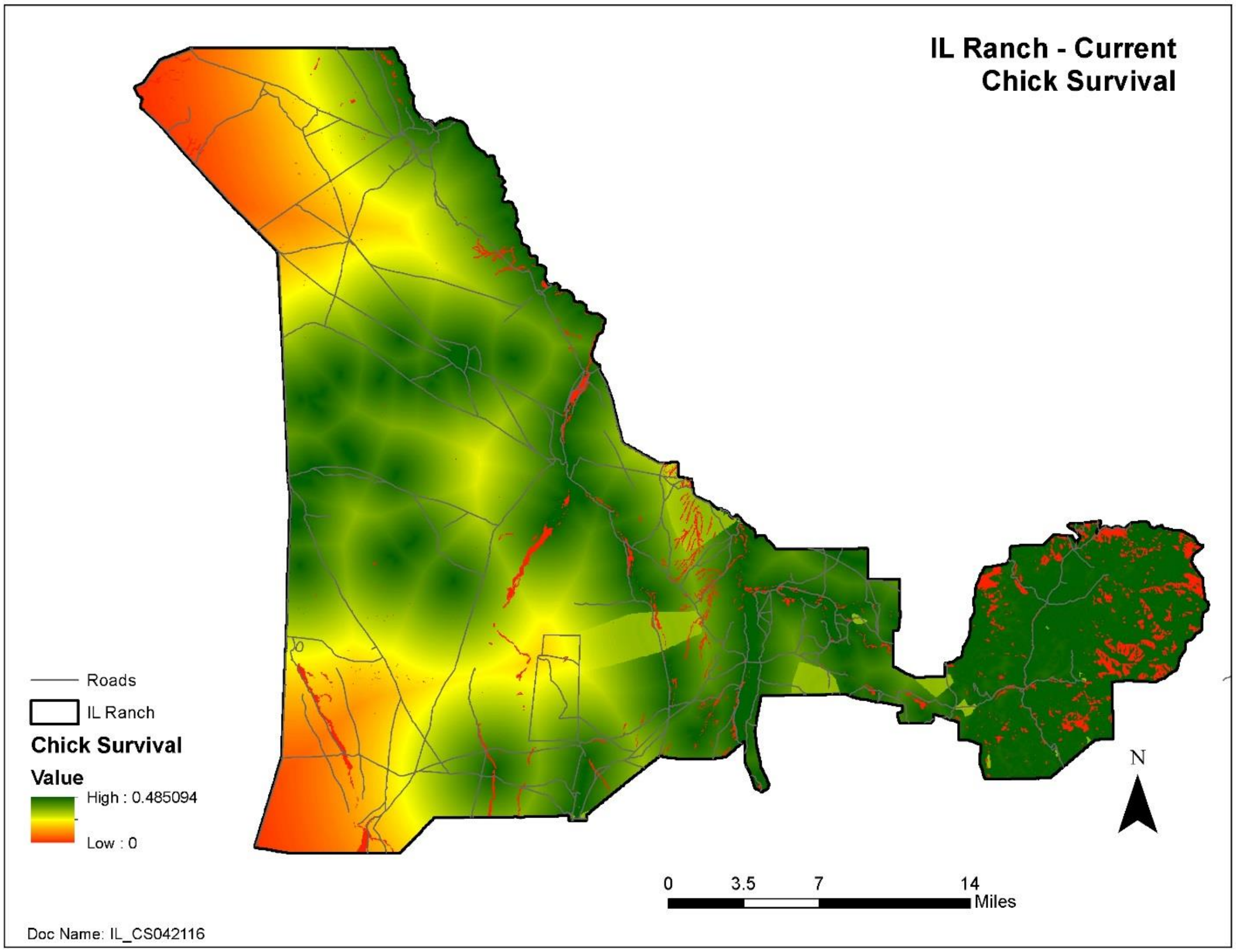


Figure 11. Spatial distribution of chick survival values for sage-grouse in the IL Ranch project area based on 2013 RapidEye satellite imagery.

The per-capita population growth rate (λ) matched closely the spatial distribution of nest site selection and chick survival while rarely exceeding a value of one (Figure 12). Therefore, the population is, at best, slightly increasing in a few areas and declining elsewhere over large areas.

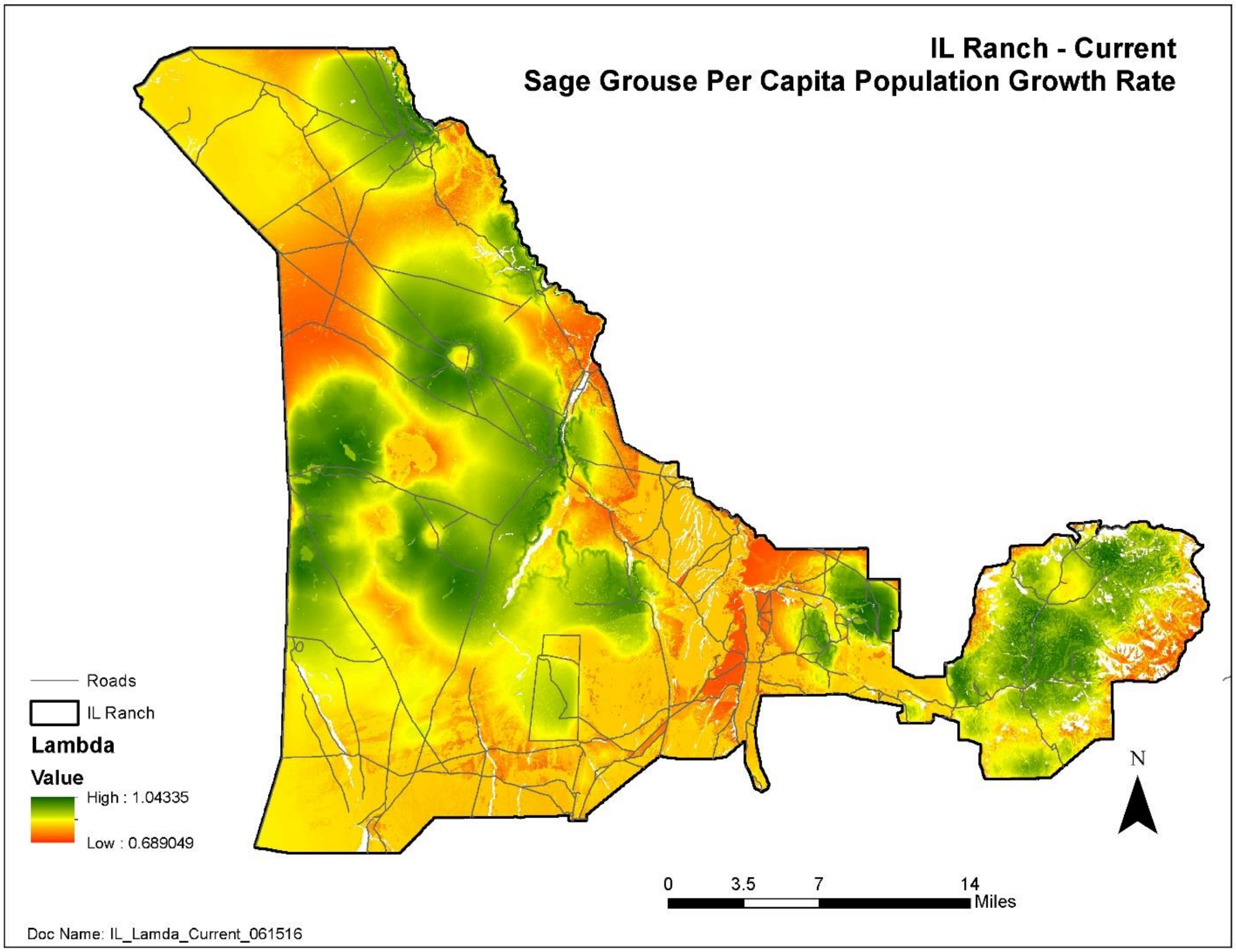


Figure 12. Spatial distribution of λ for sage-grouse in the IL Ranch project area based on 2013 RapidEye satellite imagery.

Habitat suitability is very different and generally lower for the TS-Horseshoe Ranches than the IL Ranch. Nest site selection was tightly and jointly determined by the distance from a few leks and sufficient shrub cover that either escape fires or recovered from older fires (Figure 13). The highest values of nest site selection (close to 100%) where primarily observed on the slopes of the Tuscarora Range in the northern portion of the project area and Mary's Mountain. Note that most of Boulder Valley and Crescent Valley did not qualify as sage-grouse habitat.

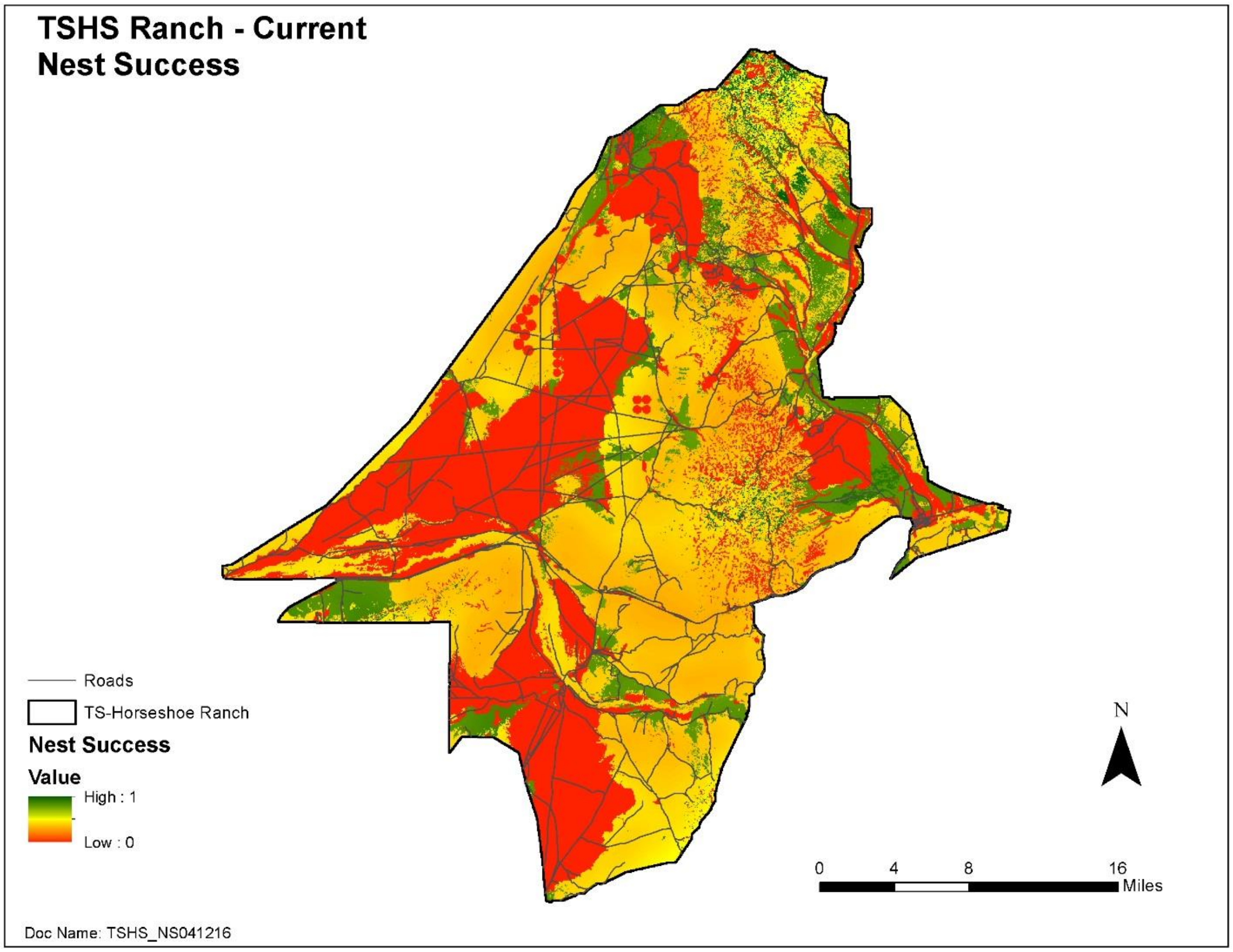


Figure 13. Spatial distribution of nest site selection for sage-grouse in the IL Ranch project area based on 2013 RapidEye satellite imagery.

There was a strong visual correlation between areas of higher nest site selection and nest success due to the presence of surrounding sagebrush cover (Figure 14). Nest success, however, was more fragmented due to the presence of many occurrences of early-succession vegetation classes (often due to fire) lowering nest success (Figure 14). In some areas, nest success approached 100%.

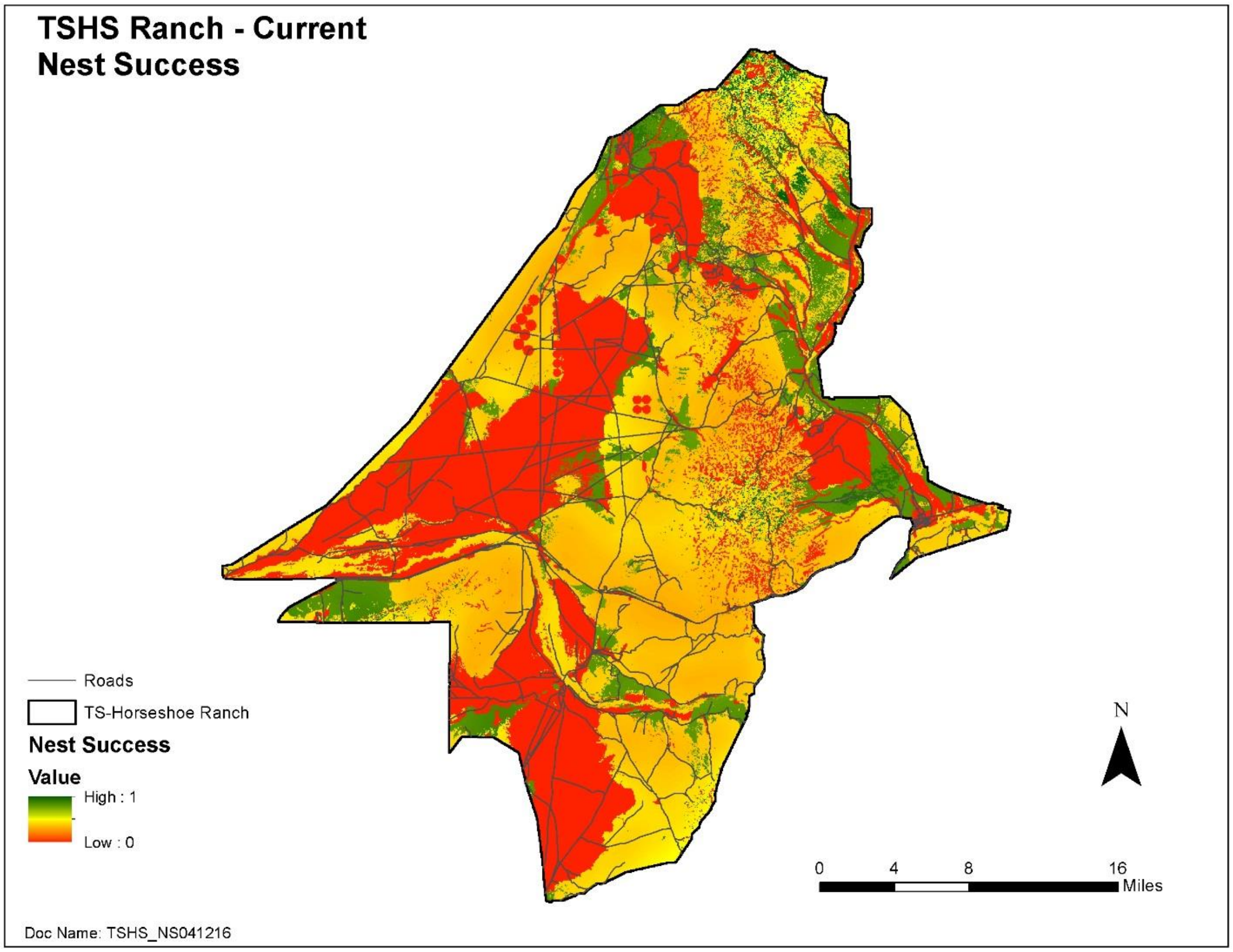


Figure 14. Spatial distribution of nest success for sage-grouse in the TS-Horseshoe Ranches project area based on 2013 RapidEye satellite imagery.

Whereas in the IL Ranch, female success resembled more nest site selection than nest success, the opposite was true for the TS-Horseshoe Ranches (Figure 15). The negative effect of all early-succession vegetation classes on nest success was apparently a strong contributor to the reduction of female success.

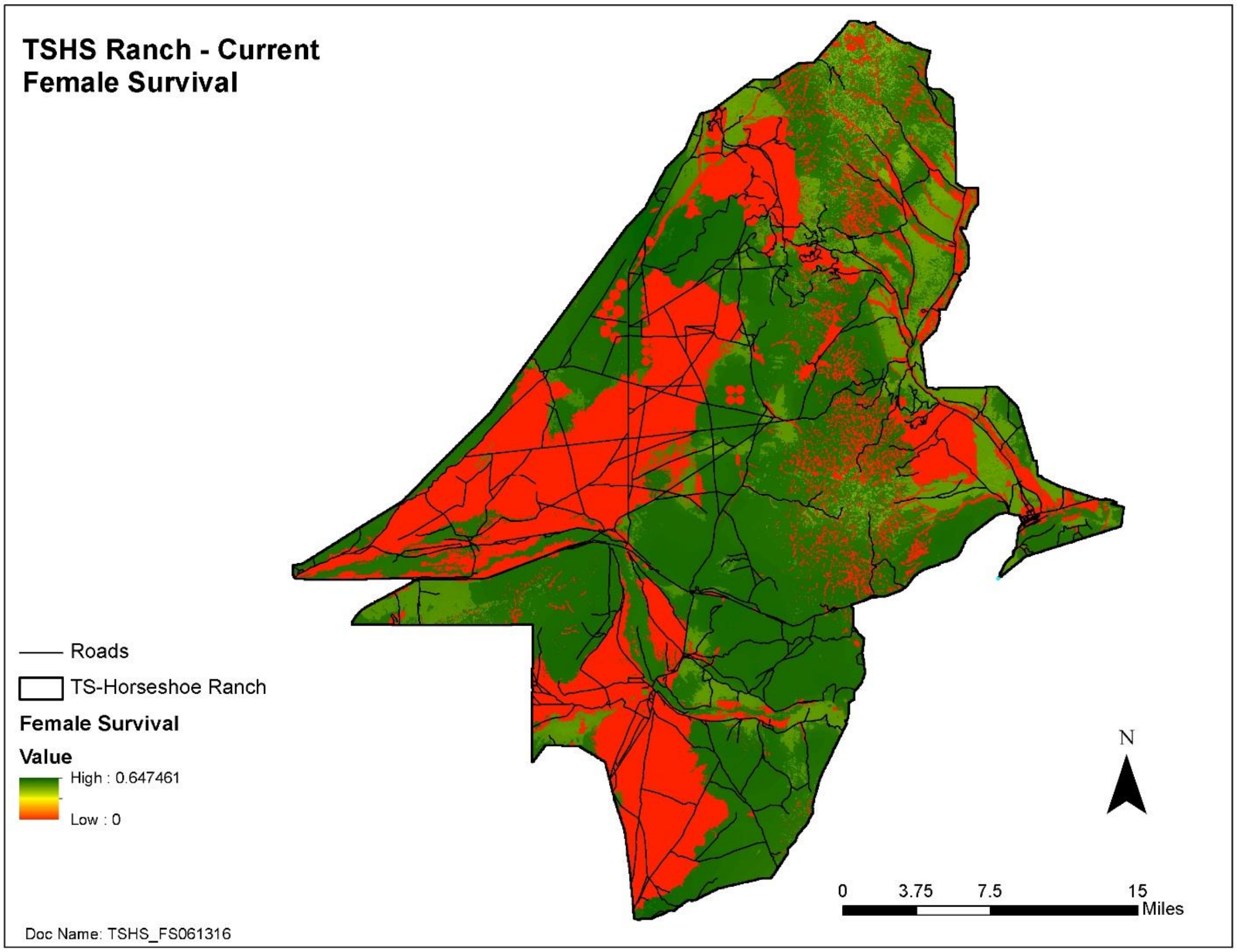


Figure 15. Spatial distribution of female survival values for sage-grouse in the TS-Horseshoe Ranches project area based on 2013 RapidEye satellite imagery.

Chick survival never exceeded 50% and was highest in the higher elevations of the Tuscarora Range dominated by montane sagebrush steppe and mountain shrubs, and the moist floodplain of the Humboldt River (Figure 16).

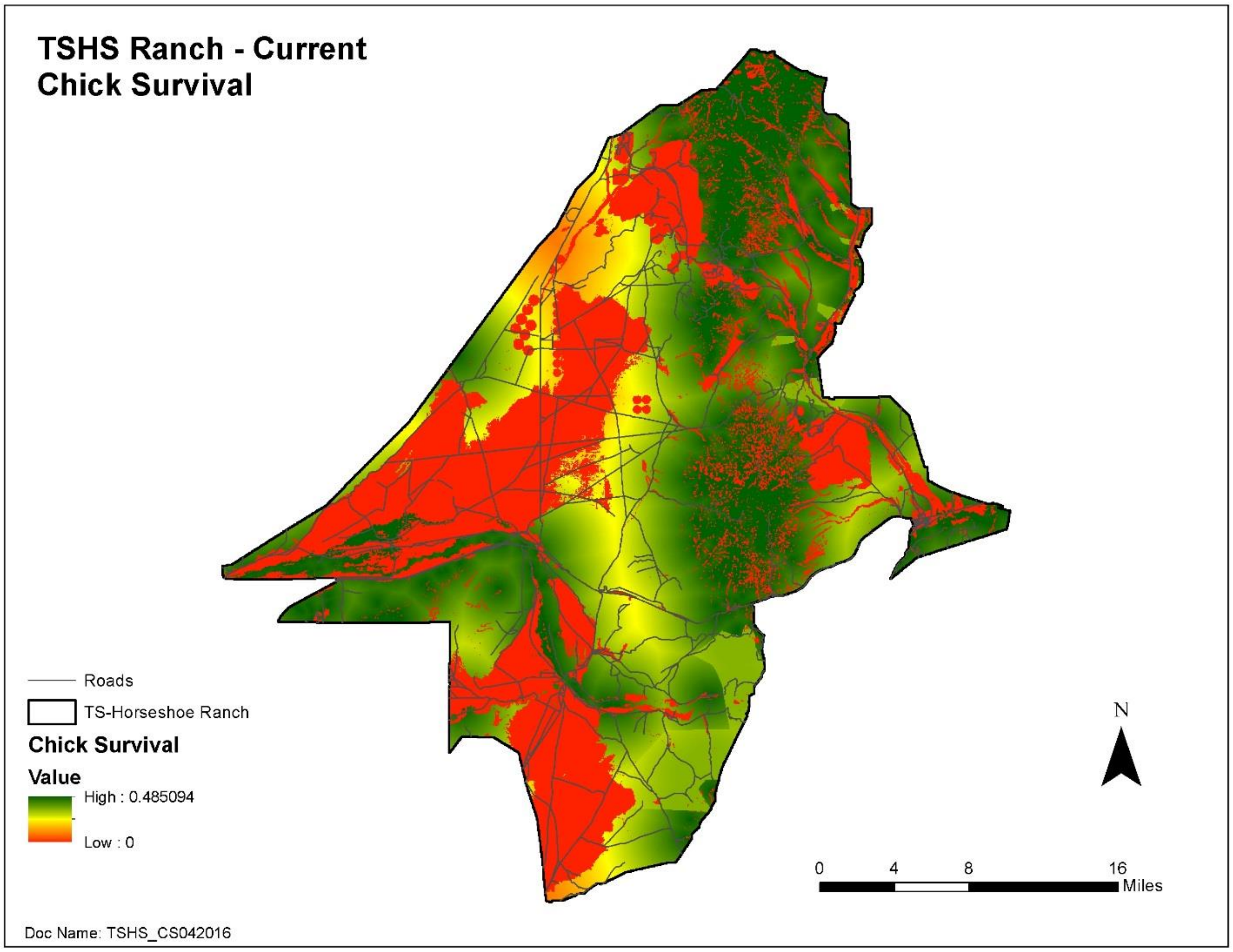


Figure 16. Spatial distribution of chick survival for sage-grouse in the TS-Horseshoe Ranches project area based on 2013 RapidEye satellite imagery.

Per capita population growth (λ) closely resembled nest success as cover of sagebrush is the most limiting feature in this well-burned landscape (Figure 17). Moreover, remaining adequate sagebrush also is spatially associated with the higher elevation late-brood habitat. The moist floodplain of the Humboldt River did not show high λ, although chick survival was high, because nest site selection and nest success are generally very poor along the river. The value of λ exceeded one for several pixels (growing population) primarily due to the strong influence of the mountain shrub classes on all aspect of habitat use at higher elevations (Figure 17).

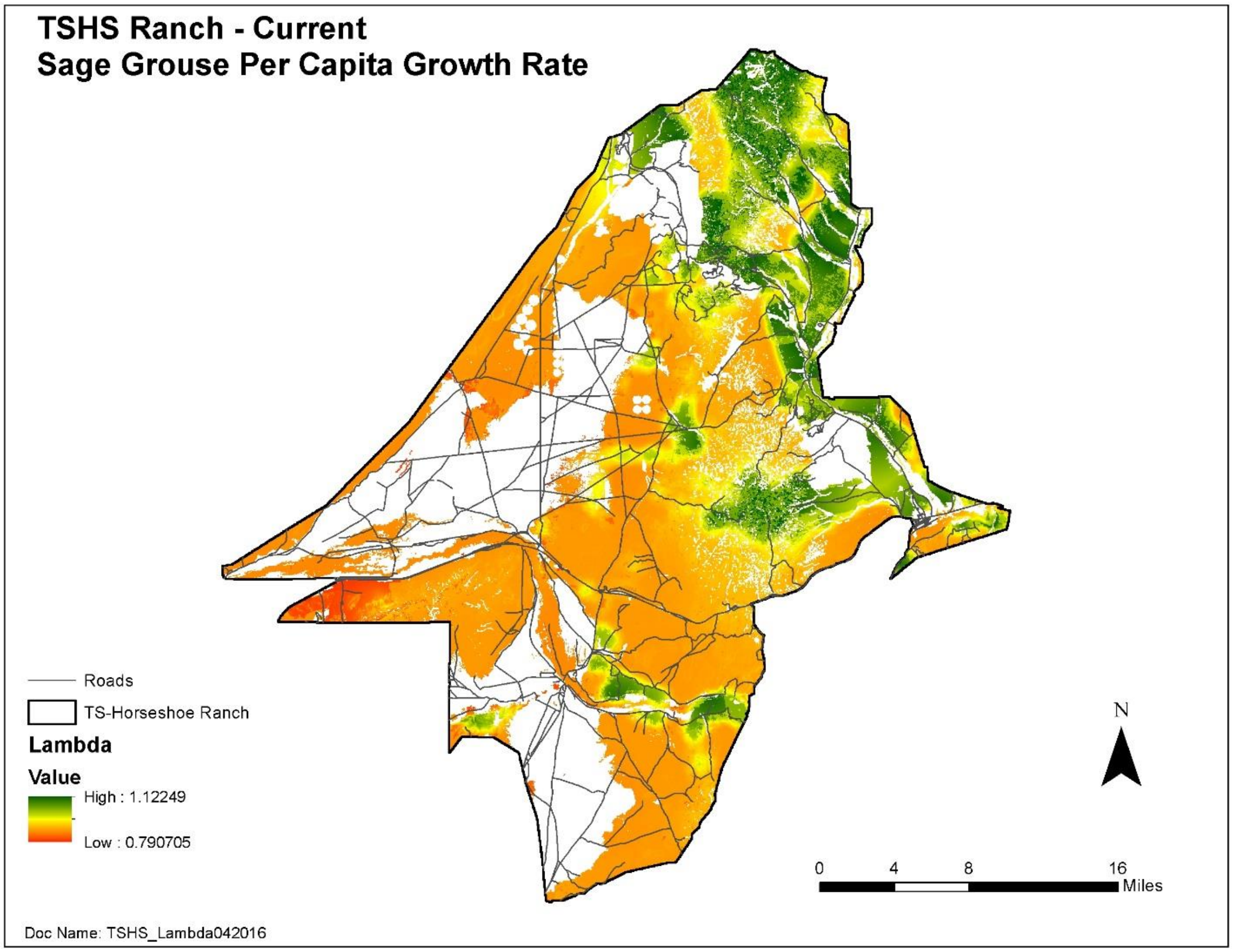


Figure 17. Spatial distribution of λ for sage-grouse in the TS-Horseshoe Ranches project area based on 2013 RapidEye satellite imagery.

Mule Deer: Habitat Suitability Index

The spatial distribution of habitat suitability values for mule deer on the IL Ranch increase from west to east because the diversity of ecological systems and elevation increase, and the proximity to migratory corridor decreases. Along the canyon of the South Fork of the Owyhee River, habitat suitability is primarily higher on the main migratory route of mule deer, although vegetation is dominated by very homogeneous upland Wyoming big sagebrush.

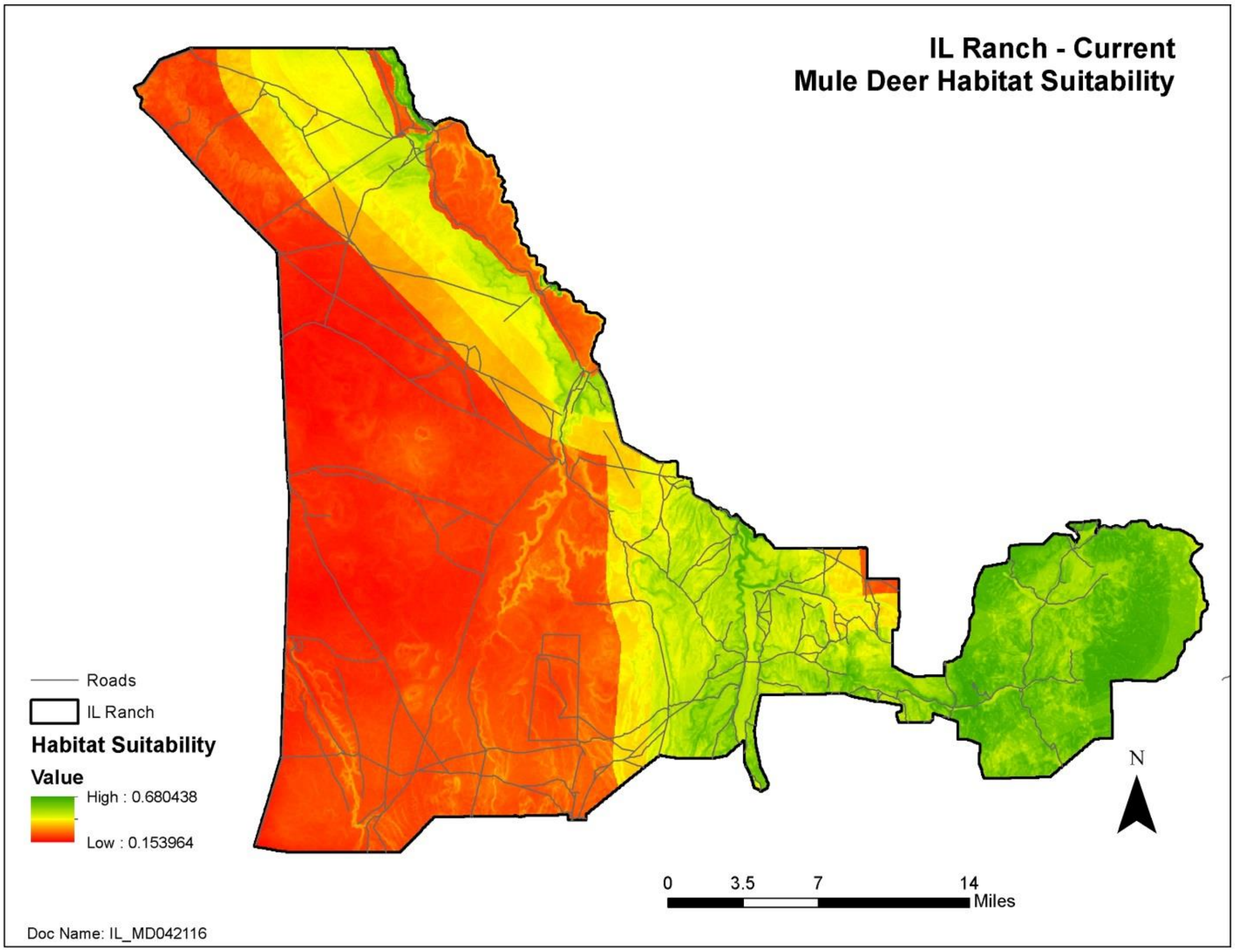


Figure 18. Spatial distribution of habitat suitability for mule deer in the IL Ranch project area based on 2013 RapidEye satellite imagery.

On the TS-Horseshoe Ranches project area, highest habitat suitability is found in the Tuscarora Range, which is a mule deer migration corridor, and the Humboldt River valley. In these areas, the diversity of desirable middle and higher elevation ecological systems is highest because of elevation gradients or presence of important riparian resources.

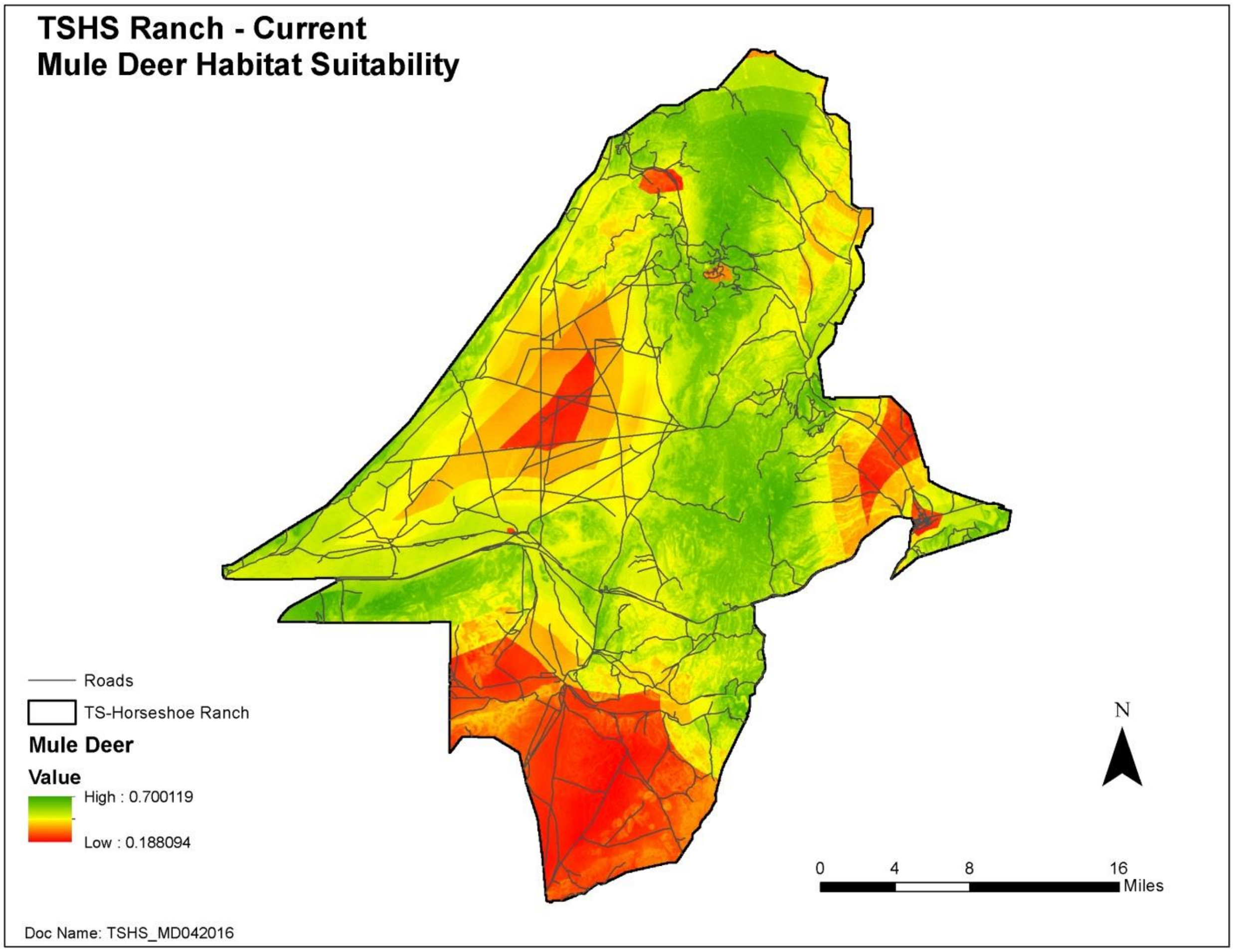


Figure 19. Spatial distribution of habitat suitability for mule deer in the TS-Horseshoe Ranches project area based on 2013 RapidEye satellite imagery.

Golden eagle: Habitat Suitability Index

The spatial distribution of habitat suitability values for golden eagle on the IL Ranch was highest for the IL meadows area and just west of the canyon of the South Fork of the Owyhee River. Both of these areas combine a reasonable distance from potential nest sites, such as cliffs and steep mountain slopes, and ecological systems more suitable for hunting preferred prey.

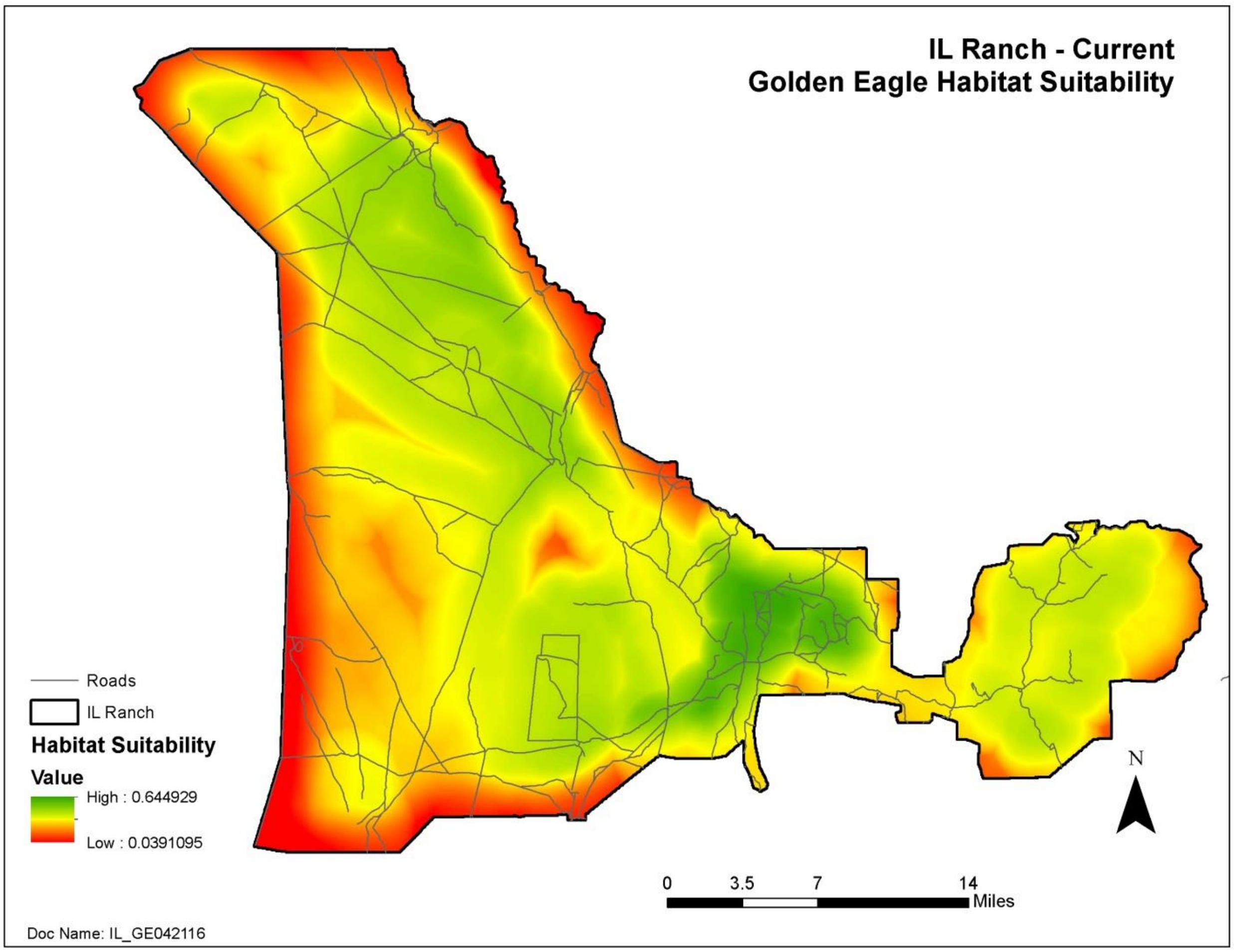


Figure 20. Spatial distribution of habitat suitability for golden eagle in the IL Ranch project area based on 2013 RapidEye satellite imagery. Note the artificial edge effect on the western portion of the IL Ranch.

For the TS-Horseshoe Ranches, highest habitat suitability for golden eagle was primarily in Boulder Valley and Crescent Valley due to the presence of deep-soil ecological systems that could support larger densities of the preferred jackrabbit prey in sufficient proximity of several potential nesting sites (Figure 21). Additionally, areas of high suitability were located mid-way through the Tuscarora Range and on the eastern slope of the Tuscarora Range near Coyote Creek where there are four resource selection functions associated with alternative food sources that reached high values (roadkill, birthing during early-season grazing, chuckar habitat, and deep/mesic soil communities).

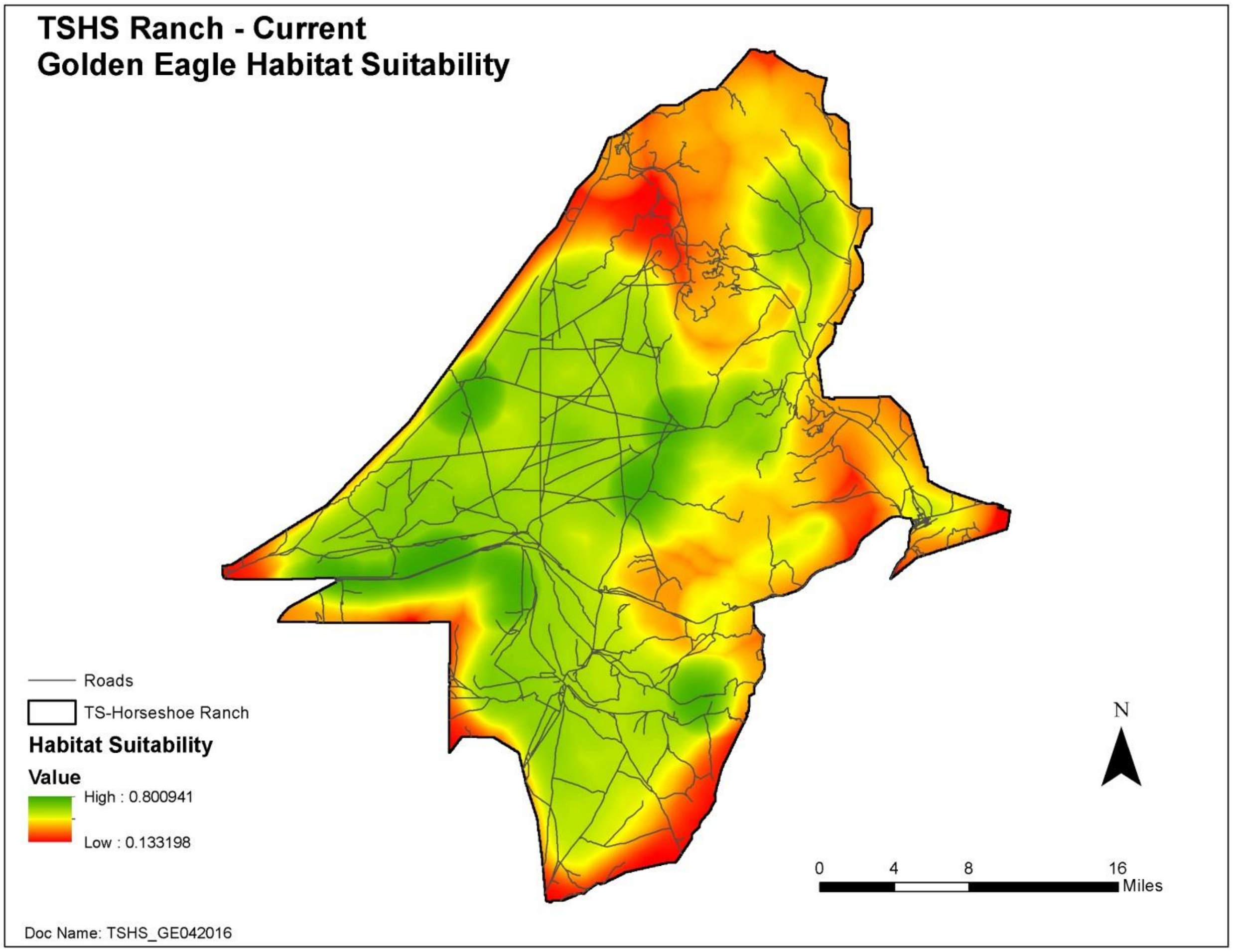


Figure 21. Spatial distribution of habitat suitability for golden eagle in the TS-Horseshoe Ranches project area based on 2013 RapidEye satellite imagery.

Identifying Systems That Deteriorated in 30 Years – MINIMUM MANAGEMENT

Ecological Systems: Unified Ecological Departure

The MINIMUM MANAGEMENT scenario plays several roles. One of them is to add information about the choice of ecological systems to retain for future simulations because UED remained high or increased after 30 years of simulation. Ecological systems were also chosen because they constitute sage-grouse habitat. Some systems were not considered for active management because they were too small or very little could be done to restore them without loss of ranch operations.

Results of model runs for the IL Ranch show various predicted changes, as measured by unified ecological departure, after 30 years under the scenario of MINIMUM MANAGEMENT. Future values of unified ecological departure for the MINIMUM MANAGEMENT scenario appear in Tables 13A (IL Ranch) and B (TS-Horseshoe Ranches).

For the IL Ranch, UED increased in basin wildrye-montane, montane riparian, montane sagebrush steppe-subalpine, and wet meadow-montane. Despite worsening of UED, the lower montane-valley grassland and montane sagebrush steppe-subalpine were not retained for future management. For the first system, restoration of the hydrology would hinder ranch operations in a large portion of the Owyhee Allotment and the use of weed control and seeding options would likely fail due to the presence of halogeton as the dominant non-native weed. The second system is very small in area, generally inaccessible by restoration equipment, and shows a great potential for healing due to subalpine elevation. Also, it needs to be reiterated that the concept of ecological departure does not apply to systems represented by very few acres. A few systems remained highly departed from reference conditions, but not further deteriorating, and could be feasibly restored at the margins: aspen woodland, aspen-mixed conifer and low sagebrush. An interesting result is the natural recovery (i.e., lower UED) from past large fires for the big sagebrush-upland system and rebalancing of reference classes through various disturbances. In theory, this system would not be considered for additional management, but big-sagebrush-upland was kept for limited management because it is the dominant sage-grouse habitat on the west side of the property.

Table 13A. Unified ecological departure at the current time, and as predicted after 30 years under MINIMUM MANAGEMENT in the IL Ranch project area. N = 10. Blue shading identifies ecological systems chosen for active management.

	IL Ranch	
Ecological System	Current	MIN MGMT 30 years (mean ± 95% CI)
Aspen Woodland	58	46 ± 2
Aspen-Mixed Conifer	74	74 ± 3

Basin Wildrye-montane	73	76 ± 1
Big Sagebrush-upland no trees	47	31 ± 2
Curl-leaf Mountain Mahogany	88	79 ± 7
Limber Pine Woodland	88	68 ± 2
Low Sagebrush	49	35 ± 1
Low Sagebrush Steppe	25	20 ± 6
Lower Montane-Valley Grassland	100	100 ± 0
Montane Riparian	58	75 ± 3
Montane Sagebrush Steppe	38	33 ± 4
Montane Sagebrush Steppe-Subalpine	33	41 ± 5
Mountain Shrub	20	14 ± 2
Owyhee River Riparian	100	100 ± 0
Subalpine-Upper Montane Grassland	71	11 ± 8
Wet Meadow - Montane	35	54 ± 3

For the TS-Horseshoe Ranches, UED significantly (beyond the 95% CI overlap) increased in greasewood, montane sagebrush steppe-upland, saline meadow, wet-meadow bottomland, and wet meadow-montane. Of all these deteriorating systems, only greasewood was not chosen for active management as the main cause of degradation is large scale exotic forb invasion, which requires a regionally coordinated control strategy exceeding the boundary of the ranch. UED meaningfully decreased in aspen woodland, juniper woodland, low sagebrush, montane riparian, and mountain shrub. Because of these decreases, low sagebrush, and mountain shrub did not require additional management. Despite the decrease in UED for aspen woodland, it was retained for minor management intervention due to localized aspen close loss, which often occurs in very small acreages that UED might not capture well when other areas of the system are recovering. A few systems remained highly departed from reference conditions, but not further deteriorating, and could be partially restored or are important for sage-grouse: both basin wildrye systems, big sagebrush-semidesert, and big sagebrush-upland with trees.

Table 13B. Unified ecological departure at the current time, and as predicted after 30 years under MINIMUM MANAGEMENT in the TS-Horseshoe Ranches project area. N = 10. Blue shading identifies ecological systems chosen for active management.

	TS-Horseshoe Ranches	
Ecological System	**Current**	**MIN MGMT 30 years (mean ± 95% CI)**
Aspen Woodland	47	28 ± 3
Basin Wildrye-bottomland	100	100 ± 0
Basin Wildrye-montane	100	100 ± 0
Big Sagebrush-semidesert	100	100 ± 0
Big Sagebrush-upland+trees	91	89 ± 1
Desert Wash	91	27 ± 8
Four-Wing Saltbush	100	100 ± 0
Greasewood	85	92 ± 0
Juniper Woodland	84	64 ± 10
Low Sagebrush	31	22 ± 0
Mixed Salt Desert	100	100 ± 0
Moist Floodplain	100	100 ± 0
Montane Riparian	91	72 ± 10
Montane Sagebrush Steppe	57	83 ± 2
Mountain Shrub	38	17 ± 4
Saline Meadow	67	79 ± 0
Wet Meadow-bottomland	43	77 ± 12
Wet Meadow-Montane	41	60 ± 2
Wetland	100	100 ± 0

Code to cell colors:			
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Greater Sage-Grouse: Habitat Suitability

The spatial distribution of λ values for sage-grouse as predicted after 30 years of MINIMUM MANAGEMENT is shown in Figure 22 for IL Ranch, and in Figure 23 for the TS-Horseshoe Ranches. Darker green values represent higher habitat suitability (i.e. better condition) and darker red values represent poorer habitat suitability.

Compared to the current λ for the IL Ranch project area (Figure 12), three primary results for λ were found with the MINIMUM MANAGEMENT scenario (Figure 22): (1) the smallest λ increase from 0.68 to 0.79, which is an improvement; (2) the maximum λ observed barely decreased from 1.043 to 1.041, which shows that the highest level of population recruitment held over time; and (3) the vegetation in all previously burned areas in the southern portion of the project area matured to habitat that can be used for sage-grouse nesting. For the entire landscape, functional acres changed from about 216,500 functional acres to about 214,780 functional acres during 30 years.

For the TS-Horseshoe Ranches, changes between the current condition (Figure 17) and the MINIMUM MANAGEMENT scenario (Figure 23) resulted in: (1) the smallest λ increased from 0.79 to 0.83; (2) the highest λ increased from 1.12 to 1.16; and (3) large high-elevation areas in the Tuscarora Range that previously burned matured into usable nesting habitat for sage-grouse. For the entire landscape, functional acres changed from about 155,000 functional acres to about 164,580 functional acres during 30 years.

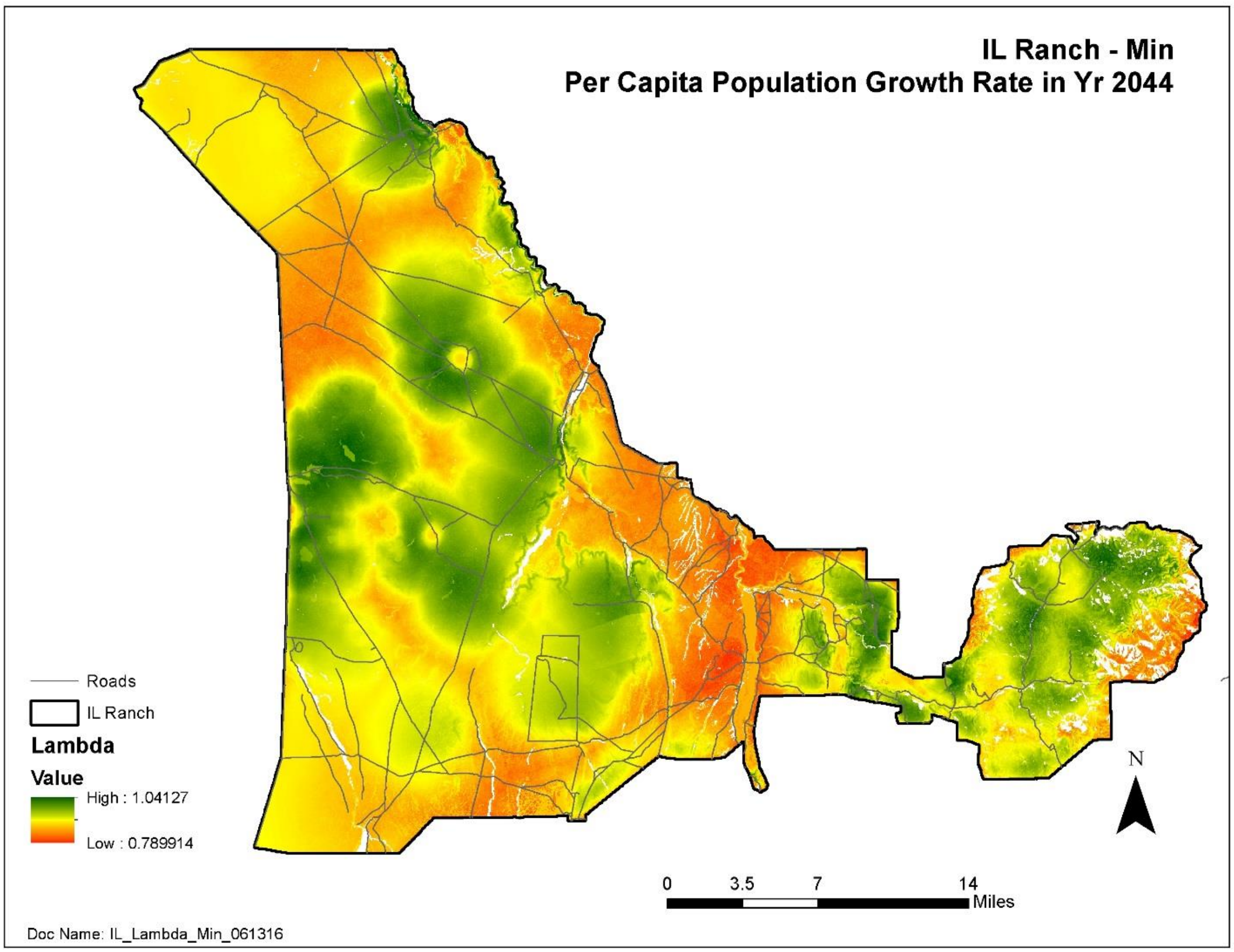


Figure 22. Spatial distribution of λ for sage-grouse in the IL Ranch project area after 30 years of MINIMUM MANAGEMENT based on 2013 RapidEye satellite imagery averaged across 10 iterations.

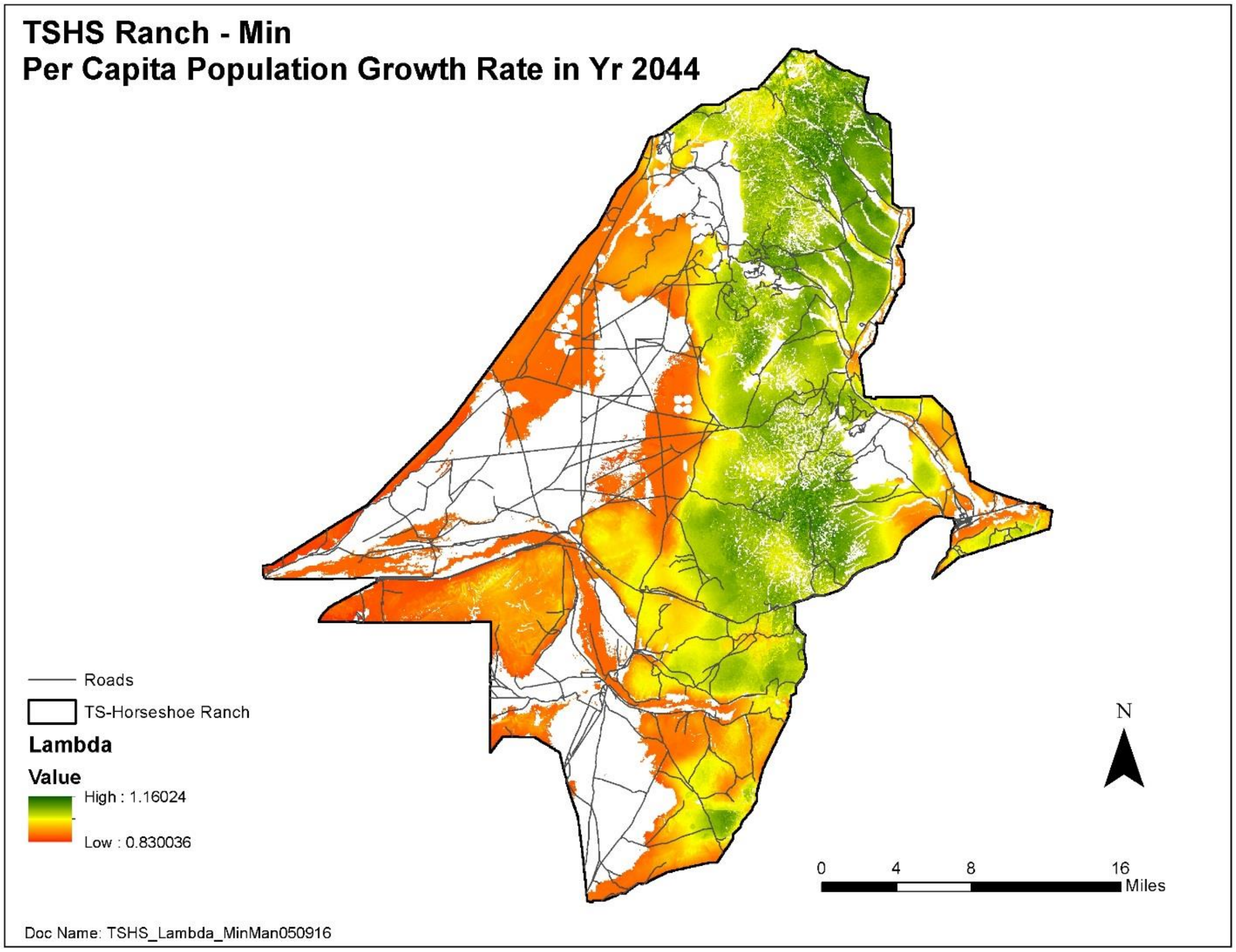


Figure 23. Spatial distribution of λ for sage-grouse in the TS-Horseshoe Ranches project area after 30 years of MINIMUM MANAGEMENT based on 2013 RapidEye satellite imagery averaged across 10 iterations.

Mule Deer: Habitat Suitability

For both the IL Ranch and TS-Horseshoe Ranches project areas, 30 years of MINIMUM MANAGEMENT scenario (respectively, Figures 24 and 25) resulted in no appreciable change in habitat suitability for mule deer compared to current conditions (respectively, Figures 18 and 19). The primary reasons for this lack of change are that mule deer respond strongly to geo-physical aspects of the habitat and to obstacles in their migration corridor. Temporary changes in vegetation composition and structure may be important for a decade, but this source of variation dampens out after 30 years of succession and patch dynamics.

Between current condition and time step 30 average habitat suitability changed from 0.3439 to 0.3559 at the IL Ranch. For the TS-Horseshoe Ranches, average habitat suitability was 0.4597 for current conditions and 0.4733 at the end of the simulation.

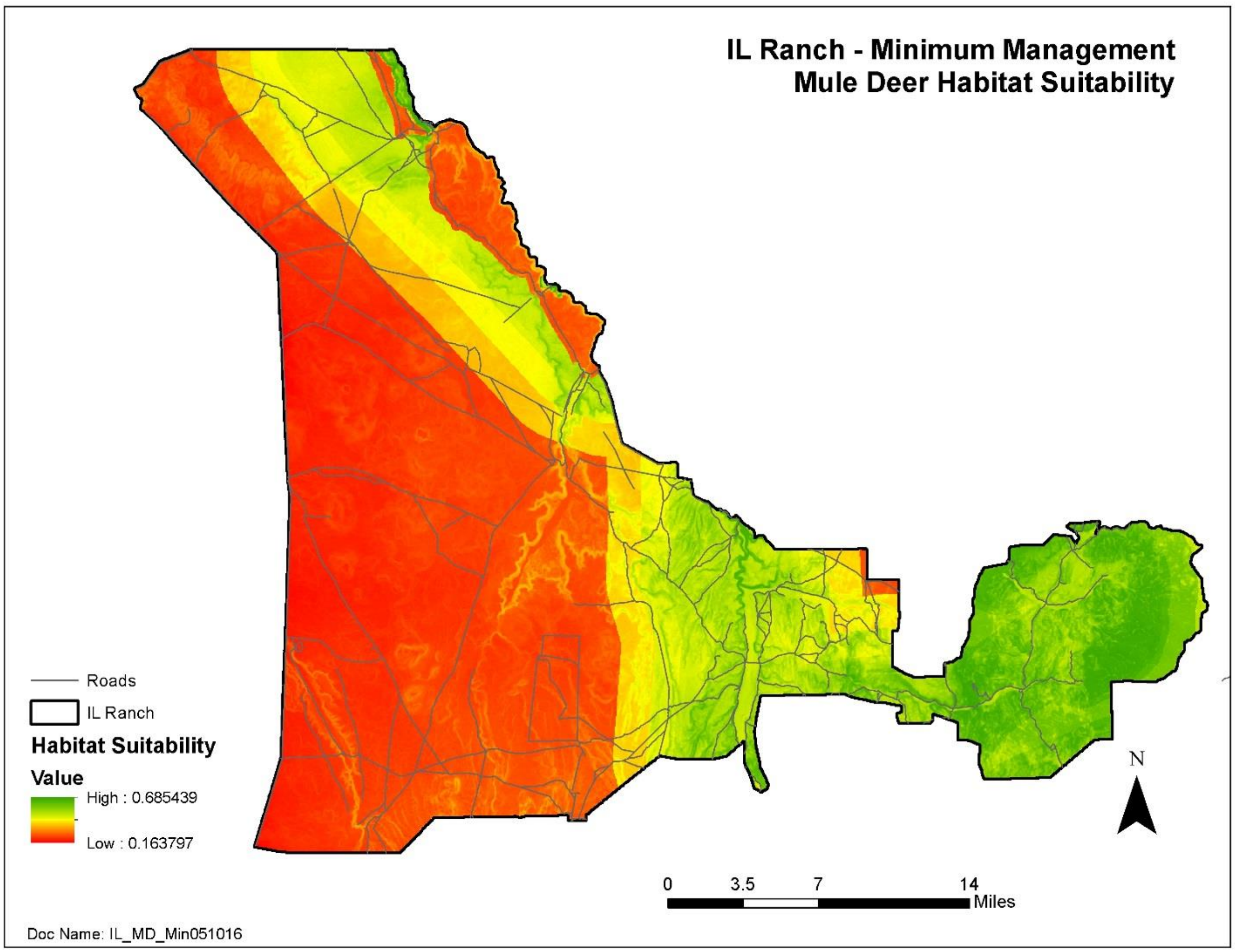


Figure 24. Spatial distribution of habitat suitability values for mule deer after 30 years of MINIMUM MANAGEMENT on the IL Ranch averaged across 10 iterations.

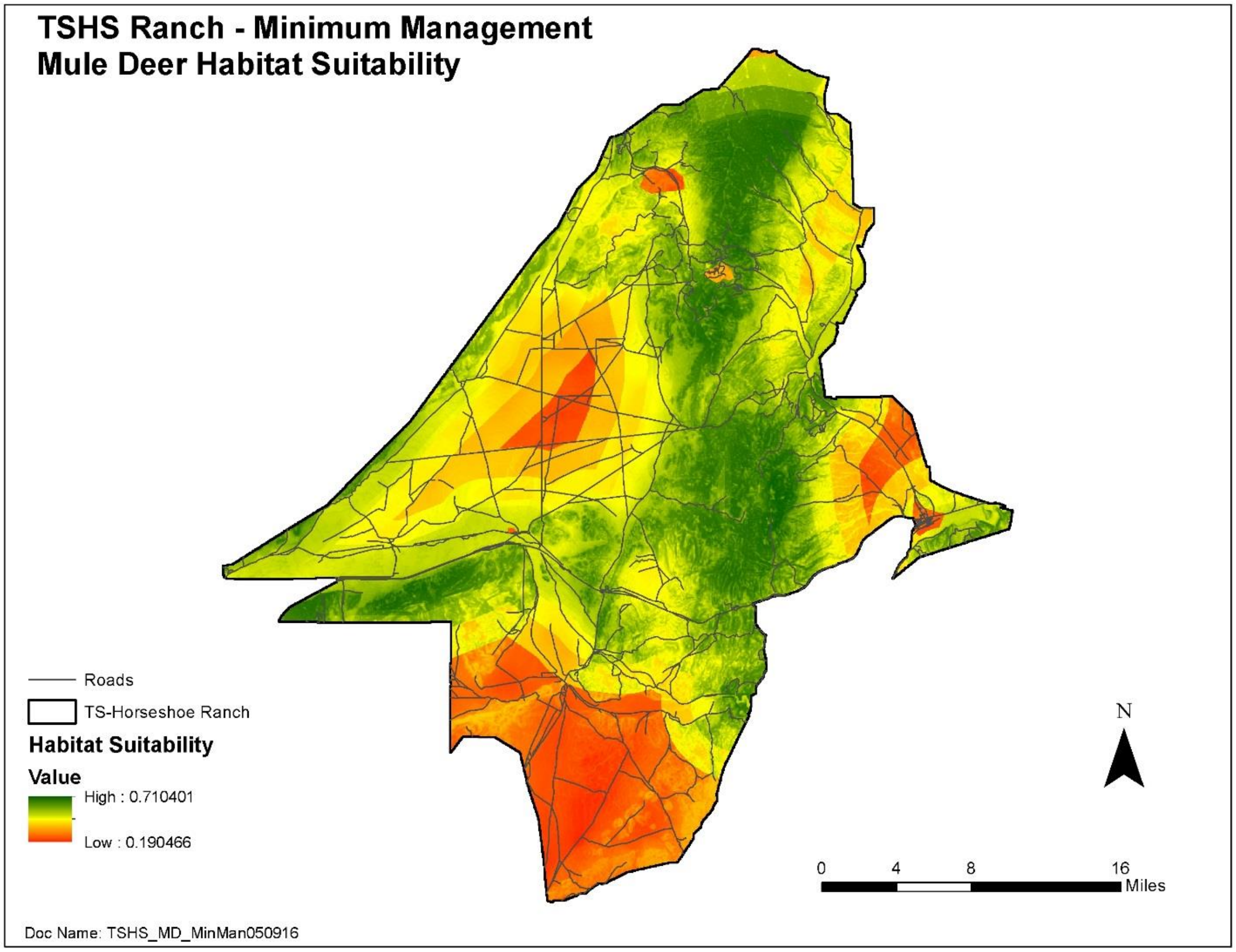


Figure 25. Spatial distribution of habitat suitability values for mule deer after 30 years of MINIMUM MANAGEMENT on the TS-Horseshoe Ranches averaged across 10 iterations.

Golden Eagle: Habitat Suitability

The lack of response to 30 years of MINIMUM MANAGEMENT scenario observed for mule deer was also observed for golden eagle (Figure 20 compared to Figure 26; Figure 21 compared to Figure 27) and for the same reasons. Golden eagle habitat suitability is highly determined by soil types and long-distance spatial attributes of the landscape, including transportation corridors generating road kills and areas of livestock birthing, that did not change in the simulations.

During 30 years average habitat suitability remained relatively stable, changing from 0.4062 to 0.4060 at the IL Ranch. At the TSHS Ranch, average habitat suitability changed from 0.5276 to 0.5273.

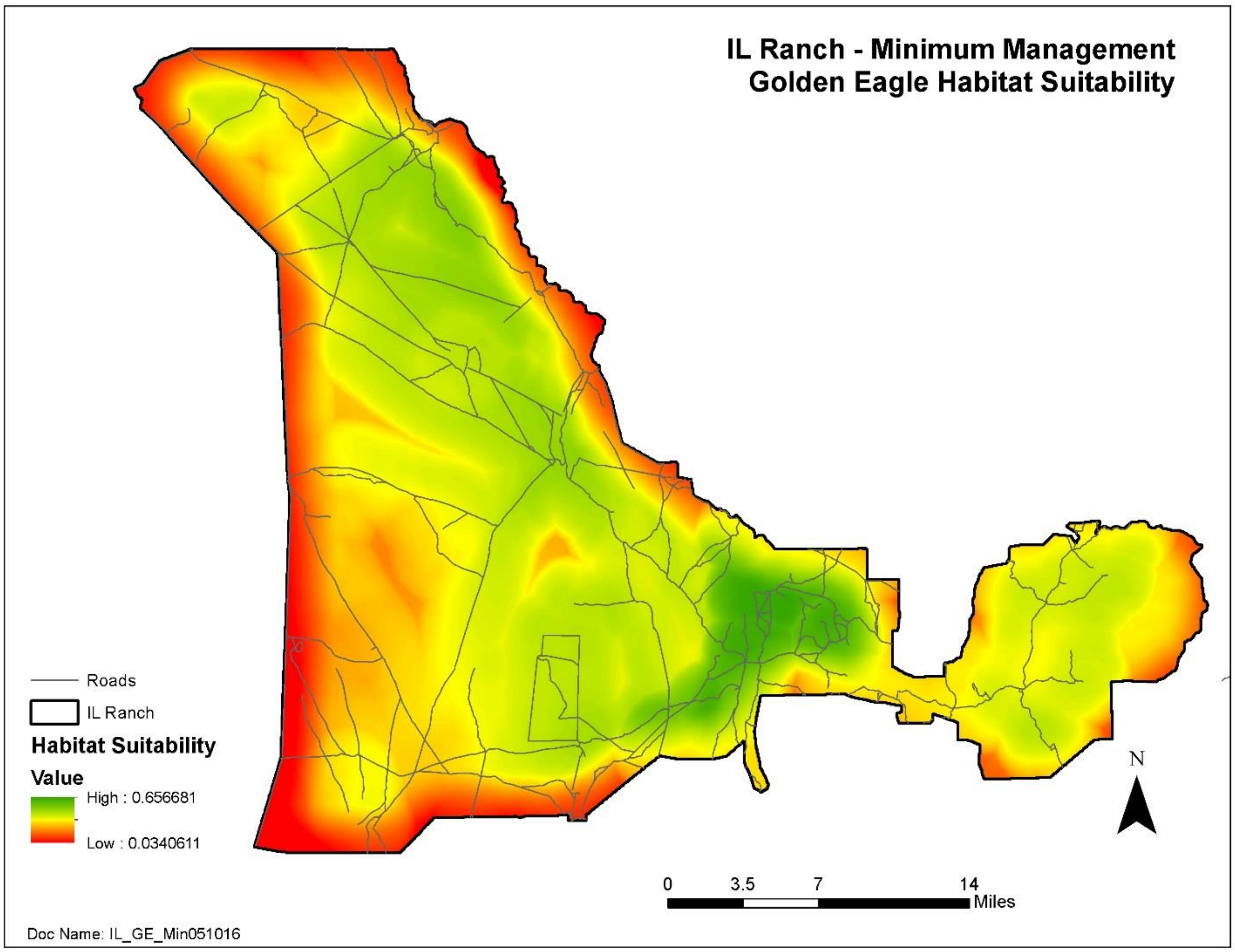


Figure 26. Spatial distribution of habitat suitability values for golden eagle after 30 years of MINIMUM MANAGEMENT on the IL Ranch averaged across 10 iterations.

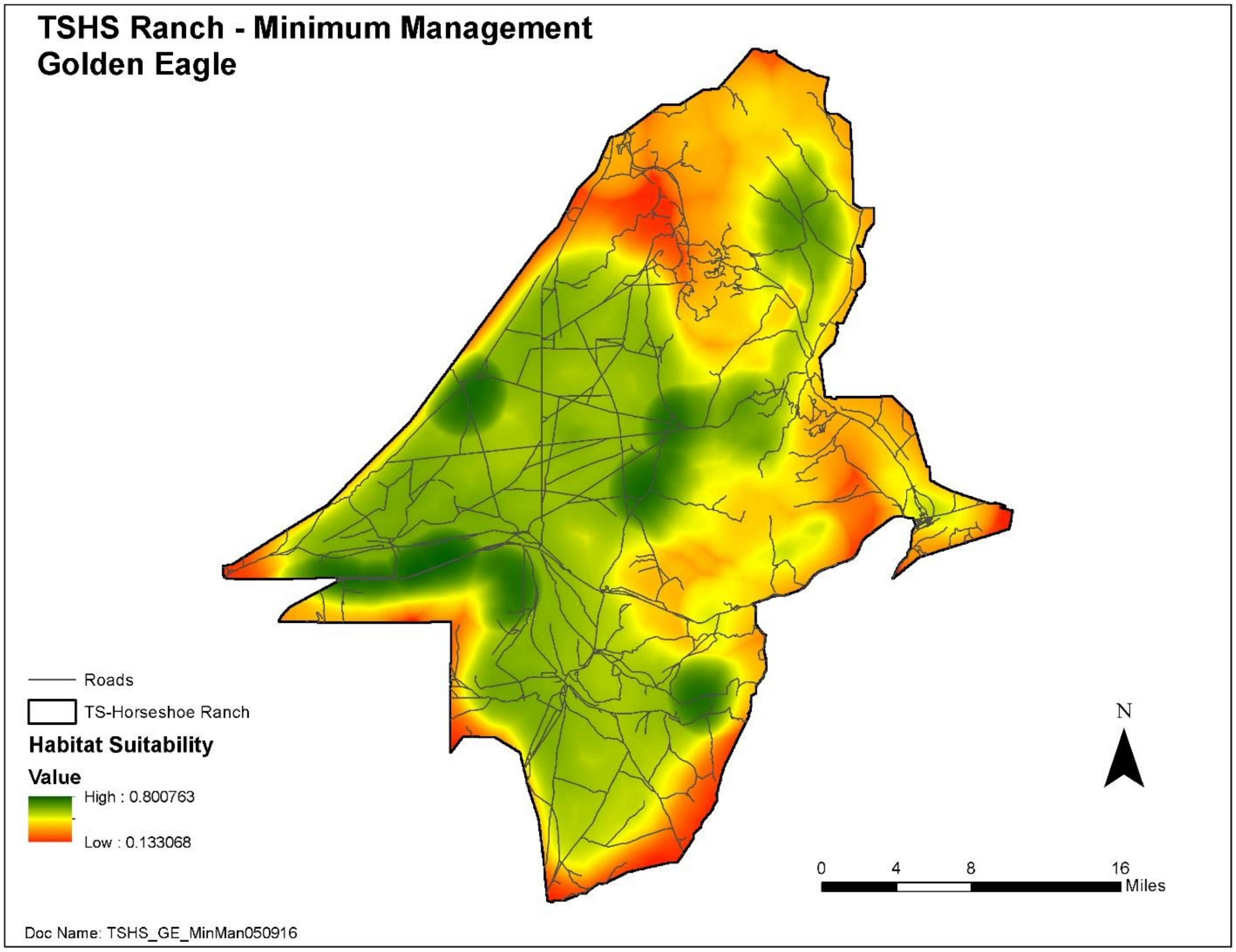


Figure 27. Spatial distribution of habitat suitability values for golden eagle after 30 years of MINIMUM MANAGEMENT on the TS-Horseshoe Ranches averaged across 10 iterations.

Predicted Future Condition – Active Management Scenarios

Introduction

For each ecological system selected for more detailed analyses (see Table 6), management actions or treatments were modeled under the two future active management scenarios of MAX GSG HS MANAGEMENT and BEST UED MANAGEMENT scenarios (see Table 7). Management actions were identified to achieve the purposes of: (1) abating the most serious current and future problems (i.e., processes) that face each ecological system or human infrastructure (fire risk); and more generally (2) improving the condition of each focal ecological system that is currently in an undesirable (highly-departed) condition.

The MAX GSG HS MANAGEMENT and BEST UED MANAGEMENT scenarios for each ecological system were tested via computer simulations using ST-Sim software to determine how well they achieved the twin purposes above. Model-run outcomes are reported for unified ecological departure after 30 years – although technically these are the average of individual UED values from each of 10 model-run iterations (replicates). Also reported are the actual average acres treated by each action over the 30-year period, and the total 30-year average costs for implementation of the actions. Finally, Return On Investment (ROI) values are shown for the MAX GSG HS MANAGEMENT and the BEST UED MANAGEMENT scenarios, each relative to the baseline MINIMUM MANAGEMENT scenario.

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

1. Brief description of the system's unified ecological departure and "problem" vegetation classes, both at present and after 30 years of MINIMUM MANAGEMENT;
2. Objectives (desired outcomes) for the system;
3. Management actions, including acres treated and cost, that are aimed at achieving the objectives under two future active management scenarios;
4. Summary of outcomes in terms of unified ecological departure (UED) and return on investment (ROI), plus one or more charts showing change in the "problem" class(es) via active management.

Following individual descriptions of the selected ecological systems at the level of UED, sub-sections briefly describe tabulated results in terms of sage-grouse, mule deer, and golden eagle habitat suitability for 30-year model runs. Statistical tests of scenario effects were performed with two-way Analysis of Variance (Two-way ANOVA). Two-way ANOVA was used because, in addition to the scenario test, all scenarios experienced the same sequence of temporal variability per replicate; thus, replicates also act as a blocking factor with nine degrees of freedom (9 = 10 replicates – 1). Because this is a classic mixed effect two-way ANOVA with only one replication within a block, the proper error term is the interaction of the scenario mean square and the replicate mean square with [(3-1) × (10-1)] = 18 dfs (Steel and Torrie 1980: 219). If the overall test of scenario effects was significant ($P \leq 0.05$), only two possible independent planned comparisons (contrasts) were performed. The first contrast was between the MINIMUM MANAGEMENT and MAX GSG HS MANAGEMENT scenarios and the second one between the MAX GSG HS MANAGEMENT and the Best UED Management scenarios, thus inferring the untested relationship between the MINIMUM MANAGEMENT and the Best UED Management scenarios.

Il Ranch: Aspen Woodland

The Aspen Woodland system exhibits moderate UED (58%) at the current time in the IL Ranch. More than 98% of this small system's acres are within reference classes, with the remainder in the uncharacteristic depleted class. It is noteworthy that more area was found in the mid-succession classes (>75%) than predicted by the reference percentage (26%) in all ownership types. Although recovery from fire can explain some of this, the eastern part of the IL Ranch supporting aspen has not recently burned; therefore, suggesting another process is causing stands of aspen to be made of small diameter and short height trees. The depleted class is at risk of losing aspen clones permanently (state class U:ASP->MSS), which is a high undesirability class, which inflated the current UED value; indeed, small areas of aspen clones were permanently lost to sagebrush (U:ASP->MSS) after 30 years of Minimum Management (table below). After 30 years in a regime of Minimum Management, the predicted UED dropped by 12% to 46%, for two main reasons: (1) non-management processes, such as fire and the temporary absence of livestock grazing from some pixels, converted part of the U:Depleted class into reference classes and (2) the reference class distribution substantially matured (from 2-Mid:Closed to 4-Late:Closed) to the expected percent reference condition. Amounts of specific vegetation classes in the Aspen Woodland system at the current time, and after 30 years of Minimum Management, are shown in the table below (light orange indicates high-risk vegetation classes):

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
Private	1-Early:Closed	8	-	0.0	0.0%	215.1	8.8%
	2-Mid:Closed	26	-	2062.9	84.2%	43.8	1.8%
	3-Late:Closed	38	-	316.7	12.9%	2002.6	81.7%
	4-Late:Open	27	-	62.3	2.5%	185.6	7.6%
	U:ASP->MSS	0	-	0.0	0.0%	0.7	0.0%
	U:Depleted	0	-	8.0	0.3%	2.1	0.1%
BLM	1-Early:Closed	8	-	0.0	0.0%	60.1	10.1%
	2-Mid:Closed	26	-	467.0	78.2%	1.2	0.2%
	3-Late:Closed	38	-	72.1	12.1%	458.6	76.8%
	4-Late:Open	27	-	53.4	8.9%	73.3	12.3%
	U:ASP->MSS	0	-	0.0	0.0%	0.5	0.1%
	U:Depleted	0	-	4.4	0.7%	3.1	0.5%
USFS	1-Early:Closed	8	-	0.0	0.0%	201.0	7.6%
	2-Mid:Closed	26	-	2238.2	85.1%	54.8	2.1%
	3-Late:Closed	38	-	379.8	14.4%	2204.4	83.8%
	4-Late:Open	27	-	12.5	0.5%	167.9	6.4%
	U:ASP->MSS	0	-	0.0	0.0%	0.7	0.0%
	U:Depleted	0	-	0.0	0.0%	1.7	0.1%

Although aspen woodland's UED was moderately departed and decreasing, minor restoration actions to prevent loss of clones from the depleted class and to promote regeneration in older reference classes were modeled only under the Best UED Management scenario as this is not sage-grouse habitat. The primary objective of management actions was to re-invigorate the deteriorating aspen clones, or at a minimum protect them from agents of further degradation and allow them to self-recover, thus moving those acres back into reference condition. The table below shows planned (see later for realized implementation rates) management actions and costs per ownership aimed at achieving this objective under the BEST UED MANAGEMENT scenario.

			Acres/Year (Avg of 10 runs)				
Ownership	Scenario	Mgmt Action	Years 1-9	Years 10-19	Years 20-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	BEST UED	Chainsaw-Thinning	0	0	5	$800	
		Fence	2	0	0	$400	
							$14,127 ± $5,959
NEWMONT PRIVATE	BEST UED	Chainsaw-Thinning	0	0	15	$800	
		Fence	5	0	0	$400	
							$55,866 ± $10,649

The actual yearly implementation rate of chainsaw-thinning and fencing (Figure 28) on BLM and Newmont's private lands are shown below. Note that realized implementation rates can exceed the planned rate because ST-Sim considers it as an average rate with variation around the mean that is more variable as the size of the ecological system and available classes to treat become smaller.

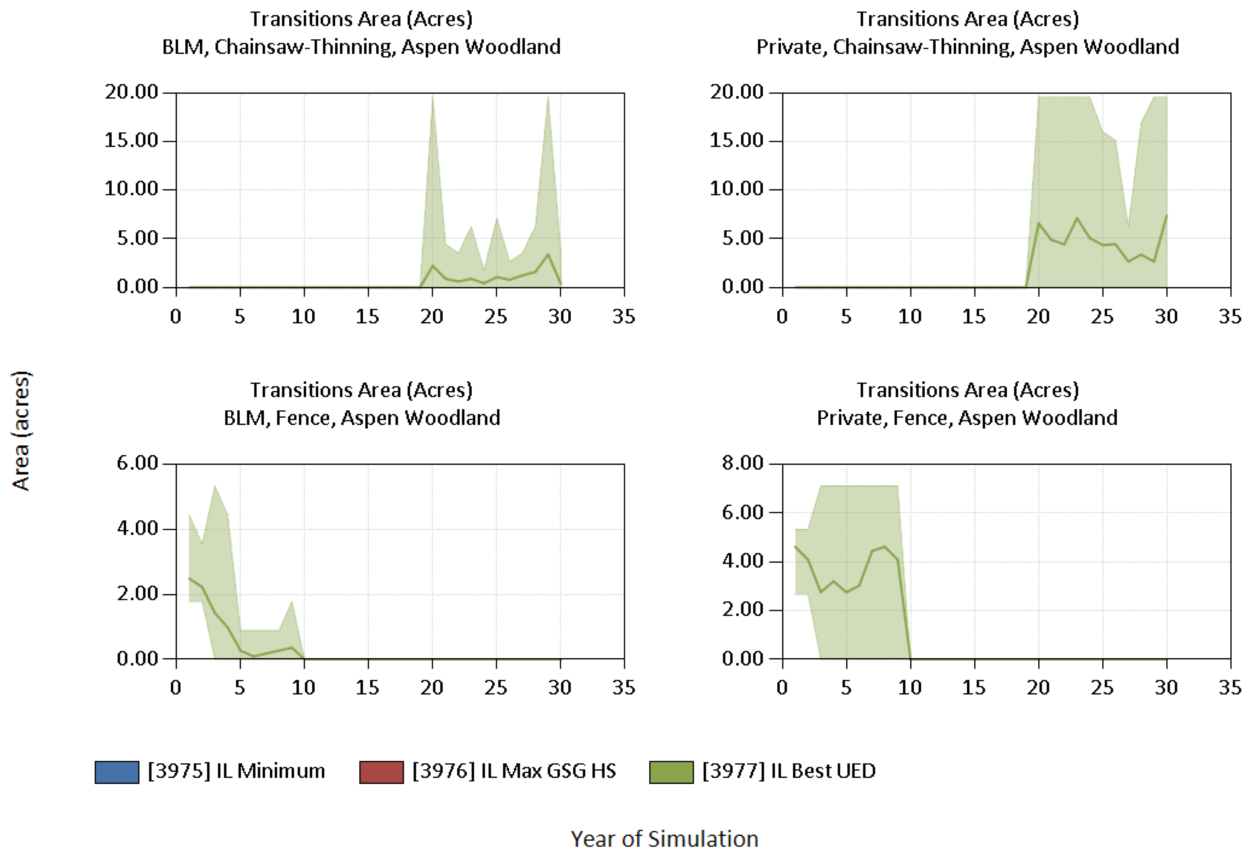


Figure 28. Realized yearly implementation rates for chainsaw thinning and fencing in the IL Ranch's aspen woodland for BLM and Newmont's private lands. Implementation was only conducted in the BEST UED scenario. Left column is BLM and private Newmont lands on the right. Top two graphs are for chainsaw-thinning, whereas the bottom two ones are for fencing. The dark line is the mean and the blue shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The table below summarizes predicted outcomes in terms of UED and total cost after 30 years of the active management scenario, along with their Current and MINIMUM MANAGEMENT values.

System Acres: 5,658	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	**Best UED**	**MAX GSG HS**
Unified Ecological Departure	58%	46% ± 1%	45% ± 2%	47% ± 1%
Cost			$69,992 ± 12,603	$0
ROI - vs Minimum Mgmt			0.27	-
ROI - 95% Confidence Interval			± 0.46	-
ROI of single scenario >0?			No[&]	-
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**n/a**	

[&] Although ROI overlaps with zero, thus indicating an ineffectual scenario for this system, the goal was to minimize the permanent loss of clones over a very small area, which was achieved.

As mentioned above, the predicted UED value under MINIMUM MANAGEMENT after 30 years has decreased to where it is about the same as for both the BEST UED and MAX GSG MANAGEMENT scenarios. All three of these future improvements reflect the conversion of the Depleted class (U:Depleted) acres to reference classes – by virtue natural disturbances in all scenarios and active management treatments in the BEST UED MANAGEMENT scenario. As a result, the ROI for BEST UED MANAGEMENT scenario is not statistically different from zero ROI and actions may not be justified. However, the goal of fencing and chainsaw thinning was to prevent further loss of aspen clones and recruitment into the depleted class for a small area. Reduction of the depleted class was the strongest improvement achieved in the BEST UED MANAGEMENT scenario compared to doing nothing (green line in Figures 29 and30). This result was in part achieved by thinning of the late-succession-open class (4-Late:Open), which also increased recruitment into the early-succession class (1-Early:Closed). Minimizing loss of clones in the U:ASP->MSS class was also achieved by this scenario. Therefore, managers may view this scenario as beneficial although the ROI may not be statistically different from zero.

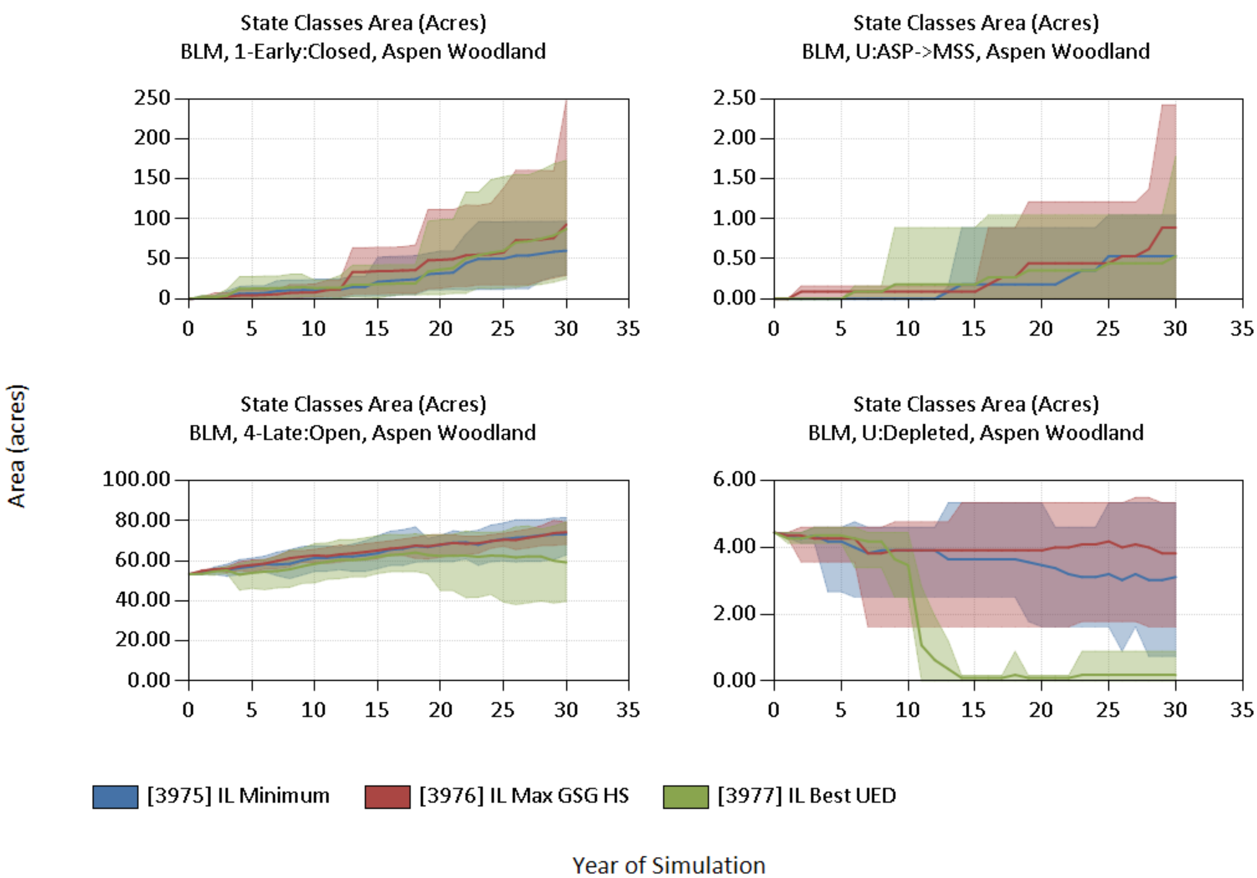


Figure 29. Area (acres) of four aspen woodland state classes targeted for ecological improvement under the BEST UED MANAGEMENT scenario located on BLM lands of the IL Ranch: early-succession (1-Early:Closed), late-succession-open (4-Late:Open), lost clones (U:ASP->MSS), and depleted (U:Depleted). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

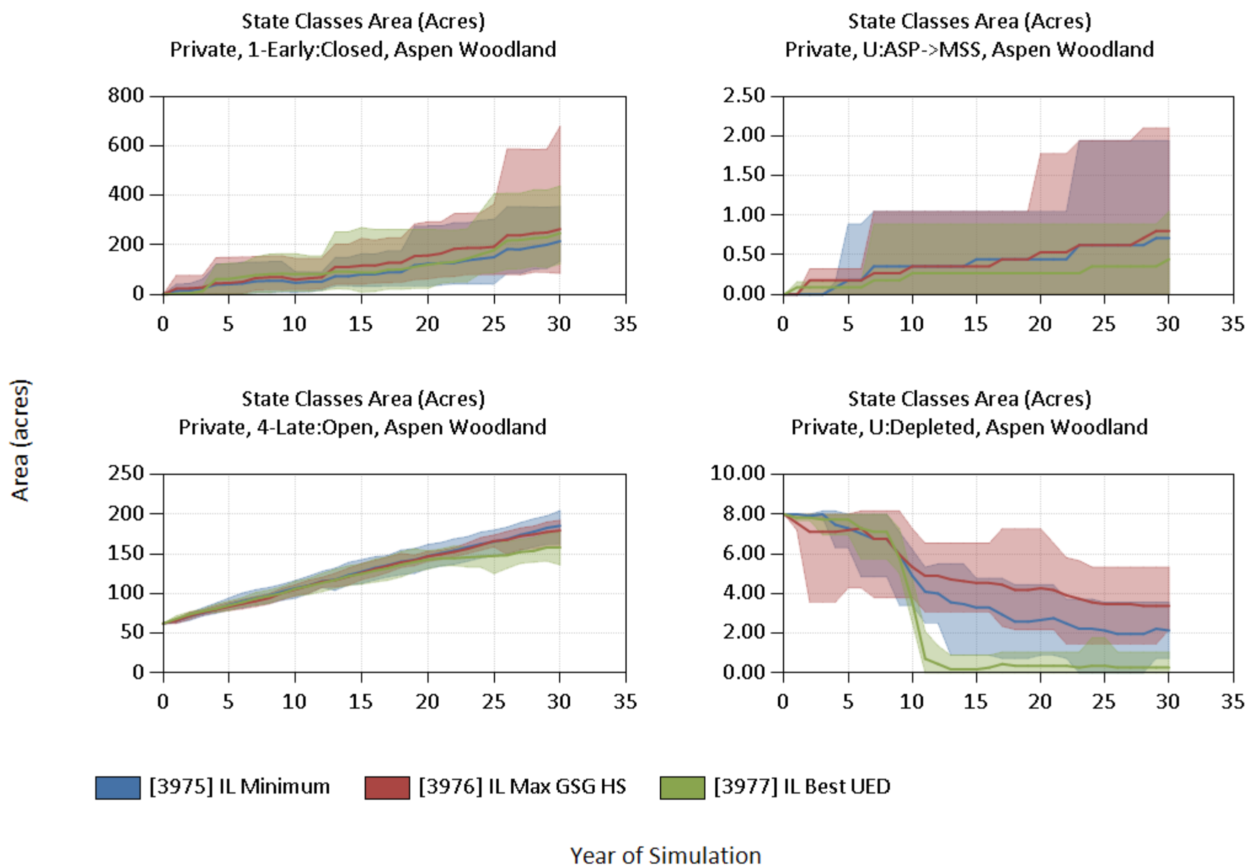


Figure 30. Area (acres) of four aspen woodland state classes targeted for ecological improvement under the BEST UED MANAGEMENT scenario located on Newmont's private lands of the IL Ranch: early-succession (1-Early:Closed), late-succession-open (4-Late:Open), lost clones (U:ASP->MSS), and depleted (U:Depleted). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

IL Ranch: Aspen-Mixed Conifer

The current state of the aspen-mixed conifer was similar for both ownerships with too many acres in the conifer-dominated late-succession-closed class (5-Late:Closed) relative to the reference condition, where we expect the late-succession closed class to represent about 5% of system. Additionally, there were too few acres in the first three successional classes (1-Early:All, 2-Mid:Closed, and 3-Late-Closed). Under Minimum Management, fire caused older classes to decrease and younger classes to recruit for about 25% of the system.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
Private	1-Early:All	9		0.0	0.0%	8.1	3.9%
	2-Mid:Closed	40		41.8	20.1%	27.5	13.2%
	3-Late:Closed	31		2.7	1.3%	38.8	18.6%
	4-Late:Open	15		5.3	2.6%	29.1	14.0%
	5-Late:Closed	5		158.3	76.1%	104.7	50.3%
	U:ASM->SF	0		0.0	0.0%	0.0	0.0%
USFS	1-Early:All	9		0.0	0.0%	16.2	5.3%
	2-Mid:Closed	40		54.3	17.9%	43.3	14.3%
	3-Late:Closed	31		30.2	10.0%	53.6	17.7%
	4-Late:Open	15		3.6	1.2%	53.6	17.7%
	5-Late:Closed	5		215.3	71.0%	136.6	45.0%
	U:ASM->SF	0		0.0	0.0%	0.0	0.0%

Further reduction of older classes continued to be the goal for restoration in non-sage-grouse habitat to prevent loss of clones to total conifer dominance and to rebalance the distribution of reference classes to approach the reference percentages (Table above). Partial restoration was accomplished by using chainsaw thinning applied to the two oldest succession classes, but with different outcomes in each class, only in the BEST UED MANAGEMENT scenario. In the oldest class dominated by conifers (5-Late-Closed), cutting of conifers and remaining aspen boles caused a transition to the early-succession class (1-Early:All). Many standing aspen trees remained after cutting the smaller conifers in the late-succession-open class (4-Late:Open), thus the transition was to the previous youngest succession class (3-Late:Closed). The table below shows the planned implementation rates of chainsaw thinning starting in year 10.

			Acres/Year (Avg of 10 runs)			
Ownership	Scenario	Mgmt Action	Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
NEWMONT PRIVATE	BEST UED	Chainsaw-Thinning	0	5	$800	
						$41,703 ± $10,566
USFS	BEST UED	Chainsaw-Thinning	0	5	$800	
						$50,101 ± $10,056

The realized rate of chainsaw thinning among all replicates in Newmont's private and USFS lands are shown in Figure 31. Note that ST-Sim considers the proposed target implementation rate as an average, and realized rates fluctuate around the average due to random number generator draws. Also, variation around the rate is higher for small systems.

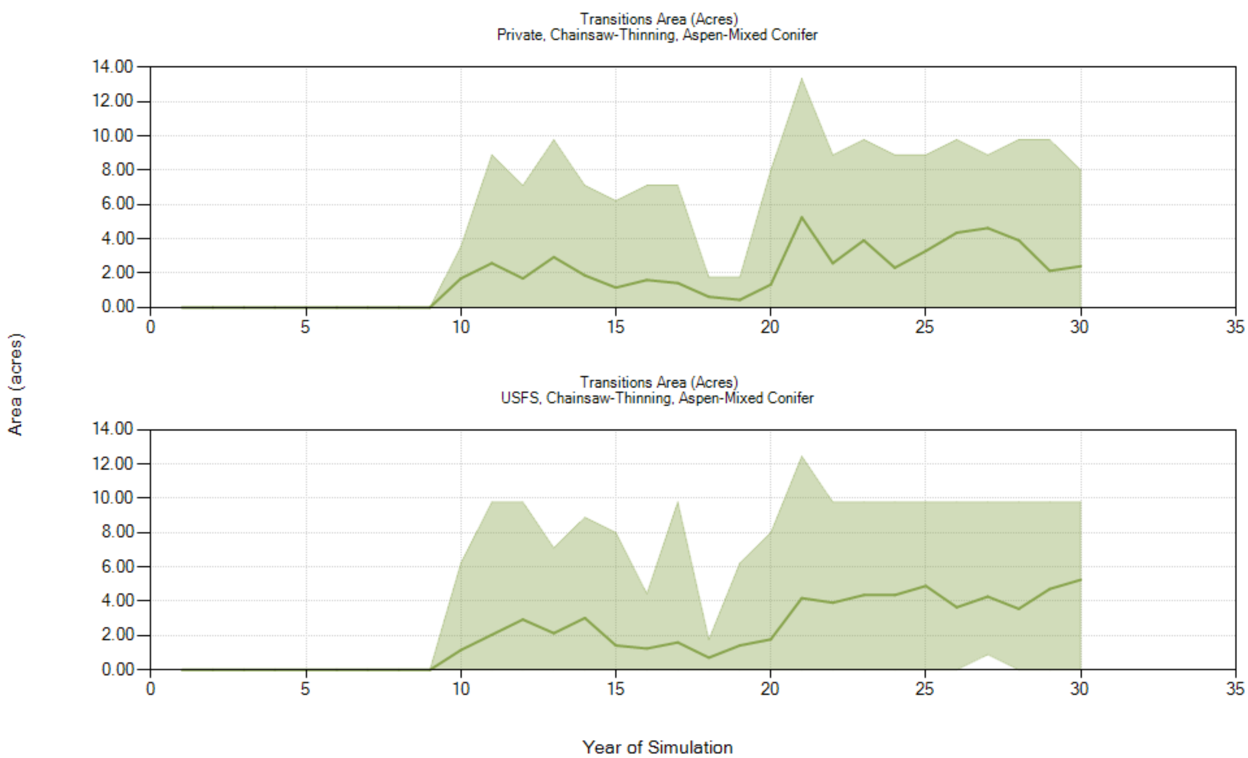


Figure 31. Realized yearly implementation rates for chainsaw thinning in the IL Ranch's aspen woodland for Newmont's private and USFS lands._Implementation was only conducted in the BEST UED scenario. First graph is Newmont's private land and USFS in on second one. The dark line is the mean and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The table below summarizes predicted outcomes in terms of UED and total cost after 30 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 515	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	Best UED	MAX GSG HS
Unified Ecological Departure	74%	63% ± 2%	61% ± 2%	67% ± 5%
Cost			$91,804 ± 17,459	$0
ROI - vs Minimum Mgmt			0.06	-
ROI - 95% Confidence Interval			± 22	-
ROI of single scenario >0?			No[&]	-
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			n/a	

[&] Although ROI overlaps with zero, thus indicating an ineffectual scenario for this system, the goals were to minimize the permanent loss of clones caused by conifer encroachment and recruit into younger succession classes by reducing the area dominated by conifer encroachment, which were realized.

As mentioned above, the predicted UED value under MINIMUM MANAGEMENT after 30 years has decreased to where it is about the same as for the BEST UED MANAGEMENT scenario; however, the UED for the MAX GSG MANAGEMENT scenario was significantly higher than the UED for the BEST UED MANAGEMENT scenario. All three of these future improvements primarily reflect the role of fire as improving this system. As a result, the ROI for BEST UED MANAGEMENT scenario is not statistically different from zero ROI and actions may not be justified. However, the goal of chainsaw thinning was to increase recruitment into younger class by thinning older classes. After year 9, reduction of the area of the two oldest classes with conifer with increased recruitment in the three younger classes was evident and apparently successful in the BEST UED MANAGEMENT scenario compared to doing nothing (green line in Figures 32 and 33). Therefore, managers may view this scenario as beneficial to aspen-mixed conifer, although the ROI may not be statistically different from zero.

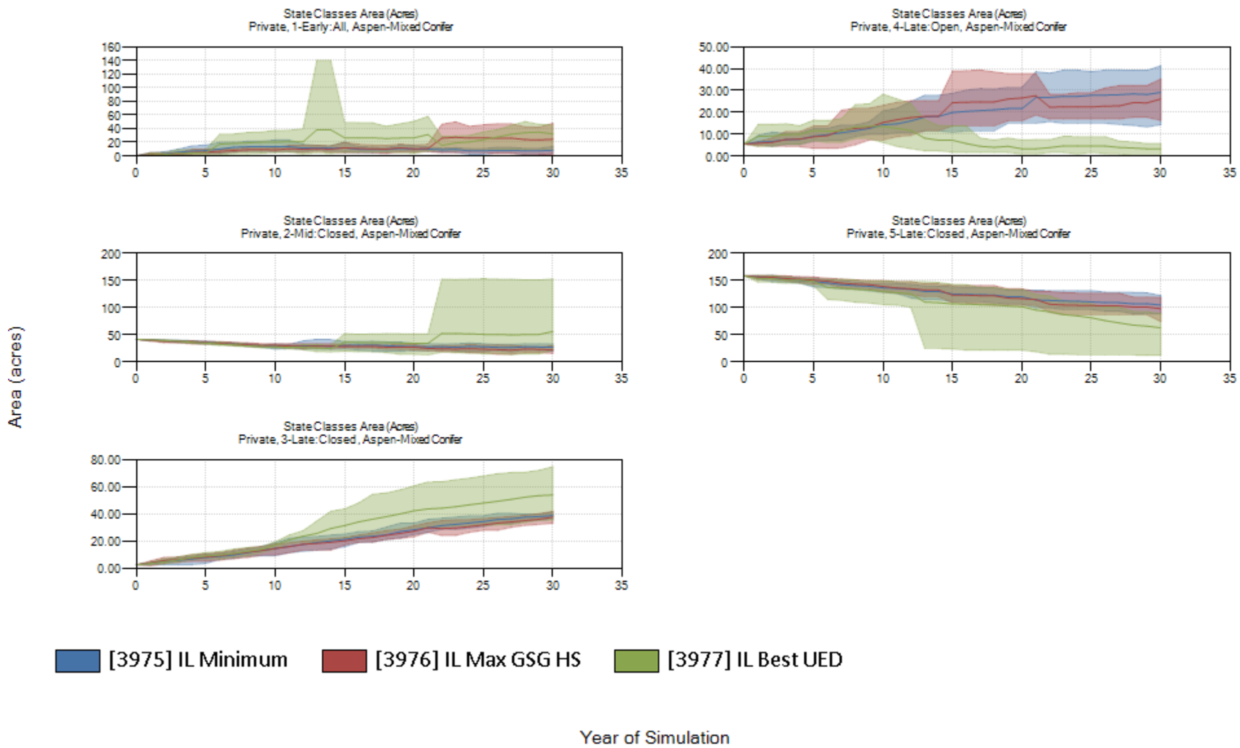


Figure 32. Area (acres) of five aspen-mixed confer state classes targeted for ecological improvement under the BEST UED MANAGEMENT scenario located on Newmont's private lands of the IL Ranch: early-succession (1-Early:ALL), mid-succession closed (2-Mid:Closed), late-succession-closed (3-Late:Closed, late-succession-open (4-Late:Open), and late-succession-closed by conifers (5-Late:Closed). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

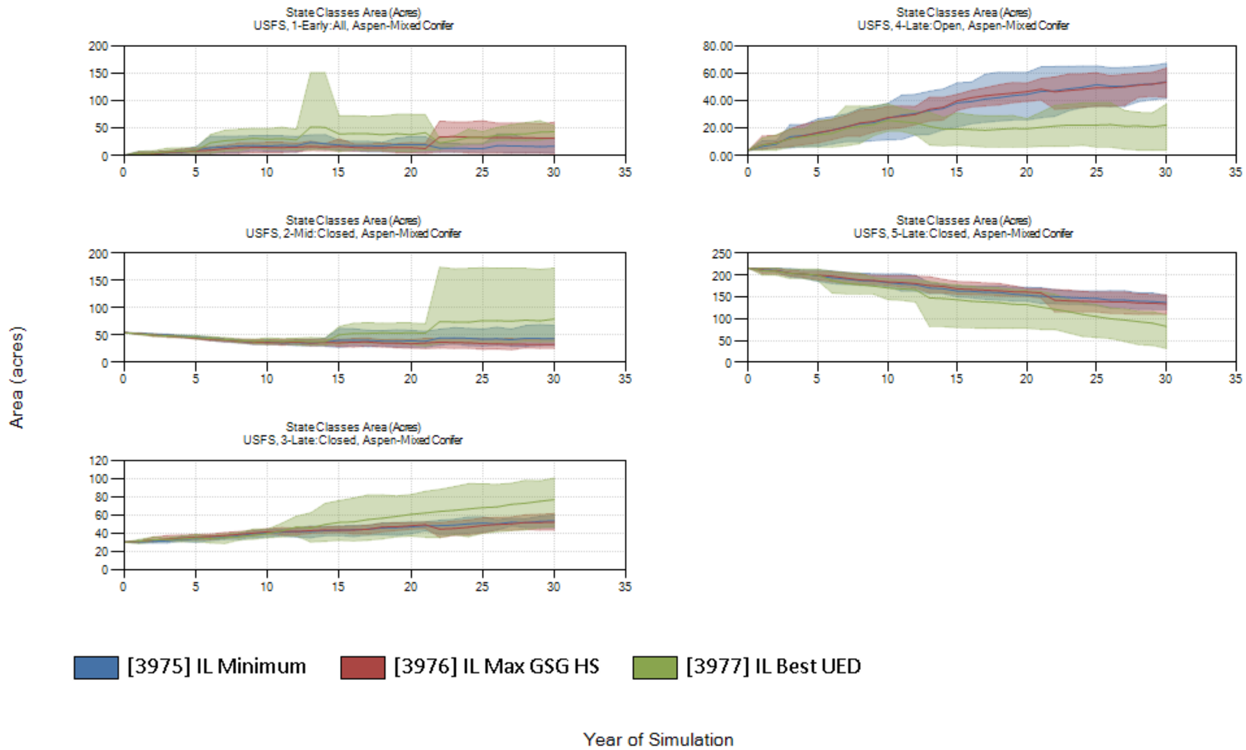


Figure 33. Area (acres) of five aspen-mixed confer state classes targeted for ecological improvement under the BEST UED MANAGEMENT scenario located on USFS lands of the IL Ranch: early-succession (1-Early:ALL), mid-succession closed (2-Mid:Closed), late-succession-closed (3-Late:Closed, late-succession-open (4-Late:Open), and late-succession-closed by conifers (5-Late:Closed). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

<u>IL Ranch: Basin Wildrye-montane</u>

Basin wildrye-montane is a linear system found in most shallow valley bottoms of the IL Ranch. Very few areas still retained reference classes (<7%), and this percentage decreased slightly after 30 years of MINIMUM MANAGEMENT scenario. Several uncharacteristic classes co-dominated (U:Annual Spp., U:ASPG, U:Depleted, U:Early Shrub, U:Exotic Forb, and U:SAP) and their percentages did not appreciably change after 30 years of MINIMUM MANAGEMENT on BLM lands, except the class of mixed non-native annual species and native perennial grass (U:ASPG) that was halved and the non-native annual species (U:Annual Spp) that increased fourfold (Table below). On Newmont's private lands, a greater amount of change was observed for all classes.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:Open	19		433.2	6.8%	28.5	0.4%
	2-Mid:Closed	66		11.6	0.2%	350.8	5.5%
	4-Late:Open	15		2.7	0.0%	5.8	0.1%

	U:Annual Spp			114.8	1.8%	420.0	6.6%
	U:ASPG			1623.5	25.6%	1228.1	19.3%
	U:Depleted			1630.6	25.7%	770.6	12.1%
	U:Early Shrub			635.2	10.0%	1082.7	17.1%
	U:Exotic Forbs			2.7	0.0%	473.1	7.5%
	U:Pasture		50	1076.4	17.0%	1076.4	17.0%
	U:SAP			817.5	12.9%	912.3	14.4%
	U:SDI			0.0	0.0%	0.0	0.0%
	U:SDI+AS			0.0	0.0%	0.0	0.0%
	U:Seeded Native		30	0.0	0.0%	0.0	0.0%
Private	1-Early:Open	19		23.1	0.5%	2.8	0.1%
	2-Mid:Closed	66		9.8	0.2%	25.1	0.5%
	4-Late:Open	15		0.9	0.0%	3.0	0.1%
	U:Annual Spp			155.7	3.2%	332.9	6.8%
	U:ASPG			195.7	4.0%	298.7	6.1%
	U:Depleted			612.9	12.4%	235.1	4.8%
	U:Early Shrub			556.0	11.3%	739.5	15.0%
	U:Exotic Forbs			5.3	0.1%	221.1	4.5%
	U:Pasture			2745.2	55.7%	2745.2	55.7%
	U:SAP			624.5	12.7%	325.8	6.6%
	U:SDI			0.9	0.0%	0.7	0.0%
	U:SDI+AS			0.0	0.0%	0.2	0.0%
	U:Seeded Native			0.0	0.0%	0.0	0.0%

For basin wildrye-montane, which can be used by sage-grouse, four levels of active management combining ownership and scenarios were identified: Max GSG and Best UED Management scenarios each implemented on BLM and Newmont's private lands. The Max GSG Management scenario was primarily designed to remove expanses of non-native annual species (U:Annual Spp), which negatively impact sage-grouse nest success, although exotic forbs (U:Exotic Forb) and standing basin big sagebrush mixed with rabbitbrush were also targeted on private land to improve range condition (standard management action) and increase basin wildrye biomass (neutral effect on nest success) at the expense of the class dominated by basin big sagebrush, rabbitbrush, and non-native annual species that would convert to non-native annual species (U:SAP) if burned.

The Best UED Management scenario on BLM lands was more complex and also targeted the depleted class dominated by basin big sagebrush (U:Depleted) and the early-shrub class dominated by rabbitbrush (U:Early-Shrub) to increase native cover through seedings (U:Seeded Native), and eventually reference classes. The table below shows the planned implementation rates of different management actions by ownership and scenario and the total 30-year cost by combination.

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	MAX GSG HS	Exotic Control	10	4	$80	
		Herbicide- Plateau + Native Seed	600	200	$295	
		Weed Inventory + Spot Treatment	400	400	$50	
						$ 430,505 ± $29,703
NEWMONT PRIVATE	MAX GSG HS	Exotic Control	5	5	$80	
		Herbicide- Plateau + Native Seed	100	50	$295	
		Thin + Plateau + Native Seed	100	50	$300	
		Weed Inventory + Spot Treatment	200	200	$50	
						$345,028 ± $29,491
BLM	BEST UED	Exotic Control	10	4	$80	
		Herbicide- Plateau + Native Seed	600	200	$295	
		Thin + 24D + Plateau + Native Seed	150	0	$475	
		Thin + Native Seed	20	0	$300	
		Thin + Plateau + Native Seed	0	300	$300	
		Weed Inventory + Spot Treatment	400	400	$50	
						$1,326,713 ± $32,796
NEWMONT PRIVATE	BEST UED	Exotic Control	5	5	$80	
		Herbicide- Plateau + Native Seed	100	50	$295	
		Thin + Plateau + Native Seed	100	50	$300	
		Weed Inventory + Spot Treatment	200	200	$50	
						$716,983 ± $19,985

The realized implementation rates for these actions are show below in Figures 34 (BLM) and 35 (Newmont private). Note that the thin+native-seed action was not implemented because the target class, which is the depleted class (U:Depleted), is in the Horse Management Area where BLM decided that seedings are incompatible with wild horse grazing.

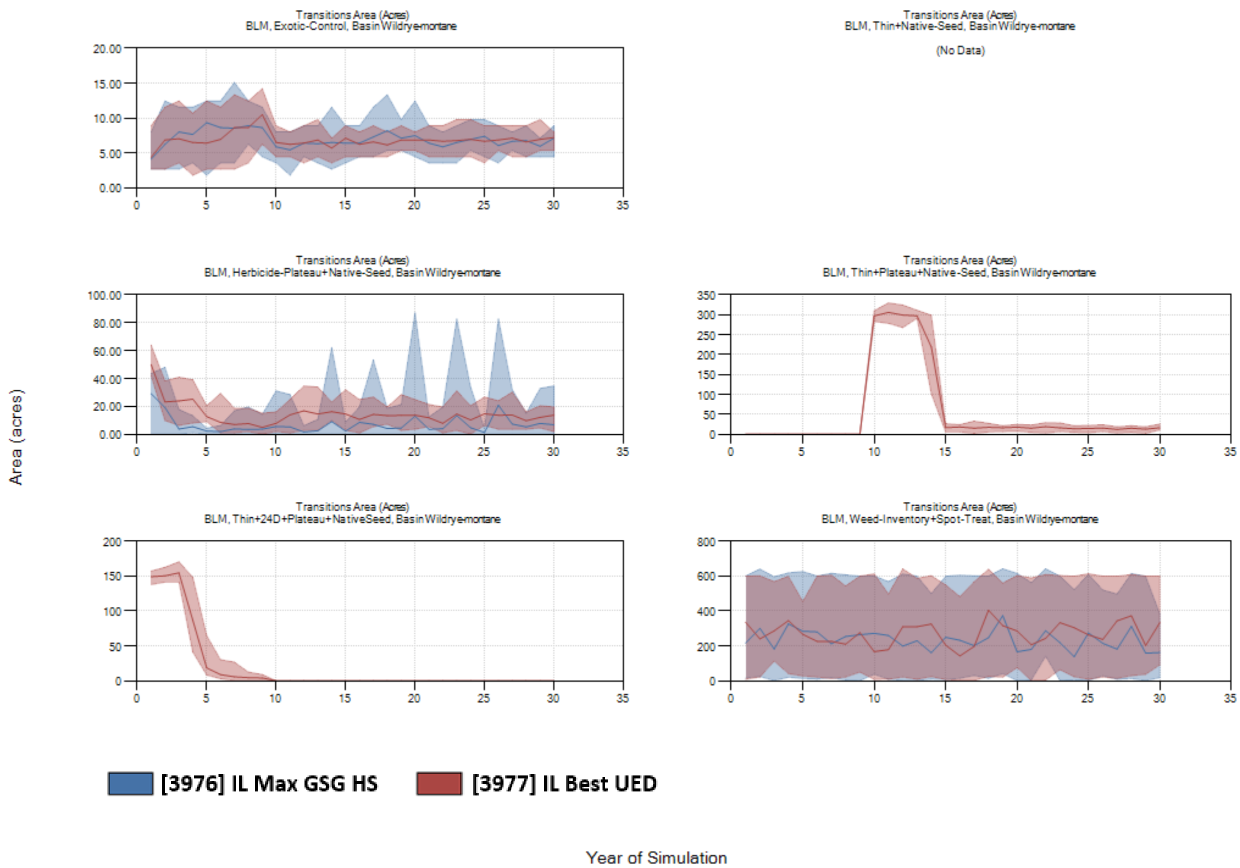


Figure 34. Realized yearly implementation rates for exotic control, herbicide-Plateau+seed, thin+24D+Plateau+native-seed, thin+native-seed, thin+Plateau+native-seed, and weed-inventory+spot-treatment of exotics in the IL Ranch's basin wildrye-montane for BLM lands. The dark line is the mean for each scenario (Highest GSG Credit in blue and Best UED in red) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

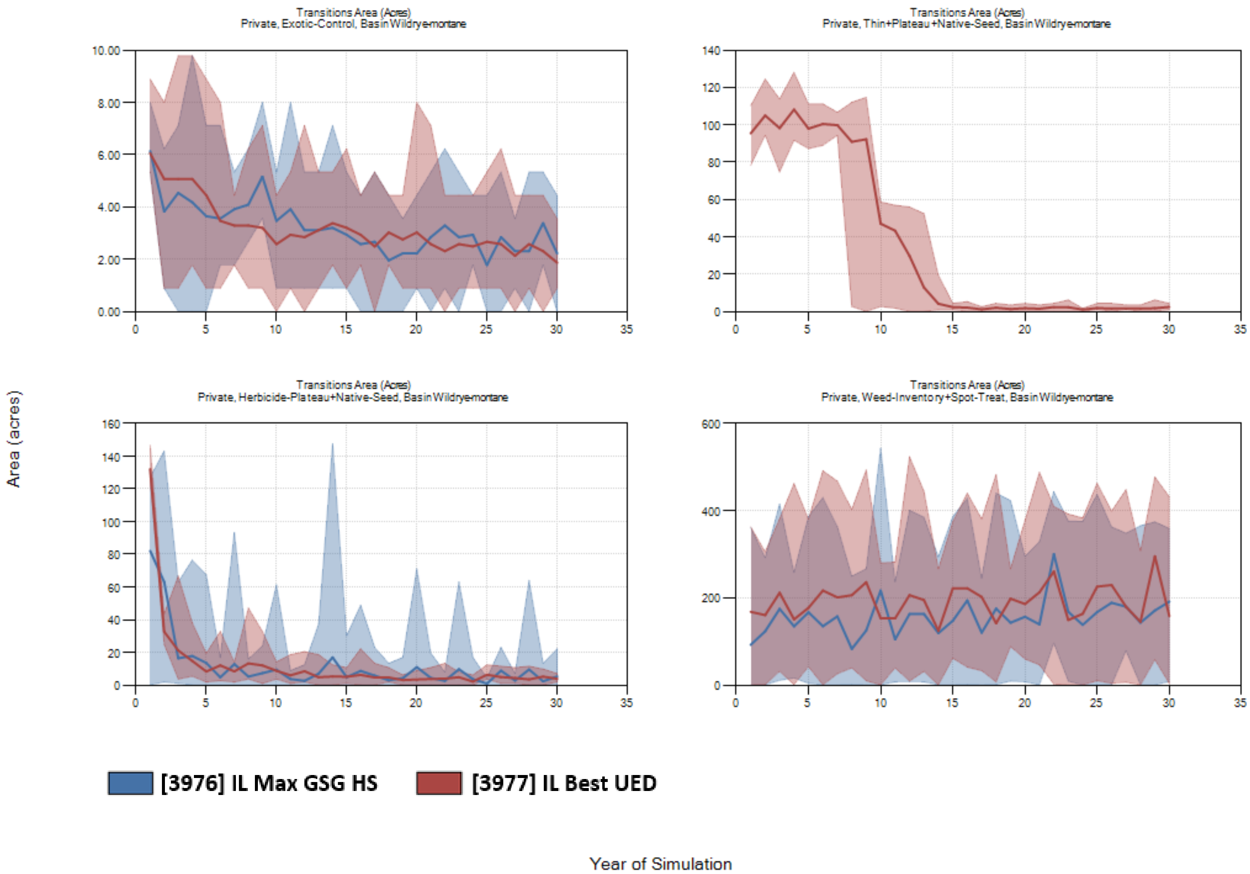


Figure 35. Realized yearly implementation rates for exotic control, herbicide-Plateau+seed, thin+Plateau+native-seed, and weed-inventory+spot-treatment of exotics in the IL Ranch's basin wildrye-montane for Newmont's private lands. The dark line is the mean for each scenario (Highest GSG Credit in blue and Best UED in red) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The BEST UED MANAGEMENT scenario improved UED from 76% to 41% (i.e., moderate departure) compared to MINIMUM MANAGEMENT, whereas the MAX GSG HS MANAGEMENT scenario resulted in only a 10% smaller UED value than MINIMUM Management (Table below). The 30-year cumulative cost was roughly three times higher for the BEST UED MANAGEMENT scenario compared to the MAX GSG HS MANAGEMENT scenario. For both active scenarios, the ROI was significantly greater than zero, therefore worth doing, and the BEST UED MANAGEMENT scenario had a significantly greater ROI than the MAX GSG HS MANAGEMENT scenario despite the higher cost. The table below summarizes predicted outcomes in terms of UED and total cost after 30 years of these two active management scenarios, along with their Current and MINIMUM values.

System Acres: 11,278		**Scenarios – 30 years (mean & 95% CI of 10 replicates)**		
	Current	**Minimum**	**Best UED**	**MAX GSG HS**
Unified Ecological Departure	73%	76% ± 1%	41% ± 1%	67% ± 1%
Cost			$2,043,696 ± 42,792	$775,533 ± 35,341

ROI - vs Minimum Mgmt	41	11
ROI - 95% Confidence Interval	± 2.4	± 1
ROI of single scenario >0?	Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →	**Yes**	

It is clear from Figures 36 and 37 that the BEST UED MANAGEMENT scenario (green line and percentiles) distinctly increased desirable classes and decreased undesirable ones. The only times both active scenarios caused a reduction of undesirable classes (blue line and percentiles for CUSTODIAL MANAGEMENT scenario distinct from other lines) were for exotic forbs (U:Exotic-Forb) and non-native annual species (U:Annual Spp).

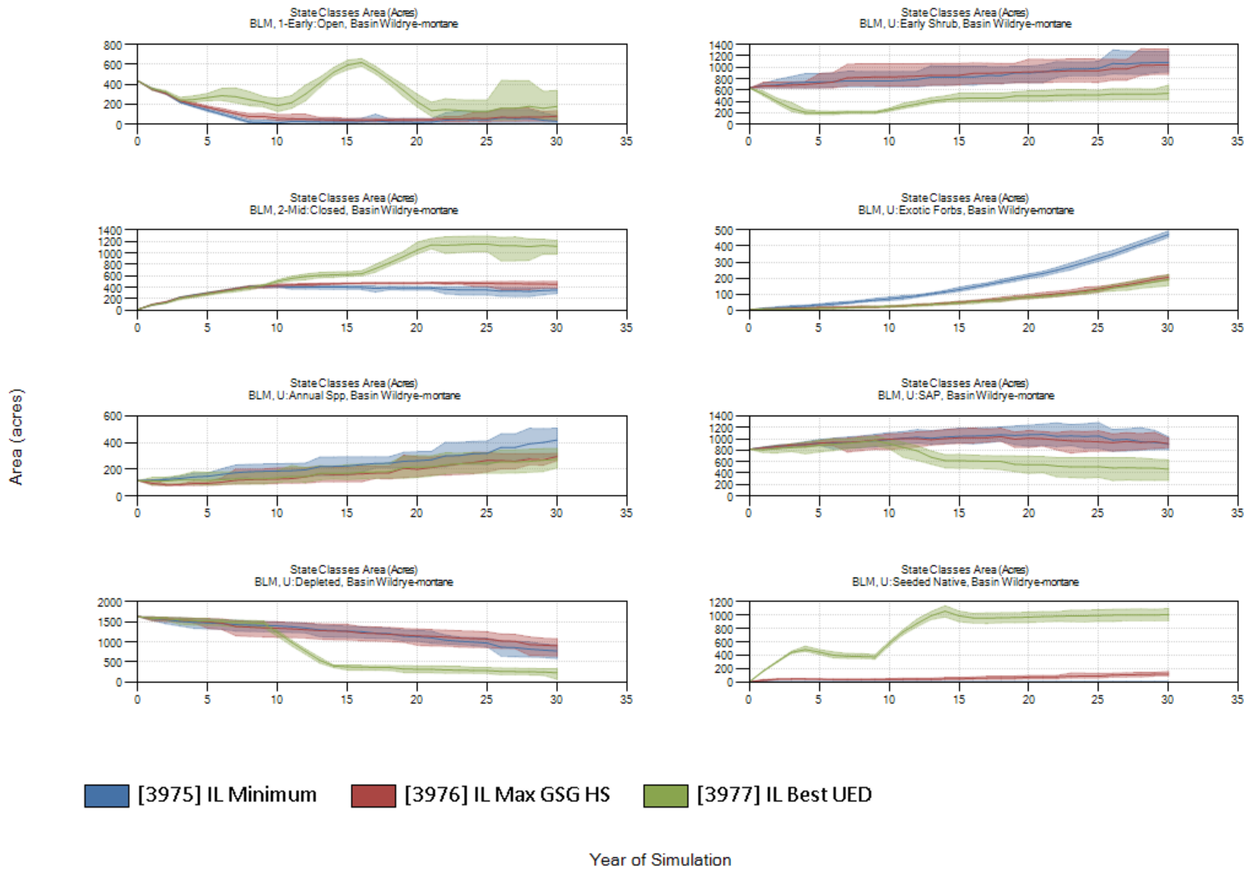


Figure 36. Area (acres) of eight basin wildrye-montane state classes targeted for ecological improvement for all scenarios located on BLM lands of the IL Ranch: early-succession (1-Early:Open), mid-succession closed (2-Mid:Closed), late-succession-closed (3-Late:Open), non-native annual species (U:Annual Spp), dominated by basin big sagebrush (U:Depleted), early-shrub dominated (U: Early-Shrub), dominated by exotic forbs (U:Exotic-Forb), shrub with annual species or native perennial grasses (U:SAP), and native seeding (U:Seeded-Native). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

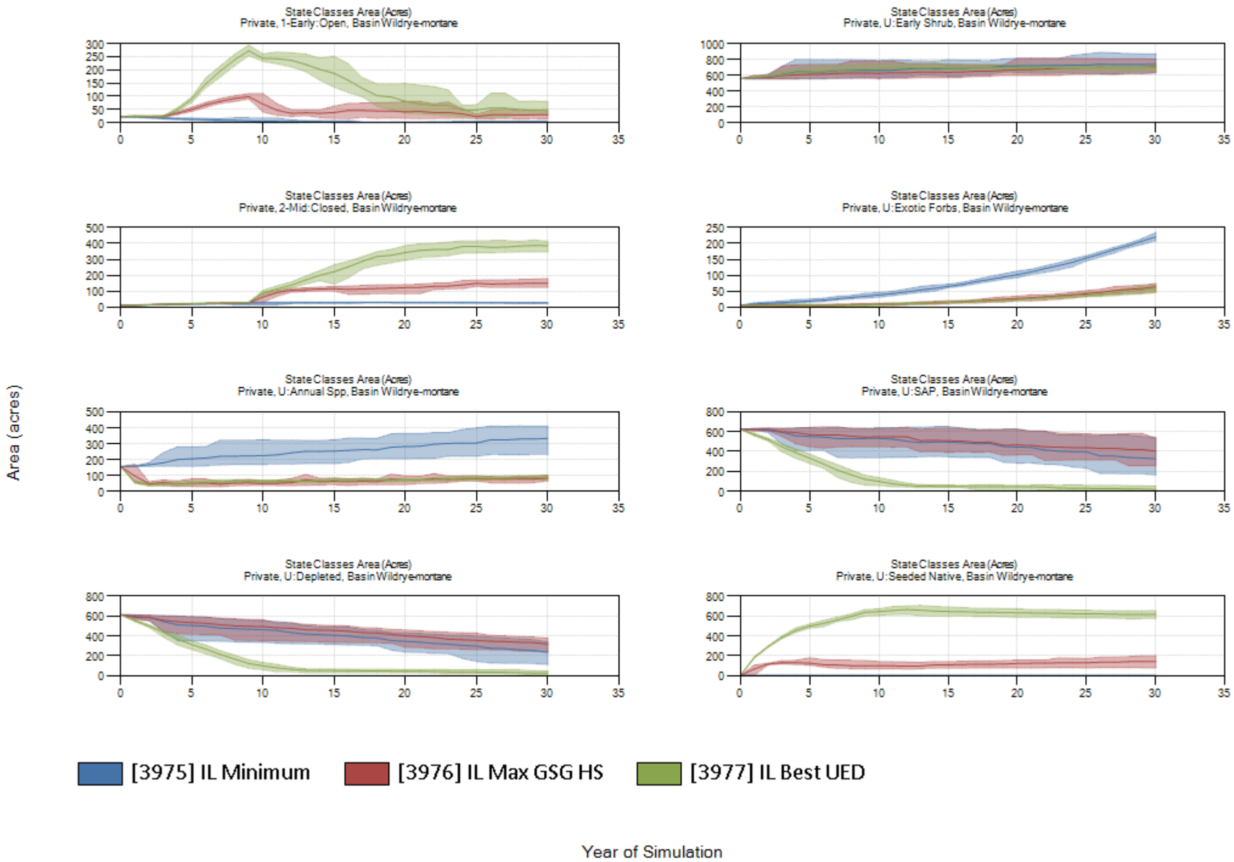


Figure 37. Area (acres) of eight basin wildrye-montane state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the IL Ranch: early-succession (1-Early:Open), mid-succession closed (2-Mid:Closed), late-succession-closed (3-Late:Open), non-native annual species (U:Annual Spp), dominated by basin big sagebrush (U:Depleted), early-shrub dominated (U: Early-Shrub), dominated by exotic forbs (U:Exotic-Forb), shrub with annual species or native perennial grasses (U:SAP), and native seeding (U:Seeded-Native). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

<u>IL Ranch: Big Sagebrush Upland No Trees</u>

On BLM lands, the largest changes in vegetation class across all scenarios were (a) the maturation of the mixed non-native annual species and perennial grass class (U:ASPG) into the shrub with non-native annual species and perennial grass class (U:SAP) and (b) the decrease of the late-succession class (3-Late:Closed) and increase of the mid-succession class (2-Mid:Open), due to recovery from fires, severe drought, and Aroga moth outbreaks (table below). Two uncharacteristic classes that increased moderately were non-native annual species (U:Annual Spp) and early shrubs (U:Early Shrub), both primarily caused by fire, but also excessive grazing by cattle and wild horses (though this effect generally occurred in a small area).

On Newmont's private lands, which covered a far smaller area, the distribution of vegetation classes was different as greater fire activity and moth outbreaks persisted later than on BLM lands in the 30-year simulations; therefore, early-succession classes did not have sufficient time to mature to the late-succession class. As for BLM lands, the U:ASPG to U:SAP maturation was a dominant change. The non-native annual species class (U:Annual Spp) also increased on Newmont's private and BLM lands, but the increase was proportionally larger on private than BLM lands (table below).

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:All	21		40600.3	10.6%	49285.4	12.8%
	2-Mid:Open	51		64799.5	16.8%	127696.2	33.2%
	3-Late:Closed	27		177400.5	46.1%	99417.7	25.8%
	4-Late:Dense	1		0.0	0.0%	13.2	0.0%
	U:Annual Spp			2375.2	0.6%	5305.5	1.4%
	U:ASPG			34389.3	8.9%	6841.1	1.8%
	U:Depleted			16254.4	4.2%	6201.3	1.6%
	U:Early Shrub			6109.6	1.6%	17547.3	4.6%
	U:Exotic Forbs			190.4	0.0%	639.4	0.2%
	U:SA-Closed			629.8	0.2%	2223.9	0.6%
	U:SA-Dense			0.0	0.0%	0.6	0.0%
	U:SAP-Closed			36398.9	9.5%	64036.1	16.6%
	U:SAP-Dense			0.0	0.0%	5.2	0.0%
	U:SDI-A		3.1	0.0	0.0%	778.2	0.2%
	U:SDI-B		4.4	5465.6	1.4%	2213.7	0.6%
	U:SDI-C		2.4	0.0	0.0%	2428.5	0.6%
	U:SDI-D		0.1	0.0	0.0%	0.2	0.0%
	U:Seeded Native			0.0	0.0%	0.0	0.0%
	U:SI-A+AS			7.1	0.0%	18.1	0.0%
	U:SI-B+AS			130.8	0.0%	62.8	0.0%
	U:SI-C+AS			39.1	0.0%	76.0	0.0%
	U:SI-D+AS			0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb			0.0	0.0%	0.0	0.0%
Private	1-Early:All	21		934.1	6.7%	2856.5	20.4%
	2-Mid:Open	51		1843.2	13.2%	1935.3	13.8%
	3-Late:Closed	27		281.1	2.0%	874.6	6.3%
	4-Late:Dense	1		0.0	0.0%	0.1	0.0%
	U:Annual Spp			1096.0	7.8%	1846.4	13.2%
	U:ASPG			4719.2	33.7%	535.3	3.8%
	U:Depleted			0.0	0.0%	0.0	0.0%
	U:Early Shrub			732.1	5.2%	714.1	5.1%
	U:Exotic Forbs			14.2	0.1%	68.3	0.5%

U:SA-Closed		234.0	1.7%	101.5	0.7%
U:SA-Dense		0.0	0.0%	0.0	0.0%
U:SAP-Closed		3463.1	24.8%	4412.7	31.5%
U:SAP-Dense		0.0	0.0%	0.5	0.0%
U:SDI-A	3.1	0.0	0.0%	157.2	1.1%
U:SDI-B	4.4	564.9	4.0%	297.6	2.1%
U:SDI-C	2.4	0.0	0.0%	189.6	1.4%
U:SDI-D	0.1	0.0	0.0%	0.0	0.0%
U:Seeded Native		0.0	0.0%	0.0	0.0%
U:SI-A+AS		87.2	0.6%	0.7	0.0%
U:SI-B+AS		12.5	0.1%	0.5	0.0%
U:SI-C+AS		9.8	0.1%	0.4	0.0%
U:SI-D+AS		0.0	0.0%	0.0	0.0%
U:Unpalat. Forb		0.0	0.0%	0.0	0.0%

For the MAX GSG HS MANAGEMENT scenario, restoration was focused on reducing non-native annual species (U:Annual Spp) with the treatment herbicide-Plateau+seed (table below) because this class directly decreases nest success for nests up to 2 km away, indirectly reduces nest site selection within 1 km of a potential nest site, and promotes fire ignitions and spread. Control of exotic forb was a standard range improvement maintenance activity not targeted at sage-grouse habitat suitability. The positioning of temporary supplemental salt blocks is a special action designed to increase sagebrush habitat resilience and future sage-grouse habitat condition. The role of salt blocks positioned for one month was to attract cattle that would then crush very small and very dispersed areas of sagebrush in high-suitability areas, thus leading to recruitment of young classes of sagebrush that would mature by the time the older sagebrush would become decadent. During the maturation of previously crushed sagebrush patches, sage-grouse would have access to early-brood and sometimes late-brood habitat.

The planned actions utilized in the MAX GSG HS MANAGEMENT scenario were retained in the BEST UED MANAGEMENT scenario, which also included three additional range improvement actions focused on thinning and seeding standing sagebrush or rabbitbrush with poor understories: thin+24D+seed for the class with rabbitbrush dominance (U:Early Shrub), thin+Plateau+seed for the shrub with non-native annual species (U:SA-Closed), and thin+seed for the depleted sagebrush class (U:Depleted) (table below).

The cumulative 30-year cost of the BEST UED MANAGEMENT scenario was about 4.5 and 1.6 times more expensive than the MAX GSG HS MANAGEMENT scenario for BLM and Newmont's private lands, respectively (table below).

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	MAX GSG HS	Exotic Control	50	50	$80	
		Herbicide- Plateau + Seed	500	100	$170	
		Supplemental Salt Block	170	0	$20	
						$559,294 ± $93,491
NEWMONT PRIVATE	MAX GSG HS	Exotic Control	5	5	$80	
		Herbicide- Plateau + Seed	100	50	$170	
		Supplemental Salt Block	15	0	$20	
						$197,884 ± $42,231
BLM	BEST UED	Exotic Control	200	75	$80	
		Herbicide -Plateau + Seed	500	100	$170	
		Supplemental salt Blocks	170	0	$20	
		Thin + 24D + Seed	100	175	$285	
		Thin + Plateau + Seed	700	0	$210	
		Thin + Seed	0	750	$175	
						$2,505,827 ± $90,543
NEWMONT PRIVATE	BEST UED	Exotic Control	5	5	$80	
		Herbicide + Plateau-Native Seed	100	50	$295	
		Supplemental salt Blocks	15	0	$20	
		Thin + 24D + Seed	50	0	$285	
		Thin + Plateau + Seed	10	0	$210	
						$318,207 ± $36,863

The realized implementation rate of actions by ownership and scenarios are shown in Figures 38 (BLM) and 39 (Newmont-private). It is worth noting that many treatments have very limited and early windows of implementation to allow sagebrush maturation for sage-grouse habitat suitability (i.e., treatments that occur later in the study period do not mature to the target class).

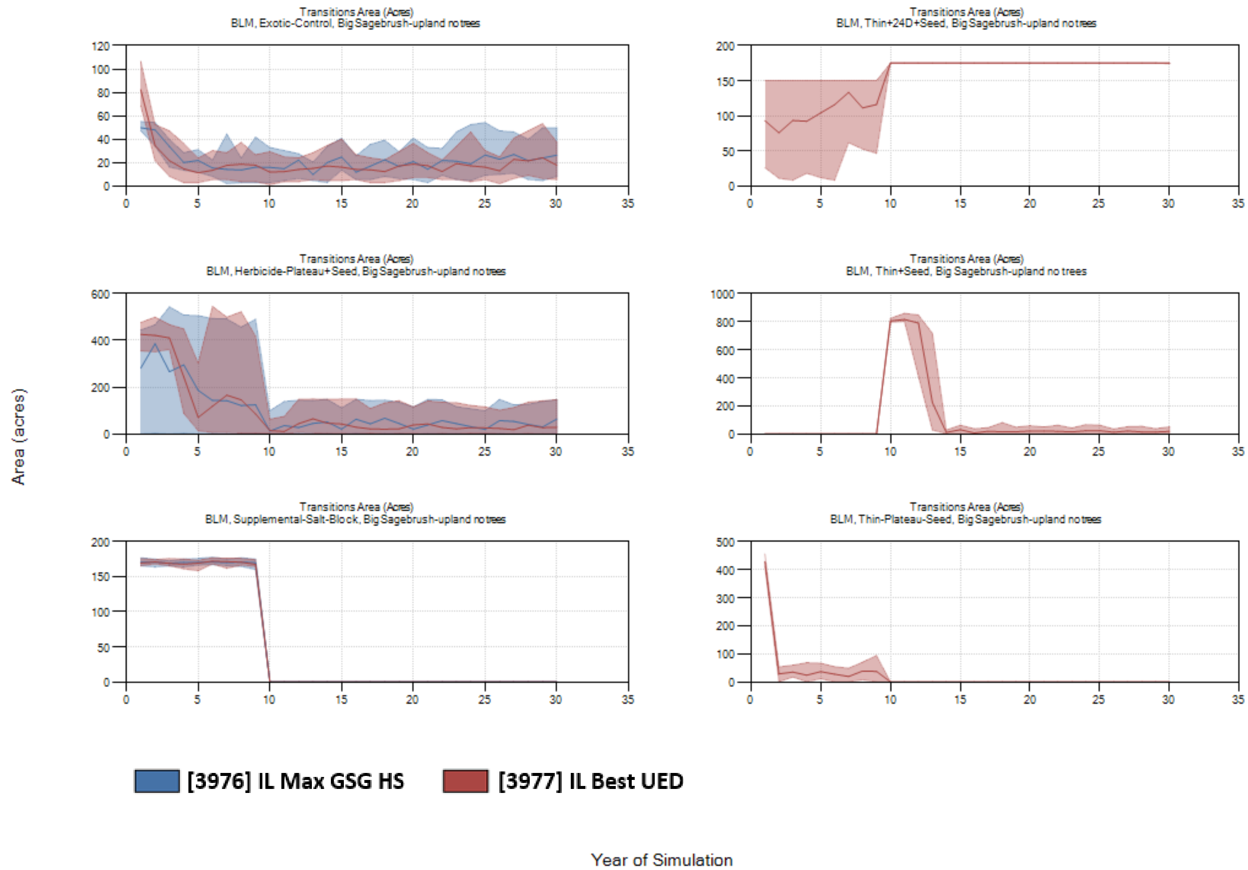


Figure 38. Realized yearly implementation rates for exotic control, herbicide-Plateau+seed, supplemental salt blocks, thin+24D+seed, thin+Plateau+seed, and thin+seed in the IL Ranch's big sagebrush-upland no trees for BLM lands. The dark line is the mean for each scenario (Max GSG Credit in blue and Best UED in red) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

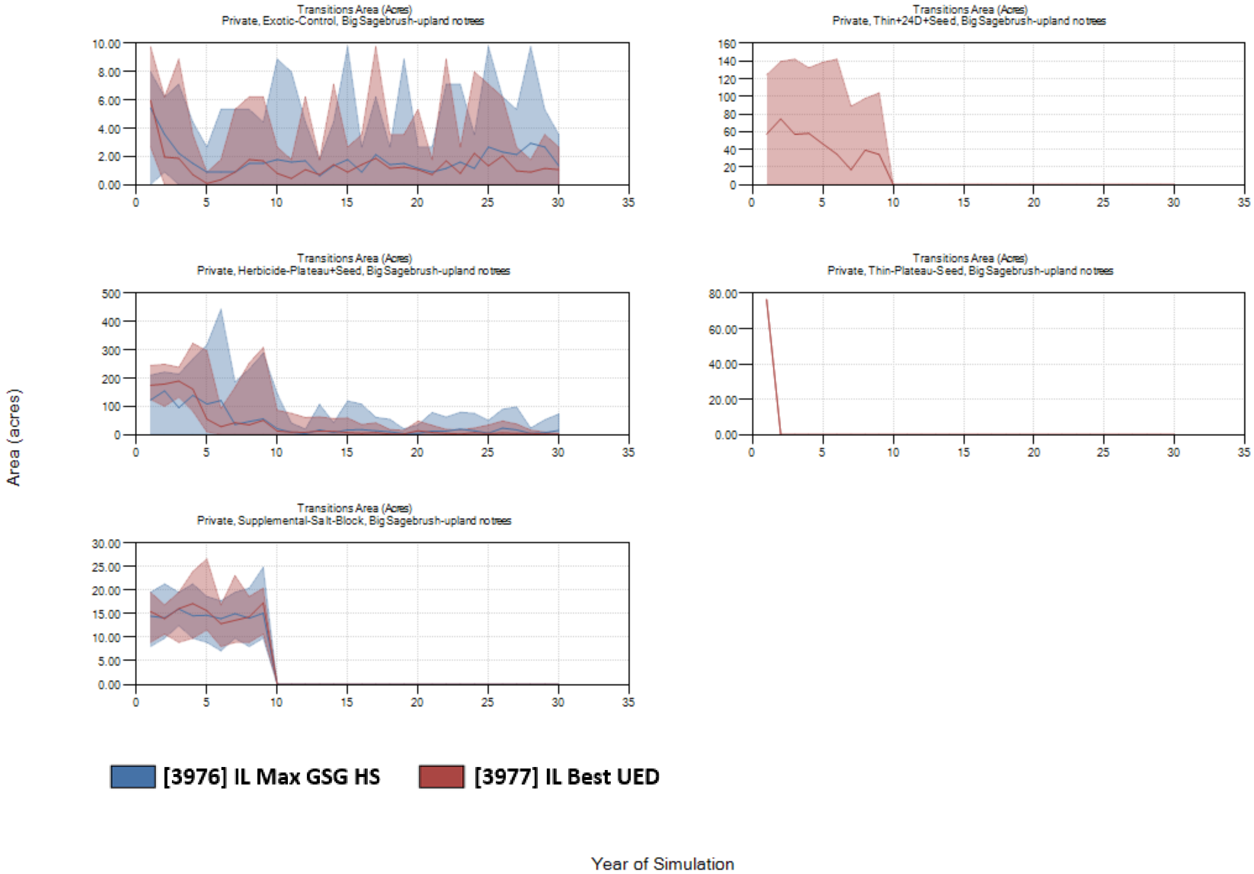


Figure 39. Realized yearly implementation rates for exotic control, herbicide-Plateau+seed, supplemental salt blocks, thin+24D+seed, and thin+Plateau+seed in the IL Ranch's big sagebrush-upland no trees for Newmont's private lands. The dark line is the mean for each scenario (Max GSG Credit in blue and Best UED in red) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

All scenarios lead to about equal decreases of UED (from 47% to about 31%) (table below). This result is due to the fact that the most abundant vegetation classes that determined UED were not treated and that natural processes account for a large part of UED improvement. For the sole purpose of decreasing UED, the MAX GSG HS MANAGEMENT scenario was not worth doing compared to the MINIMUM MANAGEMENT scenario because its negative ROI (i.e., doing nothing is better) overlapped with zero. The ROI for the BEST UED MANAGEMENT scenario was significantly, albeit only slightly, greater than zero because the ROI equation included system area in its denominator (small improvements in UED were made more important because of the large change to the entire system), thus it may be worth doing. Moreover, the BEST UED MANAGEMENT scenario's ROI was significantly greater than the ROI for the MAX GSG HS MANAGEMENT scenario.

System Acres: 398,660	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	**Best UED**	**Max GSG HS**
Unified Ecological Departure	47%	31% ± 1%	30% ± 2%	31% ± 2%
Cost			$2,824,034 ± 118,293	$757,178 ± 104,030

ROI - vs Minimum Mgmt			61	-16
ROI - 95% Confidence Interval			± 48	±46
ROI of single scenario >0?			Yes	No
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**Yes**	

Results of management actions by ownership and scenario are shown in Figures 40 (BLM) and 41 (Newmont private). Target classes were affected by scenarios as expected compared to Minimum Management with often a clear separation of the Best UED Management scenario from others (especially if the class was not targeted by Max GSG HS Management scenario). For sage-grouse habitat suitability, the Best UED Management scenario produced at least 4,000 acres more of older seedings used for sage-grouse nesting than the Max GSG HS Management scenario on BLM land (Figure 40), but to a much lesser amount for Newmont's private lands. The reduction of non-native annual species (U:Annual Spp) was remarkable in both cases with reductions as high as 4,000 and 2,000 acres, respectively, on BLM and Newmont's private lands.

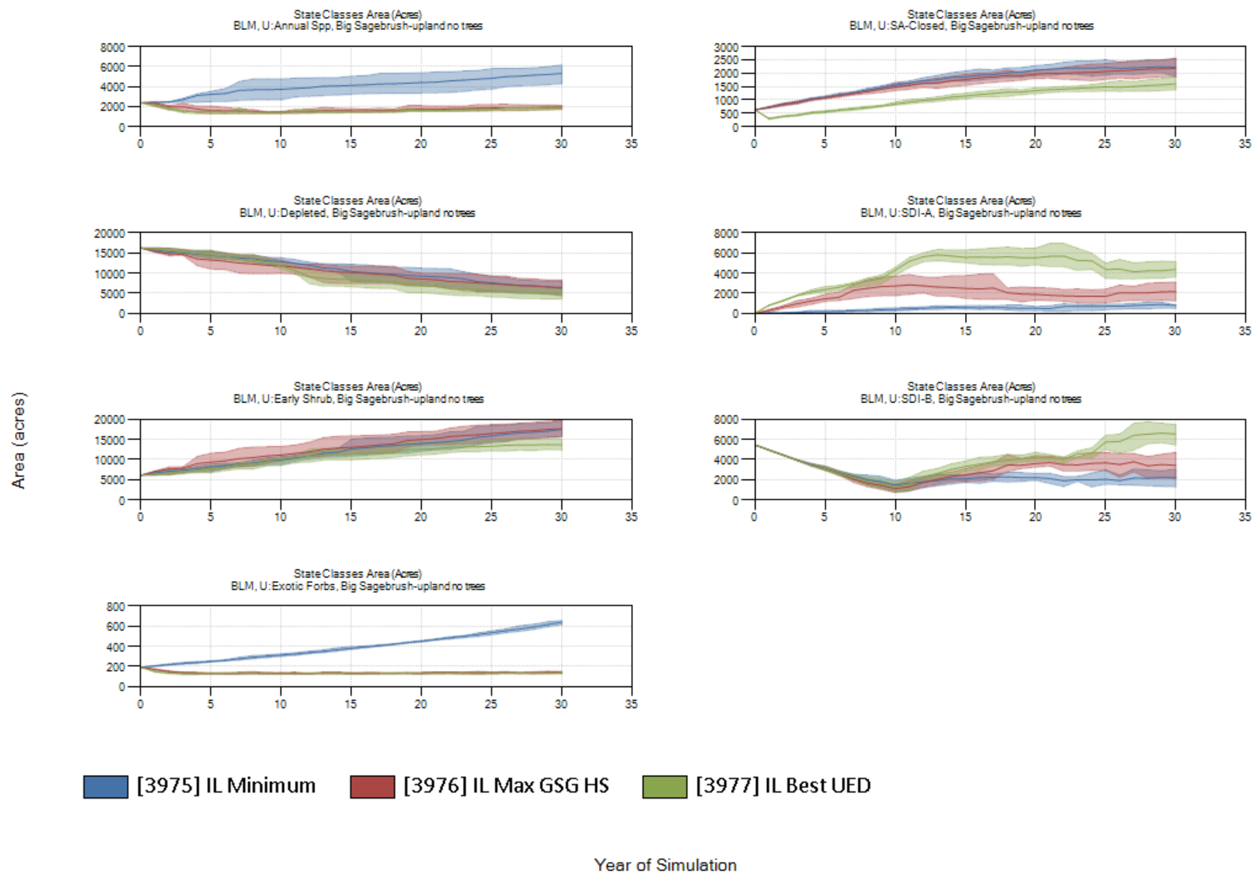


Figure 40. Area (acres) of seven big sagebrush-upland no trees state classes targeted for ecological improvement for all scenarios located on BLM lands of the IL Ranch: non-native annual species (U:Annual Spp), depleted sagebrush (U:Depleted), early-shrub dominated (U: Early-Shrub), shrub with non-native annual species (U:SA-Closed), dominated by exotic forbs (U:Exotic-Forb), and early-succession and mid-succession seedings (respectively, U:SDI-A and U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

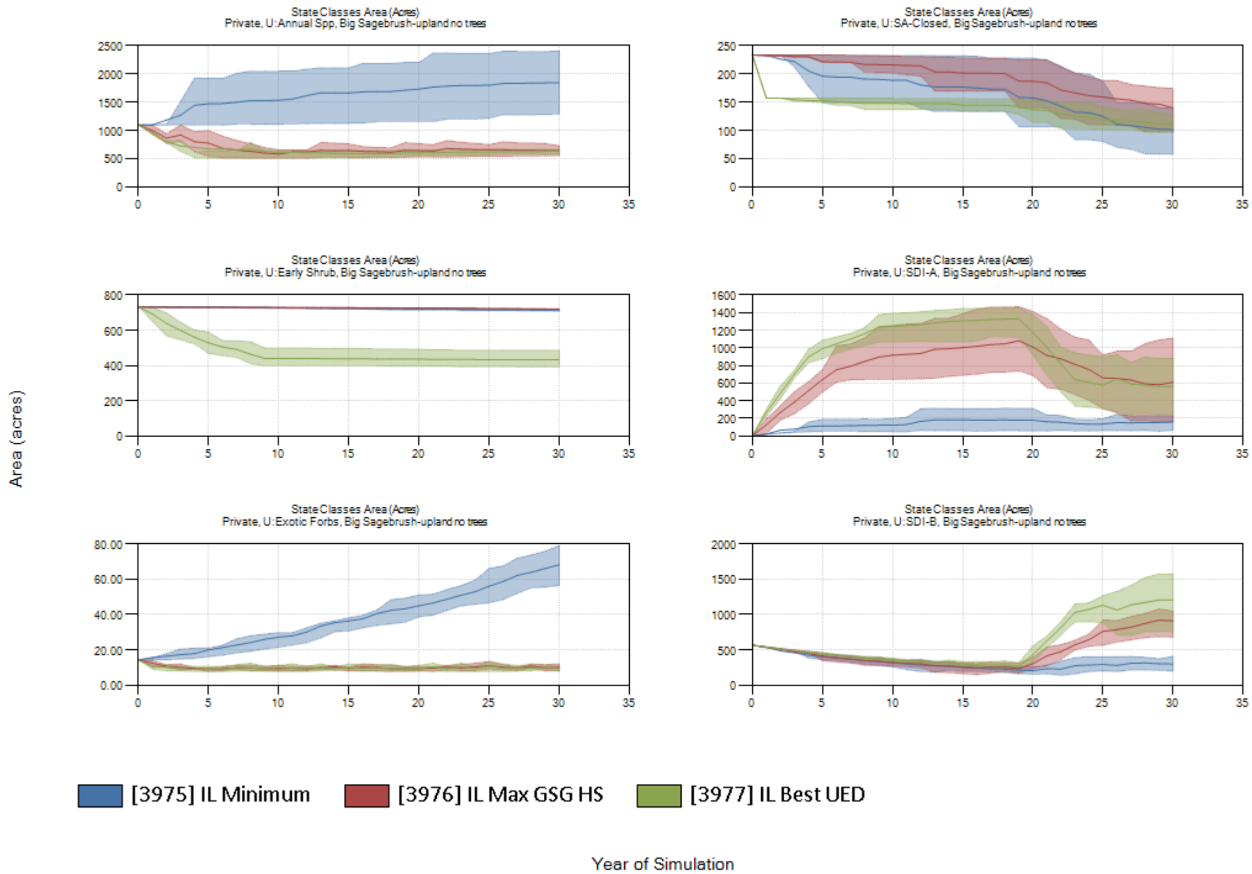


Figure 41. Area (acres) of six big sagebrush-upland no trees state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the IL Ranch: non-native annual species (U:Annual Spp), early-shrub dominated (U: Early-Shrub), shrub with non-native annual species (U:SA-Closed), dominated by exotic forbs (U:Exotic-Forb), and early-succession and mid-succession seedings (respectively, U:SDI-A and U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

<u>IL Ranch: Low Sagebrush</u>

More than 70% of the area in low sagebrush was occupied by reference classes (table below). On USFS lands, >90% of the area was reference classes. After 30 years of Minimum Management scenario, the primary change among reference classes was the maturation of the mid-succession class (2-Mid:Open) to the late-succession class (3-Late:Closed) for all ownerships. Alone, this trends causes a major decrease in UED (see later). This result representing a major shift of acres for a system with slow dynamics suggests that remote sensing mapped too much mid-succession low sagebrush that was truly more open-canopied late-succession low sagebrush, which does not correspond to the normal class description. The dominant uncharacteristic classes varied somewhat with ownership. On BLM land, the exotic forbs (U:Exotic Forb) and shrub with mixed non-native annual species and perennial grasses

(U:SAP) classes were dominant (>10% each) and increased only slightly over time. The non-native annual species class (U:Annual Spp) was practically non-existent in 2014 and increased to 0.9% of the area. On Newmont's private lands, the U:Exotic Forb and U:SAP classes were also the most abundant (>2%) uncharacteristic classes after 30 year of MINIMUM MANAGEMENT scenario, followed by the non-native annual species class (U:Annual Spp). On USFS lands, the only uncharacteristic class above 2% of the area was the U:SAP class after 30-years.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:All	12		350.5	7.7%	240.9	5.3%
	2-Mid:Open	78		2538.0	55.6%	1676.9	36.7%
	3-Late:Closed	10		661.8	14.5%	1447.2	31.7%
	U:Annual Spp			0.0	0.0%	41.5	0.9%
	U:ASPG			40.0	0.9%	8.2	0.2%
	U:Depleted			0.0	0.0%	59.8	1.3%
	U:Early Shrub			0.0	0.0%	10.4	0.2%
	U:Exotic Forbs			585.3	12.8%	589.3	12.9%
	U:SA			0.0	0.0%	5.0	0.1%
	U:SAP			387.0	8.5%	477.9	10.5%
	U:SDI-A			0.0	0.0%	0.0	0.0%
	U:SDI-B			0.0	0.0%	0.0	0.0%
	U:SDI-C			0.0	0.0%	0.0	0.0%
	U:Seeded Native			0.0	0.0%	0.0	0.0%
	U:SI-A+AS			0.0	0.0%	0.0	0.0%
	U:SI-B+AS			0.0	0.0%	0.0	0.0%
	U:SI-C+AS			0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb			2.7	0.1%	8.4	0.2%
Private	1-Early:All	12		114.8	5.6%	200.4	9.9%
	2-Mid:Open	78		1290.8	63.5%	926.4	45.6%
	3-Late:Closed	10		514.2	25.3%	733.5	36.1%
	U:Annual Spp			41.8	2.1%	51.5	2.5%
	U:ASPG			0.0	0.0%	2.8	0.1%
	U:Depleted			0.0	0.0%	0.0	0.0%
	U:Early Shrub			0.0	0.0%	0.0	0.0%
	U:Exotic Forbs			64.0	3.2%	64.9	3.2%
	U:SA			0.0	0.0%	0.0	0.0%
	U:SAP			0.9	0.0%	47.0	2.3%
	U:SDI-A			0.0	0.0%	0.0	0.0%
	U:SDI-B			0.0	0.0%	0.0	0.0%
	U:SDI-C			0.0	0.0%	0.0	0.0%
	U:Seeded Native			0.0	0.0%	0.0	0.0%
	U:SI-A+AS			0.0	0.0%	0.0	0.0%

	U:SI-B+AS		0.0	0.0%	0.0	0.0%
	U:SI-C+AS		0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb		5.3	0.3%	5.3	0.3%
USFS	1-Early:All	12	7.1	1.4%	41.7	8.5%
	2-Mid:Open	78	450.1	91.7%	295.3	60.1%
	3-Late:Closed	10	33.8	6.9%	138.2	28.1%
	U:Annual Spp		0.0	0.0%	1.3	0.3%
	U:ASPG		0.0	0.0%	0.5	0.1%
	U:Depleted		0.0	0.0%	0.0	0.0%
	U:Early Shrub		0.0	0.0%	0.0	0.0%
	U:Exotic Forbs		0.0	0.0%	0.0	0.0%
	U:SA		0.0	0.0%	0.0	0.0%
	U:SAP		0.0	0.0%	14.0	2.8%
	U:SDI-A		0.0	0.0%	0.0	0.0%
	U:SDI-B		0.0	0.0%	0.0	0.0%
	U:SDI-C		0.0	0.0%	0.0	0.0%
	U:Seeded Native		0.0	0.0%	0.0	0.0%
	U:SI-A+AS		0.0	0.0%	0.0	0.0%
	U:SI-B+AS		0.0	0.0%	0.0	0.0%
	U:SI-C+AS		0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb		0.0	0.0%	0.0	0.0%

Only two actions were used in low sagebrush on BLM and Newmont's private lands: exotic forb species control and control of non-native annual species (U:Annual Spp) with herbicide-Plateau+Seed. No treatments were applied to USFS lands. The BEST UED MANAGEMENT and MAX GSG HS MANAGEMENT scenarios were similar within any ownership due to the small need for restoration. The primary goal of restoration was to reduce the U:Annual Spp class; therefore, increasing sage-grouse nest success as sagebrush matures in seedings and preventing future fire. Exotic forb control was a standard range improvement practice, mostly directed at thistles.

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	MAX GSG HS	Exotic Control	40	20	$80	
		Herbicide + Plateau + Seed	0	40	$170	
						$68,045 ± $1,285
NEWMONT PRIVATE	MAX GSG HS	Exotic Control	10	10	$80	
		Herbicide + Plateau + Seed	40	0	$170	

						$10,992 ± $415
BLM	Best UED	Exotic Control	40	30	$80	
		Herbicide + Plateau + Seed	0	40	$170	
						$68,759 ± $1,700
Newmont Private	Best UED	Exotic Control	10	15	$80	
		Herbicide + Plateau + Native Seed	40	0	$295	
						$10,071 ± $371

Although both scenarios resulted in about the same implementation rates per ownership, the different initial conditions of vegetation classes resulted in different implementation rates of actions between BLM and Newmont's private lands (Figure 42). Exotic control persisted for the 30-year duration of simulations, whereas the application of herbicide-Plateau+seed was directed to certain periods where the non-native annual species class was present and sufficiently abundant to merit treatment.

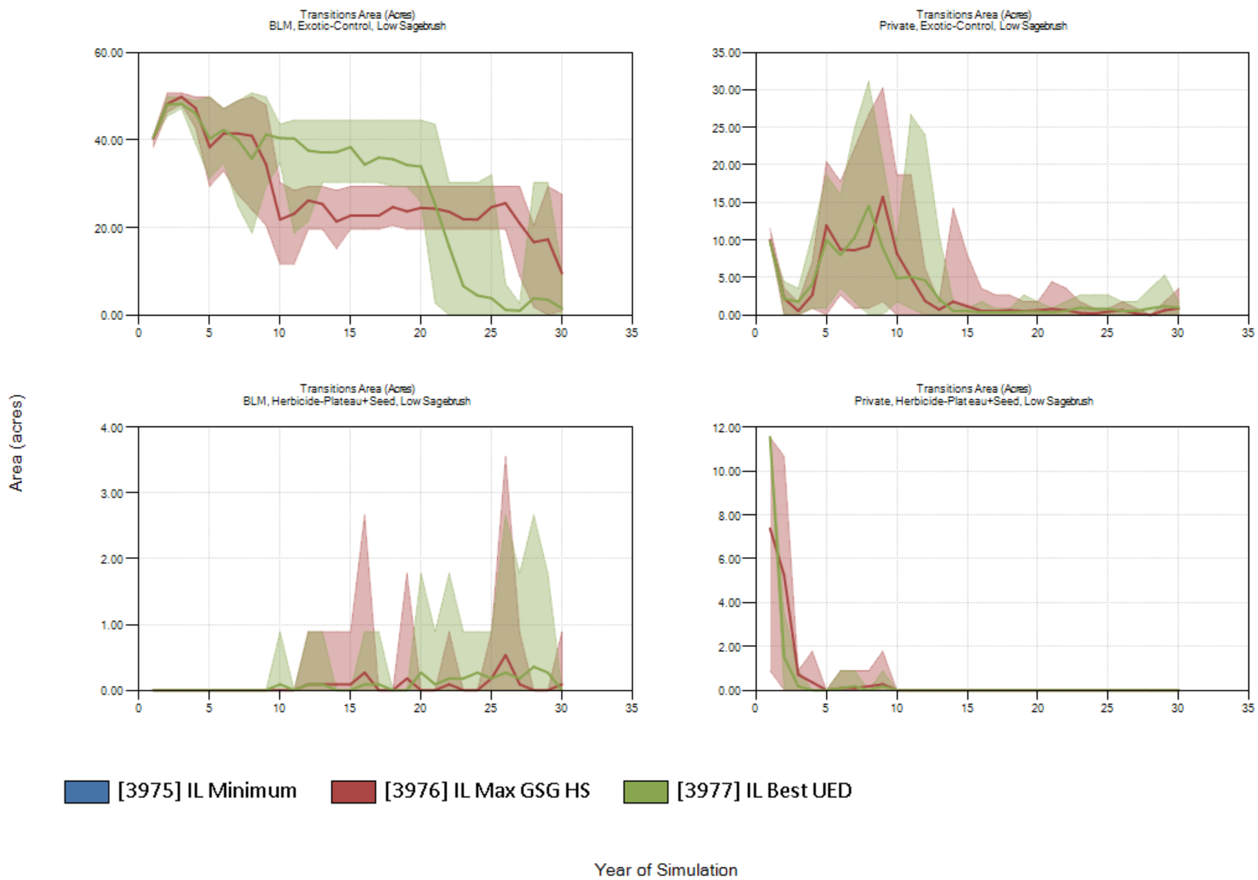


Figure 42. Realized yearly implementation rates for exotic control and herbicide-Plateau+seed in the IL Ranch's low sagebrush for BLM (first column of graphs) and Newmont's private (second column of graphs) lands._The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The MINIMUM MANAGEMENT scenario decreased UED from 47% in 2014 to about 35% in 30 years (table below). Both active management scenarios caused a decrease of UED to about comparable values (21%-22%). The ROIs for each active scenario were greater than zero (actually, the highest ROIs of any system) and, therefore, better than the no-action approach. The two scenarios were not statistically different.

System Acres: 6,908	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	**Best UED**	**MAX GSG HS**
Unified Ecological Departure	49%	35% ± 1%	21% ± 2%	22% ± 2%
Cost			$78,831 ± 1,554	$78,137 ± 1,577

ROI - vs Minimum Mgmt			100	92
ROI - 95% Confidence Interval			± 13	± 12
ROI of single scenario >0?			Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**No**	

Management actions substantially reduced the exotic forb class (U:Exotic Forb) on BLM and Newmont's private lands (Figure 43 and 44, lower left graph), however, the control of the non-native annual species class (U:Annual Spp) was more effective on Newmont's private lands than on BLM lands (figures 43 and 44, upper left graph). The recruitment of the mid-succession seeding class (U:SDI-B, lower right graph) used by sage-grouse for nesting was successful in both land ownerships.

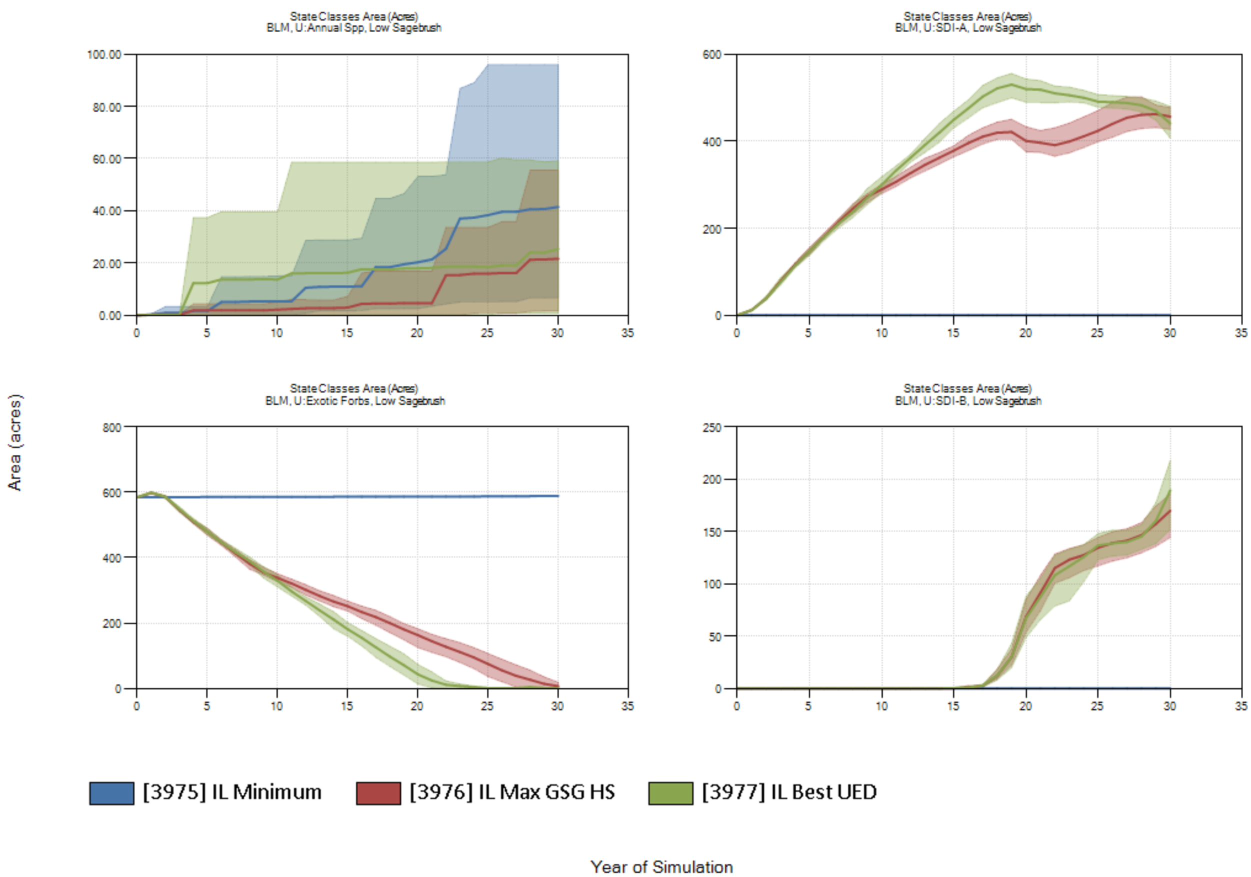


Figure 43. Area (acres) of four low sagebrush state classes targeted for ecological improvement for all scenarios located on BLM lands of the IL Ranch: non-native annual species (U:Annual Spp), depleted sagebrush (U:Depleted), exotic forbs (U:Exotic-Forb), and early-succession and mid-succession seedings (respectively, U:SDI-A and U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

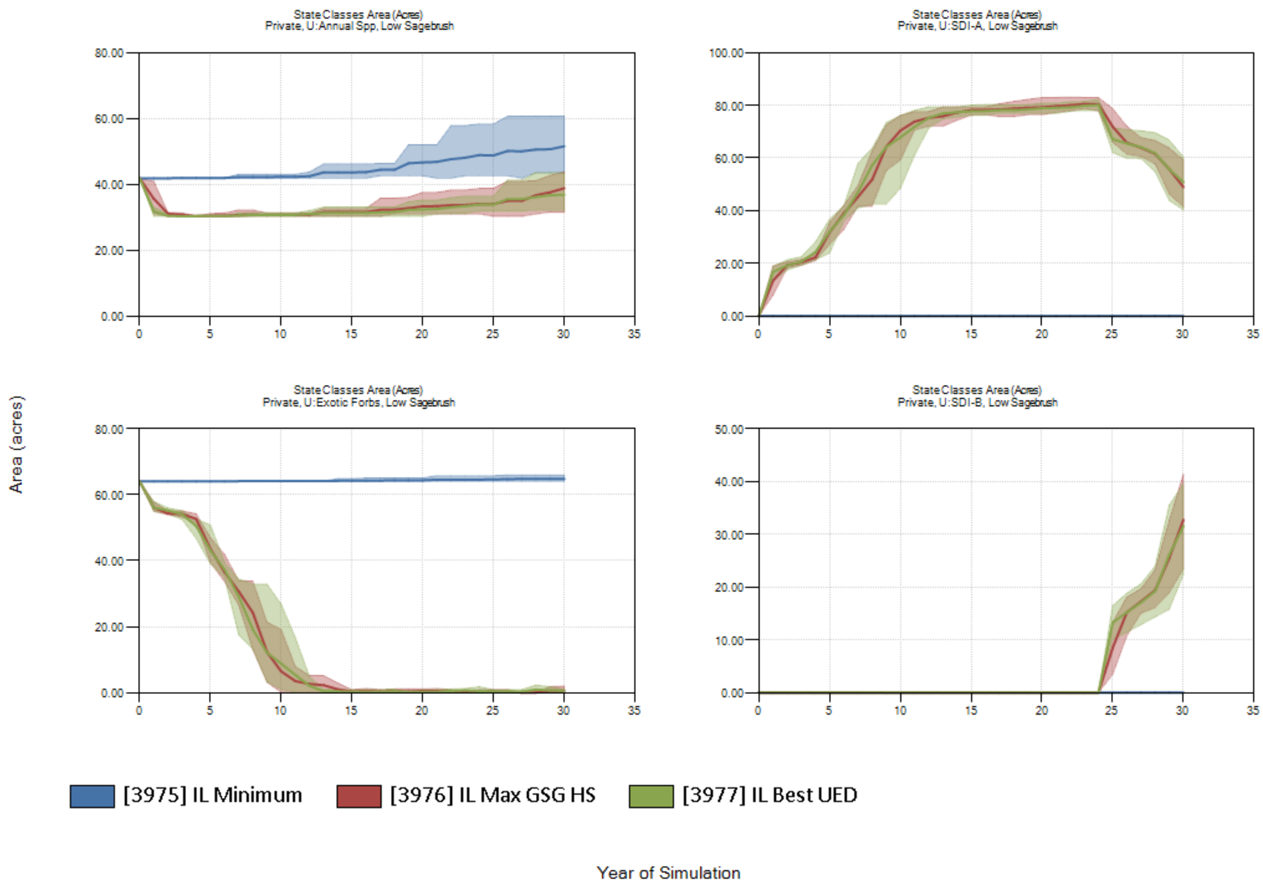


Figure 44. Area (acres) of four low sagebrush state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the IL Ranch: non-native annual species (U:Annual Spp), depleted sagebrush (U:Depleted), exotic forbs (U:Exotic-Forb), and early-succession and mid-succession seedings (respectively, U:SDI-A and U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

IL Ranch: Montane Riparian

During 30 years of the Minimum Management scenario, similar class changes occurred in all ownerships (table below). In decreasing order of importance, four processes primarily explained results: grazing by livestock and wild horses maintained or increased the abundance of early-succession reference classes by preventing willow development; grazing by livestock and wild horses increased the abundance of desertified and inset floodplain classes; exotic forb and tree invasion increased the abundance of all invaded classes; replacement fires decreased the amount of late-succession reference and uncharacteristic classes. These results suggest implementing actions for exotic control and grazing management of riparian areas.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:Cottonwood	0		2.7	0.6%	0.0	0.0%
	1-Early:Willow	33		212.6	44.0%	260.8	54.0%
	2-Mid:Cottonwood	0		0.0	0.0%	0.0	0.0%
	3-Late:Cottonwood	0		0.0	0.0%	1.6	0.3%
	3-Late:Willow	66		89.8	18.6%	10.7	2.2%
	PointBar:Bare Ground	1		113.9	23.6%	113.9	23.6%
	U:Annual Spp			0.9	0.2%	0.9	0.2%
	U:Desertified			0.9	0.2%	0.0	0.0%
	U:Early Shrub			0.0	0.0%	0.5	0.1%
	U:Exotic Forb&Tree			0.0	0.0%	27.6	5.7%
	U:Incised-EFT			0.0	0.0%	0.3	0.1%
	U:Inset-A			0.0	0.0%	31.1	6.4%
	U:Inset-B			62.3	12.9%	10.5	2.2%
	U:Inset-EFT			0.0	0.0%	5.8	1.2%
	U:Inset-HU			0.0	0.0%	0.6	0.1%
	U:Inset-SFE			0.0	0.0%	14.2	2.9%
	U:Pasture			0.0	0.0%	0.0	0.0%
	U:SAP			0.0	0.0%	0.0	0.0%
	U:SDI			0.0	0.0%	0.0	0.0%
	U:SDI+AS			0.0	0.0%	0.0	0.0%
	U:Shrb-Frb Encr			0.0	0.0%	4.5	0.9%
Private	1-Early:Cottonwood	0		0.0	0.0%	0.0	0.0%
	1-Early:Willow	33		255.3	10.9%	539.9	23.0%
	2-Mid:Cottonwood	0		0.0	0.0%	0.0	0.0%
	3-Late:Cottonwood	0		0.0	0.0%	0.0	0.0%
	3-Late:Willow	66		539.1	23.0%	214.0	9.1%
	PointBar:Bare Ground	1		13.3	0.6%	13.3	0.6%
	U:Annual Spp			124.5	5.3%	108.5	4.6%
	U:Desertified			166.4	7.1%	74.6	3.2%
	U:Early Shrub			0.0	0.0%	33.8	1.4%
	U:Exotic Forb&Tree			3.6	0.2%	75.3	3.2%
	U:Incised-EFT			0.0	0.0%	25.9	1.1%
	U:Inset-A			0.0	0.0%	703.5	30.0%
	U:Inset-B			1242.7	53.0%	120.0	5.1%
	U:Inset-EFT			0.0	0.0%	130.0	5.5%
	U:Inset-HU			0.0	0.0%	2.2	0.1%
	U:Inset-SFE			0.0	0.0%	287.1	12.2%
	U:Pasture			0.0	0.0%	0.0	0.0%
	U:SAP			0.0	0.0%	13.1	0.6%
	U:SDI			0.0	0.0%	0.0	0.0%

	U:SDI+AS		0.0	0.0%	0.0	0.0%
	U:Shrb-Frb Encr		1.8	0.1%	5.4	0.2%
USFS	1-Early:Cottonwood	0	0.0	0.0%	0.0	0.0%
	1-Early:Willow	33	96.1	23.4%	184.3	44.9%
	2-Mid:Cottonwood	0	0.0	0.0%	0.0	0.0%
	3-Late:Cottonwood	0	0.0	0.0%	0.0	0.0%
	3-Late:Willow	66	294.5	71.8%	175.2	42.7%
	PointBar:Bare Ground	1	0.0	0.0%	0.0	0.0%
	U:Annual Spp		0.0	0.0%	0.0	0.0%
	U:Desertified		0.0	0.0%	0.0	0.0%
	U:Early Shrub		0.0	0.0%	0.0	0.0%
	U:Exotic Forb&Tree		0.0	0.0%	29.8	7.3%
	U:Incised-EFT		0.0	0.0%	0.0	0.0%
	U:Inset-A		0.0	0.0%	10.1	2.5%
	U:Inset-B		19.6	4.8%	1.4	0.3%
	U:Inset-EFT		0.0	0.0%	2.1	0.5%
	U:Inset-HU		0.0	0.0%	0.4	0.1%
	U:Inset-SFE		0.0	0.0%	5.6	1.4%
	U:Pasture		0.0	0.0%	0.0	0.0%
	U:SAP		0.0	0.0%	0.0	0.0%
	U:SDI		0.0	0.0%	0.0	0.0%
	U:SDI+AS		0.0	0.0%	0.0	0.0%
	U:Shrb-Frb Encr		0.0	0.0%	1.2	0.3%

Only the early-succession willow (1-Early:Willow) contributes to chick survival. Therefore, no specific management action was used in the MAX GSG HS MANAGEMENT scenario except the standard ranch practice of controlling exotic forbs and trees in montane riparian systems (table below).

To improve UED (BEST UED MANAGEMENT scenario) within the confines of a small budget, exotic control was supplemented with the creation of riparian grazing pastures that limit the duration of livestock grazing access to montane riparian systems (i.e., fencing). This second scenario was, therefore, about five times more expensive on Newmont's private land than BLM lands.

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	MAX GSG	Exotic Control	2	1	$80	
		Weed Inventory + Spot Treatment	100	100	$50	
						$58,669 ± $5,968
NEWMONT PRIVATE	MAX GSG	Exotic Control	10	4	$80	
		Weed Inventory + Spot Treatment	100	100	$50	
						$217,679 ± $12,226
BLM	BEST UED	Exotic Control	2	2	$80	
		Livestock Grazing Control	50	0	$350	
		Weed Inventory + Spot Treatment	100	100	$50	
						$69,901 ± $6,672
NEWMONT PRIVATE	BEST UED	Exotic Control	10	4	$80	
		Livestock Grazing Control	175	0	$350	
		Weed Inventory + Spot Treatment	100	100	$50	
						$248,275 ± $13,839

As seen in Figure 45, realized rates closely matched planned rates of implementation.

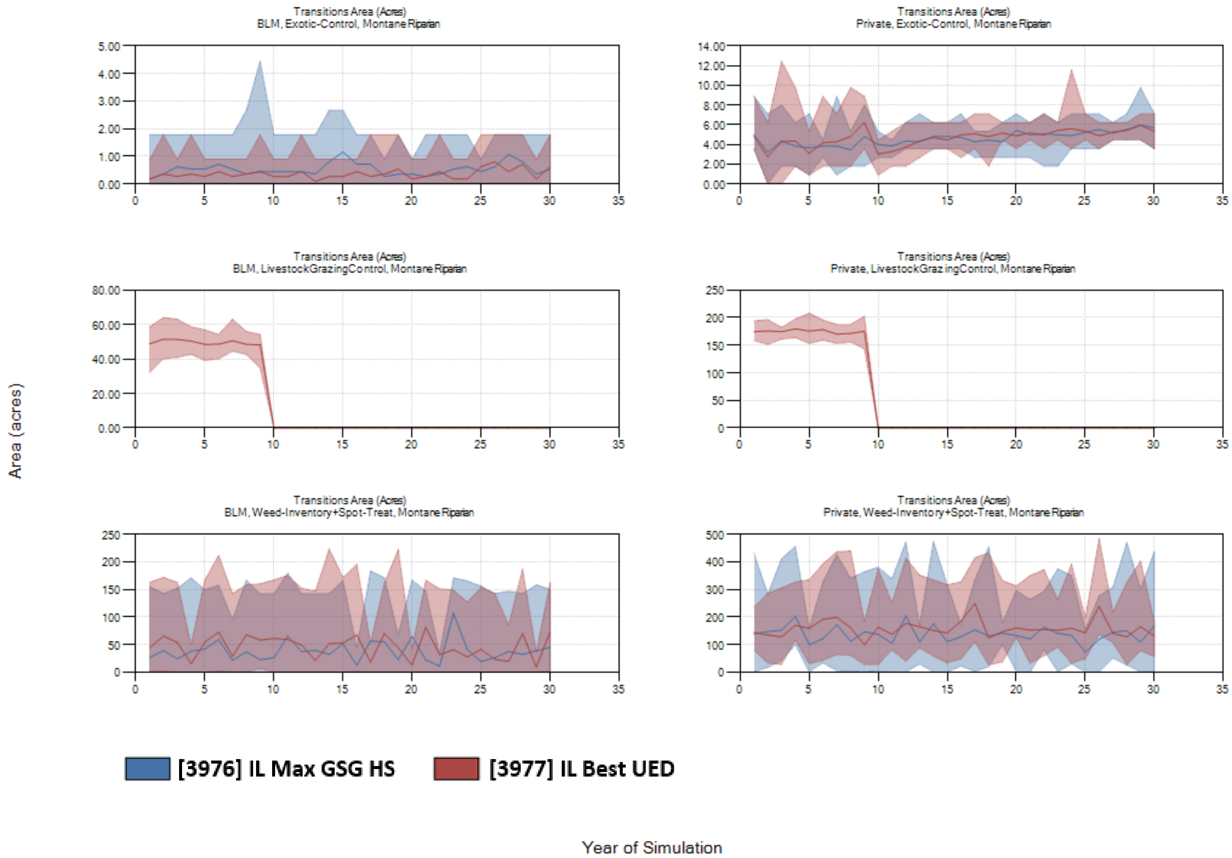


Figure 45. Realized yearly implementation rates for exotic control, livestock grazing control, and weed inventory supplemented with spot herbicide treatment in the IL Ranch's montane riparian for BLM (first column of graphs) and Newmont's private (second column of graphs) lands. The dark line is the mean for each scenario (Max GSG Credit in blue and Best UED in red) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The Minimum Management scenario increased UED from 58% in 2014 to about 75% in 30 years (table below). Compared to Minimum Management scenario, both active scenario improved UED; 66% for Max GSG HS Management scenario and 53% for Best UED Management scenario, respectively. Only the Best UED Management scenario had a lower UED (53%) compared to current UED (58%). The ROIs for each active scenario were greater than zero and, therefore, better than doing nothing. The ROI for the Best UED Management scenario was about twice that of the Max GSG HS Management scenario and 95% CIs did not overlap. Therefore, restoring montane riparian by lowering UED using fenced riparian pastures while controlling noxious weeds was worth the additional investment.

System Acres: 3,234	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	Best UED	MAX GSG HS
Unified Ecological Departure	58%	75% ± 2%	53% ± 2%	66% ± 3%
Cost			$359,075 ± 12,080	$311,030 ± 14,605

ROI - vs Minimum Mgmt		17	7
ROI - 95% Confidence Interval		± 1	± 1
ROI of single scenario >0?		Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →		**Yes**	

There were too many vegetation classes in the montane riparian to include here. Six informative classes are presented in Figures 46 and 47. The primary results that distinguished the MAX GSG HS MANAGEMENT scenario from the MINIMUM MANAGEMENT scenario were the exotic forbs and trees (U:Exotic Forb & Tree) and the inset floodplain invaded by exotic forbs and trees (U:Inset-EFT) classes (shown in red boxes). These figures show that both active scenarios reduced noxious species abundance compared the MINIMUM MANAGEMENT scenario (Figures 46 and 47). In other graphs, the MAX GSG HS MANAGEMENT scenario results were not different from those of the MINIMUM MANAGEMENT scenario. In all other graphs, the MAX GSG HS MANAGEMENT scenario results (shown in red) were different and contributed to reducing UED, including allowing the growth of the early-succession willow class (1-Early:Willow) into the late-succession willow class (3-Late:Willow).

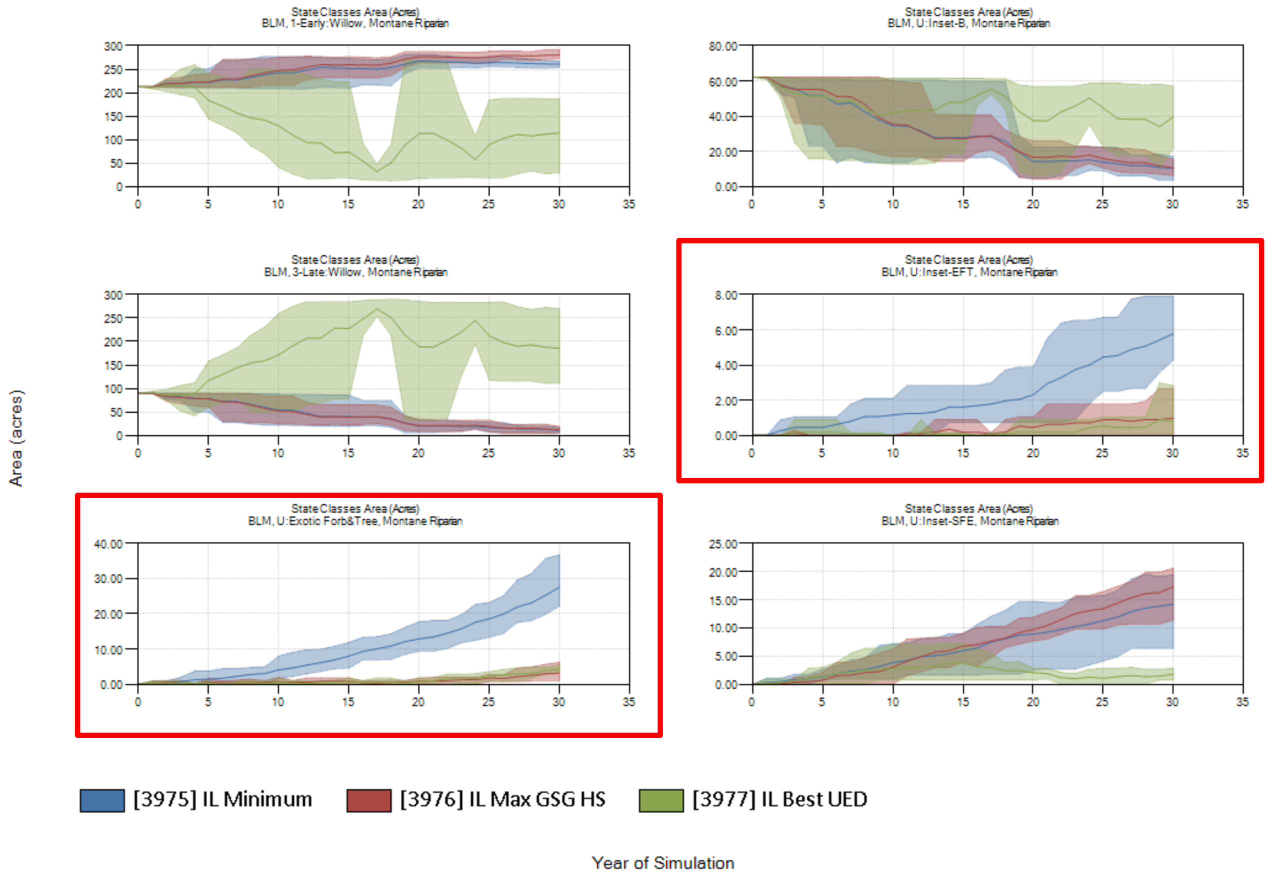


Figure 46. Area (acres) of six montane riparian state classes targeted for ecological improvement for all scenarios located on BLM lands of the IL Ranch: Early-succession and late-succession willow (respectively, 1-Early:Willow and 3-Late:Willow), exotic forbs and trees (U:Exotic-Forb & Tree), late-succession inset floodplain (U:Inset-B), inset floodplain with exotic forbs and trees (U:Inset-EFT), and inset floodplain encroached by forbs and shrubs (U:Inset-SFE). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates. The red boxes highlight the two classes which contributed the greatest differences between Minimum Management and Max GSG HS Management scenarios.

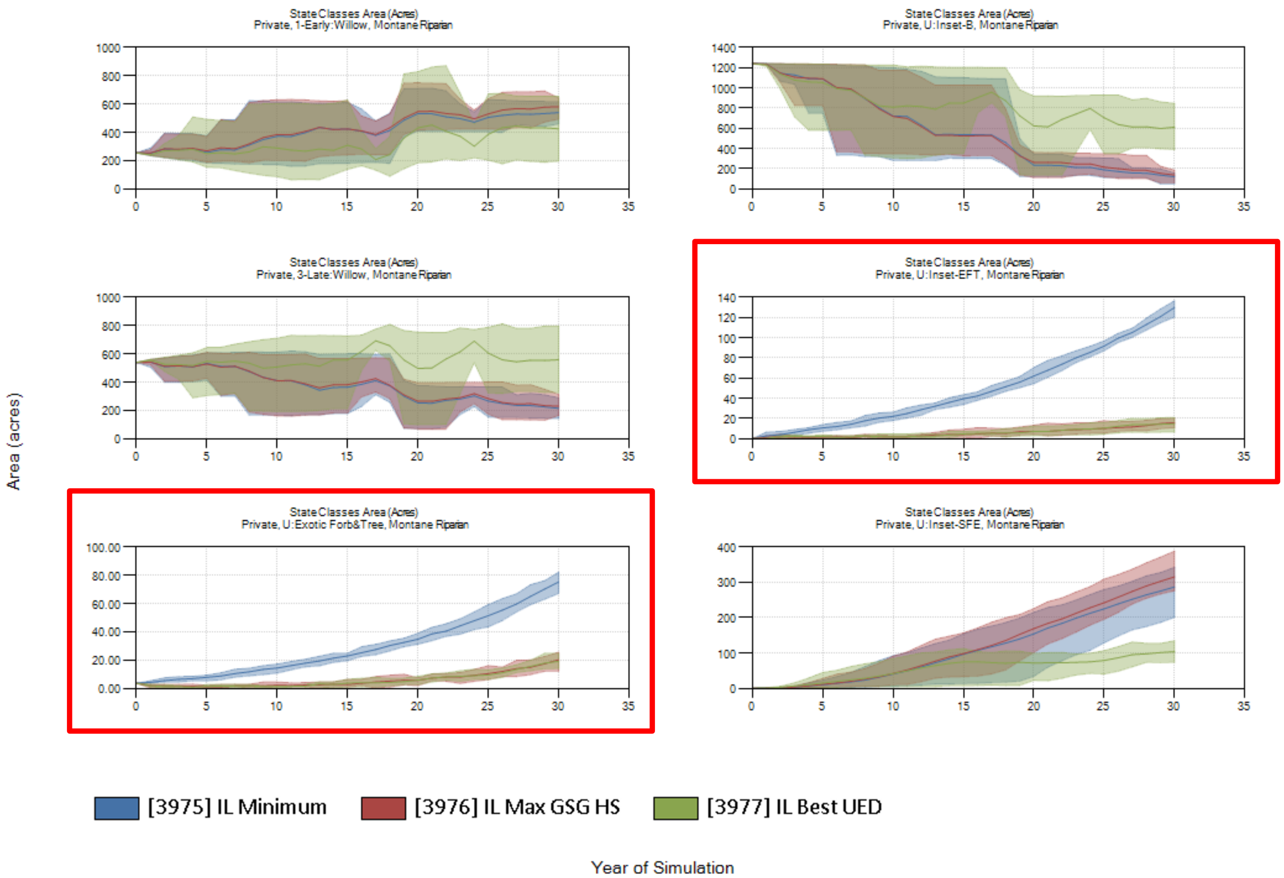


Figure 47. Area (acres) of six montane riparian state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the IL Ranch: Early-succession and late-succession willow (respectively, 1-Early:Willow and 3-Late:Willow), exotic forbs and trees (U:Exotic-Forb & Tree), late-succession inset floodplain (U:Inset-B), inset floodplain with exotic forbs and trees (U:Inset-EFT), and inset floodplain encroached by forbs and shrubs (U:Inset-SFE). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates. The red boxes highlight the two classes which contributed the greatest differences between MINIMUM MANAGEMENT and MAX GSG HS MANAGEMENT scenarios.

IL Ranch: Montane Sagebrush Steppe – Upland

Montane sagebrush steppe ranked relatively low UED compared to other systems because the current or future MINIMUM MANAGEMENT scenario vegetation class proportions for each ownership were close to the reference condition (table below). The greatest departure was on BLM lands where the early-succession class (1-Early:All) was about at a 10% deficit from reference. The dominant uncharacteristic classes with mixed non-native annual species and perennial grasses (U:ASPG and U:SAP) or dominated by unpalatable forbs (mule-ears) were not treated, but can represent between 10%-20% total of the system. The non-native annual species class (U:Annual Spp) showed a modest increase from 0% to about 5% in each ownership and could warrant restoration if accessible by equipment.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:All	25		118.3	1.4%	1014.9	11.8%
	2-Mid:Open	48		2580.7	30.0%	2912.8	33.8%
	3-Late:Closed	26		4059.1	47.1%	2316.5	26.9%
	4-Late:Dense	1		14.2	0.2%	23.7	0.3%
	U:Annual Spp			0.0	0.0%	466.6	5.4%
	U:ASPG			13.3	0.2%	385.3	4.5%
	U:Depleted			0.0	0.0%	2.8	0.0%
	U:Early Shrub			0.0	0.0%	21.9	0.3%
	U:Exotic Forbs			0.0	0.0%	6.9	0.1%
	U:SA-Closed			25.8	0.3%	11.7	0.1%
	U:SA-Dense			0.0	0.0%	0.0	0.0%
	U:SAP-Closed			1185.8	13.8%	828.7	9.6%
	U:SAP-Dense			0.0	0.0%	5.6	0.1%
	U:SDI-A		3.2	0.0	0.0%	0.0	0.0%
	U:SDI-B		4.4	0.0	0.0%	0.0	0.0%
	U:SDI-C		2.3	0.0	0.0%	0.0	0.0%
	U:SDI-D		0.2	0.0	0.0%	0.0	0.0%
	U:Seeded Native			0.0	0.0%	0.0	0.0%
	U:SI-A+AS			0.0	0.0%	0.0	0.0%
	U:SI-B+AS			0.0	0.0%	0.0	0.0%
	U:SI-C+AS			0.0	0.0%	0.0	0.0%
	U:SI-D+AS			0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb			613.8	7.1%	613.8	7.1%
Private	1-Early:All	25		590.7	2.9%	2758.4	13.6%
	2-Mid:Open	48		6755.5	33.3%	7026.5	34.6%
	3-Late:Closed	26		8962.5	44.2%	5285.8	26.1%
	4-Late:Dense	1		0.9	0.0%	54.5	0.3%
	U:Annual Spp			0.0	0.0%	956.2	4.7%
	U:ASPG			24.9	0.1%	691.4	3.4%
	U:Depleted			0.0	0.0%	0.0	0.0%
	U:Early Shrub			0.0	0.0%	40.4	0.2%
	U:Exotic Forbs			0.0	0.0%	23.7	0.1%
	U:SA-Closed			38.3	0.2%	6.6	0.0%
	U:SA-Dense			0.0	0.0%	0.1	0.0%
	U:SAP-Closed			2080.7	10.3%	1606.5	7.9%
	U:SAP-Dense			0.0	0.0%	7.8	0.0%
	U:SDI-A		3.2	0.0	0.0%	33.0	0.2%

	U:SDI-B		4.4	149.4	0.7%	59.3	0.3%
	U:SDI-C		2.3	0.0	0.0%	53.3	0.3%
	U:SDI-D		0.2	0.0	0.0%	0.0	0.0%
	U:Seeded Native			0.0	0.0%	0.0	0.0%
	U:SI-A+AS			0.0	0.0%	0.1	0.0%
	U:SI-B+AS			0.0	0.0%	0.6	0.0%
	U:SI-C+AS			1.8	0.0%	0.4	0.0%
	U:SI-D+AS			0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb			1684.0	8.3%	1684.0	8.3%
USFS	1-Early:All	25		315.8	3.6%	1114.6	12.9%
	2-Mid:Open	48		4495.9	51.9%	3953.5	45.6%
	3-Late:Closed	26		3715.8	42.9%	2841.5	32.8%
	4-Late:Dense	1		30.2	0.3%	26.6	0.3%
	U:Annual Spp			0.0	0.0%	71.9	0.8%
	U:ASPG			0.0	0.0%	48.5	0.6%
	U:Depleted			0.0	0.0%	0.0	0.0%
	U:Early Shrub			0.0	0.0%	3.6	0.0%
	U:Exotic Forbs			0.0	0.0%	1.5	0.0%
	U:SA-Closed			0.0	0.0%	0.0	0.0%
	U:SA-Dense			0.0	0.0%	0.0	0.0%
	U:SAP-Closed			0.0	0.0%	493.5	5.7%
	U:SAP-Dense			0.0	0.0%	2.6	0.0%
	U:SDI-A		3.2	0.0	0.0%	0.0	0.0%
	U:SDI-B		4.4	0.0	0.0%	0.0	0.0%
	U:SDI-C		2.3	0.0	0.0%	0.0	0.0%
	U:SDI-D		0.2	0.0	0.0%	0.0	0.0%
	U:Seeded Native			0.0	0.0%	0.0	0.0%
	U:SI-A+AS			0.0	0.0%	0.0	0.0%
	U:SI-B+AS			0.0	0.0%	0.0	0.0%
	U:SI-C+AS			0.0	0.0%	0.0	0.0%
	U:SI-D+AS			0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb			107.6	1.2%	107.6	1.2%

Actions that were applied to montane sagebrush steppe were either designed to increase the long-term resilience and condition of high-suitability sage-grouse habitat with supplemental salt blocks (see Big sagebrush-upland no trees) or eventually convert small amounts of uncharacteristic vegetation classes into more resilient vegetation or vegetation usable for nesting and late brood-rearing by sage-grouse (table below for planned implementation rates). Actions used were exotic control for exotic forbs (U:Exotic Forb), herbicide-Plateau+seed for non-native annual species (U:Annual Spp), masticate+Plateau+native-seed for depleted (U:Depleted), and shrubs with non-native annual species (U:SA-Closed and U:SA-Dense), and Spike+Plateau+seed for the latter two classes.

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	Max GSG HS	Exotic Control	0	5	$80	
		Herbicide + Plateau + Seed	50	100	$170	
		Masticate + Plateau + Native Seed	0	40	$600	
		Supplemental Salt Block	25	0	$20	
						$42,313 ± 7,839
Newmont Private	Max GSG HS	Exotic Control	0	5	$80	
		Herbicide + Plateau + Seed	50	200	$170	
		Supplemental Salt Block	25	0	$20	
						$86,619 ± $13,201
USFS	Max GSG HS	Exotic Control	0	5	$80	
		Herbicide + Plateau + Seed	0	50	$170	
		Supplemental Salt Block	9	0	$20	
						$3,322 ± 514
BLM	Best UED	Exotic Control	0	5	$80	
		Herbicide + Plateau + Seed	50	100	$170	
		Supplemental salt Blocks	25	0	$20	
		Masticate + Plateau + Native Seed	0	40	$600	
		Spike + Plateau + Seed	0	60	$125	
						$47,936 ± $6,615
Newmont Private	Best UED	Exotic Control	0	5	$80	
		Herbicide + Plateau + Seed	50	200	$170	
		Supplemental salt Blocks	25	0	$20	
		Spike + Plateau + Seed	30	0	$125	
						$86,231 ± $12,047
USFS	Best UED	Exotic Control	0	5	$80	
		Herbicide + Plateau + Seed	0	50	$170	
		Supplemental Salt Block	9	0	$20	
						$3,626 ± 615

The realized implementation rates of actions are shown in Figures 48-50. The supplemental salt block action was closest to the planned implementation rate, whereas the rates of other actions were more variable because only small areas of each vegetation class were available for treatment or became sporadically available. Also, the herbicide-Plateau+seed and

Spike+Plateau+seed actions could not be implemented on slopes >15%. For example, no area was available due to steep slopes for the Spike+Plateau+seed treatment on Newmont's private lands although the 30 acres per year could have been implemented during the first 10 years.

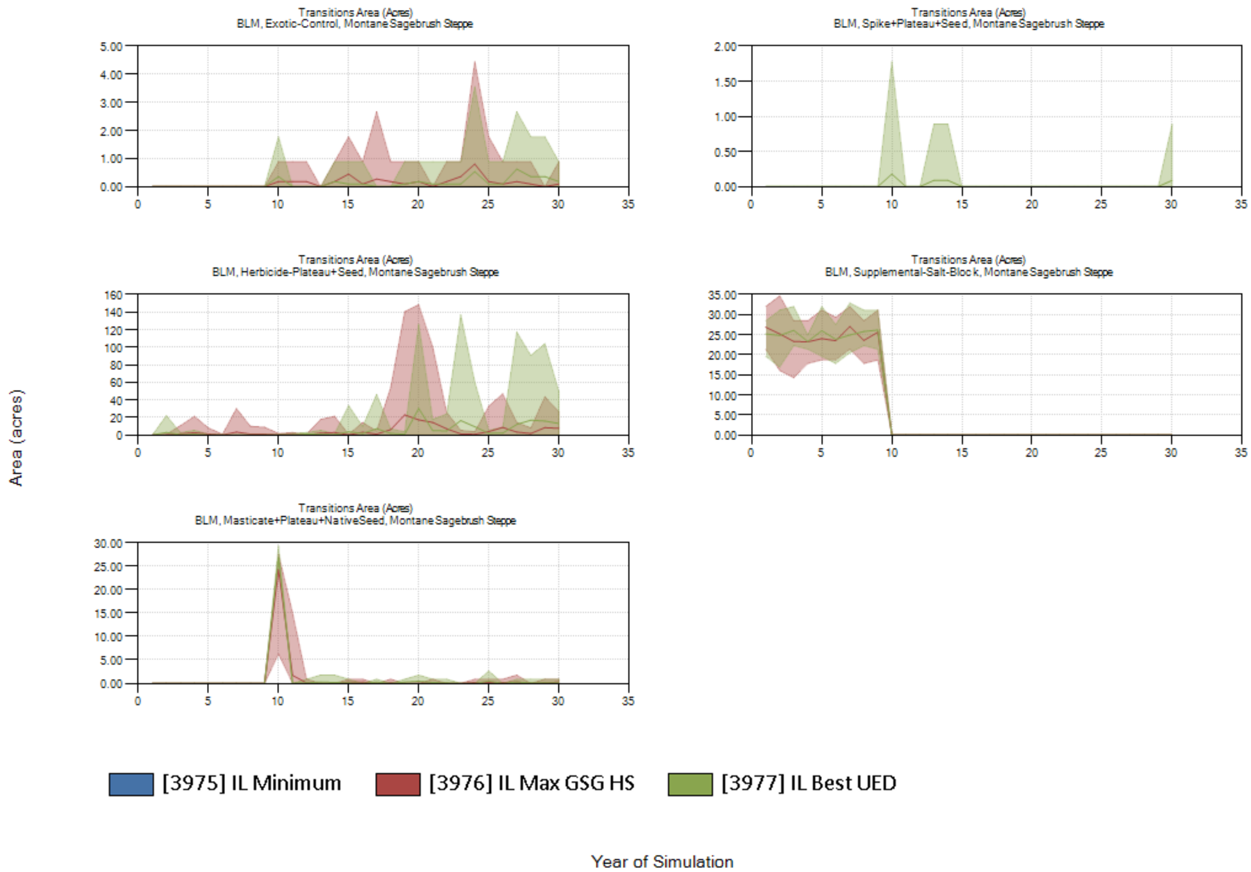


Figure 48. Realized yearly implementation rates for exotic control, herbicide-Plateau+seed, masticate+Plateau+native-seed, Spike+Plateau+seed, and supplemental salt blocks in the IL Ranch's montane sagebrush steppe for BLM lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

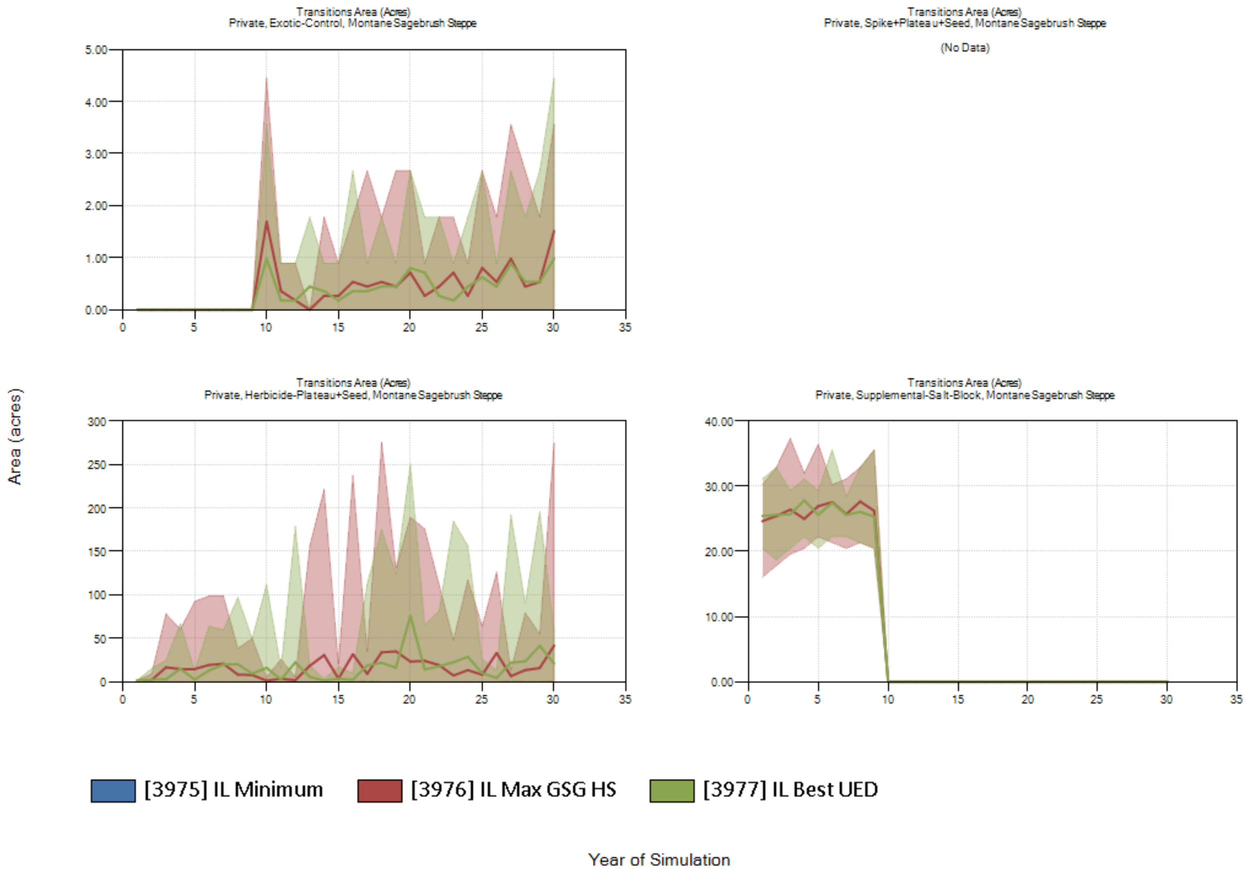


Figure 49. Realized yearly implementation rates for exotic control, herbicide-Plateau+seed, Spike+Plateau+seed, and supplemental salt blocks in the IL Ranch's montane sagebrush steppe for Newmont's private lands. Note that no area of Montane Sagebrush Steppe was treated by the Spike+Plateau+seed due to steep slopes precluding this action. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

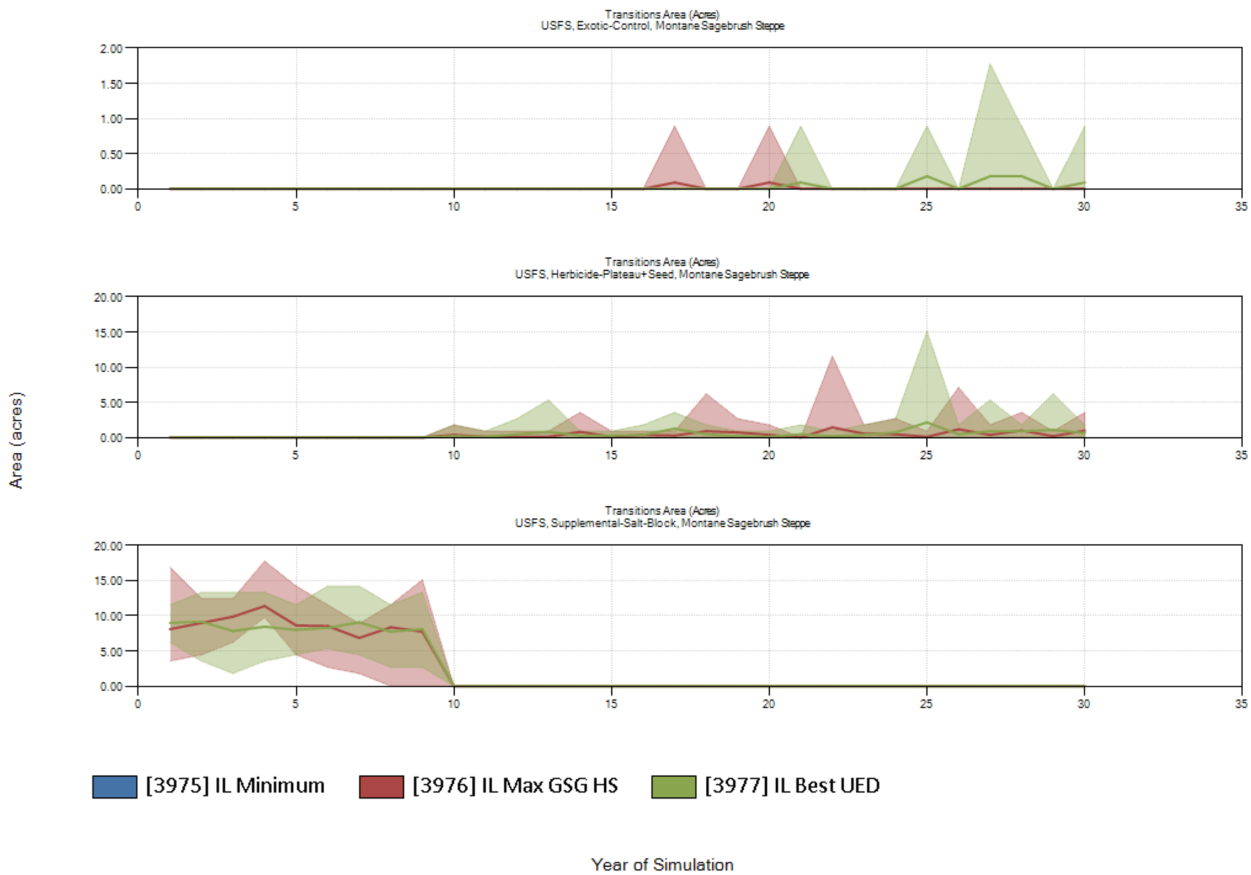


Figure 50. Realized yearly implementation rates for exotic control, herbicide-Plateau+seed, and supplemental salt blocks in the IL Ranch's montane sagebrush steppe for USFS lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The MINIMUM MANAGEMENT scenario slightly improved UED from 38% in 2014 to about 33% in 30 years (table below). Compared to the 33% for MINIMUM MANAGEMENT scenario, both active scenarios did not cause a significant decrease of UED to 30% for MAX GSG HS MANAGEMENT scenario and 31% for BEST UED MANAGEMENT scenario. The ROIs for each active scenario were greater than zero and, therefore, better than doing nothing. Although the ROI for the MAX GSG HS MANAGEMENT scenario (62) appeared greater than that of the BEST UED MANAGEMENT scenario (46), the overlapping 95% CIs indicated no statistical difference between ROIs. Since ROIs are statistically equal, then the MAX GSG HS MANAGEMENT scenario is the best choice if saving funding is important.

System Acres: 37,565		Scenarios – 30 years (mean & 95% CI of 10 replicates)		
	Current	Minimum	Best UED	Max GSG HS
Unified Ecological Departure	38%	33% ± 3%	31% ± 2%	30% ± 3%
Cost			$137,793 ± 16,579	$132,255 ± 19,175

ROI - vs Minimum Mgmt		46	62
ROI - 95% Confidence Interval		± 21	± 19
ROI of single scenario >0?		Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →		**No**	

Area results for targeted classes by ownership shown in Figures 51-53. The two types of results are classes that restoration was intended to reduce (U:Annual Spp, U:Depleted, and U:SA-Closed) and to increase (seedings, U:SDI-A, U:SDI-B, and U:Seeded Native). Treatments were clearly effective as shown by the Minimum Management scenario line and percentile range (blue line) separating from the active scenario lines, except for the shrubs with non-native annual species class (U:SA-Closed) on Newmont's private lands (treatment not implemented as show above; Figure 52) and in general for all classes on USFS lands. In the latter case, implementation levels were low and a slight reduction of the non-native annual species class was observed and a few acre seedings were created (Figure 53).

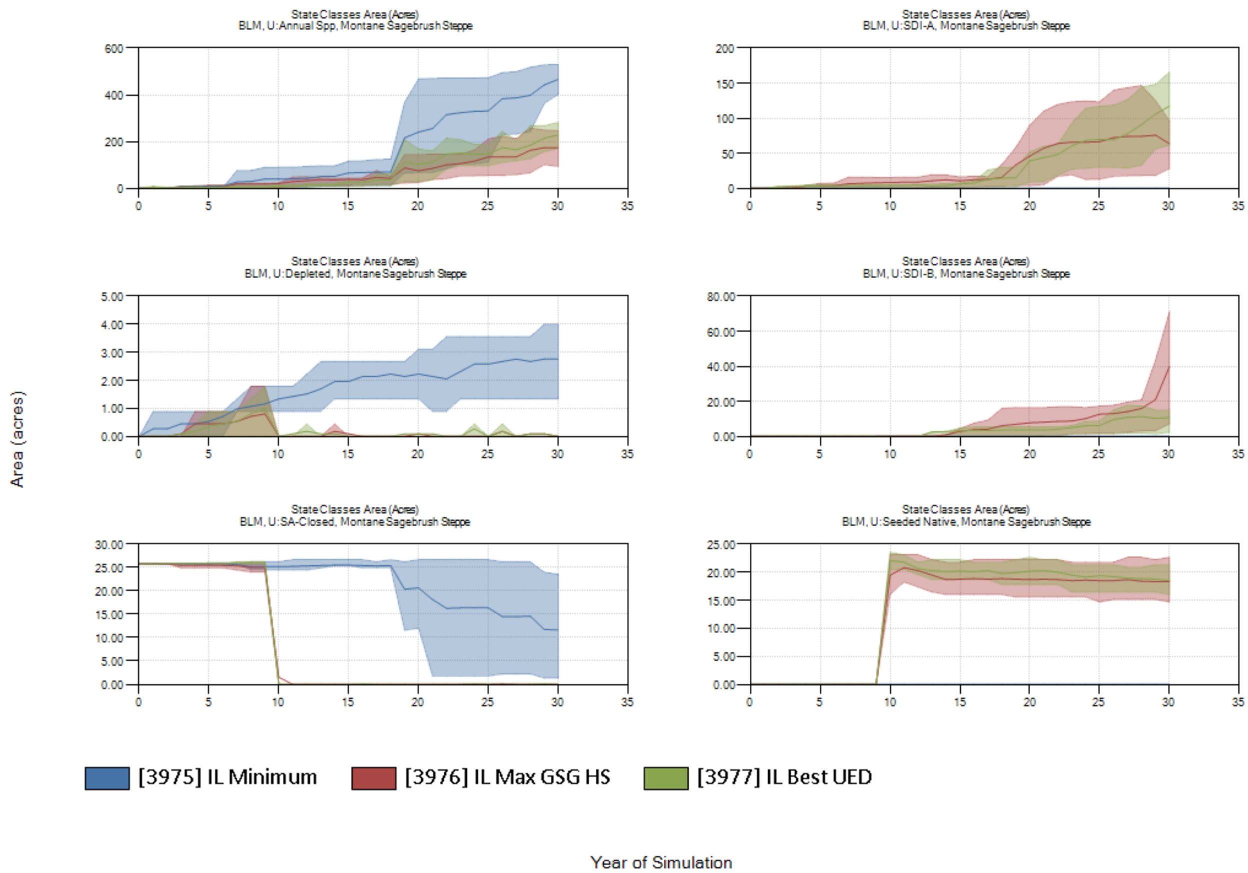


Figure 51. Area (acres) of six montane sagebrush steppe state classes targeted for ecological improvement for all scenarios located on BLM lands of the IL Ranch: Non-native annual species (U:Annual Spp), depleted sagebrush (U:Depleted), shrubs with non-native annual species (U:SA-Closed), early-succession introduced species seeding (U:SDI-A), mid-succession introduced species seeding (U:SDI-B), and native species seeding (U:Seeded-Native). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

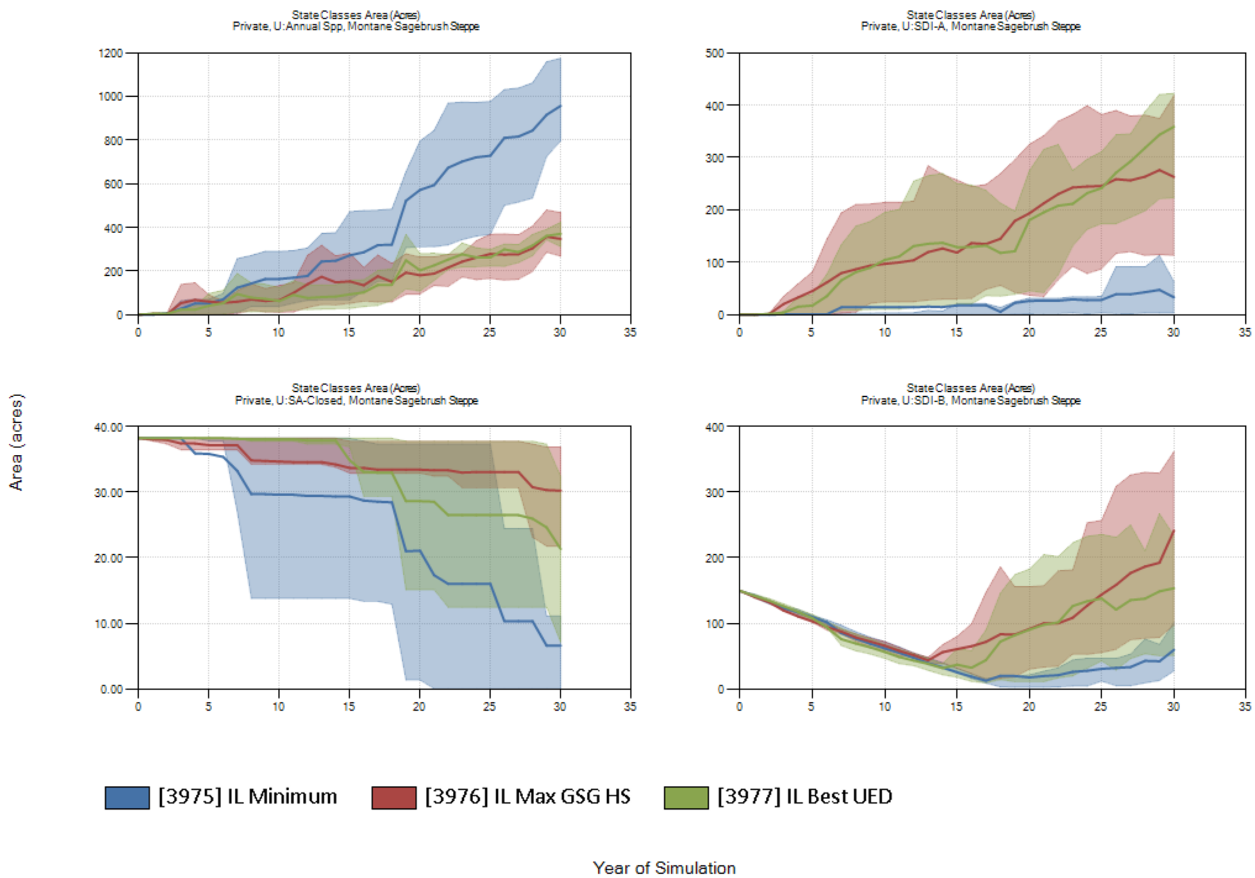


Figure 52. Area (acres) of four montane sagebrush steppe state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the IL Ranch: Non-native annual species (U:Annual Spp), shrubs with non-native annual species (U:SA-Closed), early-succession introduced species seeding (U:SDI-A), and mid-succession introduced species seeding (U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

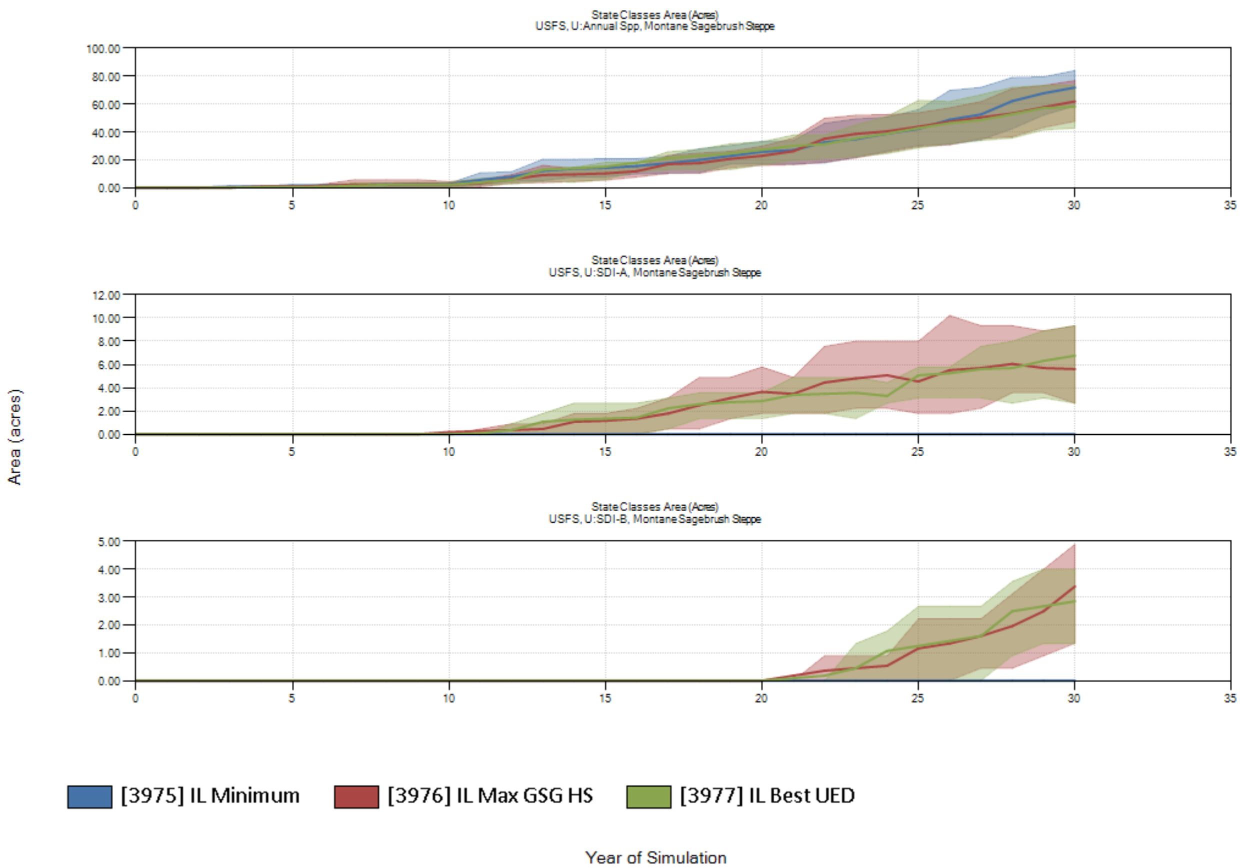


Figure 53. Area (acres) of three montane sagebrush steppe state classes targeted for ecological improvement for all scenarios located on USFS lands of the IL Ranch: Non-native annual species (U:Annual Spp), early-succession introduced species seeding (U:SDI-A), and mid-succession introduced species seeding (U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

<u>IL Ranch: Wet Meadow- Montane</u>

General patterns about current and future 30-year MINIMUM MANAGEMENT scenario results can be observed in all ownerships (table below). The mid-succession reference class (2-Mid:Closed) was always much less abundant than predicted by reference conditions. This result alone can explain at least a 30% increase in the absolute value of UED. The mid-succession reference class is also one of the most critical classes for sage-grouse chick survival. All uncharacteristic classes with exotic forbs increased over time, by as much as 8+% more than starting conditions. Due to the high level of undesirability of any exotic forb class, the result adds another 15% to the absolute value of UED. Depending on ownership, the hummocked class (U:Hummocked) and other drier classes found in incised wet meadows had percentages of area ranging from fractions to five percent.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area- Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:Open	8		66.7	5.5%	78.0	6.5%
	2-Mid:Closed	91		784.6	65.0%	651.6	54.0%
	3-Late:Open	0+		0.0	0.0%	23.7	2.0%
	U:Annual Spp			0.0	0.0%	36.7	3.0%
	U:Desertified			277.5	23.0%	206.1	17.1%
	U:Early Shrub			0.0	0.0%	11.0	0.9%
	U:Exotic Forbs			0.0	0.0%	84.5	7.0%
	U:Hummocked			48.0	4.0%	56.2	4.7%
	U:Incised-EFT			0.0	0.0%	27.9	2.3%
	U:Pasture		4	8.9	0.7%	8.9	0.7%
	U:SAP			5.3	0.4%	4.6	0.4%
	U:Shrb-Frb Encr			16.0	1.3%	14.9	1.2%
	U:Unpalat. Forb			0.0	0.0%	0.0	0.0%
	Wallow:Bare Ground	1		0.0	0.0%	3.0	0.3%
Private	1-Early:Open	8		298.9	6.1%	297.8	6.1%
	2-Mid:Closed	91		3403.5	69.3%	2956.2	60.2%
	3-Late:Open	0+		0.0	0.0%	66.0	1.3%
	U:Annual Spp			0.0	0.0%	113.2	2.3%
	U:Desertified			780.2	15.9%	586.8	11.9%
	U:Early Shrub			0.0	0.0%	3.5	0.1%
	U:Exotic Forbs			0.0	0.0%	397.1	8.1%
	U:Hummocked			137.0	2.8%	129.8	2.6%
	U:Incised-EFT			0.0	0.0%	90.2	1.8%
	U:Pasture		4	179.7	3.7%	179.7	3.7%
	U:SAP			29.4	0.6%	18.2	0.4%
	U:Shrb-Frb Encr			84.5	1.7%	59.8	1.2%
	U:Unpalat. Forb			0.0	0.0%	0.0	0.0%
	Wallow:Bare Ground	1		0.0	0.0%	14.9	0.3%
USFS	1-Early:Open	8		0.0	0.0%	4.3	10.2%
	2-Mid:Closed	91		41.8	100.0%	31.8	76.2%
	3-Late:Open	0+		0.0	0.0%	1.0	2.3%
	U:Annual Spp			0.0	0.0%	0.0	0.0%
	U:Desertified			0.0	0.0%	0.0	0.0%
	U:Early Shrub			0.0	0.0%	0.0	0.0%
	U:Exotic Forbs			0.0	0.0%	3.1	7.4%
	U:Hummocked			0.0	0.0%	1.4	3.4%
	U:Incised-EFT			0.0	0.0%	0.0	0.0%
	U:Pasture		4	0.0	0.0%	0.0	0.0%

U:SAP		0.0	0.0%	0.0	0.0%
U:Shrb-Frb Encr		0.0	0.0%	0.1	0.2%
U:Unpalat. Forb		0.0	0.0%	0.0	0.0%
Wallow:Bare Ground	1	0.0	0.0%	0.1	0.2%

Planned yearly implementation rates focus on controlling the amount of grazing (livestock grazing control), spraying exotic forbs (exotic control and weed inventory + spot treatment) and native forbs and shrubs that encroached upon wet meadows (herbicide-shrubs), and elevating the water table where small incisions occurred (inexpensive floodplain control, i.e., small permeable rock check dams) (table below). Cumulative 30-year cost was minimal on USFS lands, whereas cost climbed to >$75,000 on BLM lands and >$325,000 on Newmont's private lands. The largest single line item cost per action was livestock grazing control, which can be achieved through fencing "riparian" pastures, cowboying, or other actions that lead to the same hydrologic and vegetation outcomes.

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	MAX GSG HS	Exotic Control	10	10	$80	
		Herbicide-Shrubs	8	0	$125	
		Inexpensive Floodplain Restoration	100	50	$100	
		Livestock Grazing Control	200	100	$350	
		Weed Inventory + Spot Treatment	10	10	$50	
						$75,491 ± $5,331
NEWMONT PRIVATE	MAX GSG HS	Exotic Control	5	10	$80	
		Herbicide-Shrubs	10	0	$125	
		Inexpensive Floodplain Restoration	1000	0	$100	
		Livestock Grazing Control	50	0	$350	
		Weed Inventory + Spot Treatment	10	10	$50	
						$326,634 ± $15,962
USFS	MAX GSG HS	Exotic Control	3	3	$80	
		Livestock Grazing Control	10	0	$350	
		Weed Inventory + Spot Treatment	1	1	$50	
						$ 5,842 ± $1,624
BLM	BEST UED	Exotic Control	10	10	$80	
		Herbicide-Shrubs	8	0	$125	
		Inexpensive Floodplain Restoration	100	50	$100	

		Livestock Grazing Control	200	100	$350	
		Weed Inventory + Spot Treatment	10	10	$50	
						$87,724 ± $4,143
Newmont Private	Best UED	Exotic Control	5	10	$80	
		Herbicide-Shrubs	100	0	$125	
		Inexpensive Floodplain Restoration	100	10	$100	
		Livestock Grazing Control	70	0	$350	
		Weed Inventory + Spot Treatment	10	10	$50	
						$371,803 ± $23,717
USFS	Best UED	Exotic Control	3	3	$80	
		Livestock Grazing Control	10	0	$350	
		Weed Inventory + Spot Treatment	1	1	$50	
						$ 5,768 ± $1,162

The realized yearly implementation rates in the figures below (Figures 54 [BLM], 55 [Newmont private], and 56 [USFS]) display well the long-term maintenance actions designed primarily to control exotic forbs over 30 years (outlined in blue) and the “pulse” actions designed to improve sage-grouse habitat and restore classes requiring more substantial funding (outlined in red). In the latter case, ST-Sim often could not find any more uncharacteristic classes to treat.

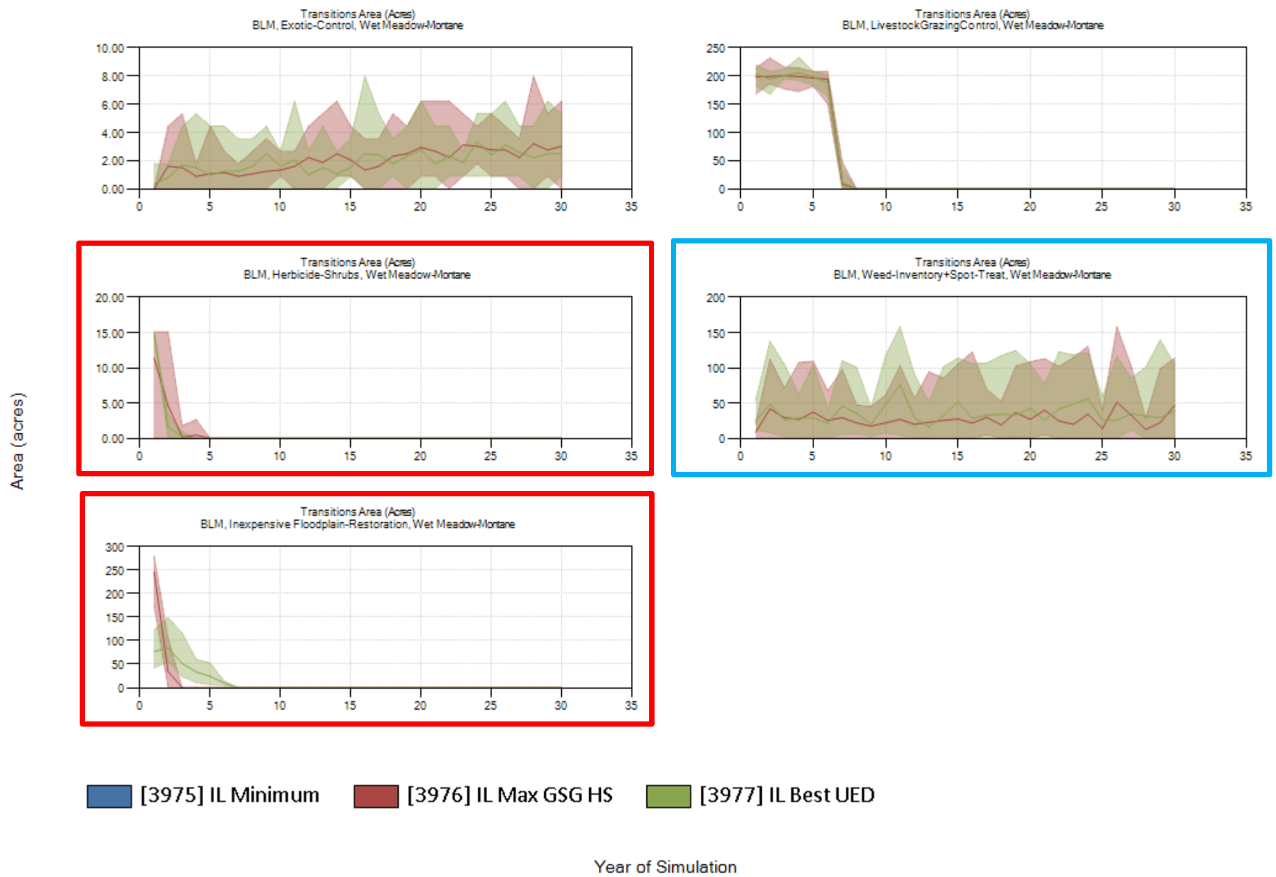


Figure 54. Realized yearly implementation rates for exotic control, herbicide-shrub, inexpensive floodplain restoration (e.g., check dams), livestock grazing control (e.g., fenced riparian pastures), and weed inventory with spot treatment of exotics forbs in the IL Ranch’s wet meadow-montane for BLM lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

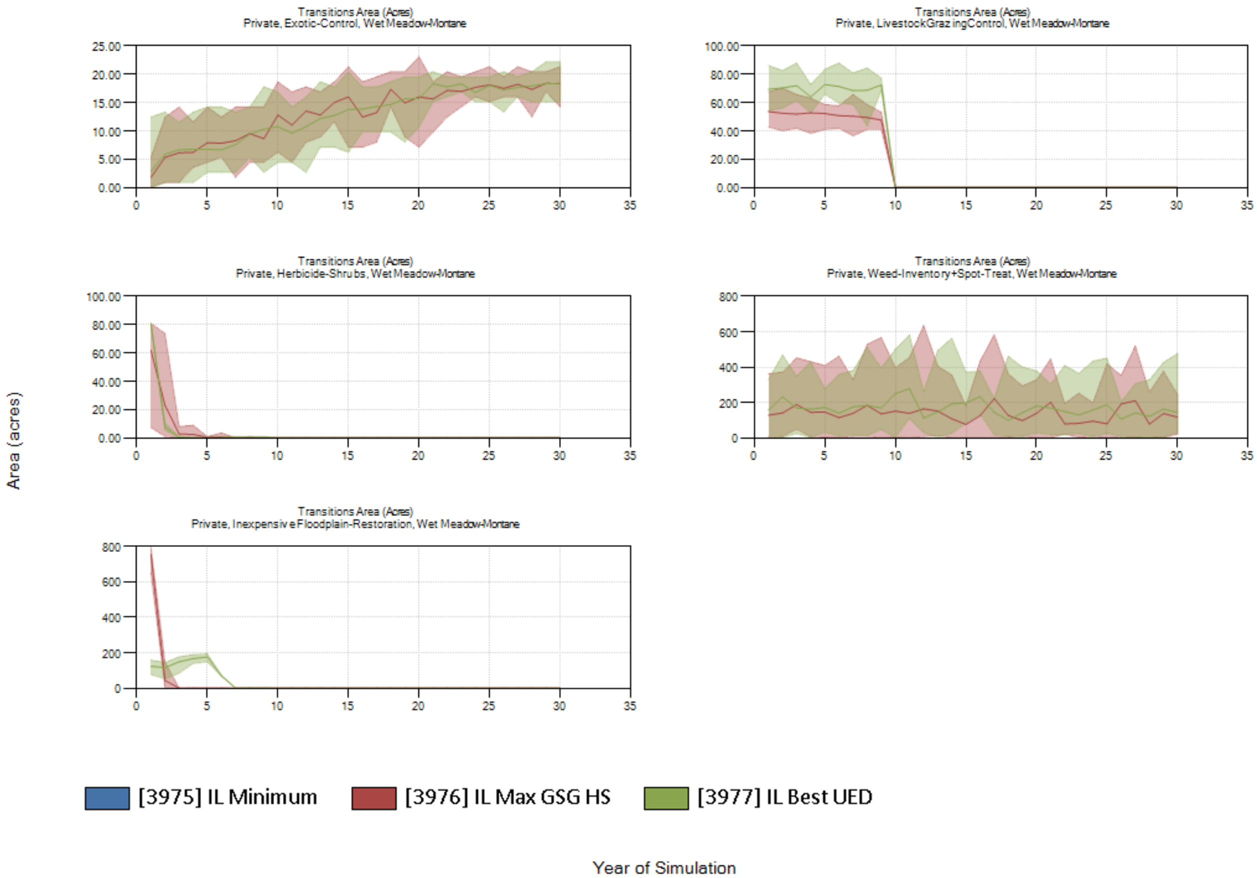


Figure 55. Realized yearly implementation rates for exotic control, herbicide-shrub, inexpensive floodplain restoration (e.g., check dams), livestock grazing control (e.g., fenced riparian pastures), and weed inventory with spot treatment of exotics forbs in the IL Ranch's wet meadow-montane for Newmont's private lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

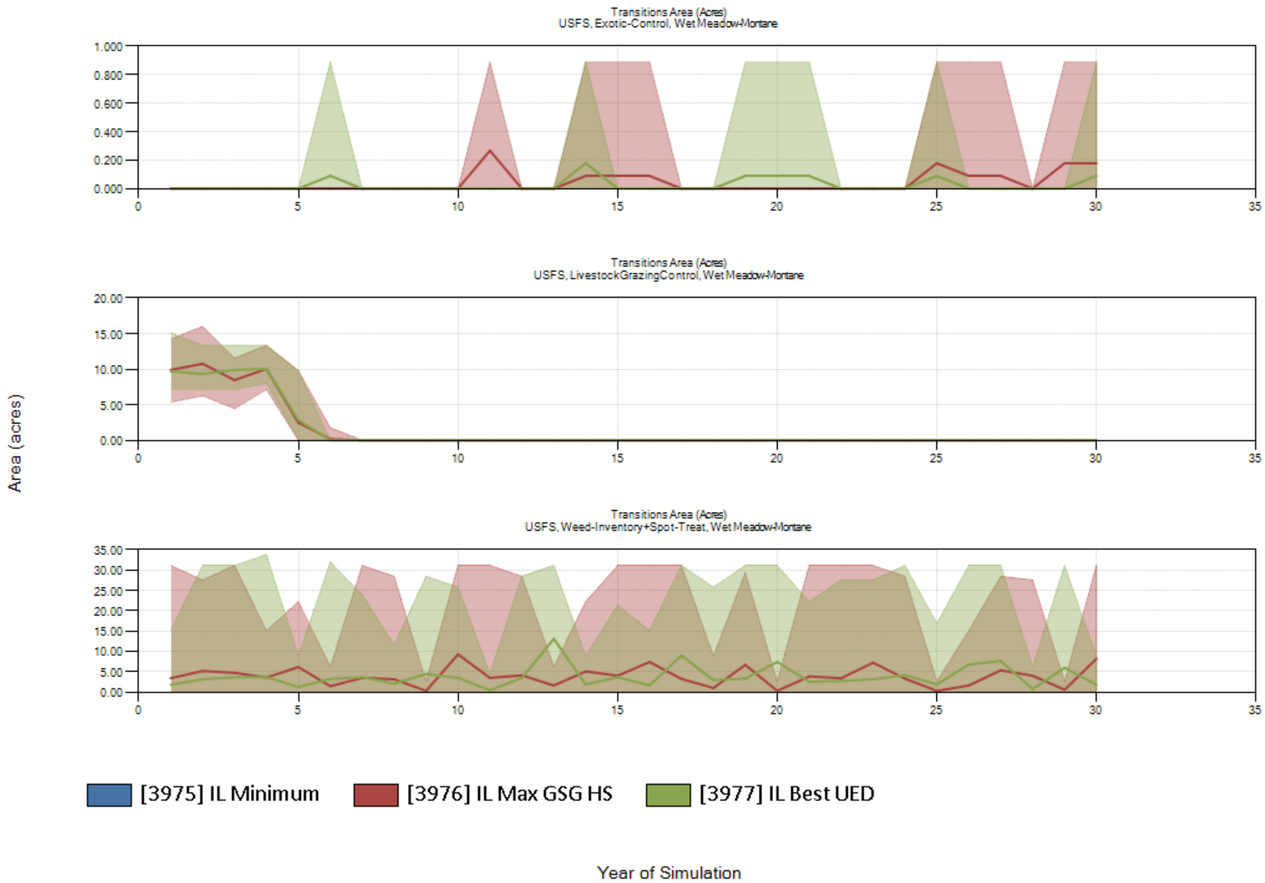


Figure 56. Realized yearly implementation rates for exotic control, livestock grazing control (e.g., fenced riparian pastures), and weed inventory with spot treatment of exotics forbs in the IL Ranch's wet meadow-montane for USFS lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The MINIMUM MANAGEMENT scenario increased UED from 35% in 2014 to about 54% in 30 years (table below). Compared to the 54% for MINIMUM MANAGEMENT scenario, both active scenarios caused a significant improvement of UED to 14%-15%. The ROIs for each active scenario were greater than zero and, therefore, better than doing nothing. Although the ROI for the BEST UED MANAGEMENT scenario (48) appeared greater than that of the MAX GSG HS MANAGEMENT scenario (47), the overlapping 95% CIs indicated no strong statistical difference between ROIs. If saving funding is important, then the MAX GSG HS MANAGEMENT scenario, which spends less money on Newmont private lands than the BEST UED MANAGEMENT scenario, is the best choice.

System Acres: 6,162		**Scenarios – 30 years (mean & 95% CI of 10 replicates)**		
	Current	**Minimum**	**Best UED**	**MAX GSG HS**
Unified Ecological Departure	35%	54% ± 2%	14% ± 3%	15% ± 3%
Cost			$465,291 ± 26,350	$407,966 ± 17,438

ROI - vs Minimum Mgmt			48	47
ROI - 95% Confidence Interval			± 3	± 2
ROI of single scenario >0?			Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**No**	

On BLM lands, management actions increased by 400 acres the mid-succession reference class (2-Mid:Closed), which is key to success, and reduced many uncharacteristic classes (Figure 57). The area of the exotic forb class (U:Exotic Forb) was not as successfully controlled by herbicide application despite a clear difference between all active scenarios and the MINIMUM MANAGEMENT scenario (upper right graph), therefore indicating that a greater implementation rate was needed.

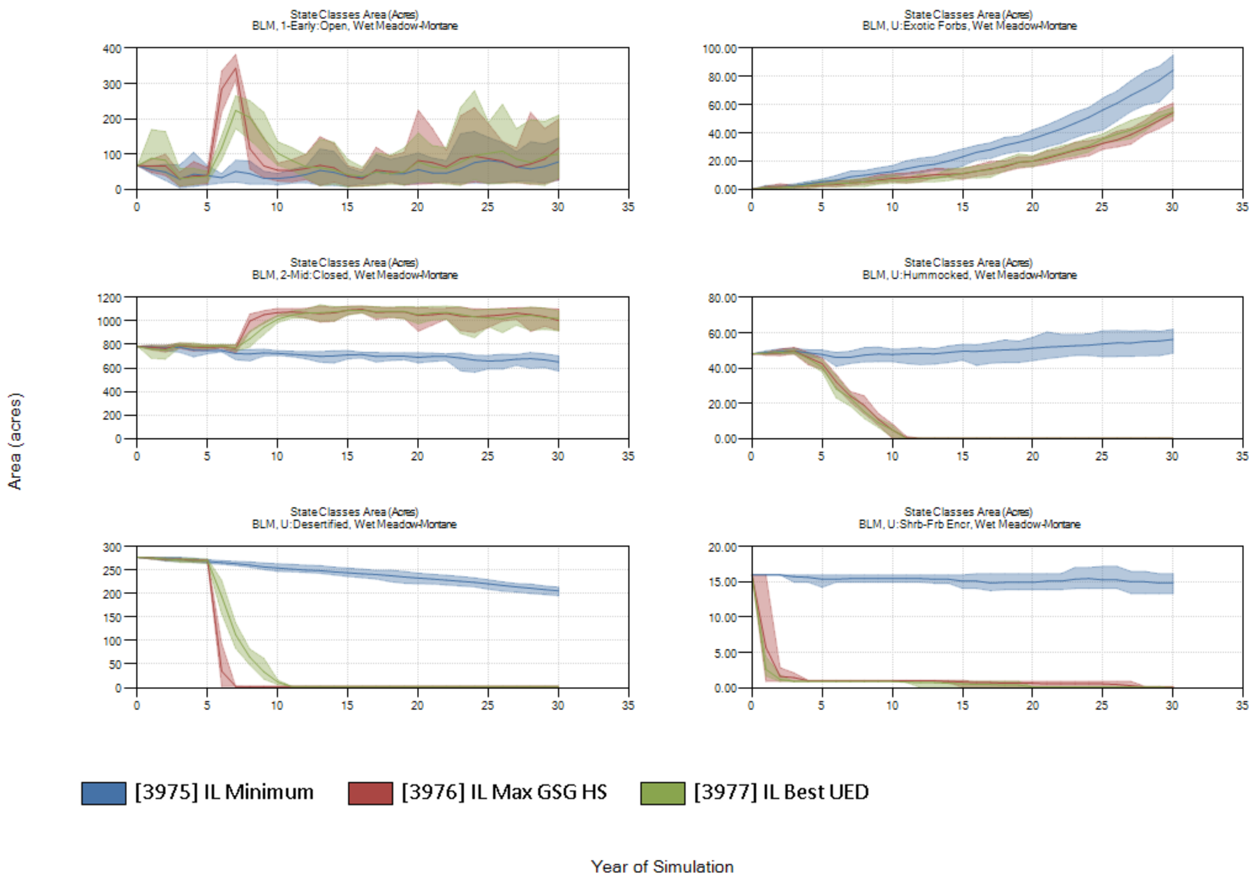


Figure 57. Area (acres) of six wet meadow-montane state classes targeted for ecological improvement for all scenarios located on BLM lands of the IL Ranch: early- and late-succession reference classes (1-Early:Open and 2-Mid:Closed), incised meadow (U:Desertified), invaded by exotic species (U:Exotic Forb), hummocked (U:Hummocked), and encroached by native shrubs and forbs (U:Shrb-Forb-Forb). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

Results for Newmont's private lands resembled closely those for BLM lands, except that (i) the control of exotic forbs was more successful compared to the MINIMUM MANAGEMENT scenario and (ii) the lower implementation rate of livestock grazing controls led to less of the hummocked meadows (U:Hummocked) being treated (center-right graph; Figure 58). About 2,000 acres of mid-succession reference class was added due to treatments.

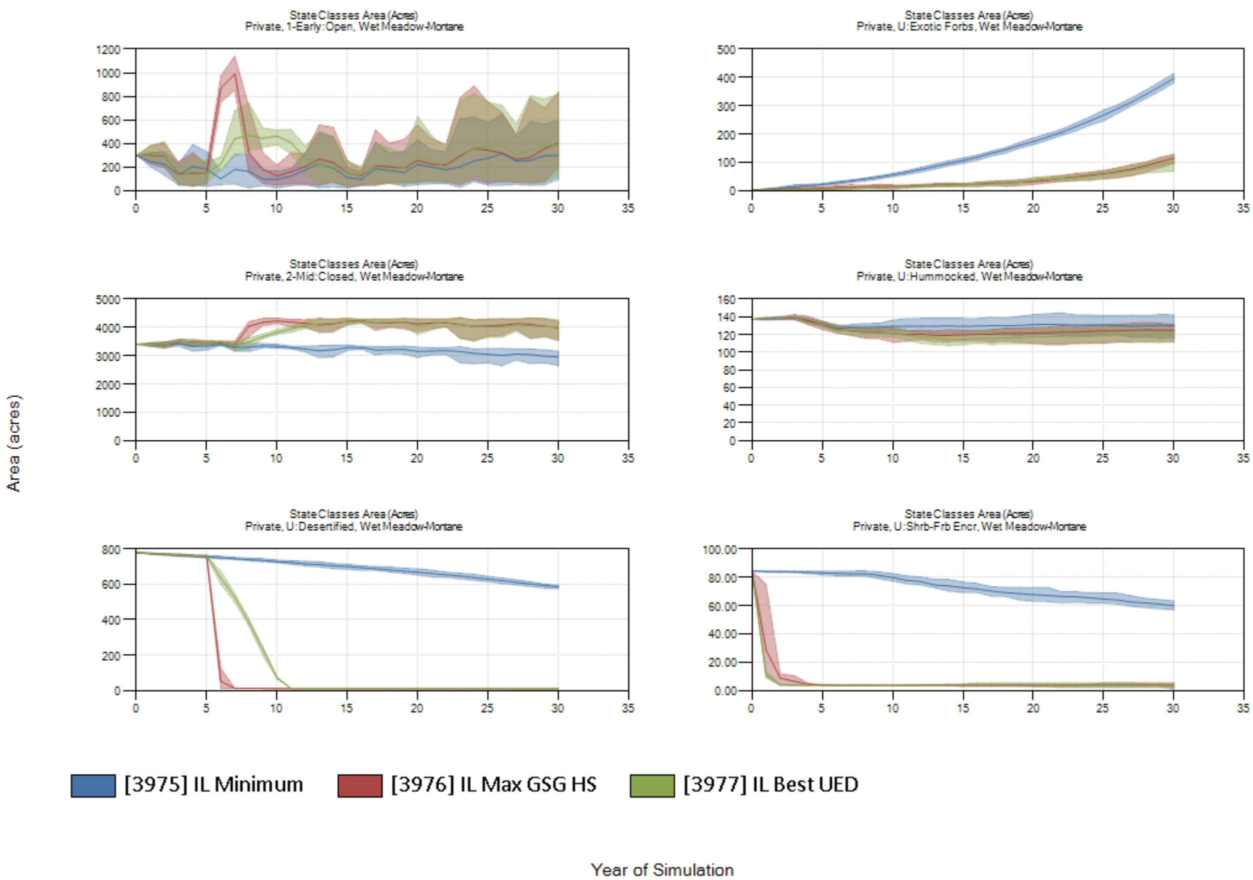


Figure 58. Area (acres) of six wet meadow-montane state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the IL Ranch: early- and late-succession reference classes (1-Early:Open and 2-Mid:Closed), incised meadow (U:Desertified), invaded by exotic species (U:Exotic Forb), hummocked (U:Hummocked), and encroached by native shrubs and forbs (U:Shrb-Forb-Forb). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

The modest area gains for reference class and decreases of uncharacteristic classes were more obvious on USFS lands due to the more modest implementation rates and small areas for these classes (Figure 59). On these lands, it is unclear if active scenarios made any difference compared to MINIMUM MANAGEMENT.

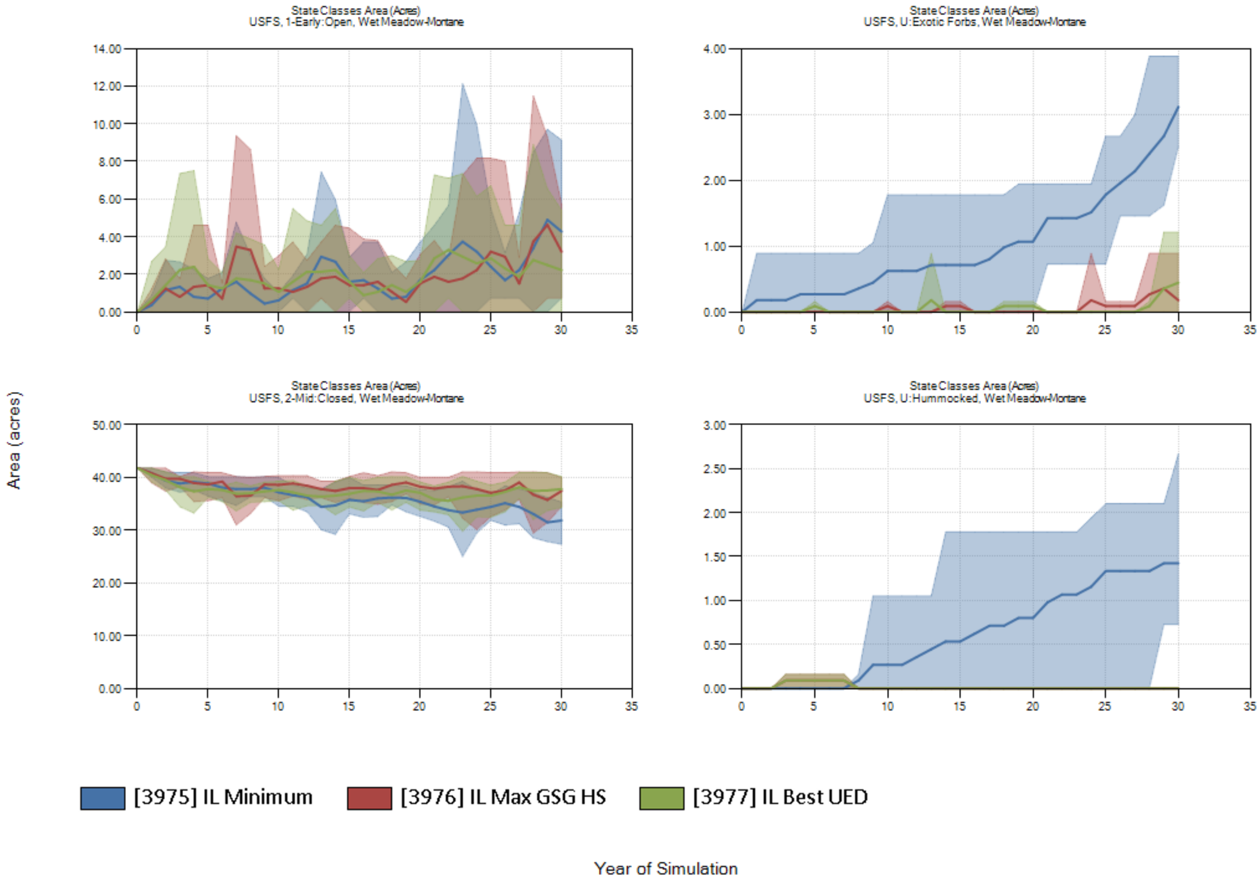


Figure 59. Area (acres) of four wet meadow-montane state classes targeted for ecological improvement for all scenarios located on USFS lands of the IL Ranch: early- and late-succession reference classes (1-Early:Open and 2-Mid:Closed), invaded by exotic species (U:Exotic Forb), and hummocked (U:Hummocked). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

TS-Horseshoe Ranches: Aspen Woodland

The aspen woodland system exhibits moderate UED (47%) at the current time. More than 97% of this system's acres are within reference classes (table below). The remaining 0.1% and 2.7% of acres are, respectively, in the lost aspen clone class (U:ASP->MSS) and depleted vegetation class (U:Depleted) found on Newmont's private and BLM lands (high-risk vegetation class in yellow). After 30 years in a regime of MINIMUM MANAGEMENT, the predicted UED improved (31%), because the abundant mid-succession reference class (2-Mid:Closed) matured into the late-succession closed reference class (3-Late:Closed). The area representing permanent loss of aspen clones to montane sagebrush steppe increased slightly from 0 to 2.9 acres on BLM lands. Amounts of specific vegetation classes in the aspen woodland system at the current time, and after 30 years of MINIMUM MANAGEMENT, are shown in the table below:

Ownership	State Class	% Ref.	% Allowable Threshold	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
Private	1-Early:Closed	8	-	17.8	1.6%	55.8	4.9%
	2-Mid:Closed	26	-	855.8	75.0%	144.6	12.7%
	3-Late:Closed	38	-	72.9	6.4%	768.0	67.3%
	4-Late:Open	27	-	194.8	17.1%	172.8	15.1%
	U:ASP->MSS	0	-	0.0	0.0%	0.0	0.0%
	U:Depleted	0	-	0.0	0.0%	0.1	0.0%
BLM	1-Early:Closed	8	-	42.7	4.5%	48.9	5.2%
	2-Mid:Closed	26	-	625.4	65.9%	135.7	14.3%
	3-Late:Closed	38	-	56.0	5.9%	578.2	60.9%
	4-Late:Open	27	-	200.2	21.1%	182.5	19.2%
	U:ASP->MSS	0	-	0.0	0.0%	2.9	0.3%
	U:Depleted	0	-	24.9	2.6%	0.8	0.1%

Although aspen woodland's UED was moderately departed and decreasing, minor restoration actions to prevent loss of clones from the depleted and early-succession classes were modeled only under the BEST UED MANAGEMENT scenario on Newmont's private lands as this is not sage-grouse habitat. The primary objective of management actions is to re-invigorate deteriorating aspen clones, or at a minimum protect them from agents of further degradation and allow them to self-recover, thus moving those acres back into reference condition. The table below shows planned management action and cost per ownership aimed at achieving this objective under active management scenarios: BEST UED.

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Years 20-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
NEWMONT PRIVATE	BEST UED	Fence	10	0	0	$400	
							$32,095 ± 2,883

The actual yearly implementation rate of fencing (Figure 60) on Newmont's private lands is shown below.

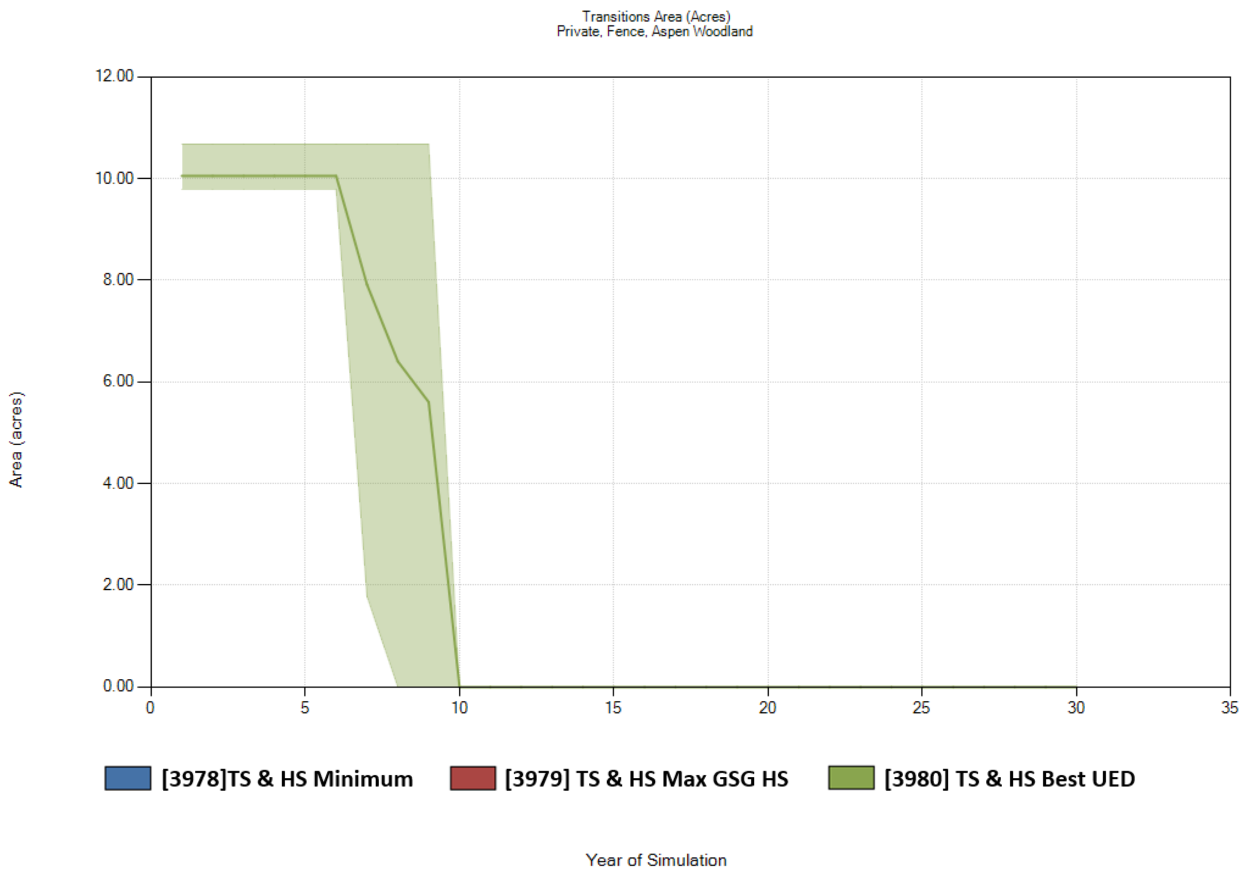


Figure 60. Realized yearly implementation rates for fencing in the TS-Horseshoe Ranches' aspen woodland for Newmont's private lands. The dark line is the mean for each scenario (Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The table below summarizes predicted outcomes in terms of UED and total cost after 30 years of the Best UED Management scenario, along with their CURRENT and MINIMUM MANAGEMENT scenario values. No actions were implemented in the MAX GSG HS MANAGEMENT scenario. The MINIMUM MANAGEMENT scenario and both active scenarios resulted in UED values lower than

33% after 30 years. The ROI for the BEST UED MANAGEMENT scenario was significantly greater than zero, therefore this scenario was better than doing nothing.

System Acres: 2,091	Current	Scenarios – 30 years (mean of 5 replicates)		
		MINIMUM	**BEST UED**	**MAX GSG HS**
Unified Ecological Departure	47%	31% ± 2	27% ± 3	28% ± 3
Cost			$32,095 ± 2,883	-
ROI - vs Minimum Mgmt			26.8	-
ROI - 95% Confidence Interval			± 16.9	-
ROI of single scenario >0?			Yes	n/a
ROIs of Maximum and Preferred Significantly Different (95% CI)? →			**n/a**	

Depleted aspen (U:Depleted) was the targeted vegetation class, which was only slightly reduced by fencing due to the very few acres involved (Figure 61). Depleted aspen disappeared after 15 years in the BEST UED MANAGEMENT scenario, but not other scenarios. However, in all scenarios, the depleted class was near zero by year 15, suggesting that management intervention may not be necessary for this system.

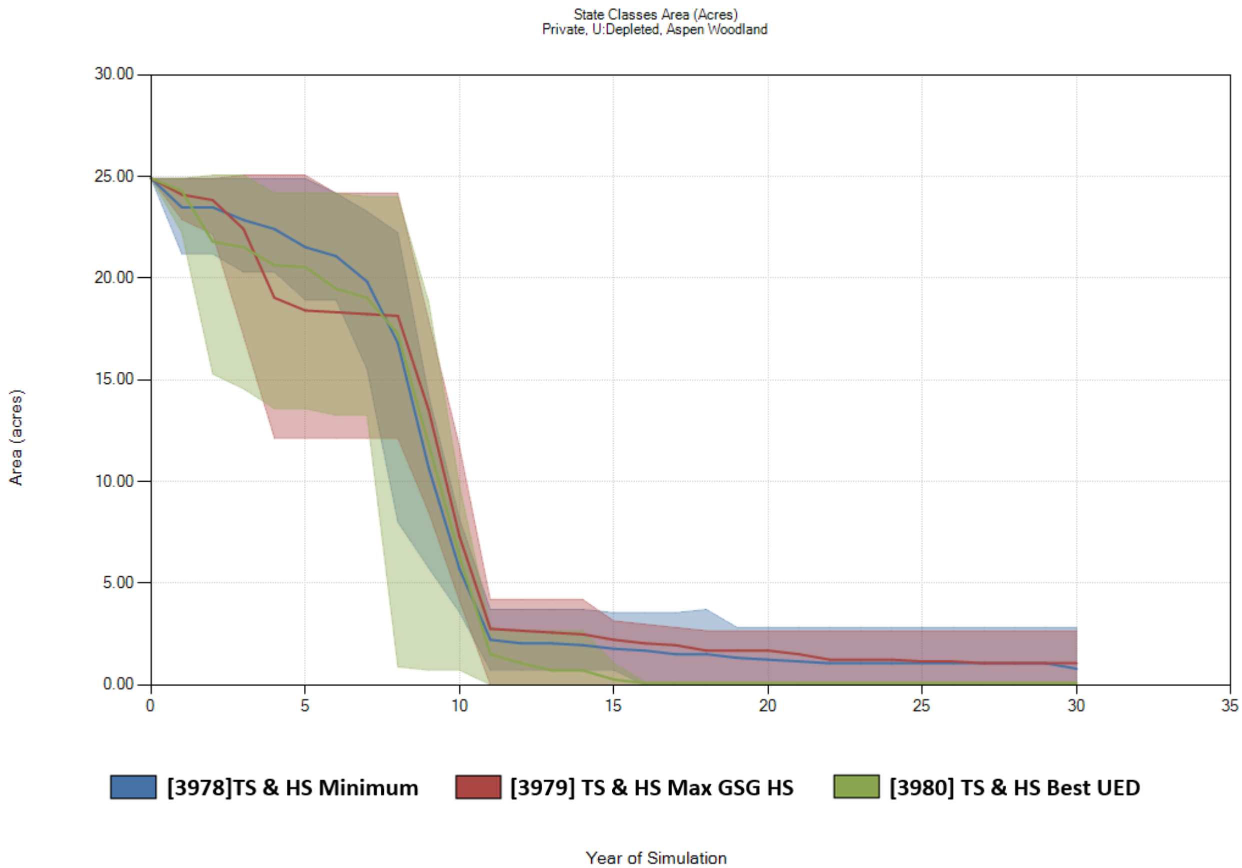


Figure 61. Area (acres) of depleted aspen woodland (U:Depleted) in the TS-Horseshoe Ranches on Newmont's private lands. The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

TS-Horseshoe Ranches: Basin Wildrye-bottomland

Basin wildrye-bottomland is an expansive floodplain grassland system mostly found on Newmont's private lands of the TS-Horseshoe Ranches' Boulder Valley (table below). Very few areas still retained reference classes (<2% for BLM lands, <10% of Newmont's private land, and <5% on BOR lands). These percentages minimally increased after 30 years of MINIMUM MANAGEMENT scenario. Focusing of Newmont's private lands, four uncharacteristic classes co-dominated the current condition (4.6% for U:ASPG, 61.3% for U:Depleted, 17.7% for U:Early Shrub, and 14.6% for U:Exotic Forb). Their percentages change after 30 years of MINIMUM MANAGEMENT, except the class of mixed non-native annual species and native perennial grass (from 4.6% to 3.6% for U:ASPG). The most worrisome change was the increase of the exotic forb class (U:Exotic Forb) from 14% to 23.5%, translating to 7,267 aces. While the area of the depleted class (U:Depleted) was halved over 30 years, the area of the early shrub class (U:Early Shrub) increased by the same amount as crushed or burned depleted wildrye most often becomes dominated by rabbitbrush.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:Open	24		0.0	0.0%	0.9	0.8%
	2-Mid:Closed	68		0.0	0.0%	1.3	1.2%
	4-Late:Open	8		0.0	0.0%	0.0	0.0%
	6-Late:Channel	<0.1		0.0	0.0%	0.0	0.0%
	U:Annual Spp			0.0	0.0%	1.1	1.0%
	U:ASPG			7.1	6.5%	6.4	5.8%
	U:Depleted			67.6	61.3%	30.8	27.9%
	U:Early Shrub			19.6	17.7%	39.3	35.6%
	U:Exotic Forbs			16.0	14.5%	25.2	22.8%
	U:Pasture		1	0.0	0.0%	0.0	0.0%
	U:SAP			0.0	0.0%	5.3	4.8%
	U:SDI		10	0.0	0.0%	0.0	0.0%
	U:SDI+AS			0.0	0.0%	0.0	0.0%
	U:Seeded Native		10	0.0	0.0%	0.0	0.0%
Private	1-Early:Open	24		1833.4	5.9%	339.1	1.1%
	2-Mid:Closed	68		1171.6	3.8%	2179.8	7.1%
	4-Late:Open	8		90.7	0.3%	390.5	1.3%
	6-Late:Channel	<0.1		129.9	0.4%	129.9	0.4%
	U:Annual Spp			120.1	0.4%	548.9	1.8%
	U:ASPG			1435.8	4.6%	1118.2	3.6%
	U:Depleted			12690.7	41.1%	6189.1	20.0%
	U:Early Shrub			8635.1	27.9%	11044.0	35.7%
	U:Exotic Forbs			4322.5	14.0%	7266.9	23.5%
	U:Pasture		1	0.0	0.0%	0.0	0.0%
	U:SAP			309.6	1.0%	1549.7	5.0%
	U:SDI		10	158.3	0.5%	136.9	0.4%
	U:SDI+AS			0.0	0.0%	4.7	0.0%
	U:Seeded Native		10	0.0	0.0%	0.0	0.0%
BOR	1-Early:Open	24		0.0	0.0%	0.5	0.3%
	2-Mid:Closed	68		0.0	0.0%	0.0	0.0%
	4-Late:Open	8		0.0	0.0%	0.0	0.0%
	6-Late:Channel	<0.1		0.0	0.0%	0.0	0.0%
	U:Annual Spp			4.4	2.2%	6.2	3.1%
	U:ASPG			0.0	0.0%	1.2	0.6%
	U:Depleted			152.1	75.7%	95.6	47.6%
	U:Early Shrub			2.7	1.3%	25.0	12.4%
	U:Exotic Forbs			41.8	20.8%	57.5	28.6%
	U:Pasture		1	0.0	0.0%	0.0	0.0%
	U:SAP			0.0	0.0%	14.9	7.4%
	U:SDI		10	0.0	0.0%	0.0	0.0%

U:SDI+AS		0.0	0.0%	0.0	0.0%
U:Seeded Native	10	0.0	0.0%	0.0	0.0%

For basin wildrye-bottomland, which is not used by sage-grouse, only the BEST UED MANAGEMENT scenario was implemented on Newmont's private lands (table below). Actions were designed to reduce (i) the depleted class (U:Depleted) dominated by basin big sagebrush and restore seeded native grassland and, eventually, reference classes, and (ii) marginally treat the exotic forb class (U:Exotic Forb) while a more comprehensive regional weed control program is developed for the upper Humboldt River watershed. The table below shows the planned implementation rates of different management actions and the total 30-year cost by combination.

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
NEWMONT PRIVATE	BEST UED	Exotic Control	0	100	$80	
		Thin + Plateau + Native Seed	200	200	$300	
						$195,8241 ± $11,524

The realized implementation rates for these actions are show below in Figure 62. Rates were constant because the treatable area far exceeded the cumulative rate of implementation over 30 years.

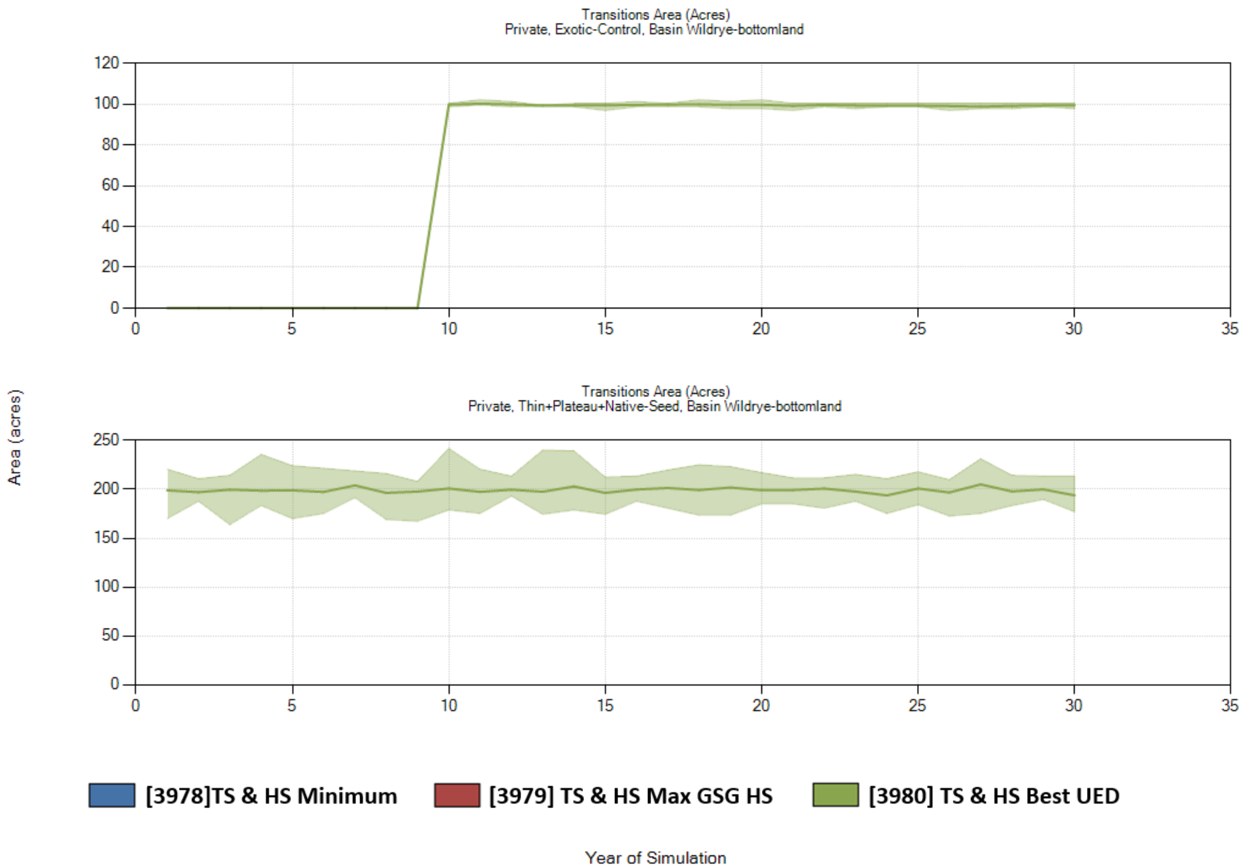


Figure 62. Realized yearly implementation rates for exotic control and thin+Plateau+native-seed in the TS-Horseshoe Ranches' basin wildrye-bottomland for Newmont's private lands. The dark line is the mean for each scenario (Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The Best UED Management scenario decreased UED from 100% to 99% (high departure) compared to Minimum Management and Max GSG HS Management scenarios (table below). The 30-year cumulative cost was $1.96 million. The ROI was barely significantly greater than zero, therefore the Best UED Management scenario might not be worth doing to improve UED, however, other values may be served by these actions. It is possible that the treatment is worth doing to increase the forage base of livestock.

System Acres: 31,209	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	**Best UED**	**Max GSG HS**
Unified Ecological Departure	100%	100% ± 0%	99% ± 1%	100% ± 0%
Cost			$1,955,241 ± 11,524	-
ROI - vs Minimum Mgmt			1.6	-
ROI - 95% Confidence Interval			± 1.2	-
ROI of single scenario >0?			Yes	-
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**n/a**	

While the ROI on the entire system did not significantly change, it is clear from Figure 63 that the Best UED Management scenario (green line and percentiles) distinctly increased desirable classes and decreased undesirable ones, albeit less strongly for exotic control of the exotic forb class (U:Exotic Forb).

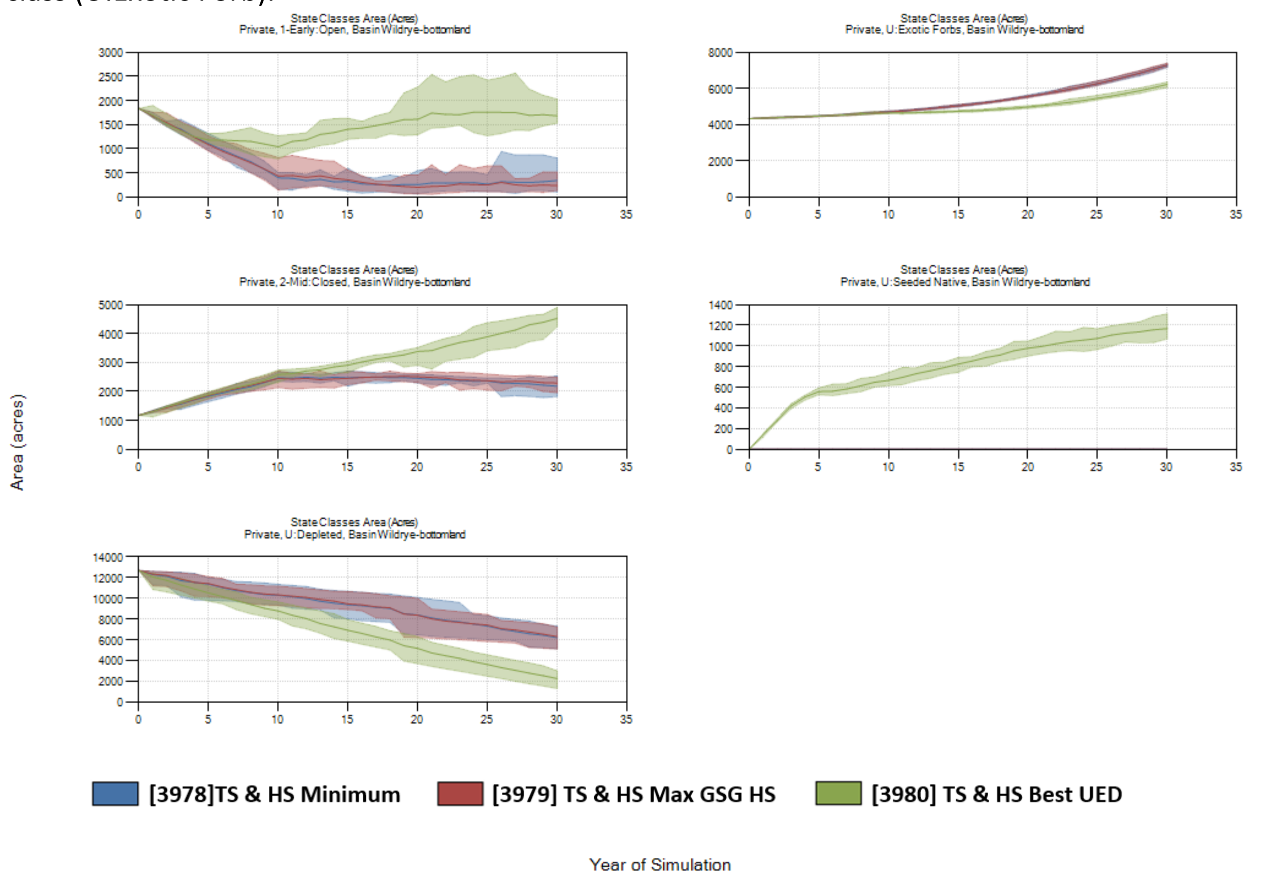


Figure 63. Area (acres) of five basin wildrye-bottomland state classes targeted for ecological improvement for the BEST UED MANAGEMENT scenarios located on Newmont's private lands in the TS-Horseshoe Ranches: early-succession (1-Early:Open), mid-succession closed (2-Mid:Closed), depleted (U:Depleted), dominated by exotic forbs (U:Exotic-Forb), and native seeding (U:Seeded-Native). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

TS-Horseshoe Ranches: Basin Wildrye-montane

Basin wildrye-montane is a linear system found in most shallow valley bottoms. Very few areas still retained reference classes (<5%), and this percentage decreased slightly after 30 years of MINIMUM MANAGEMENT scenario (table below). On BLM lands, the most dominant classes were those with mixed non-native annual species and native perennial grass (U:ASPG and U:SAP) and large changes in their abundance reflected succession dynamics from U:ASPG to U:SAP. The rabbitbrush-dominated class (U:Early Shrub) and the exotic forb-dominated class (U:Exotic Forb) occupied the second tier of co-dominance after 30 years, however, only the exotic forb class showed a dramatic increase from 0+% to 8.9% (921 acres) over time. The non-native annual species class (U:Annual Spp) was also noteworthy by increasing from 0+% to about 6%. Sage-grouse nest success is negatively affected by this class. On Newmont's private lands, the uncharacteristic woody succession from U:ASPG to U:SAP observed on BLM lands was present with the same importance. The early shrub (U:Early Shrub), exotic forb (U:Exotic Forb), and non-native annual species (U:Annual Spp) classes also showed similar temporal dynamics, except percentages and area were greater.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area- Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:Open	19		467.0	4.5%	40.8	0.4%
	2-Mid:Closed	66		0.0	0.0%	369.9	3.6%
	4-Late:Open	15		0.0	0.0%	0.0	0.0%
	U:Annual Spp			4.4	0.0%	616.7	6.0%
	U:ASPG			8019.5	77.8%	4403.9	42.7%
	U:Depleted			279.3	2.7%	98.7	1.0%
	U:Early Shrub			885.1	8.6%	916.6	8.9%
	U:Exotic Forbs			1.8	0.0%	920.6	8.9%
	U:Pasture		50	0.0	0.0%	0.0	0.0%
	U:SAP			352.3	3.4%	2674.2	25.9%
	U:SDI			217.1	2.1%	211.7	2.1%
	U:SDI+AS			86.3	0.8%	59.8	0.6%
	U:Seeded Native		30	0.0	0.0%	0.0	0.0%
Private	1-Early:Open	19		758.8	3.7%	40.3	0.2%
	2-Mid:Closed	66		161.9	0.8%	687.4	3.3%
	4-Late:Open	15		16.0	0.1%	79.6	0.4%
	U:Annual Spp			63.2	0.3%	1361.6	6.6%
	U:ASPG			12485.2	60.8%	6300.1	30.7%
	U:Depleted			2430.3	11.8%	942.1	4.6%
	U:Early Shrub			2898.2	14.1%	3552.3	17.3%
	U:Exotic Forbs			204.6	1.0%	2166.0	10.5%
	U:Pasture		50	89.0	0.4%	89.0	0.4%
	U:SAP			979.4	4.8%	4927.6	24.0%

U:SDI		230.4	1.1%	303.3	1.5%
U:SDI+AS		177.0	0.9%	60.9	0.3%
U:Seeded Native	30	53.4	0.3%	37.3	0.2%

For basin wildrye-montane, four levels of active management combining ownership and scenarios were identified: MAX GSG HS and BEST UED MANAGEMENT scenarios each implemented on BLM and Newmont's private lands (table below). The MAX GSG HS MANAGEMENT scenario was primarily designed to remove expanses of non-native annual species (U:Annual Spp), which negatively impact sage-grouse nest success within a 2 km of potential nesting sites. Exotic forbs (U:Exotic Forb) and standing basin big sagebrush mixed with rabbitbrush were also targeted on private land to improve range condition (standard management action) and increase basin wildrye biomass (neutral effect on nest success) at the expense of the class dominated by basin big sagebrush, rabbitbrush, and non-native annual species that would convert to non-native annual species (U:SAP) if burned.

The BEST UED MANAGEMENT scenario was more complex and also targeted the depleted class dominated by basin big sagebrush (U:Depleted) to increase native cover through seedings (U:Seeded Native), and eventually reference classes. The table below shows the planned implementation rates of different management actions by ownership and scenario and the total 30-year cost by combination.

			Acres/Year (Avg of 10 runs)			
Ownership	Scenario	Mgmt Action	Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	MAX GSG HS	Exotic Control	0	50	$80	
		Herbicide- Plateau + Native Seed	0	300	$295	
		Herbicide- Plateau + Seed	0	100	$170	
		Weed Inventory + Spot Treatment	0	250	$50	
						$ 440,891 ± $26,588
NEWMONT PRIVATE	MAX GSG HS	Exotic Control	100	100	$80	
		Weed Inventory + Spot Treatment	300	300	$50	
						$1,209,838 ± $28,683
BLM	BEST UED	Exotic Control	2	50	$80	
		Herbicide- Plateau + Native Seed	0	500	$295	
		Herbicide + Plateau + Seed	0	200	$170	
		Thin + Plateau + Native Seed	0	50	$300	
		Weed Inventory + Spot Treatment	200	250	$50	
						$823,749 ± $31,097
NEWMONT PRIVATE	BEST UED	Exotic Control	50	100	$80	

Herbicide- Plateau + Native Seed	0	50	$295	
Thin + Plateau + Native Seed	0	100	$300	
Weed Inventory + Spot Treatment	300	300	$50	
				$1,949,605 ± $37,511

The realized implementation rates for these actions are shown below in Figures 64 (BLM) and 65 (Newmont private). Several action's implementation rates peaked during the first year followed by more moderate levels because the area of vegetation classes available for treatment became less common.

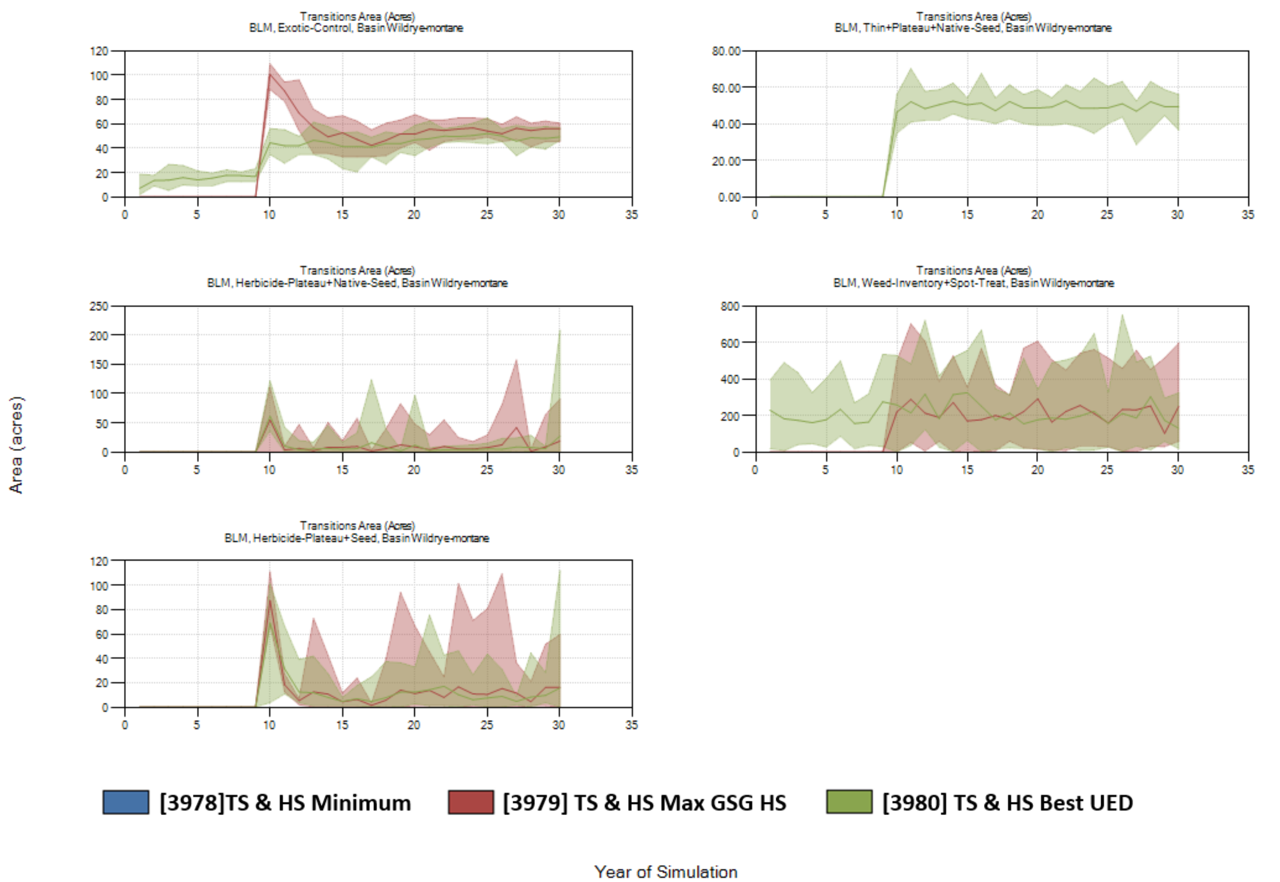


Figure 64. Realized yearly implementation rates for exotic control, herbicide-Plateau+native seed, herbicide+Plateau+seed, thin+Plateau+native-seed, and weed-inventory+spot-treatment of exotics in the TS-Horseshoe Ranches' basin wildrye-montane for BLM lands. The dark line is the mean for each scenario (Highest GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

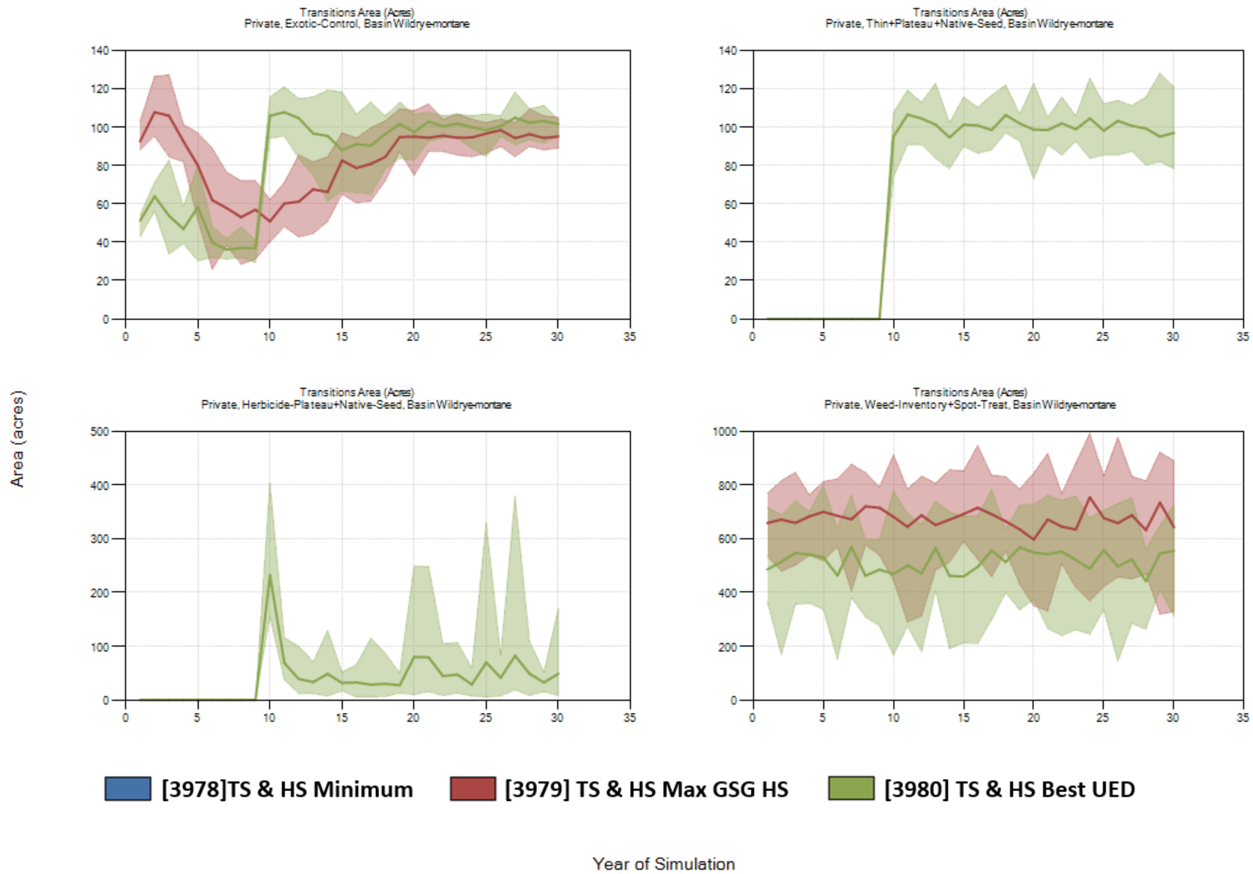


Figure 65. Realized yearly implementation rates for exotic control, herbicide-Plateau+seed, thin+Plateau+native-seed, and weed-inventory+spot-treatment of exotics in the TS-Horseshoe Ranches' basin wildrye-montane for Newmont's private lands. The dark line is the mean for each scenario (Highest GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The Best UED Management scenario decreased UED from 100% to 84% (high departure) compared to Minimum Management, whereas the Max GSG HS Management scenario resulted in only a 4% smaller UED value (table below). The 30-year cumulative cost was about 1.7× higher and \$2.77 million for the most successful of the two active scenarios. For both active scenarios, the ROI was significantly greater than zero, and the Best UED Management scenario had a significantly greater ROI than the Max GSG HS Management scenario.

System Acres: 30,860	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	**Best UED**	**Max GSG HS**
Unified Ecological Departure	100%	100% ± 0%	84% ± 0.4%	96% ± 0.5%
Cost			$2,773,354 ± 45,686	$1,605,729 ± 22,455

ROI - vs Minimum Mgmt			17.7	8
ROI - 95% Confidence Interval			± 0.4	± 0.7
ROI of single scenario >0?			Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**Yes**	

It is clear from Figures 66 (BLM) and 67 (Newmont private) that actions not treating shrub-dominated classes were more effective than actions involving thinning of shrubs (as in classes U:Depleted and U:SAP). Although the area of desirable classes increased by nearly a thousand acres, the sum of the areas is small compared to the >30,000 acres of the system dominated primarily by uncharacteristic classes.

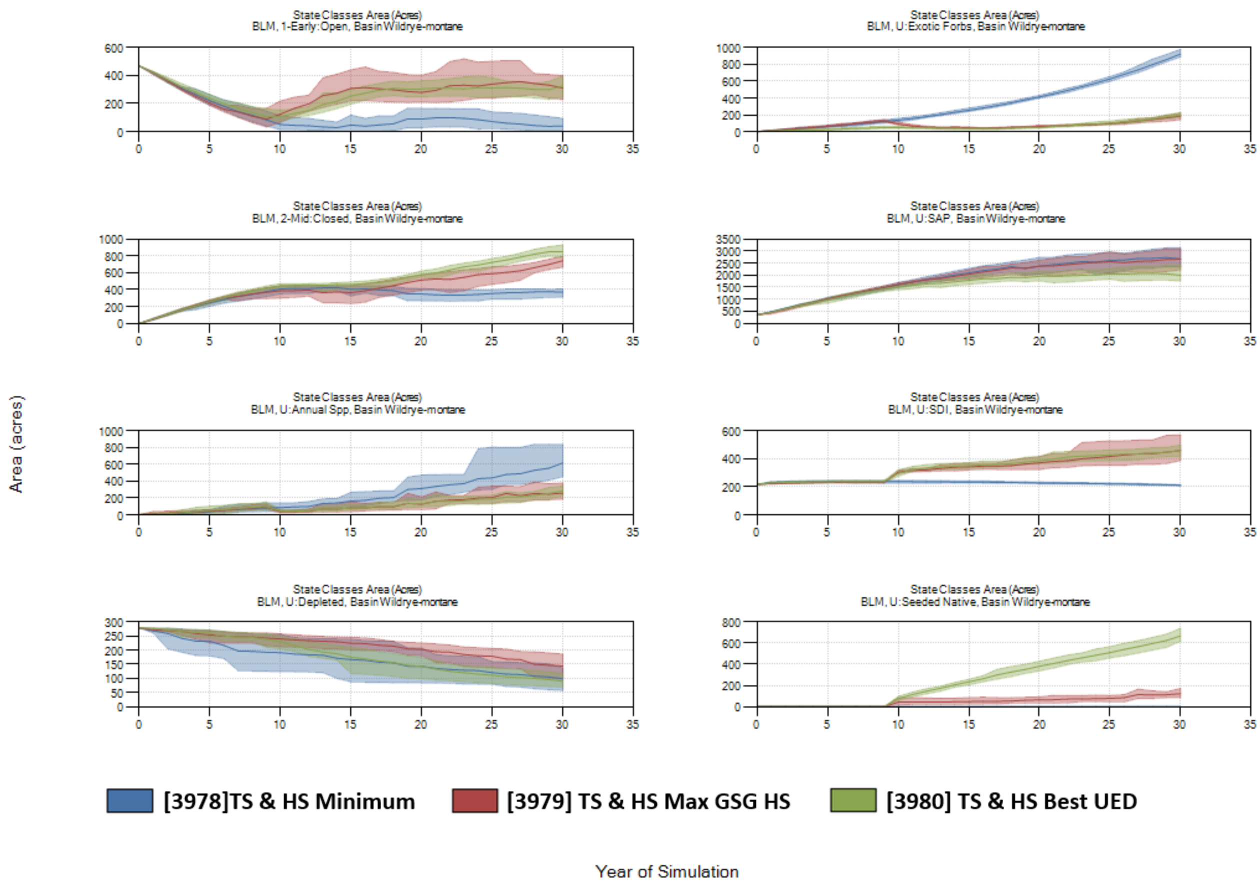


Figure 66. Area (acres) of eight basin wildrye-montane state classes targeted for ecological improvement for all scenarios located on BLM lands of the IL Ranch: early-succession (1-Early:Open), mid-succession closed (2-Mid:Closed), non-native annual species (U:Annual Spp), dominated by basin big sagebrush (U:Depleted), shrub with non-native annual species (U: SAP), dominated by exotic forbs (U:Exotic-Forb), shrub with annual species or native perennial grasses (U:SAP), seeding of mixed introduced and native species (U:SDI), and native seeding (U:Seeded-Native). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

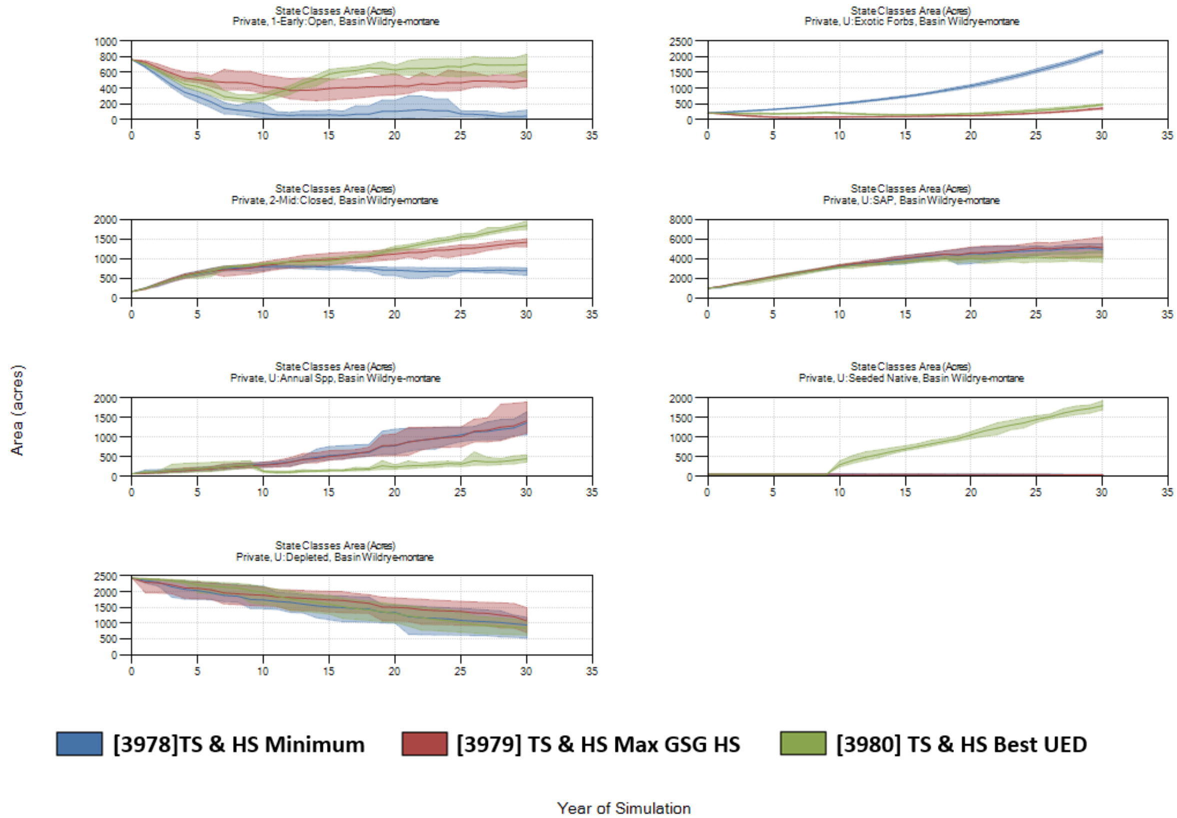


Figure 67. Area (acres) of seven basin wildrye-montane state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the IL Ranch: early-succession (1-Early:Open), mid-succession closed (2-Mid:Closed), non-native annual species (U:Annual Spp), dominated by basin big sagebrush (U:Depleted), shrub with non-native annual species (U: SAP), dominated by exotic forbs (U:Exotic-Forb), shrub with annual species or native perennial grasses (U:SAP), seeding of mixed introduced and native species (U:SDI), and native seeding (U:Seeded-Native). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

<u>TS-Horseshoe Ranches: Big Sagebrush-semidesert</u>

In the Big Sagebrush-semidesert system, the largest changes in vegetation class in the MINIMUM MANAGEMENT scenario were (a) the maturation of the mixed non-native annual species and perennial grass class (U:ASPG) into the shrub with non-native annual species and perennial grass class (U:SAP) and (b) the increase of the non-native annual species class (U:Annual Spp). Seeded classes also matured. On both land ownerships, but more so on Newmont's private lands, the exotic forb class (U:Exotic Forb) was abundant. Halogeton was the primary species in this class.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area- Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:All	20		13.3	0.1%	11.4	0.1%
	2-Mid:Open	5		45.4	0.2%	27.0	0.1%
	3-Late:Closed	29		0.9	0.0%	24.2	0.1%
	4-Late:Dense	1		0.0	0.0%	0.0	0.0%
	U:Annual Spp			3298.6	15.0%	4852.8	22.0%
	U:ASPG			11129.5	50.5%	3549.9	16.1%
	U:Depleted			268.7	1.2%	81.2	0.4%
	U:Early Shrub			193.9	0.9%	353.7	1.6%
	U:Exotic Forbs			520.4	2.4%	752.4	3.4%
	U:SA-Closed			1023.9	4.6%	547.5	2.5%
	U:SA-Dense			0.0	0.0%	0.0	0.0%
	U:SAP-Closed			3702.4	16.8%	10007.7	45.4%
	U:SAP-Dense			0.0	0.0%	0.1	0.0%
	U:SDI-A		2.9	698.3	3.2%	234.9	1.1%
	U:SDI-B		4.5	0.0	0.0%	781.3	3.5%
	U:SDI-C		2.5	0.0	0.0%	755.7	3.4%
	U:SDI-D		0.1	0.0	0.0%	0.1	0.0%
	U:SI-A+AS			1144.9	5.2%	8.0	0.0%
	U:SI-B+AS			0.0	0.0%	23.0	0.1%
	U:SI-C+AS			0.0	0.0%	29.4	0.1%
	U:SI-D+AS			0.0	0.0%	0.0	0.0%
Private	1-Early:All	20		25.8	0.0%	42.5	0.1%
	2-Mid:Open	5		439.5	0.7%	157.5	0.2%
	3-Late:Closed	29		1.8	0.0%	241.0	0.4%
	4-Late:Dense	1		0.0	0.0%	0.0	0.0%
	U:Annual Spp			13575.8	21.2%	16902.1	26.4%
	U:ASPG			21157.7	33.1%	6227.0	9.7%
	U:Depleted			1301.5	2.0%	360.6	0.6%
	U:Early Shrub			531.1	0.8%	1352.8	2.1%
	U:Exotic Forbs			13275.2	20.7%	13895.8	21.7%
	U:SA-Closed			4468.4	7.0%	2699.0	4.2%
	U:SA-Dense			0.0	0.0%	0.1	0.0%
	U:SAP-Closed			5687.1	8.9%	18611.4	29.1%
	U:SAP-Dense			0.0	0.0%	0.6	0.0%
	U:SDI-A		2.9	844.2	1.3%	396.4	0.6%
	U:SDI-B		4.5	0.0	0.0%	1237.4	1.9%
	U:SDI-C		2.5	0.0	0.0%	872.8	1.4%
	U:SDI-D		0.1	0.0	0.0%	0.0	0.0%
	U:SI-A+AS			2704.3	4.2%	158.5	0.2%
	U:SI-B+AS			0.0	0.0%	437.8	0.7%

U:SI-C+AS	0.0	0.0%	419.0	0.7%
U:SI-D+AS	0.0	0.0%	0.1	0.0%

No actions were implemented under the MAX GSG HS MANAGEMENT scenario because restoration of the non-native annual species class (U:Annual Spp) to an introduced species seeding class would be prone to failure and take too many years of maturation to be useful for sage-grouse. However, only one action was planned in the BEST UED MANAGEMENT scenario and only on BLM lands: spraying Plateau and seeding introduced species to control the spread of the non-native annual species class (U:Annual Spp; table below). Unlike for the other scenario, the goal here is to stop future fires, which might benefit sage-grouse through indirect habitat protection. Furthermore, treatment implementation starts in the tenth year so that this potential cost is not incurred in the first decade while most other actions are funded. No halogeton control was used as there is currently not an effective treatment for this plant.

			Acres/Year (Avg of 10 runs)			
Ownership	Scenario	Mgmt Action	Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	BEST UED	Herbicide - Plateau + Seed	0	500	$170	
						$822,500 ± $112,131

The realized implementation rate of the Herbicide-Plateau+seed action is shown in Figures 68. The realized implementation rate approximated the planned rate during the first six years, and then fell to much lower levels as areas of the non-native annual species class (U:Annual Spp) became scarce or inaccessible.

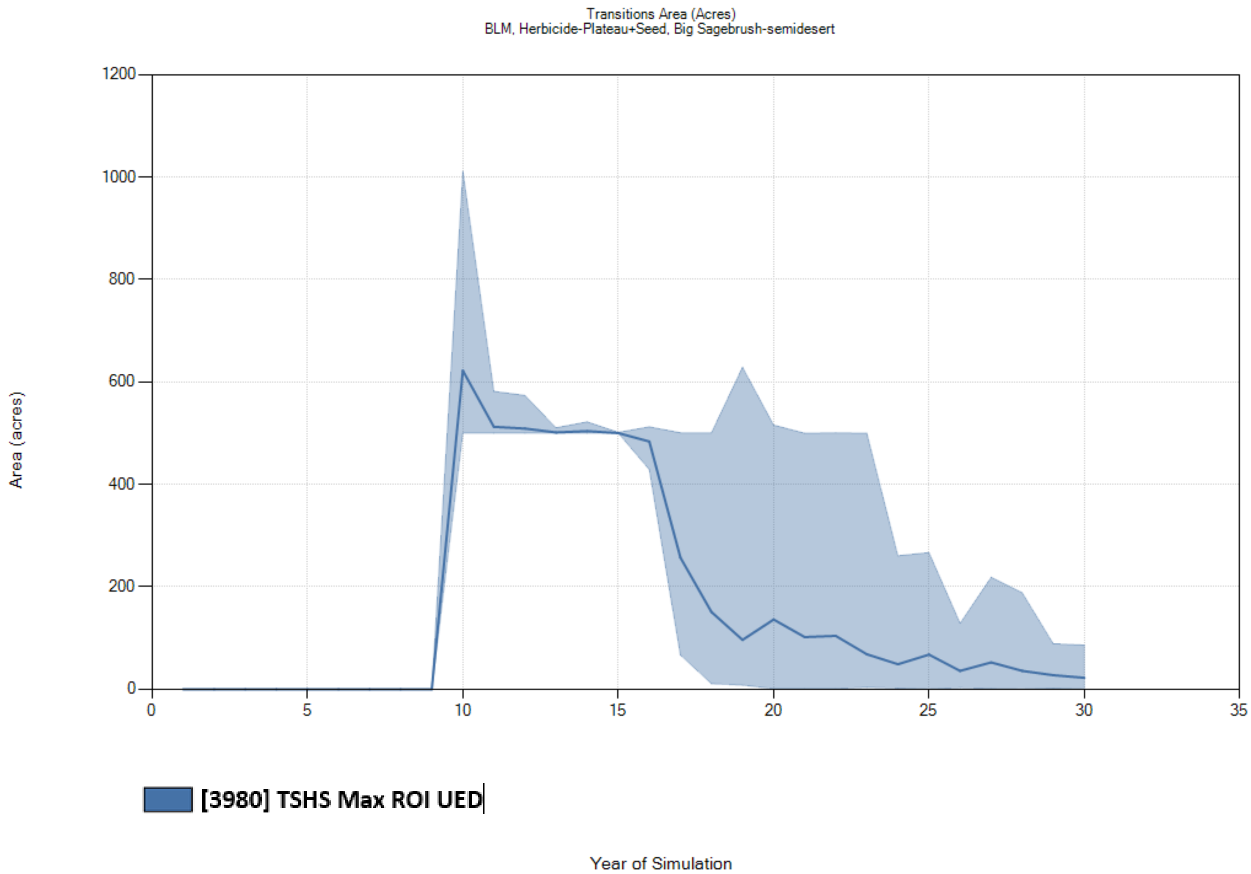


Figure 68. Realized yearly implementation rates for herbicide-Plateau+seed in the TS-Horseshoe Ranches' big sagebrush-semidesert for BLM lands. The dark line is the mean for each scenario and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The BEST UED MANAGEMENT scenario did not decrease UED (100%) compared to MINIMUM MANAGEMENT scenario or the current condition (table below). The ROI for the BEST UED MANAGEMENT scenario, therefore, was not different than zero and not worth doing specifically to improve UED, but may be important for other reasons.

System Acres: 86,079	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	**Best UED**	**MAX GSG HS**
Unified Ecological Departure	100%	100% ± 0%	100% ± 0%	100% ± 0%
Cost			$822,500 ± 112,131	-
ROI - vs Minimum Mgmt			0	-
ROI - 95% Confidence Interval			± 0	-
ROI of single scenario >0?			No	-
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**n/a**	

Results of the herbicide-Plateau+seed action from the BEST UED scenario on BLM lands are shown in Figure 69. The non-native annual species class (U:Annual Spp) was decreased by at least 3,000 acres in the BEST UED MANAGEMENT scenario compared to doing nothing. This action nearly eliminated this uncharacteristic class. Moreover, despite the long succession recovery time, restoration of potential nesting habitat (though less valuable at this elevation) and reduction of fire ignition were achieved. Therefore, although UED's ROI did not justify any management action, whether to use this action could be decided based on sage-grouse habitat suitability protection.

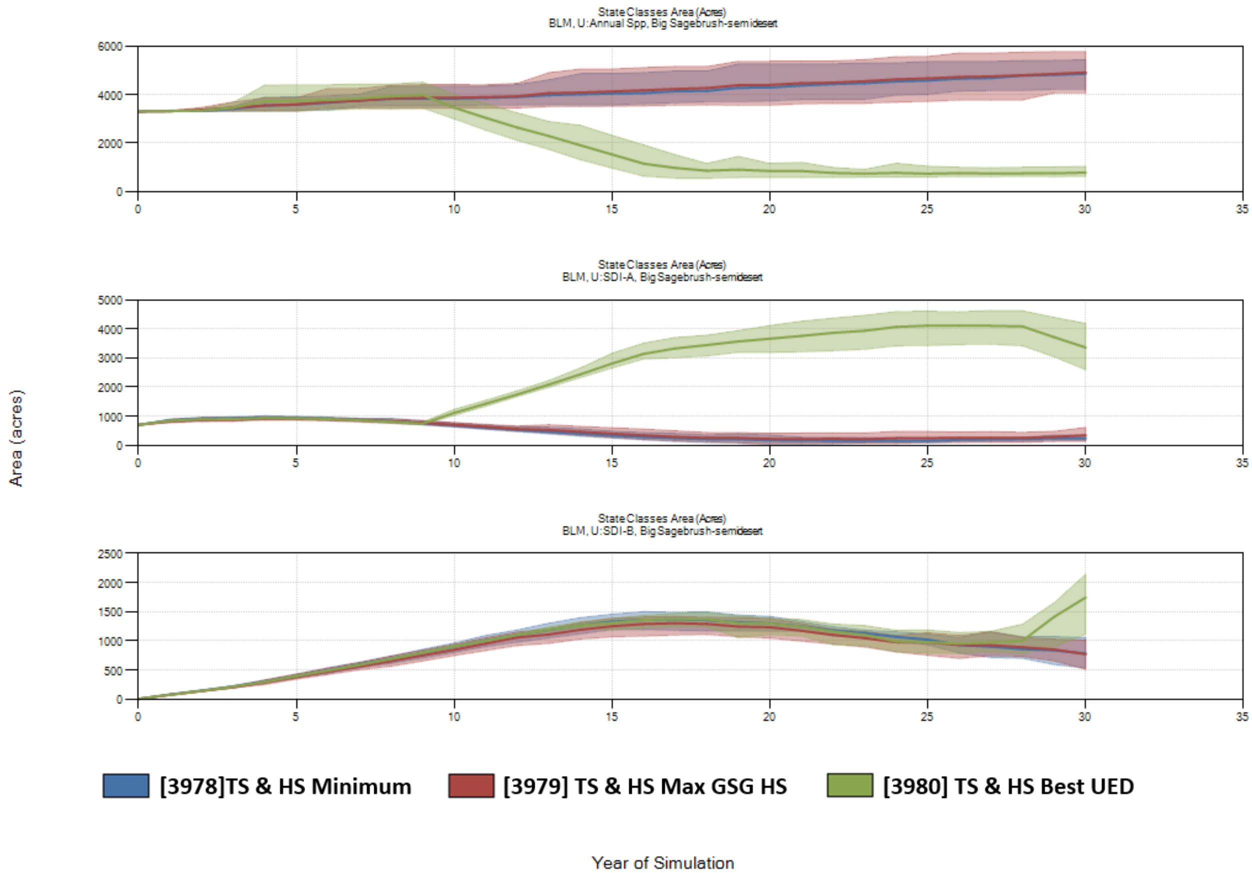


Figure 69. Area (acres) of three big sagebrush-semidesert state classes targeted for ecological improvement for all scenarios located on BLM lands of the TS-Horseshoe Ranches: non-native annual species (U:Annual Spp), and early-succession and mid-succession seedings (respectively, U:SDI-A and U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

TS-Horseshoe Ranches: Big Sagebrush Upland with Trees

On both BLM and Newmont's private lands, the largest changes in vegetation class in the MINIMUM MANAGEMENT scenario were (a) the maturation of the mixed non-native annual species and perennial grass class (U:ASPG) into the shrub with non-native annual species and perennial grass class (U:SAP) and (b) the smaller areas of early- (1-Early:All) and mid-succession (2-Mid:Open) classes, respectively, maturing into the mid-succession (2-Mid:Open) and late-succession class (3-Late:Closed) classes (table below). These changes were primarily due to the recovery from past fires. The non-native annual species class (U:Annual Spp) approximately doubled from the current condition because of new fires.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:All	21		4421.2	5.3%	1196.3	1.4%
	2-Mid:Open	51		1704.4	2.1%	3032.1	3.7%
	3-Late:Closed	27		1337.9	1.6%	2729.2	3.3%
	4-Late:Dense	1		0.0	0.0%	0.9	0.0%
	5-Late:Open			0.0	0.0%	0.0	0.0%
	6-Late:Dense			0.0	0.0%	0.0	0.0%
	U:Annual Spp			4448.8	5.4%	8888.5	10.8%
	U:ASPG			41621.6	50.3%	13024.2	15.8%
	U:Depleted			1218.7	1.5%	350.3	0.4%
	U:Early Shrub			2005.1	2.4%	3096.7	3.7%
	U:Exotic Forbs			20.5	0.0%	203.2	0.2%
	U:SA-Closed			841.5	1.0%	1068.6	1.3%
	U:SA-Dense			0.0	0.0%	0.0	0.0%
	U:SAP-Closed			12444.3	15.1%	36578.6	44.2%
	U:SAP-Dense			4.4	0.0%	4.3	0.0%
	U:SDI-A		3.1	2082.5	2.5%	1086.6	1.3%
	U:SDI-B		4.4	63.2	0.1%	5596.1	6.8%
	U:SDI-C		2.4	7.1	0.0%	4051.5	4.9%
	U:SDI-D		0.1	0.0	0.0%	0.7	0.0%
	U:SDI-E			0.0	0.0%	0.0	0.0%
	U:Seeded Native			0.0	0.0%	0.0	0.0%
	U:SI-A+AS			9724.0	11.8%	271.5	0.3%
	U:SI-B+AS			683.2	0.8%	751.2	0.9%
	U:SI-C+AS			51.6	0.1%	749.3	0.9%
	U:SI-D+AS			0.0	0.0%	0.2	0.0%
	U:SI-E+AS			0.0	0.0%	0.0	0.0%
	U:TEA			0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb			0.0	0.0%	0.0	0.0%
Private	1-Early:All	21		6598.0	5.9%	1558.5	1.4%
	2-Mid:Open	51		3178.5	2.8%	5045.4	4.5%
	3-Late:Closed	27		2367.2	2.1%	4571.3	4.1%
	4-Late:Dense	1		0.0	0.0%	1.2	0.0%
	5-Late:Open			0.0	0.0%	0.0	0.0%
	6-Late:Dense			0.0	0.0%	0.0	0.0%
	U:Annual Spp			5692.4	5.1%	10949.8	9.8%
	U:ASPG			59303.7	53.0%	15270.6	13.7%
	U:Depleted			1386.9	1.2%	356.2	0.3%
	U:Early Shrub			2974.7	2.7%	4379.5	3.9%
	U:Exotic Forbs			37.4	0.0%	288.0	0.3%
	U:SA-Closed			804.2	0.7%	1718.8	1.5%

U:SA-Dense		0.0	0.0%	0.3	0.0%
U:SAP-Closed		16489.2	14.7%	54815.0	49.0%
U:SAP-Dense		0.0	0.0%	4.8	0.0%
U:SDI-A	3.1	2173.2	1.9%	902.8	0.8%
U:SDI-B	4.4	184.1	0.2%	3221.1	2.9%
U:SDI-C	2.4	31.1	0.0%	2846.9	2.5%
U:SDI-D	0.1	0.0	0.0%	0.4	0.0%
U:SDI-E		0.0	0.0%	0.0	0.0%
U:Seeded Native		0.0	0.0%	0.0	0.0%
U:SI-A+AS		9707.1	8.7%	711.0	0.6%
U:SI-B+AS		814.0	0.7%	2227.9	2.0%
U:SI-C+AS		94.3	0.1%	2965.9	2.7%
U:SI-D+AS		0.0	0.0%	0.5	0.0%
U:SI-E+AS		0.0	0.0%	0.0	0.0%
U:TEA		0.0	0.0%	0.0	0.0%
U:Unpalat. Forb		0.0	0.0%	0.0	0.0%

For the MAX GSG HS MANAGEMENT scenario, restoration was focused on reducing non-native annual species (U:Annual Spp) with the treatment herbicide-Plateau+seed (table below) because this class decreases nest success for nests up to 2 km away and promotes fire ignitions and spread. Levels of implementation were high. No other action was used in this scenario.

The planned actions in the BEST UED MANAGEMENT scenario also contained the herbicide-Plateau+seed treatment for the non-native annual species class (U:Annual Spp) (table below). In addition, minor levels of exotic forb control were employed as a standard range improvement maintenance activity.

The cumulative 30-year cost of the BEST UED MANAGEMENT scenario was about $200,000-$300,000 less expensive than for the MAX GSG HS MANAGEMENT scenario for BLM and Newmont's private lands (table below).

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	MAX GSG HS	Herbicide- Plateau + Seed	1,500	200	$170	
						$1,700,350 ± $115,862
NEWMONT PRIVATE	MAX GSG HS	Herbicide- Plateau + Seed	1,200	500	$170	
						$2,206,424 ± $98,174
BLM	BEST UED	Exotic Control	10	10	$80	

		Herbicide -Plateau + Seed	1,500	100	$170	
						$1,551,538 ± $104,221
Newmont Private	Best UED	Exotic Control	10	10	$80	
		Herbicide + Plateau-Seed	400	500	$170	
						$1,943,088 ± $80,816

The realized implementation rate of actions by ownership and scenarios are shown in Figure 70 for BLM) and Newmont private lands. It is worth noting that many treatments have very limited and early windows of implementation to allow sagebrush maturation for sage-grouse habitat suitability within the study period.

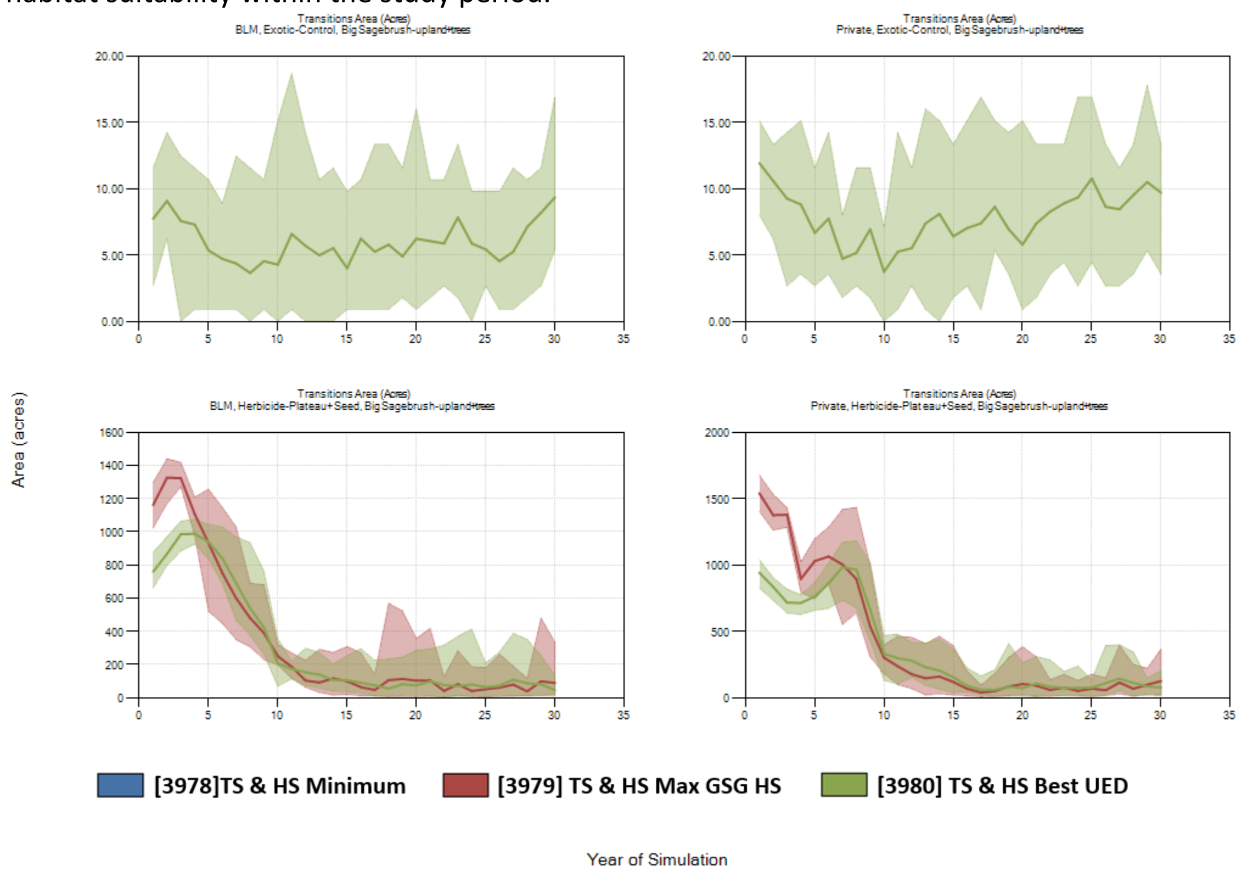


Figure 70. Realized yearly implementation rates for exotic control and herbicide-Plateau+seed, in the TS-Horseshoe Ranches' big sagebrush-upland with trees for BLM and Newmont's private lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

All scenarios lead to about equal decreases of UED (from 90% to about 85%) (table below). UED remained high despite significant investments in part because the most abundant vegetation classes that drive UED are 1) not treated and 2) restored classes were also uncharacteristic, but with small allowable no-penalty thresholds. Despite this. the ROIs for the Best UED Management and Max GSG HS Management scenarios were still significantly greater than zero, thus they were worth doing. The Max GSG HS Management scenario's ROIs was not statistically different than the Best UED Management scenario's ROI suggesting that the additional expenditures of $500,000 over 30 years may not be necessary.

System Acres: 194,517		Scenarios – 30 years (mean & 95% CI of 10 replicates)		
	Current	**Minimum**	**Best UED**	**Max GSG HS**
Unified Ecological Departure	91%	90% ± 1%	85% ± 1%	85% ± <1%
Cost			$3,494,626 ± 180,294	$3,906,774 ± 207,048
ROI - vs Minimum Mgmt			24.1	21
ROI - 95% Confidence Interval			± 2.9	± 2.9
ROI of single scenario >0?			Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**No**	

Results of management actions by ownership and scenario are shown in Figures 71 (BLM) and 72 (Newmont private). The non-native annual species class (U:Annual Spp) was reduced by at least 4,000 acres on BLM lands and 6,000 acres on Newmont's private lands for each active scenario compared to the Minimum Management scenario. Only the Best UED Management scenario reduced classes invaded by exotic forbs (U:Exotic Forb) compared to the Minimum Management scenario and Max GSG HS Management scenario where no control was implemented. Interestingly, lower abundance of the exotic forb class was observed in the Max GSG HS Management scenario compared to the Minimum Management scenario despite no resources being devoted to exotic control. This may have resulted an indirect benefit of moving non-native annual species acres into the more invasion resistant seeded class.

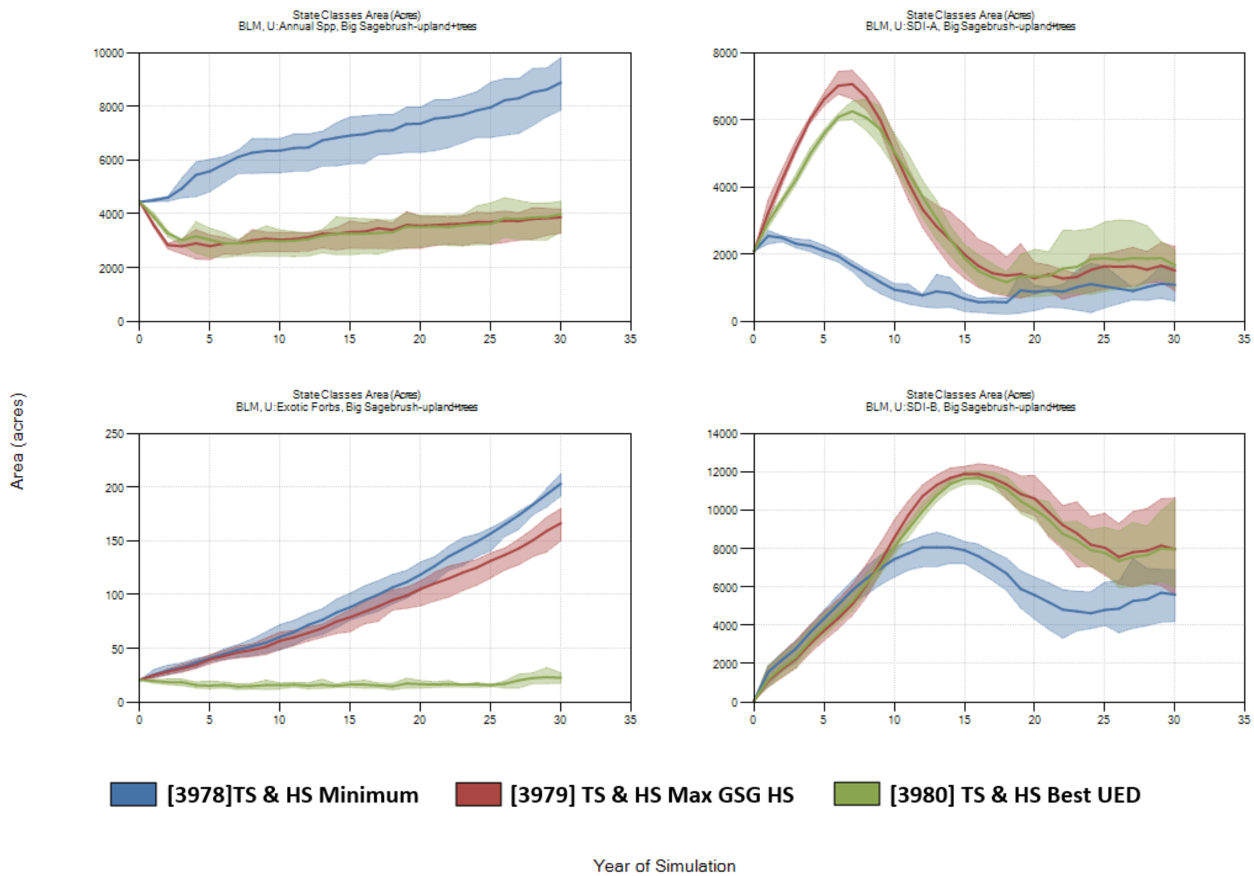


Figure 71. Area (acres) of four big sagebrush-upland with trees state classes targeted for ecological improvement for all scenarios located on BLM lands of the TS-Horseshoe Ranches: non-native annual species (U:Annual Spp), exotic forbs (U:Exotic Forb), and early-succession and mid-succession seedings (respectively, U:SDI-A and U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

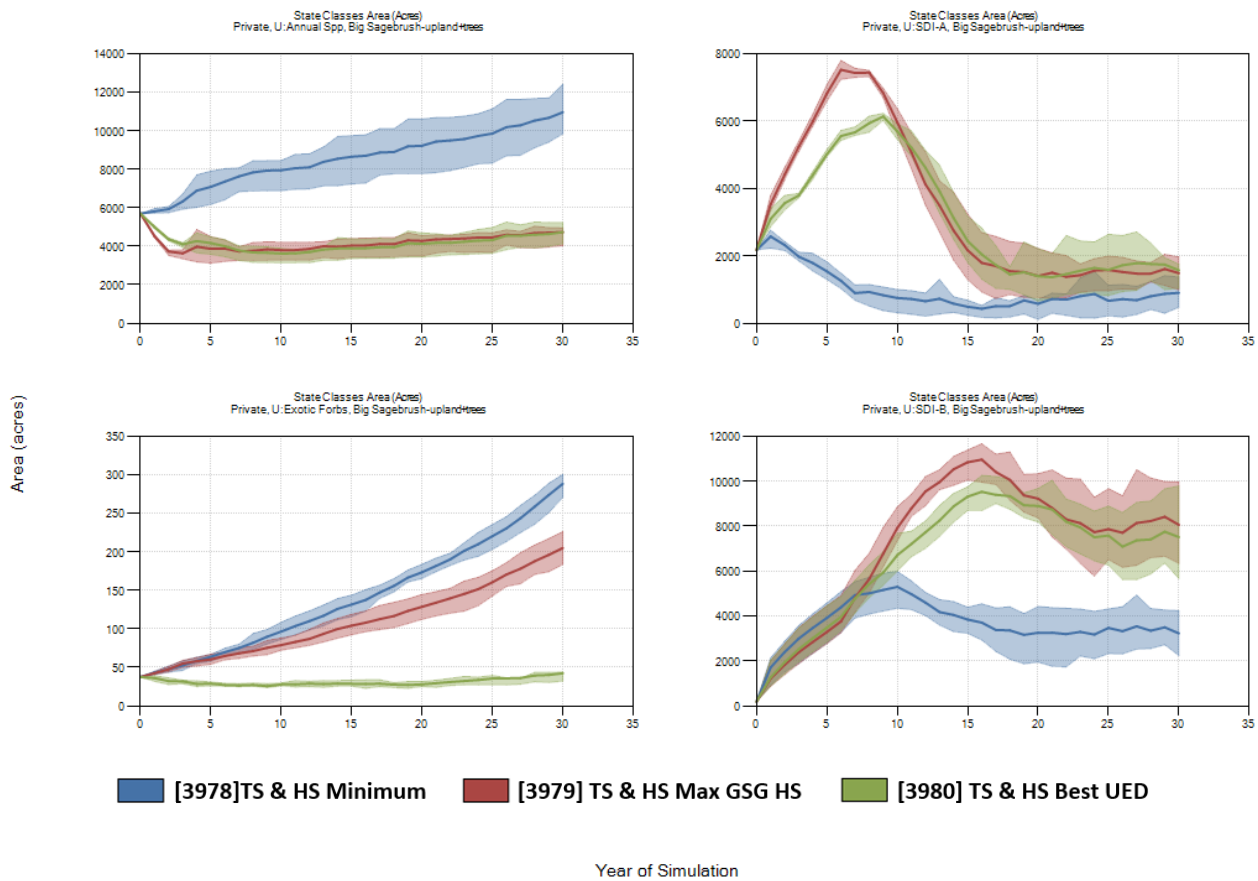


Figure 72. Area (acres) of four big sagebrush-upland with trees state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the TS-Horseshoe Ranches: non-native annual species (U:Annual Spp), exotic forbs (U:Exotic Forb), and early-succession and mid-succession seedings (respectively, U:SDI-A and U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

<u>TS-Horseshoe Ranches: Montane Riparian</u>

During 30 years of MINIMUM MANAGEMENT scenario, the two exotic forb classes (U:Exotic Forb&Tree and U:Incised-EFT) increased, the incised class (U:Desertified) decreased, and the early-succession willow class (1-Early:Willow) increased on BLM lands increased slightly (table below). On Newmont's private lands, the same classes changed as on BLM lands and the incised early shrub class (U:Early Shrub) increased from 0% to about 11%. Three processes primarily explained results; in decreasing order of importance they are: 1) all forms of grazing maintained or increased the abundance of early-succession reference classes by preventing willow development and increased the abundance of desertified classes; 2) exotic forb and tree invasion increased the abundance of all invaded classes; and 3) replacement fires decreased the amount of late-succession reference and uncharacteristic classes. These results suggest implementing actions for exotic control and grazing management of riparian areas.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:Cottonwood	0		0.0	0.0%	0.4	0.1%
	1-Early:Willow	33		103.2	20.4%	116.9	23.1%
	2-Mid:Cottonwood	0		82.7	16.3%	2.2	0.4%
	3-Late:Cottonwood	0		0.0	0.0%	47.1	9.3%
	3-Late:Willow	66		217.9	43.1%	229.6	45.4%
	PointBar:Bare Ground	1		0.0	0.0%	0.0	0.0%
	U:Annual Spp			0.0	0.0%	0.0	0.0%
	U:Desertified			100.5	19.9%	34.2	6.7%
	U:Early Shrub			0.0	0.0%	22.0	4.3%
	U:Exotic Forb&Tree			1.8	0.4%	36.7	7.3%
	U:Incised-EFT			0.0	0.0%	6.2	1.2%
	U:Inset-A			0.0	0.0%	0.6	0.1%
	U:Inset-B			0.0	0.0%	0.0	0.0%
	U:Inset-EFT			0.0	0.0%	0.0	0.0%
	U:Inset-HU			0.0	0.0%	0.0	0.0%
	U:Inset-SFE			0.0	0.0%	0.2	0.0%
	U:Pasture			0.0	0.0%	0.0	0.0%
	U:SAP			0.0	0.0%	9.0	1.8%
	U:SDI			0.0	0.0%	0.0	0.0%
	U:SDI+AS			0.0	0.0%	0.0	0.0%
	U:Shrb-Frb Encr			0.0	0.0%	1.1	0.2%
Private	1-Early:Cottonwood	0		8.9	0.4%	0.9	0.0%
	1-Early:Willow	33		332.7	15.6%	550.6	25.9%
	2-Mid:Cottonwood	0		129.9	6.1%	2.9	0.1%
	3-Late:Cottonwood	0		0.0	0.0%	83.3	3.9%
	3-Late:Willow	66		334.5	15.7%	570.3	26.8%
	PointBar:Bare Ground	1		9.8	0.5%	9.8	0.5%
	U:Annual Spp			0.0	0.0%	1.3	0.1%
	U:Desertified			1180.5	55.5%	247.8	11.7%
	U:Early Shrub			0.0	0.0%	230.3	10.8%
	U:Exotic Forb&Tree			129.0	6.1%	264.8	12.5%
	U:Incised-EFT			0.0	0.0%	81.4	3.8%
	U:Inset-A			0.0	0.0%	5.5	0.3%
	U:Inset-B			0.0	0.0%	0.1	0.0%
	U:Inset-EFT			0.0	0.0%	1.2	0.1%
	U:Inset-HU			0.0	0.0%	0.0	0.0%
	U:Inset-SFE			0.0	0.0%	1.4	0.1%
	U:Pasture			0.0	0.0%	0.0	0.0%
	U:SAP			0.0	0.0%	66.6	3.1%

U:SDI	0.0	0.0%	0.0	0.0%
U:SDI+AS	0.0	0.0%	0.0	0.0%
U:Shrb-Frb Encr	1.8	0.1%	8.7	0.4%

Only the early-succession willow (1-Early:Willow) contributed to chick survival. Therefore, no specific management action was used in the MAX GSG HS MANAGEMENT scenario except the standard ranch practice of controlling exotic forbs and trees in montane riparian systems (table below).

To improve UED (BEST UED MANAGEMENT scenario) while maintaining a reasonable expenditure, exotic control was supplemented with the creation of riparian grazing pastures that limit the duration of livestock grazing access to montane riparian systems (i.e., fencing). This second scenario was, therefore, about ten times more expensive for Newmont's private land, which contains much of the riparian zones, versus BLM land.

			Acres/Year (Avg of 10 runs)			
Ownership	Scenario	Mgmt Action	Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	MAX GSG	Exotic Control	2	2	$80	
		Weed Inventory + Spot Treatment	50	50	$50	
						$14,973 ± $1,022
NEWMONT PRIVATE	MAX GSG	Exotic Control	60	4	$80	
		Weed Inventory + Spot Treatment	450	450	$50	
						$180,295 ± $7,052
BLM	BEST UED	Exotic Control	2	2	$80	
		Livestock Grazing Control	20	0	$350	
		Weed Inventory + Spot Treatment	50	50	$50	
						$17,895 ± $1,981
NEWMONT PRIVATE	BEST UED	Exotic Control	60	4	$80	
		Livestock Grazing Control	150	0	$350	
		Weed Inventory + Spot Treatment	250	250	$50	
						$151,369 ± $5,872

The realized rates for BLM lands generally matched the planned rates, except for the weed inventory and spot-herbicide spraying because once a pixel was inventoried, it could not be inventoried again for another three years (Figure 73). Therefore, too few areas were available due to this self-imposed logistic efficiency.

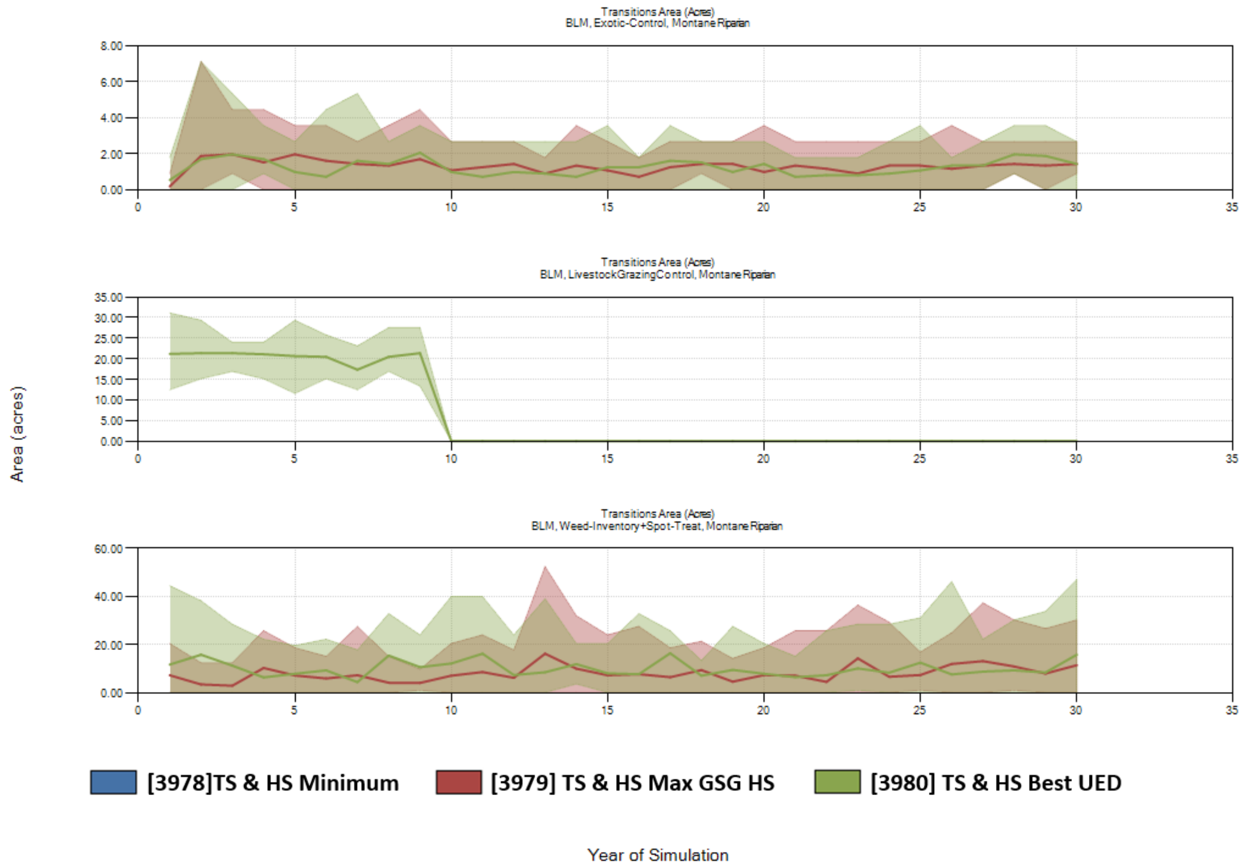


Figure 73. Realized yearly implementation rates for exotic control, livestock grazing control, and weed inventory supplemented with spot herbicide treatment in the TS-Horseshoe Ranches' montane riparian for BLM lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The realized implementation rates were also lower than the planned rates on Newmont's private lands (Figure 74). Again, higher planned rates of implementation were not possible because of self-imposed logistic efficiencies on retreating pixels already inventoried. The realized implementation of fencing for riparian pastures (i.e., livestock grazing control) matched the planned rate.

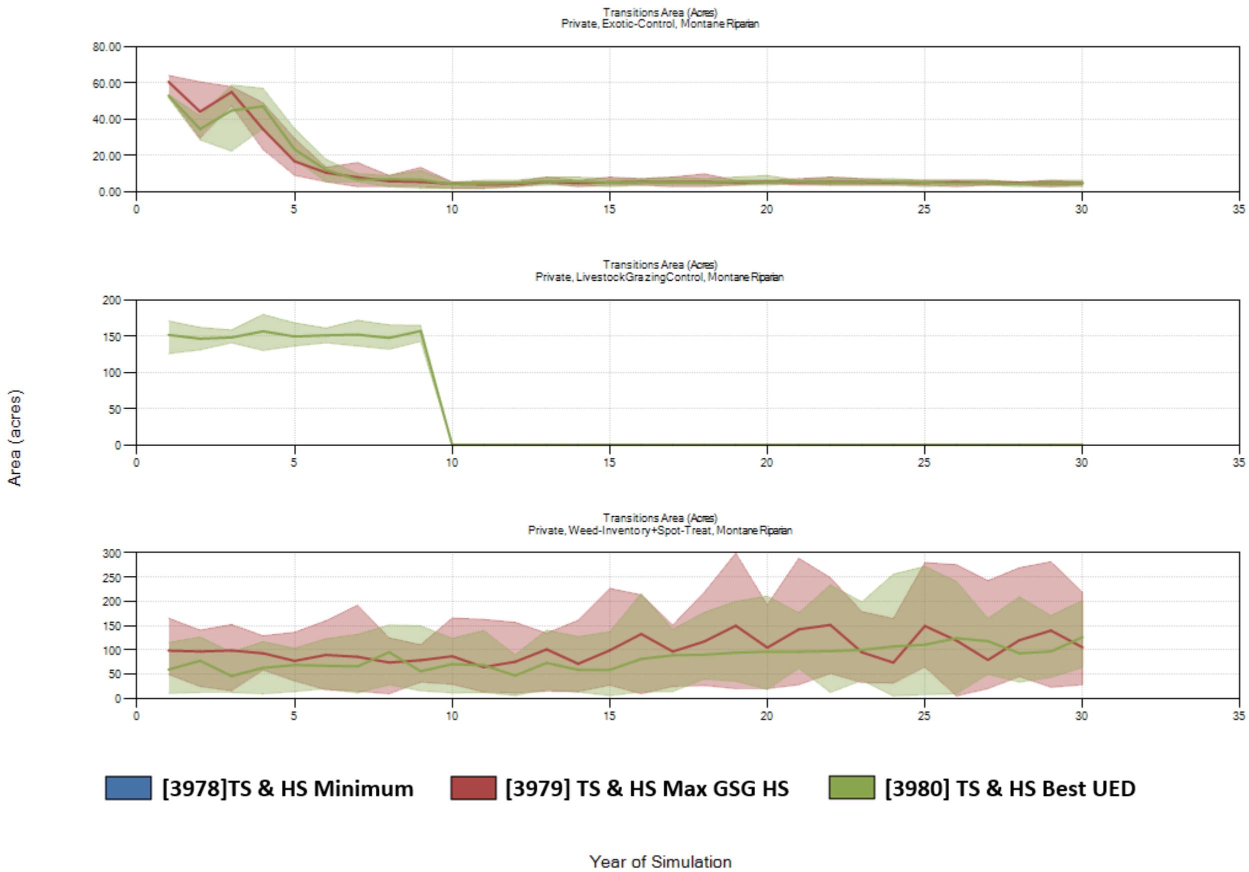


Figure 74. Realized yearly implementation rates for exotic control, livestock grazing control, and weed inventory supplemented with spot herbicide treatment in the TS-Horseshoe Ranches' montane riparian for Newmont's private lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The Minimum Management scenario decreased UED from 91% in 2014 to about 73% in 30 years (table below). Compared to the 73% for Minimum Management scenario, both active scenarios caused an additional decrease of UED to 59% for Max GSG HS Management scenario and 36% for Best UED Management scenario. The ROI for each active scenario was greater than zero and, therefore, better than the no-action alternative. The ROI for the Best UED Management scenario was about 2-3 times more in absolute value than that of the Max GSG HS Management scenario and 95% CIs did not overlap. Therefore, restoring montane riparian using a combination of fenced riparian pastures while controlling noxious weeds was more effective and less expensive than the weed-only alternative.

System Acres: 2,633		Scenarios – 30 years (mean & 95% CI of 10 replicates)		
	Current	**Minimum**	**Best UED**	**Max GSG HS**
Unified Ecological Departure	91%	73% ± 6%	36% ± 9%	59% ± 6%
Cost			$169,264 ± 5,790	$195,269 ± 7,110
ROI - vs Minimum Mgmt			57.9	20
ROI - 95% Confidence Interval			± 8.5	± 5.1
ROI of single scenario >0?			Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**Yes**	

Two vegetation classes for BLM lands and five vegetation classes for Newmont's private lands are presented in Figures 75 and 76. Both active scenarios reduced the area of the exotic forb and tree class (un-incised and incised) compared to the Minimum Management scenario on BLM lands (Figure 75), although acres involved were small. Management actions did not affect other classes. On Newmont's private lands (Figure 76), more classes were affected because management actions were implemented at higher rates. Exotic forb and tree classes were well controlled by both active scenarios compared to the Minimum Management scenario, and more so by the Best UED Management scenario than the Max GSG HS Management scenario. Fencing riparian pastures decreased the area of incised classes (U:Desertified, U:Early Shrub) and increased the area of the late-succession willow class (3-Late:Willow).

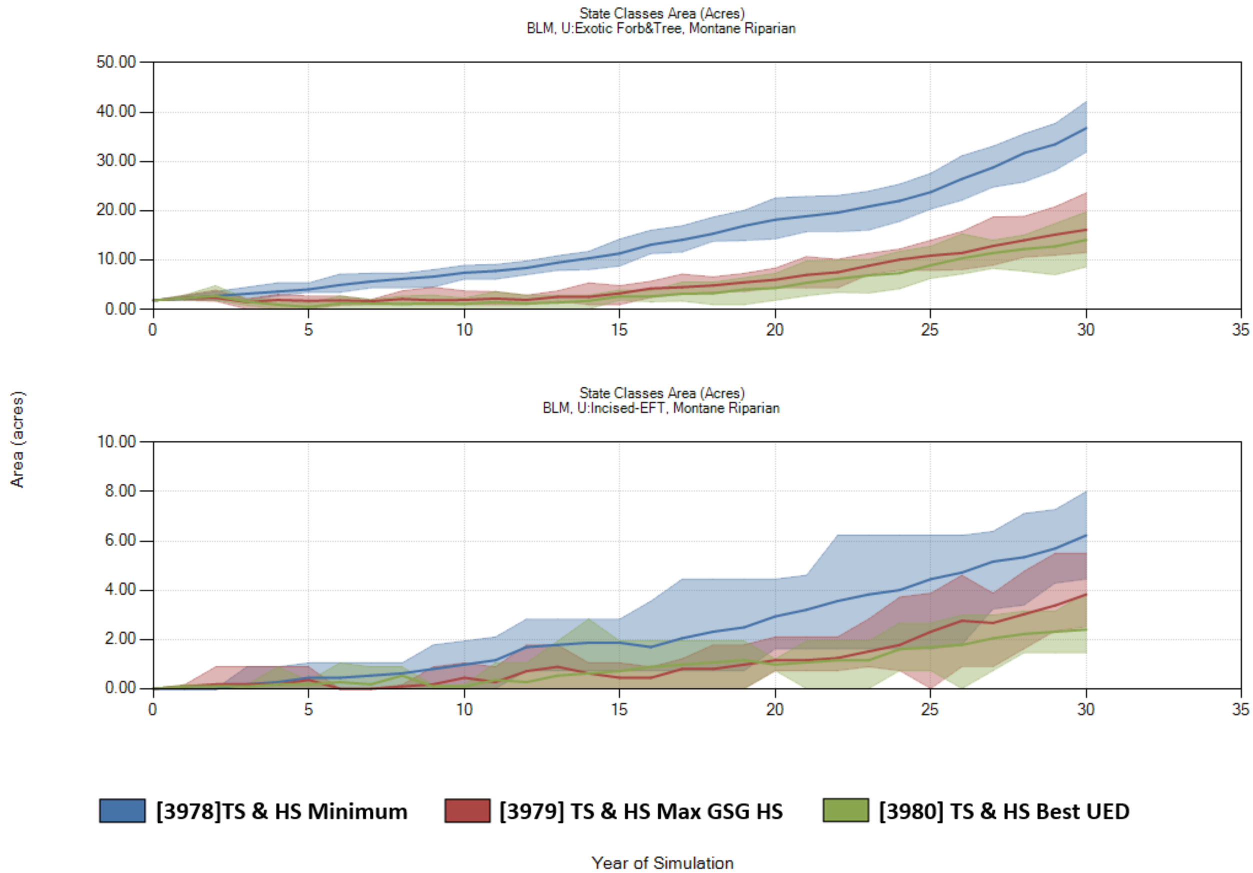


Figure 75. Area (acres) of two montane riparian state classes targeted for ecological improvement for all scenarios located on BLM lands of the TS-Horseshoe Ranches: exotic forbs and trees (U:Exotic-Forb & Tree), incised floodplain with exotic forbs and trees (U:Incised-EFT). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

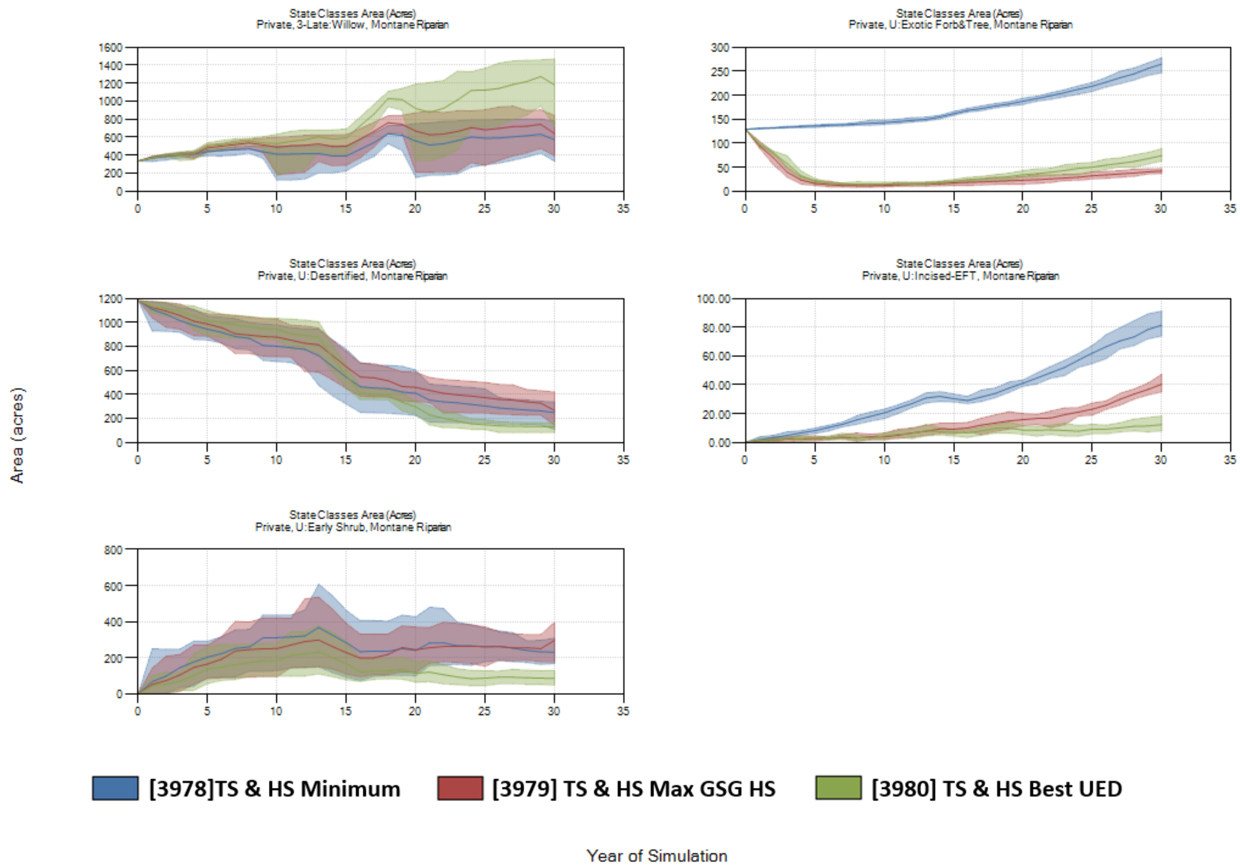


Figure 76. Area (acres) of five montane riparian state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the TS-Horseshoe Ranches: Late-succession willow (3-Late:Willow), incised (U:Desertified), early shrub (U:Early Shrub), exotic forbs and trees (U:Exotic-Forb & Tree), and incised floodplain with exotic forbs and trees (U:Incised-EFT). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

<u>TS-Horseshoe Ranches: Montane Sagebrush Steppe – Upland</u>

Three uncharacteristic classes currently dominated montane sagebrush steppe-upland: early-succession with mixed non-native annual species and perennial grasses (U:ASPG), late-succession with mixed non-native annual species and perennial grasses (U:SAP), and non-native annual species class (U:Annual Spp) (table below). The early-succession with mixed non-native annual species and perennial grass class (U:ASPG) decreased during 30 years as sagebrush matured into the late-succession with mixed non-native annual species and perennial grass class (U:SAP), which substantially increased in area. The non-native annual species class (U:Annual Spp) increased to >13% as a result of new fires and other minor sources of stand replacement.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:All	25		2223.9	18.9%	1130.6	9.6%
	2-Mid:Open	48		1743.6	14.8%	1827.9	15.5%
	3-Late:Closed	26		1551.4	13.2%	2123.1	18.0%
	4-Late:Dense	1		0.0	0.0%	18.9	0.2%
	U:Annual Spp			0.0	0.0%	1539.6	13.1%
	U:ASPG			5625.7	47.7%	995.8	8.4%
	U:Depleted			0.0	0.0%	2.8	0.0%
	U:Early Shrub			0.0	0.0%	81.4	0.7%
	U:Exotic Forbs			0.0	0.0%	59.7	0.5%
	U:SA-Closed			0.0	0.0%	8.9	0.1%
	U:SA-Dense			0.0	0.0%	0.0	0.0%
	U:SAP-Closed			149.4	1.3%	3487.0	29.6%
	U:SAP-Dense			0.0	0.0%	18.6	0.2%
	U:SDI-A		3.2	0.0	0.0%	0.0	0.0%
	U:SDI-B		4.4	0.0	0.0%	0.0	0.0%
	U:SDI-C		2.3	0.0	0.0%	0.0	0.0%
	U:SDI-D		0.2	0.0	0.0%	0.0	0.0%
	U:Seeded Native			0.0	0.0%	0.0	0.0%
	U:SI-A+AS			0.0	0.0%	0.0	0.0%
	U:SI-B+AS			0.0	0.0%	0.0	0.0%
	U:SI-C+AS			0.0	0.0%	0.0	0.0%
	U:SI-D+AS			0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb			493.7	4.2%	493.7	4.2%
Private	1-Early:All	25		1816.5	20.6%	691.1	7.8%
	2-Mid:Open	48		842.4	9.5%	1134.0	12.8%
	3-Late:Closed	26		870.0	9.9%	1417.4	16.1%
	4-Late:Dense	1		0.0	0.0%	13.5	0.2%
	U:Annual Spp			0.0	0.0%	1479.8	16.8%
	U:ASPG			4966.5	56.3%	811.3	9.2%
	U:Depleted			0.0	0.0%	5.3	0.1%
	U:Early Shrub			0.0	0.0%	74.6	0.8%
	U:Exotic Forbs			0.0	0.0%	48.4	0.5%
	U:SA-Closed			0.0	0.0%	20.2	0.2%
	U:SA-Dense			0.0	0.0%	0.0	0.0%
	U:SAP-Closed			157.5	1.8%	2944.7	33.4%
	U:SAP-Dense			0.0	0.0%	12.5	0.1%
	U:SDI-A		3.2	0.0	0.0%	0.0	0.0%
	U:SDI-B		4.4	0.0	0.0%	0.0	0.0%
	U:SDI-C		2.3	0.0	0.0%	0.0	0.0%

U:SDI-D	0.2	0.0	0.0%	0.0	0.0%
U:Seeded Native		0.0	0.0%	0.0	0.0%
U:SI-A+AS		0.0	0.0%	0.0	0.0%
U:SI-B+AS		0.0	0.0%	0.0	0.0%
U:SI-C+AS		0.0	0.0%	0.0	0.0%
U:SI-D+AS		0.0	0.0%	0.0	0.0%
U:Unpalat. Forb		173.5	2.0%	173.5	2.0%

Only one action, which was herbicide-Plateau+seed, was applied to montane sagebrush steppe to reduce the area of the non-native annual species class (U:Annual Spp) in both active scenarios on BLM and Newmont's private lands (table below). This class was the primary one that could be treated without directly decreasing sage-grouse habitat suitability. The herbicide-Plateau+seed action was implemented later in the simulation to reduce total project cost incurred during the first 10 years and because restoration of this system was less urgent or simply not possible due to steep slopes. Despite the different scenarios of implementation of the action, 30-year cumulative costs were comparable.

			Acres/Year (Avg of 10 runs)				
Ownership	Scenario	Mgmt Action	Years 1-3	Years 4-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	Max GSG HS	Herbicide + Plateau + Seed	0	0	150	$170	
							$22,834 ± 4,133
Newmont Private	Max GSG HS	Herbicide + Plateau + Seed	0	50	50	$170	
							$21,522 ± $3,688
BLM	Best UED	Herbicide + Plateau + Seed	0	0	75	$170	
							$22,416 ± $4,194
Newmont Private	Best UED	Herbicide + Plateau + Seed	0	0	50	$170	
							$21,236 ± $3,005

The realized implementation rates of herbicide-Plateau+seed (Figures 77) was far lower than the planned rates (table above) because slopes were too steep (>15%) in montane sagebrush steppe to allow equipment to function. As a consequence, the action was barely implemented and cost per year was very small.

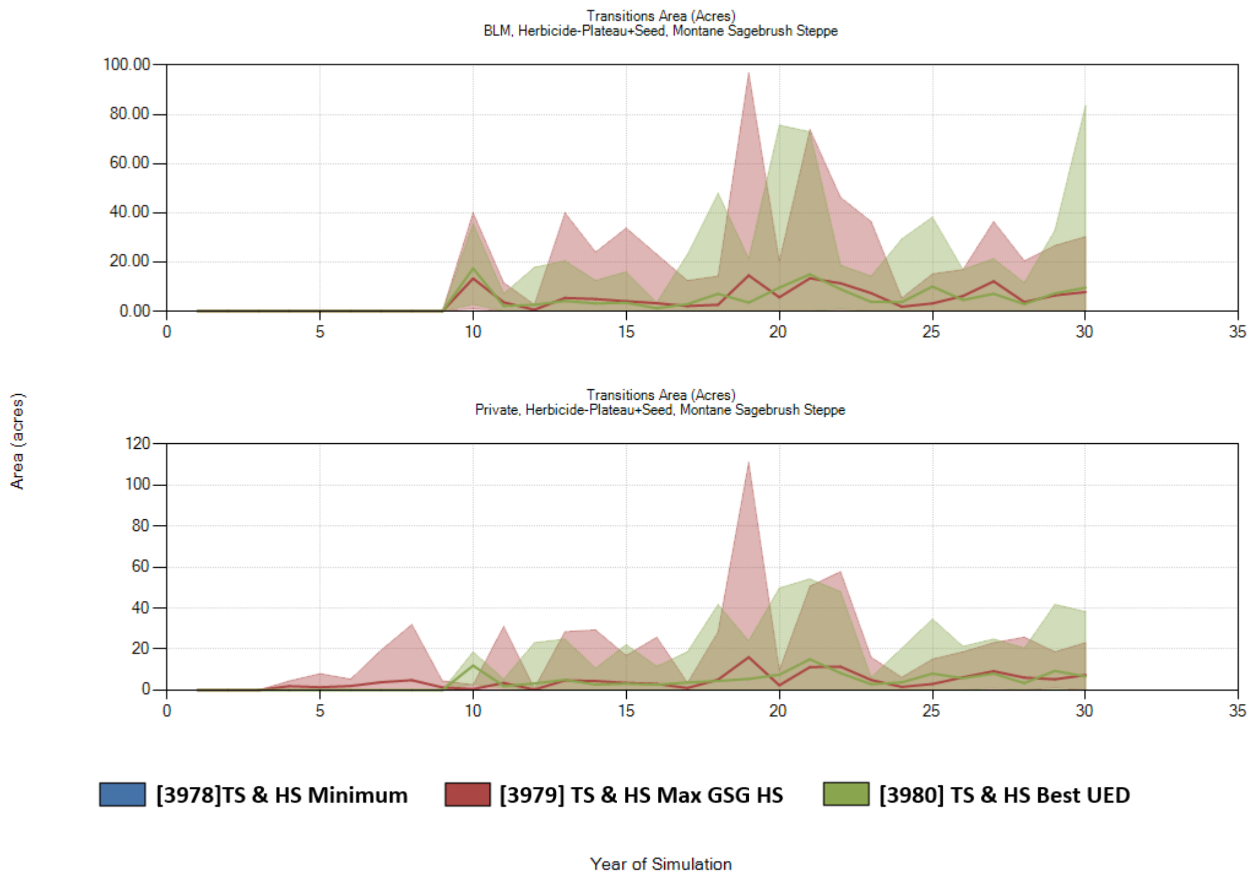


Figure 77. Realized yearly implementation rates for herbicide-Plateau+seed in the TS-Horseshoe Ranches' montane sagebrush steppe for BLM and Newmont's private lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

The MINIMUM MANAGEMENT scenario increased UED from 57% in current condition to about 83% in 30 years (table below). Compared to the 83% for MINIMUM MANAGEMENT scenario, both active scenarios caused a minor but significant decrease of UED to 81% for both scenarios. The ROIs for each active scenario were greater than zero, actually some of the highest on a relative scale, and, therefore, better than doing nothing. ROIs were high because the cost was small and the system area large (see ROI equation for UED in section **Ecological Return-On-Investment Analysis)**. Although the ROI for the MAX GSG HS MANAGEMENT scenario (100) appeared greater than that of the BEST UED MANAGEMENT scenario (93.2), the overlapping 95% CIs indicated no statistical difference between ROIs. Scenarios were statistically equivalent.

System Acres: 20,614		**Scenarios – 30 years (mean & 95% CI of 10 replicates)**		
	Current	**Minimum**	**Best UED**	**MAX GSG HS**
Unified Ecological Departure	57%	83% ± 1%	81% ± 1%	81% ± 1%
Cost			$43,652 ± 6,876	$44,356 ± 7,568

ROI - vs Minimum Mgmt		93.2	100
ROI - 95% Confidence Interval		± 50.4	± 24.5
ROI of single scenario >0?		Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →		**No**	

Area results for targeted classes by ownership are shown in Figure 78. The two types of results are classes that restoration was intended to reduce (non-native annual species – U:Annual Spp) and increase (seedings – U:SDI-A and U:SDI-B). Treatments were not very effective, but consistent due to the very low levels of realized implementation limited by steep slopes as shown by the MINIMUM MANAGEMENT scenario line and percentile range (blue line) overlapping with the active scenario lines.

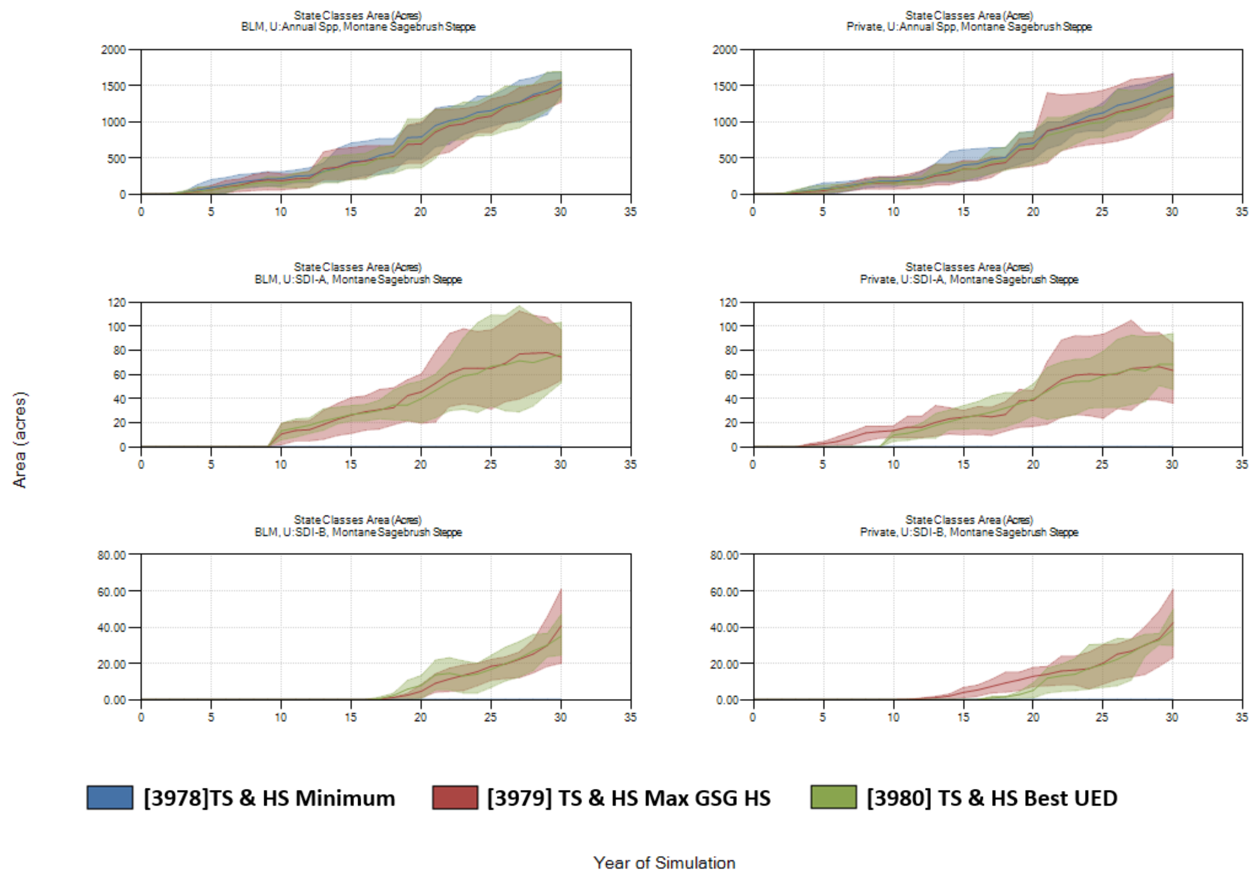


Figure 78. Area (acres) of three montane sagebrush steppe state classes targeted for ecological improvement for all scenarios located on BLM and Newmont's private lands of the TS-Horseshoe Ranches: Non-native annual species (U:Annual Spp), early-succession introduced species seeding (U:SDI-A), mid-succession introduced species seeding (U:SDI-B). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

TS-Horseshoe Ranches: Saline Meadow

During the 30 years of MINIMUM MANAGEMENT scenario, the distribution of class percentages did not dramatically change in saline meadow (table below). This is to be expected in the sodic soils where the system is found. On BLM lands, the exotic forb class (U:Exotic Forb) nearly tripled in area reaching 15.5% of the system, whereas the increase was modest on Newmont's private lands where the area invaded by exotic forbs was 39.7%. The depleted class (U:Depleted) was the second most uncharacteristic class on BLM and Newmont's private lands.

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:Open	0		4.4	1.1%	1.1	0.3%
	2-Mid:Closed	73		177.9	43.1%	183.2	44.4%
	3-Late:Open	27		121.9	29.5%	68.9	16.7%
	U:Annual Spp			11.6	2.8%	10.5	2.5%
	U:ASPG			0.0	0.0%	10.4	2.5%
	U:Depleted			75.6	18.3%	56.5	13.7%
	U:Exotic Forbs			21.3	5.2%	63.9	15.5%
	U:SAP			0.0	0.0%	18.4	4.5%
Private	1-Early:Open	0		72.9	1.0%	11.7	0.2%
	2-Mid:Closed	73		2309.3	31.6%	2208.9	30.2%
	3-Late:Open	27		1229.4	16.8%	758.1	10.4%
	U:Annual Spp			179.7	2.5%	164.8	2.3%
	U:ASPG			0.0	0.0%	138.2	1.9%
	U:Depleted			1147.6	15.7%	883.3	12.1%
	U:Exotic Forbs			2369.8	32.4%	2904.7	39.7%
	U:SAP			0.0	0.0%	238.9	3.3%
BOR	1-Early:Open	0		0.0	0.0%	0.0	0.0%
	2-Mid:Closed	73		0.0	0.0%	1.2	1.5%
	3-Late:Open	27		0.0	0.0%	0.0	0.0%
	U:Annual Spp			0.0	0.0%	0.0	0.0%
	U:ASPG			0.0	0.0%	1.8	2.1%
	U:Depleted			84.5	100.0%	66.0	78.1%
	U:Exotic Forbs			0.0	0.0%	7.9	9.4%
	U:SAP			0.0	0.0%	7.6	8.9%

Planned yearly implementation rates focused on spraying exotic forbs (exotic control), spraying Plateau to control non-native annual species (U:ASPG) followed by native grass species seeding, spraying the depleted shrub class invaded by non-native annual species (U:SAP) with Spike to reduce shrubs and with Plateau for non-native annual species followed by native grass species seeding, and mechanically thinning the native shrubs in the depleted class (U:Depleted) followed by seeding of native grasses (table below). Only the BEST UED MANAGEMENT scenario had actions. Cumulative 30-year cost was twice as much on Newmont's private lands than on BLM lands.

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	BEST UED	Exotic Control	5	5	$80	
		Herbicide-Plateau+Native-Seed	0	10	$295	
		Spike+Plateau+Native-Seed	0	10	$225	
		Thin+Native-Seed	0	50	$300	
						$36,068 ± $787
NEWMONT PRIVATE	BEST UED	Exotic Control	0	0	$80	
		Herbicide-Plateau+Native-Seed	0	25	$295	
		Spike+Plateau+Native-Seed	0	0	$225	
		Thin+Native-Seed	0	0	$300	
						$66,315 ± $1,365

The realized yearly implementation rates in Figures 79 [BLM] and 80 [Newmont private] showed short duration of implementation as treatments rapidly decreased the areas of target uncharacteristic classes. Although a greater variety of actions were used on BLM lands, their cumulative cost was lower than on Newmont's private lands where only one action was used (exotic control) because its duration of implementation was longer.

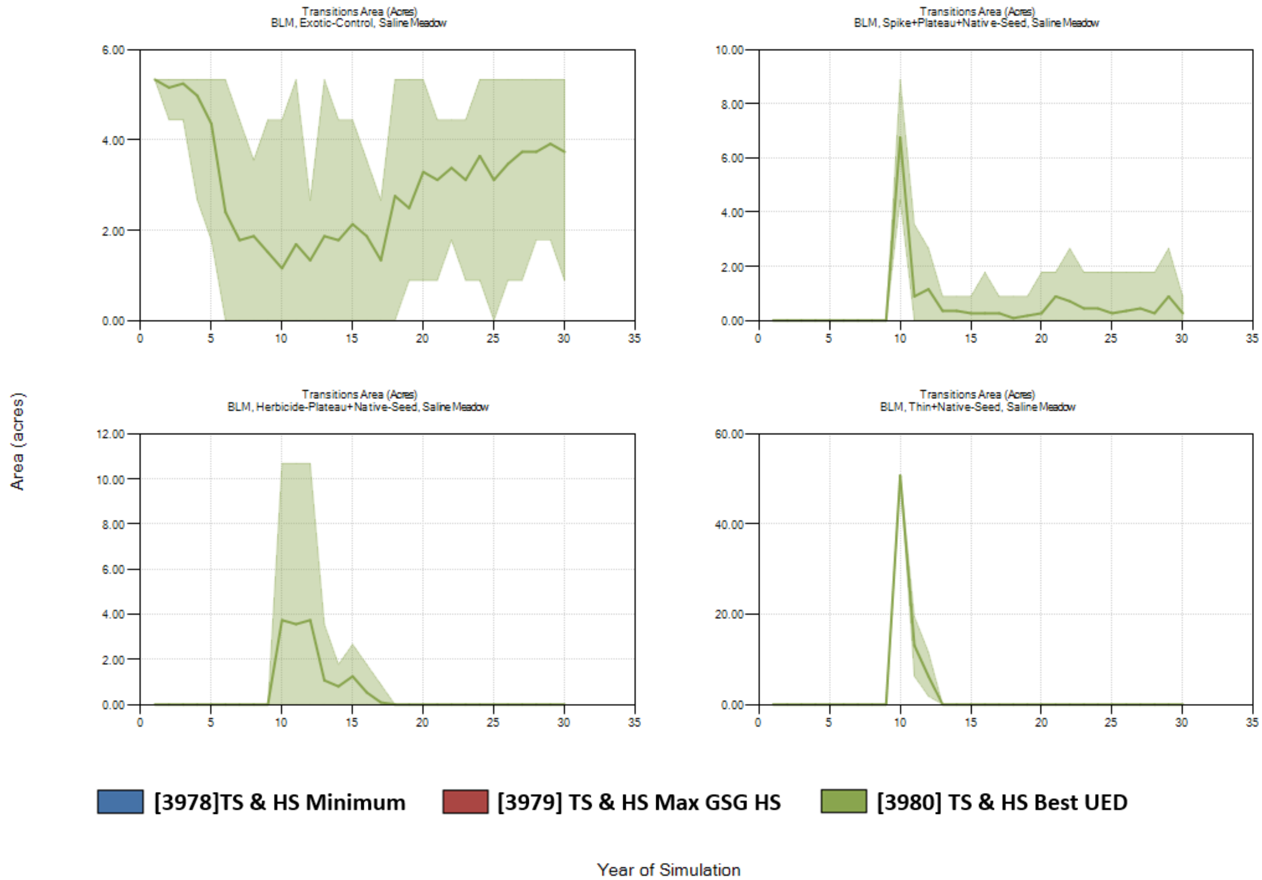


Figure 79. Realized yearly implementation rates for exotic control, herbicide-Plateau+native seed, Spike+Plateau+native seed, thin+native seed in the TS-Horseshoe Ranches' saline meadow for BLM lands. The dark line is the mean for each scenario (Max GSG Credit in red and Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

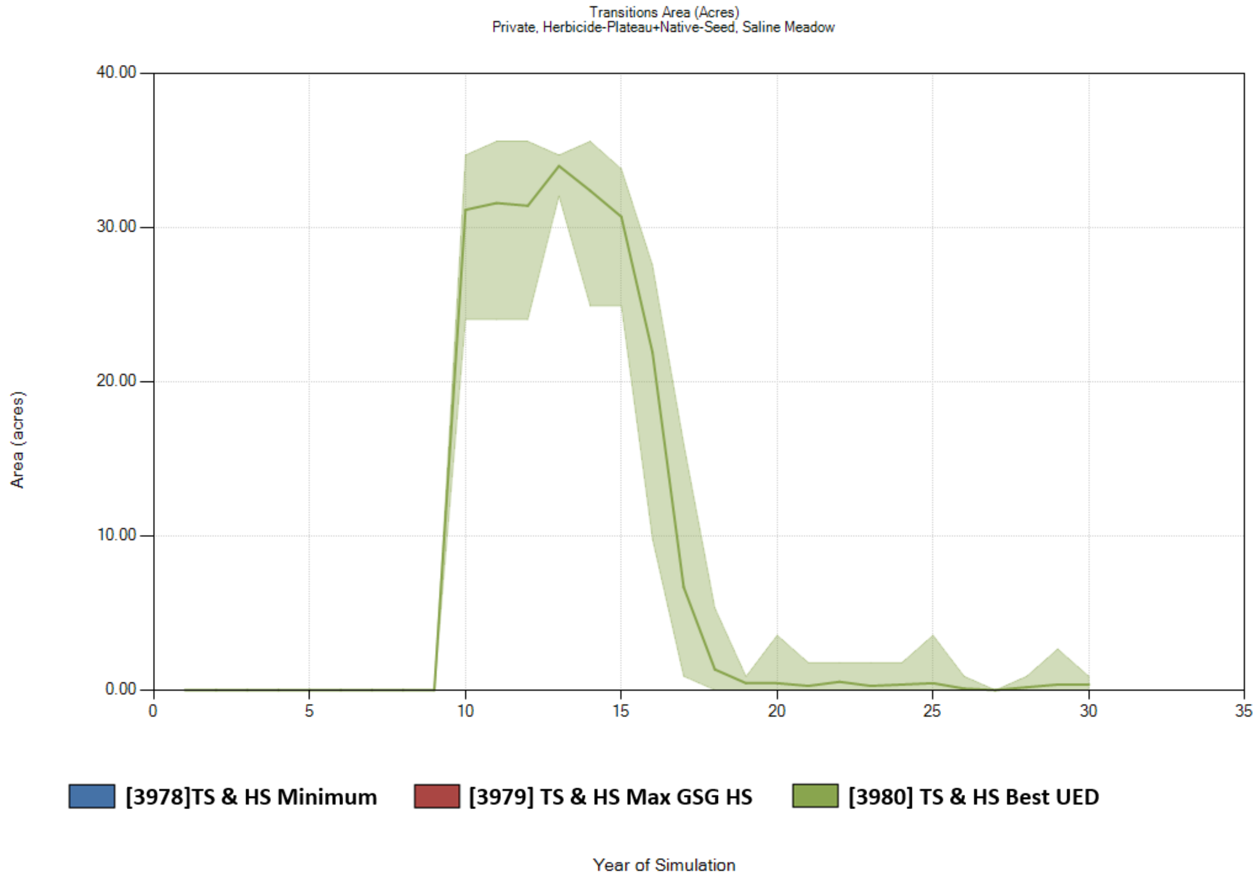


Figure 80. Realized yearly implementation rates for herbicide-Plateau+native seed in the TS-Horseshoe Ranches' saline meadow for Newmont's private lands. The dark line is the mean for each scenario (Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

In the MINIMUM MANAGEMENT scenario UED increased from 67% in 2014 to about 79% in 30 years (table below). Compared to the 79% for MINIMUM MANAGEMENT scenario, only the BEST UED MANAGEMENT scenario caused a modest and significant decrease of UED to 73%. No actions were used in the MAX GSG HS MANAGEMENT scenario. The ROI for BEST UED MANAGEMENT scenario was far greater than zero and, therefore, better than doing nothing.

System Acres: 7,806	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	Best UED	MAX GSG HS
Unified Ecological Departure	67%	79% ± 0%	73% ± 0%	79% ± 0%
Cost			$102,382 ± 1,543	-
ROI - vs Minimum Mgmt			45.9	-
ROI - 95% Confidence Interval			± 2	-
ROI of single scenario >0?			Yes	
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**n/a**	

On BLM lands, management actions in the Best UED Management scenario increased by at least 100 acres the mid-succession reference class (2-Mid:Closed) after the early-succession reference class matured (1-Early:Open), and sharply reduced many uncharacteristic classes (Figure 81). The area of the exotic forb class (U:Exotic Forb) was not completely controlled by herbicide application leaving about 10 acres of this class compared to the 60 acres for the Minimum Management and Max GSG HS Management scenarios.

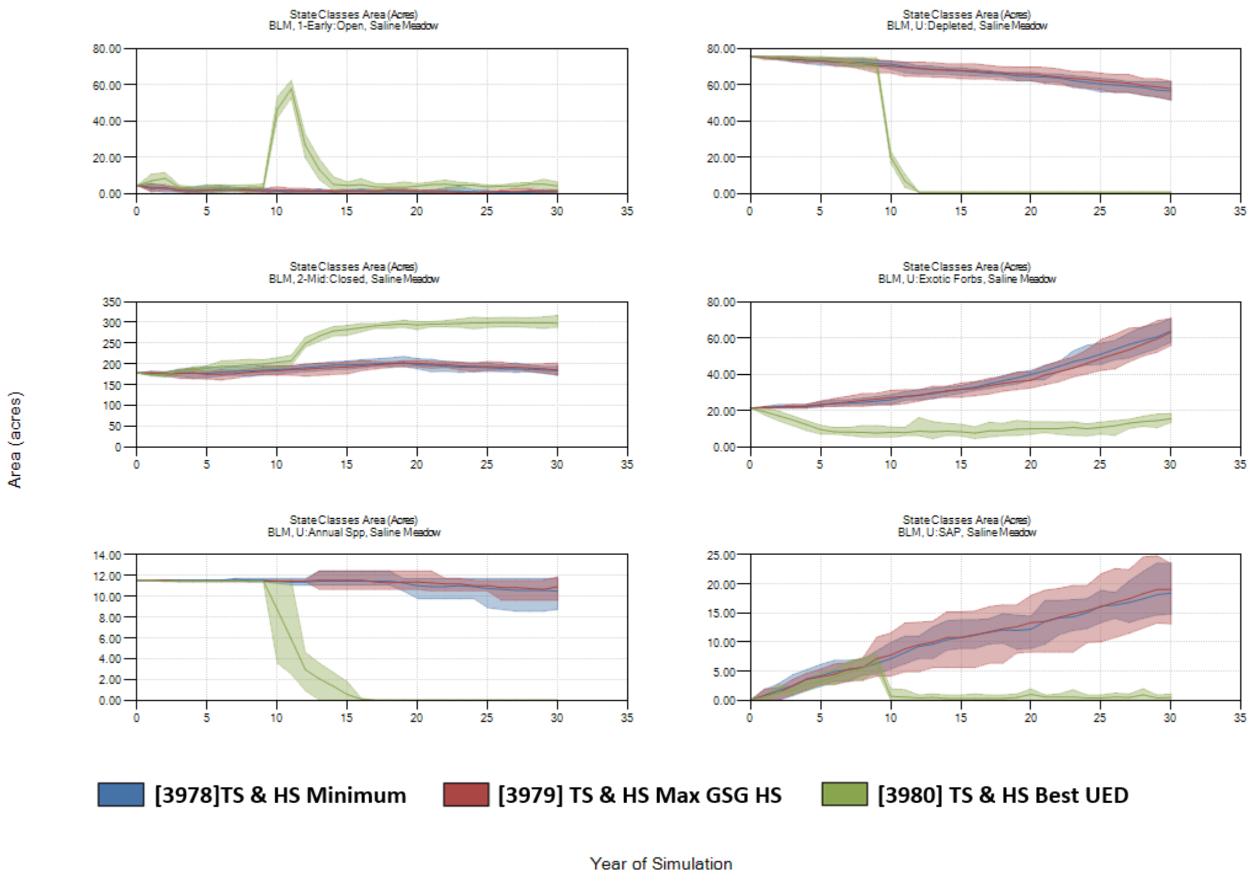


Figure 81. Area (acres) of six saline meadow state classes targeted for ecological improvement for all scenarios located on BLM lands of the TS-Horseshoe Ranches: early- and mid-succession reference classes (1-Early:Open and 2-Mid:Closed), depleted meadow (U:Depleted), invaded by exotic species (U:Exotic Forb), non-native annual species (U:Annual Spp), shrubs with non-native annual species and perennial grass (U:SAP). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

Only the non-native annual species class (U:Annual Spp) was treated in the Best UED Management scenario and was completely reduced on Newmont's private lands (Figure 82) compared to the about 175 remaining acres for the Minimum Management and Max GSG HS Management scenarios. Recruitment of acres into the early- (1-Early:Open) and mid-succession (2-Mid:Closed) classes was visible, but small.

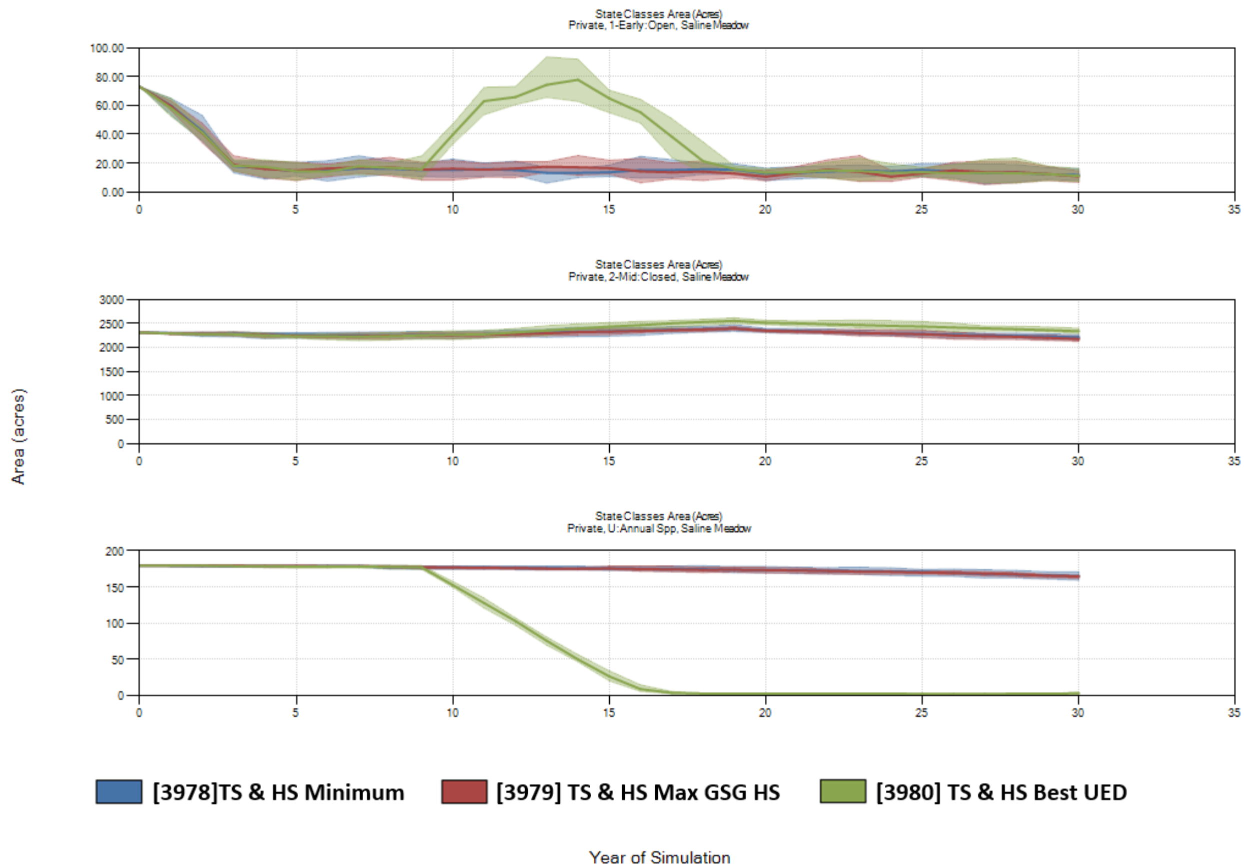


Figure 82. Area (acres) of three saline meadow state classes targeted for ecological improvement for all scenarios located on Private lands of the TS-Horseshoe Ranches: early- and mid-succession reference classes (1-Early:Open and 2-Mid:Closed), and non-native annual species (U:Annual Spp). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

<u>TS-Horseshoe Ranches: Wet Meadow- Bottomland</u>

General patterns about current and future 30-year MINIMUM MANAGEMENT scenario results can be observed in all ownerships (table below). The current condition on both BLM and Newmont's private lands lacked the critical mid-succession reference class (2-Mid:Closed) and had too many acers in the exotic forb class (U:Exotic Forb).

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:Open	2		0.0	0.0%	0.0	0.0%
	2-Mid:Closed	97		3.6	100.0%	2.4	67.5%
	3-Late:Open	1		0.0	0.0%	0.7	20.0%
	U:Annual Spp			0.0	0.0%	0.0	0.0%

	U:Desertified		0.0	0.0%	0.0	0.0%
	U:Early Shrub		0.0	0.0%	0.0	0.0%
	U:Exotic Forbs		0.0	0.0%	0.4	12.5%
	U:Hummocked		0.0	0.0%	0.0	0.0%
	U:Incised-EFT		0.0	0.0%	0.0	0.0%
	U:SA		0.0	0.0%	0.0	0.0%
	U:Shrb-Frb Encr		0.0	0.0%	0.0	0.0%
Private	1-Early:Open	2	0.0	0.0%	0.0	0.0%
	2-Mid:Closed	97	333.6	78.5%	220.2	51.8%
	3-Late:Open	1	0.0	0.0%	69.8	16.4%
	U:Annual Spp		0.0	0.0%	0.0	0.0%
	U:Desertified		0.0	0.0%	0.0	0.0%
	U:Early Shrub		0.0	0.0%	0.0	0.0%
	U:Exotic Forbs		91.6	21.5%	128.4	30.2%
	U:Hummocked		0.0	0.0%	6.8	1.6%
	U:Incised-EFT		0.0	0.0%	0.0	0.0%
	U:SA		0.0	0.0%	0.0	0.0%
	U:Shrb-Frb Encr		0.0	0.0%	0.0	0.0%

Planned yearly implementation rates were done differently for this small system found mostly on Newmont's private lands. In ST-Sim, treatment implementation rates were not restricted to any ownership, therefore the software implemented actions where it was possible. Output for cost (table below) and realized rates were reported by ownership *a posteriori*. More than 95% of the cost was spent on Newmont's private lands. These treatments were only executed in the BEST UED MANAGEMENT scenario.

			Acres/Year (Avg of 10 runs)			
Ownership	Scenario	Mgmt Action	Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
JOINTLY BLM & NEWMONT PRIVATE	BEST UED	Exotic Control	20	1	$80	
		Weed Inventory + Spot Treatment	200	100	$50	
		BLM				$993 ± $169
		NEWMONT PRIVATE				$155,214 ± 960

The realized yearly implementation rates in the figure below (Figure 83) displayed well the much lower rates of exotic forb control on BLM lands compared to the higher rates on Newmont's private lands during 30 years. In the latter case, ST-Sim often could not find any more uncharacteristic classes to treat after 10 years.

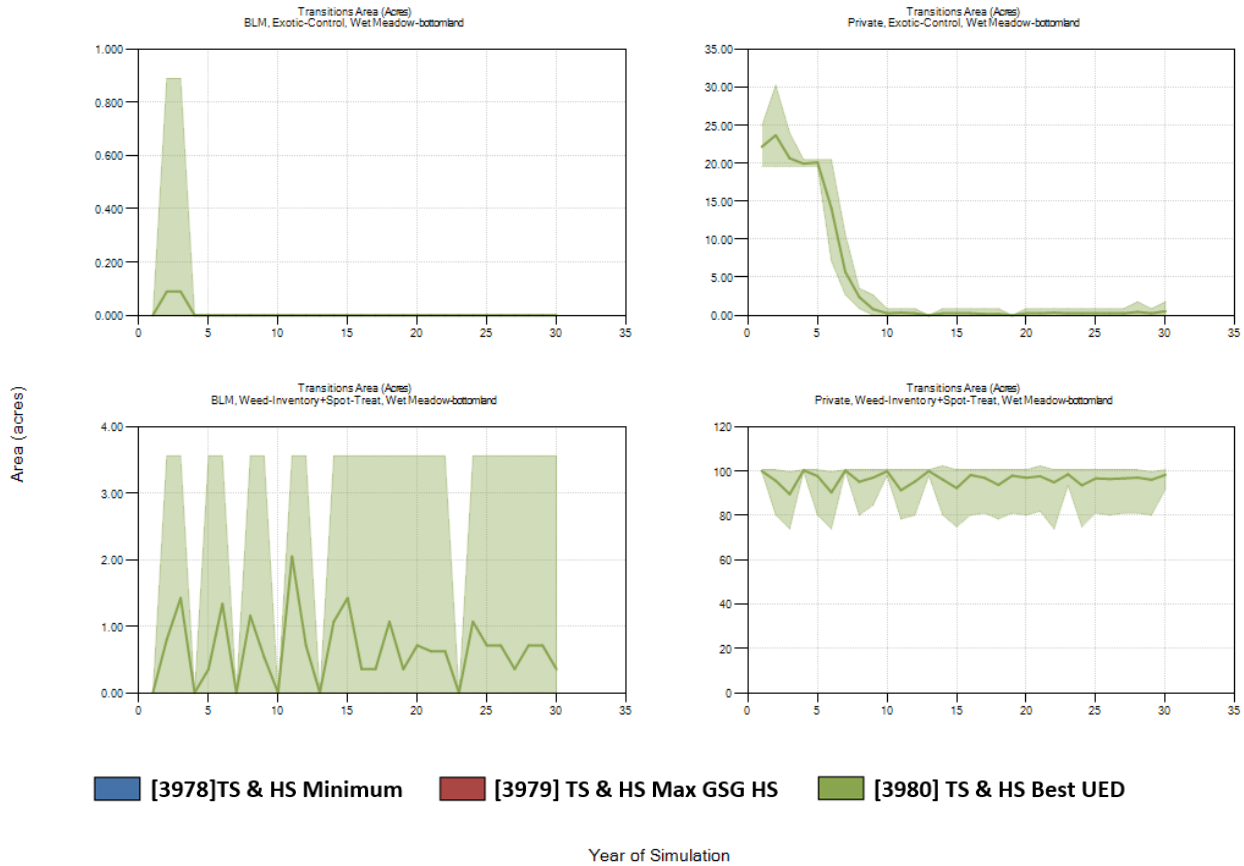


Figure 83. Realized yearly implementation rates for exotic control and weed inventory with spot treatment of exotics forbs in the TS-Horseshoe Ranches' wet meadow-bottomland for BLM and Newmont's private lands. The dark line is the mean for each scenario (Best UED in green) and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

UED increased in the Minimum Management scenario from 43% in 2014 to about 78% in 30 years (table below). Note that UED estimates for such small systems are potentially biased. Compared to the 78% for Minimum Management scenario, the Best UED Management scenario caused a significant decrease of UED to about 26% through exotic species control. The ROI for the Best UED Management scenario was greater than zero and, therefore, better than doing nothing.

System Acres: 429	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	**Best UED**	**Max GSG HS**
Unified Ecological Departure	43%	78% ± 8%	26% ± 9%	76% ± 8%
Cost			$156,207 ± 817	-
ROI - vs Minimum Mgmt			14.5	-
ROI - 95% Confidence Interval			± 0.8	-
ROI of single scenario >0?			Yes	-
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**n/a**	

So few acres were involved for BLM lands that results were not shown. Results for Newmont's private lands resembled closely these for BLM lands, which showed that treatments successfully reduced the acres of the exotic forb class (U:Exotic Forb), while temporarily increasing the early-succession class (1-Early:Open). With time, these treatments resulted in permanently increasing the area of mid-succession class (2-Mid:Closed) (Figure 84).

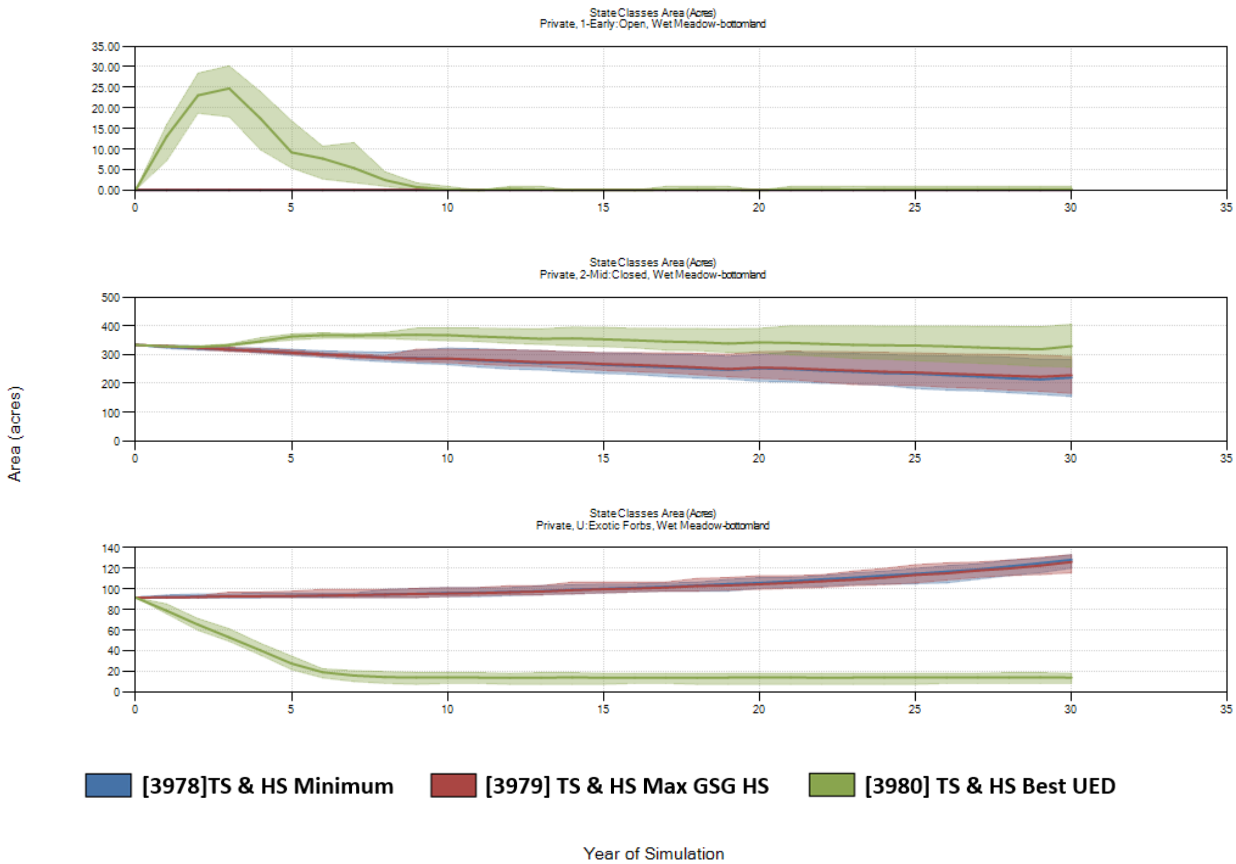


Figure 84. Area (acres) of three wet meadow-bottomland state classes targeted for ecological improvement for all scenarios located on BLM and Newmont's private lands of the TS-Horseshoe Ranches: early- and late-succession reference classes (1-Early:Open and 2-Mid:Closed), and invaded by exotic species (U:Exotic Forb). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

<u>TS-Horseshoe Ranches: Wet Meadow- Montane</u>

Several uncharacteristic classes of wet meadow-montane were represented in the current condition. The greatest change in area over 30 years was observed in the exotic forb class (U:Exotic Forb) on both BLM (from 4% to 12.7%) and Newmont's private lands (7.3% to 16.8%; table below). The two other uncharacteristic classes present, albeit less abundant than the exotic forb class were the hummocked class (U:Hummocked) and unpalatable forb class (U:Unpalat. Forb).

Ownership	State Class	% Ref.	% Allow. Thresh.	Area-Current (Acres)	% Current	Area - Min. Mgmt.	% Min. Mgmt.
BLM	1-Early:Open	8		97.0	16.9%	45.1	7.8%
	2-Mid:Closed	91		376.3	65.5%	386.3	67.2%
	3-Late:Open	0+		0.0	0.0%	9.7	1.7%
	U:Annual Spp			9.8	1.7%	10.0	1.7%
	U:Desertified			14.2	2.5%	12.5	2.2%
	U:Early Shrub			0.0	0.0%	0.1	0.0%
	U:Exotic Forbs			23.1	4.0%	73.2	12.7%
	U:Hummocked			44.5	7.7%	25.9	4.5%
	U:Incised-EFT			0.0	0.0%	2.7	0.5%
	U:SA			0.0	0.0%	0.0	0.0%
	U:Shrb-Frb Encr			0.0	0.0%	0.0	0.0%
	U:Unpalat. Forb			9.8	1.7%	8.1	1.4%
	Wallow:Bare Ground	1		0.0	0.0%	0.0	0.0%
Private	1-Early:Open	8		59.6	3.1%	132.5	6.9%
	2-Mid:Closed	91		1318.4	68.4%	1089.4	56.5%
	3-Late:Open	0+		46.3	2.4%	38.1	2.0%
	U:Annual Spp			10.7	0.6%	14.0	0.7%
	U:Desertified			63.2	3.3%	58.3	3.0%
	U:Early Shrub			0.0	0.0%	0.9	0.0%
	U:Exotic Forbs			141.4	7.3%	323.6	16.8%
	U:Hummocked			129.9	6.7%	121.2	6.3%
	U:Incised-EFT			0.0	0.0%	7.1	0.4%
	U:SA			0.0	0.0%	0.0	0.0%
	U:Shrb-Frb Encr			0.0	0.0%	0.2	0.0%
	U:Unpalat. Forb			158.3	8.2%	138.1	7.2%
	Wallow:Bare Ground	1		0.0	0.0%	0.0	0.0%

Planned yearly implementation rates in montane wet meadows were front-loaded during the first 10 years followed by maintenance exotic control and weed inventory with spot herbicide spraying for small patches of exotic forbs (table below). Treatments involved spraying herbicide for exotic control, spraying shrubs that encroach degraded wet meadows, elevating the water table in incised meadows, and fencing wet meadows in riparian pastures to control livestock's season of use. Fencing was the most expensive action per acre. The costs of implementation were about 4 to 6 times higher on Newmont's private lands compared to those on BLM lands in both active management scenarios.

Ownership	Scenario	Mgmt Action	Acres/Year (Avg of 10 runs) Years 1-9	Years 10-30	Cost/Ac	30-Yr Total Cost (mean ± 95% CI)
BLM	MAX GSG HS	Exotic Control	10	5	$80	
		Herbicide-Shrubs	10	0	$125	
		Inexpensive Floodplain Restoration	50	0	$100	
		Livestock Grazing Control	150	0	$350	
		Weed Inventory + Spot Treatment	25	25	$50	
						$34,148 ± $2,334
NEWMONT PRIVATE	MAX GSG HS	Exotic Control	75	10	$80	
		Herbicide-Shrubs	200	0	$125	
		Inexpensive Floodplain Restoration	250	0	$100	
		Livestock Grazing Control	300	0	$350	
		Weed Inventory + Spot Treatment	100	50	$50	
						$220,723 ± $8,707
BLM	BEST UED	Exotic Control	10	5	$80	
		Herbicide-Shrubs	10	0	$125	
		Inexpensive Floodplain Restoration	25	0	$100	
		Livestock Grazing Control	125	0	$350	
		Weed Inventory + Spot Treatment	25	25	$50	
						$36,594 ± $2,685
NEWMONT PRIVATE	BEST UED	Exotic Control	50	10	$80	
		Herbicide-Shrubs	160	0	$125	
		Inexpensive Floodplain Restoration	100	0	$100	
		Livestock Grazing Control	150	10	$350	
		Weed Inventory + Spot Treatment	50	50	$50	
						$175,044 ± $6,961

The realized yearly implementation rates for exotic control, herbicide-shrub, inexpensive floodplain restoration, and livestock grazing control were implemented for a shorter period than specified in the table above on BLM and Newmont's private lands (Figures 85 and 86). This means that ST-Sim could not find any more uncharacteristic classes to treat within the first 10 years. The weed inventory action continued to be implemented as it does not depend on exhausting the area of the exotic class.

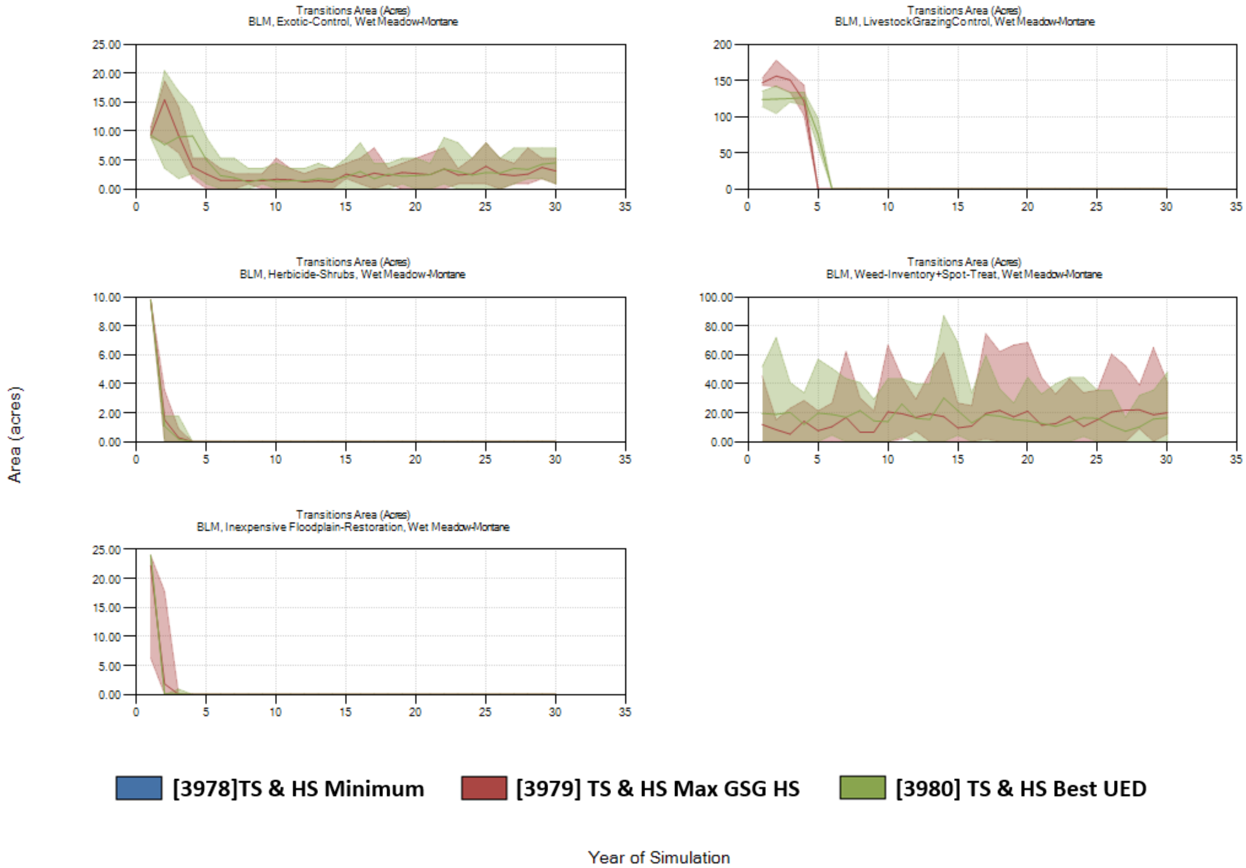


Figure 85. Realized yearly implementation rates for exotic control, spraying herbicide on encroaching shrubs, inexpensive floodplain restoration, livestock grazing control, and weed inventory with spot treatment of exotics forbs in the TS-Horseshoe Ranches' wet meadow-montane for BLM lands. The dark line is the mean for each scenario and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

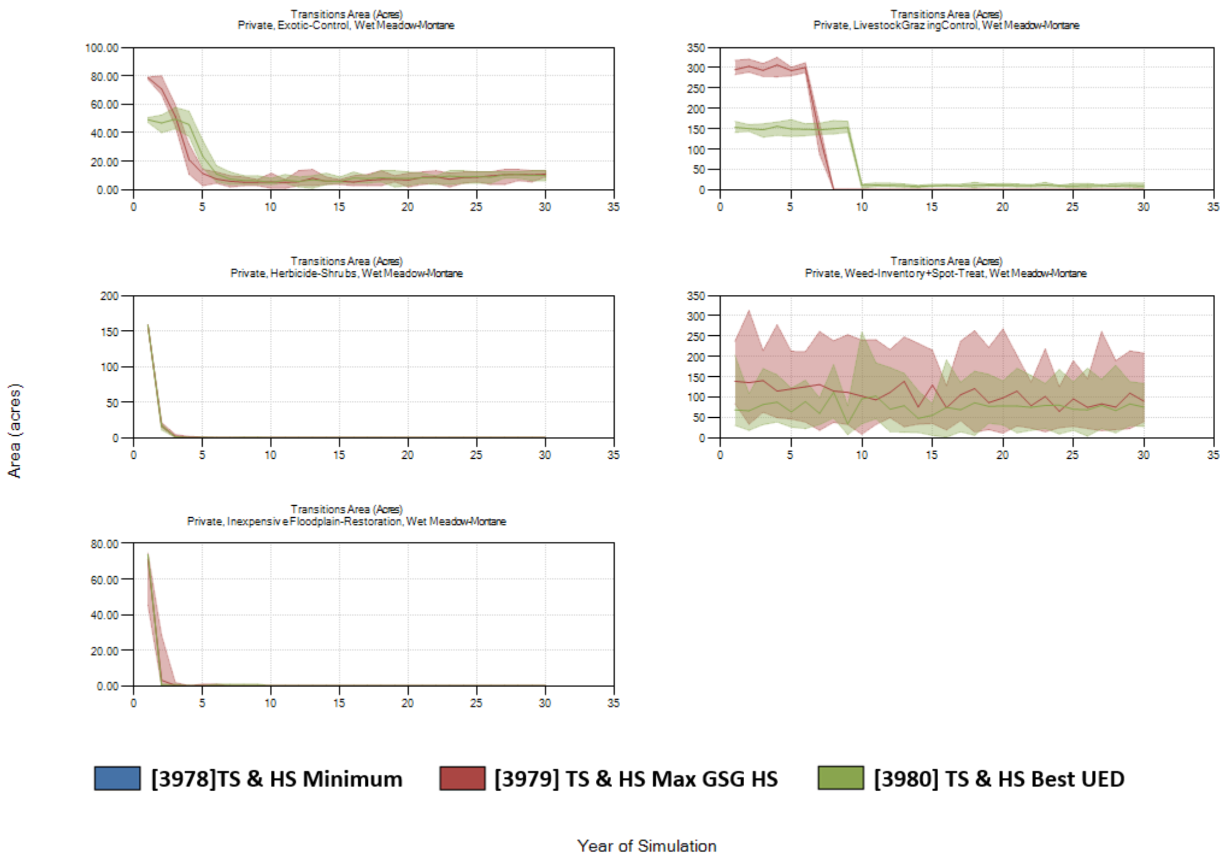


Figure 86. Realized yearly implementation rates for exotic control, spraying herbicide on encroaching shrubs, inexpensive floodplain restoration, livestock grazing control, and weed inventory with spot treatment of exotics forbs in the TS-Horseshoe Ranches' wet meadow-montane for Newmont's private lands. The dark line is the mean for each scenario and the shaded areas represent the minimum and maximum occurrences of any of 10 replicates.

In the MINIMUM MANAGEMENT scenario UED increased from 41% in 2014 to about 60% in 30 years (table below). The exotic forb class was the primary reason for the rise in UED. Compared to the 60% for MINIMUM MANAGEMENT scenario, both active scenarios caused a large improvement of UED to about 11%. UED for both active management scenarios was the same and significantly better than the MINIMUM MANAGEMENT scenario. The ROIs for the BEST UED MANAGEMENT scenario and MAX GSG HS MANAGEMENT scenario were greater than zero and, therefore, better than doing nothing. The ROI of the BEST UED MANAGEMENT scenario was significantly greater, than the ROI for the MAX GSG HS MANAGEMENT scenario suggesting that the less expensive option was more cost-effective.

System Acres: 2,502	Current	Scenarios – 30 years (mean & 95% CI of 10 replicates)		
		Minimum	Best UED	Max GSG HS
Unified Ecological Departure	41%	60% ± 3%	11% ± 5%	11% ± 5%
Cost			$156,207 ± 817	$254,872 ± 8,493
ROI - vs Minimum Mgmt			58.8	48.3
ROI - 95% Confidence Interval			± 3.4	± 3.7
ROI of single scenario >0?			Yes	Yes
ROIs of Best UED and Max GSG HS Significantly Different (95% CI)? →			**Yes**	

All uncharacteristic classes targeted for restoration were successfully decreased by treatments on BLM (Figure 87) and Newmont's private (Figure 88) lands. As a result, and after a 5-year period of recovery, treatments more permanently increased the area of the mid-succession class (2-Mid:Closed), which is highly beneficial to sage-grouse habitat suitability.

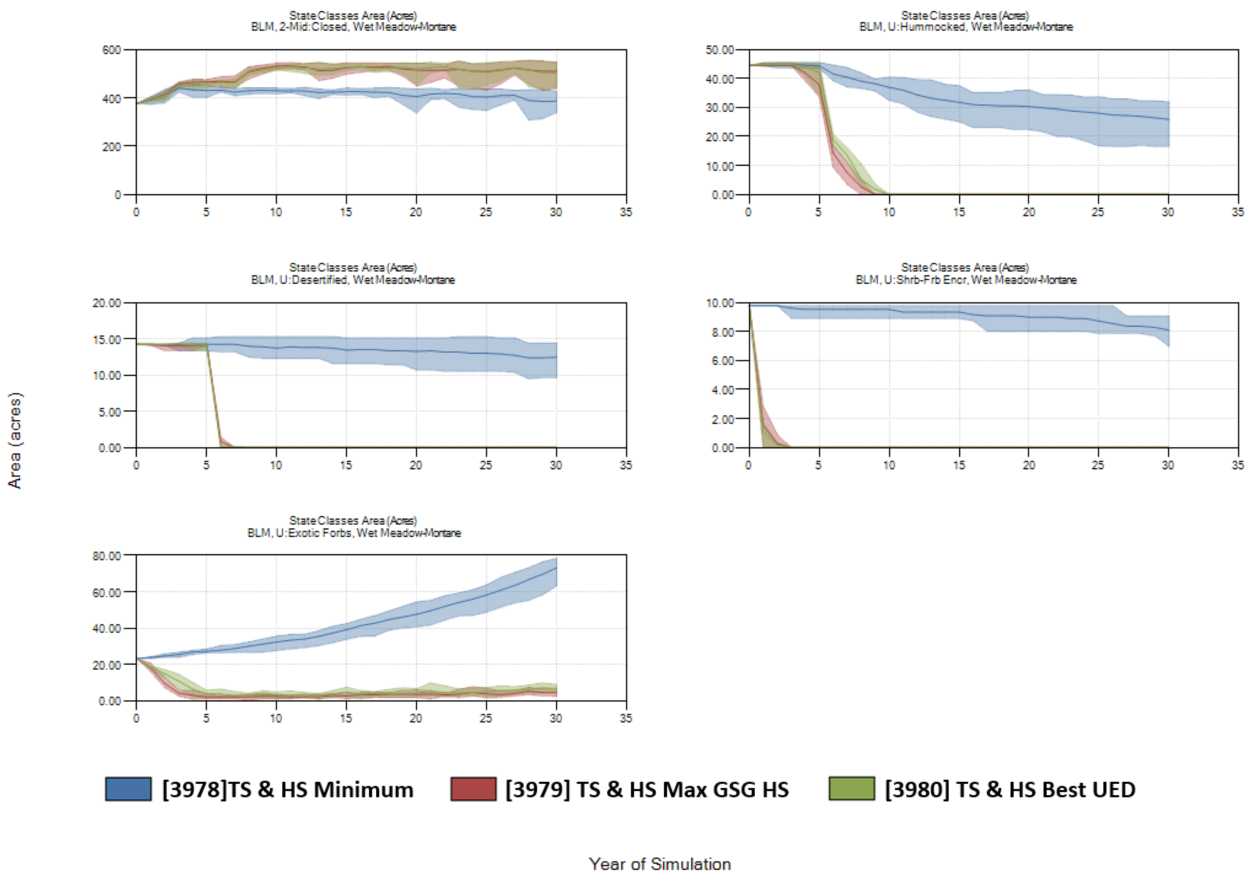


Figure 87. Area (acres) of five wet meadow-montane state classes targeted for ecological improvement for all scenarios located on BLM lands of the TS-Horseshoe Ranches: mid-succession reference classes (2-Mid:Closed), desertified (U:Desertified), invaded by exotic species (U:Exotic Forb), hummocked (U:Hummocked), and encroached by shrubs and forbs (U:Shrub-Forb-Encroached). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

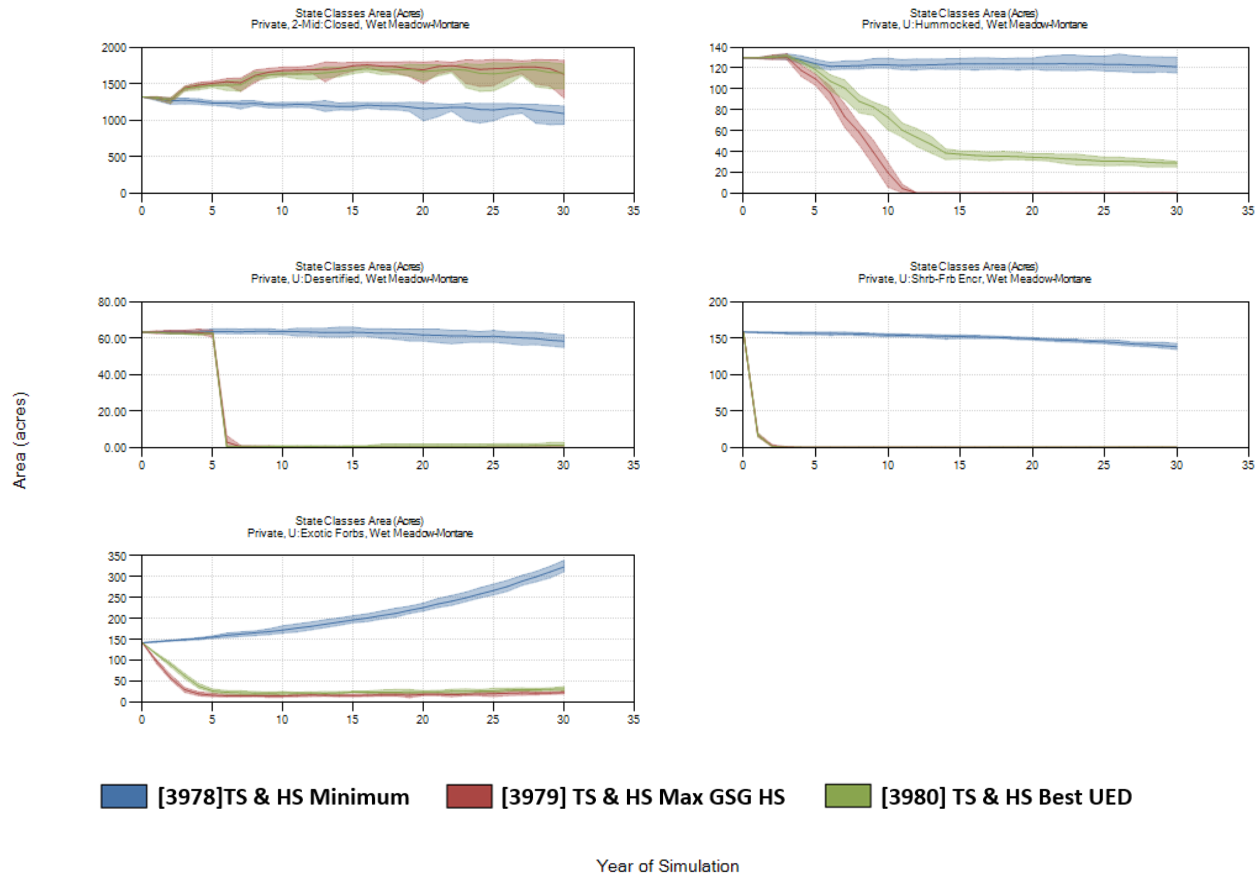


Figure 88. Area (acres) of three wet meadow-bottomland state classes targeted for ecological improvement for all scenarios located on Newmont's private lands of the TS-Horseshoe Ranches: early- and late-succession reference classes (1-Early:Open and 2-Mid:Closed), and invaded by exotic species (U:Exotic Forb). The dark line is the mean and the shaded areas represent the 10% to 90% percentiles of 10 replicates.

Overview of ROIs and Costs

In the previous section, ROIs were shown one ecological system at a time. Here they are shown together with costs for easy comparison (Table 14). When both active scenarios were compared, the scenario with the significantly greater ROI was marked in blue. If the scenarios are not colored, they are statistically equal (95% CIs overlap the mean). Most often the BEST UED MANAGEMENT scenario demonstrated the highest ROI, although five ties were recorded (Table 14). The MAX GSG HS MANAGEMENT scenario was higher in the montane sagebrush steppe only for the IL Ranch.

The **total** thirty-year cumulative costs were always higher in the BEST UED MANAGEMENT than MAX GSG HS MANAGEMENT scenario and this inequality was generally true by ecological system, except for the TS-Horseshoe Ranches' following systems: big sagebrush upland with trees, montane riparian, montane sagebrush steppe, and wet meadow montane (Table 14). For those four systems, costs were comparable between scenarios because action implementation levels were similar. The greatest costs were observed in the basin wildrye montane and big sagebrush upland systems.

Table 14. Overview of all average ROIs and 30-year cumulative cost by ownership, management scenario, and ecological system. The scenario with the significantly greater ROI was marked in blue. The ROI was relativized such that the highest value (best ROI) is equal to 100%, whereas ROI can reach negative values if a scenario did worse than MINIMUM MANAGEMENT. Cumulative cost is shown as yearly cost would suggest annual implementation even during decades when restoration actions were not implemented; many expensive actions were front-loaded during the first 10 years of simulation. Sample size was 10 replicates.

Ecological System	Max GSG HS			Best UED		
IL Ranch	Cumulative Cost ($)	ROI	±95% CI	Cumulative Cost ($)	ROI	±95% CI
Aspen Woodland	n/a	n/a	n/a	69,992	0	0
Aspen-Mixed Conifer	n/a	n/a	n/a	91,804	0	0
Basin Wildrye-montane	775,532	11	1	2,043,696	41	2
Big Sagebrush-upland no trees	757,178	-16	46	2,824,034	61	48
Low Sagebrush	78,138	92	12	78,830	100	13
Montane Riparian	311,030	7	1	359,076	17	1
Montane Sagebrush Steppe	132,255	62	19	137,793	46	21
Wet Meadow-Montane	407,966	47	2	465,295	48	3
Total	**2,462,099**			**6,070,521**		
TS-Horseshoe Ranches						
Aspen Woodland	n/a	n/a	n/a	32,096	27	17
Basin Wildrye-bottomland	n/a	n/a	n/a	1,958,241	2	1
Basin Wildrye-montane	1,650,729	8	1	2,773,354	18	0
Big Sagebrush-semidesert	n/a	n/a	n/a	822,500	0	0
Big Sagebrush-upland+trees	3,906,774	21	3	3,494,626	24	3
Montane Riparian	195,269	20	5	169,263	58	9
Montane Sagebrush Steppe	44,356	100	24	43,652	93	50
Saline Meadow	n/a	n/a	n/a	102,382	46	2
Wet Meadow-bottomland	n/a	n/a	n/a	156,207	15	1
Wet Meadow-Montane	254,871	48	4	211,638	59	3
Total	**6,051,999**			**9,763,959**		

Comparison of Species' Habitat Suitability Across 30-Year Management Scenarios

Greater Sage-Grouse

On the IL Ranch, Functional Acres declined for the first the 25 years in the MINIMUM MANAGEMENT scenario, and then raised during the last 5 years, whereas Functional Acres consistently declined during 30 years in the active management scenarios (Figure 89). The MAX GSG HS MANAGEMENT and BEST UED MANAGEMENT scenarios showed lower average Functional Acres during the first 10 years, then greater Functional Acres from 15 to 30 years than the MINIMUM MANAGEMENT scenario. Functional Acres at the end of the 30-year simulations were significantly different among scenarios (Two-way ANOVA; $F_{2,18} = 5$, $P > 0.0167$; Table 15; Figure 89). Although not statistically different, the difference between the averages for the MINIMUM MANAGEMENT and MAX GSG HS MANAGEMENT scenarios was 185 Functional Acres for year 30. BEST UED MANAGEMENT significantly had 368 more Functional Acres than the MINIMUM MANAGEMENT scenario. The ROIs were not significantly different between the two active scenarios (Two-way ANOVA; $F_{1,9} = 0.03$, $P > 0.83$; Table 15B).

Table 15A. GSG functional acres at the IL Ranch for the three simulated scenarios averaged across the 10 replicates. Based on current conditions, functional acres were estimated at 216,496.

Scenario	Year 5	Year 10	Year 15	Year 20	Year 25	Year 30	Contrast Year 30
MIN MGMT	216,389	215,869	215,295	214,984	214,576	214,783	a
MAX GSG HS	216,362	215,848	215,578	215,240	215,104	214,968	ab
BEST UED-ROI	216,340	215,826	215,625	215,326	215,167	215,151	b

Table 15B. ROI for GSG functional acres at the IL Ranch for the two active management scenarios averaged across the 10 replicates.

Scenario	Avg Cumulative Cost ($)	Avg ROI	ROI 95% C.I.	Two-Way ANOVA
MAX GSG HS	2,462,099	0.073	0.11	a
BEST UED-ROI	6,070,521	0.063	0.03	a

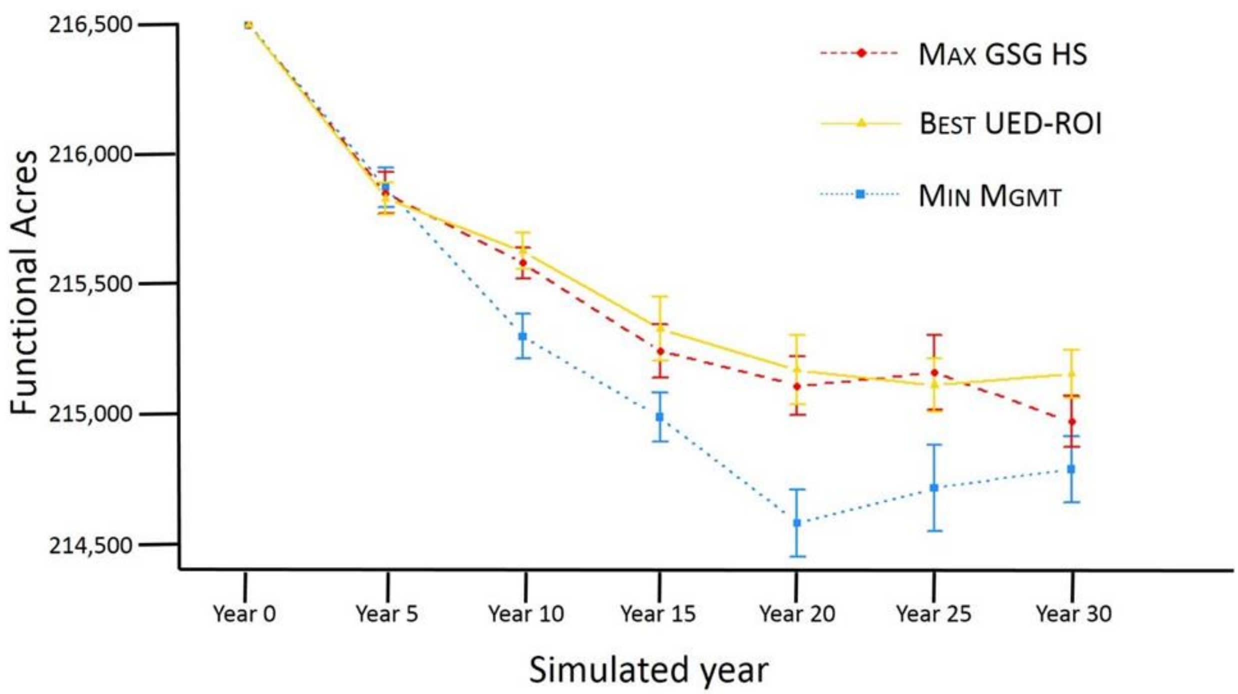


Figure 89. GSG functional acres at the IL Ranch for the three simulated scenarios averaged acro the 10 replicates. The error bars represent one standard error.

Two important reasons for the temporal loss of Functional Acres were that fires and Aroga moth outbreaks chipped away at the very widespread nesting habitat in different key areas of the IL Ranch. More fire was found in the MINIMUM MANAGEMENT scenario than in both active scenarios (Figure 90A) due primarily to the lack of fuel breaks and less dispersed grazing of more ignitable non-native annual grass species present in several vegetation classes in the MINIMUM MANAGEMENT scenario. The model assumed that grazing temporally suppressed fire in pixels; therefore, more concentrated grazing due to the more limited water sources in the MINIMUM MANAGEMENT scenario compared to others allowed higher fire activity in ungrazed areas. Moth outbreaks were the same in all scenarios (Figure 90B). Increased dispersal of livestock was caused by adding more dispersed water sources in the active scenarios. Fire, however, was not the only reason for decline because more fire was observed in the last 15 years than first 15 years. The increase or reduced loss of rate of Functional Acres after 20 years was explained by the maturation of (a) the abundant early-succession non-native annual species and perennial grass class (U:ASPG), created by pre-mapping fires, into the shrub with non-native annual species and perennial grass class (U:SAP), and (b) of the early-succession seedings into later succession seedings (U:SDI-B and U:SDI-C; Figure 91), all of which are usable sage-grouse nesting habitat. However, maturation of sagebrush into the older succession classes caused greater nest success but a concomitant strong decrease of female survival due to negatively correlated vital rate tradeoffs; therefore, λ will be dragged down as many seedings reach the late-succession class of big sagebrush communities.

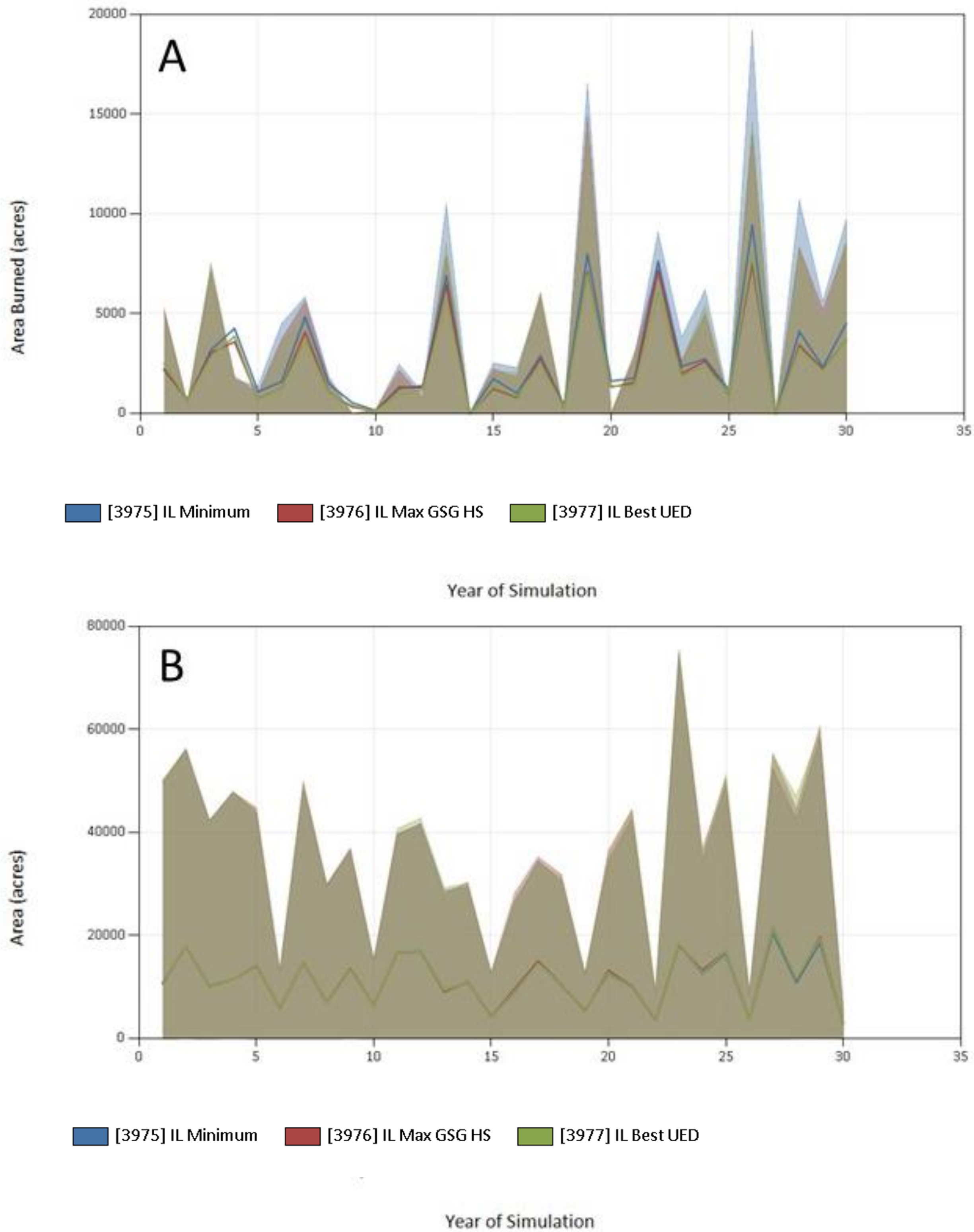


Figure 90. (A) Area burned (acres) and (B) area of Aroga moth outbreaks at the IL Ranch for the three simulated scenarios averaged across the 10 replicates. Scenarios completely overlapped for Aroga moth outbreaks.

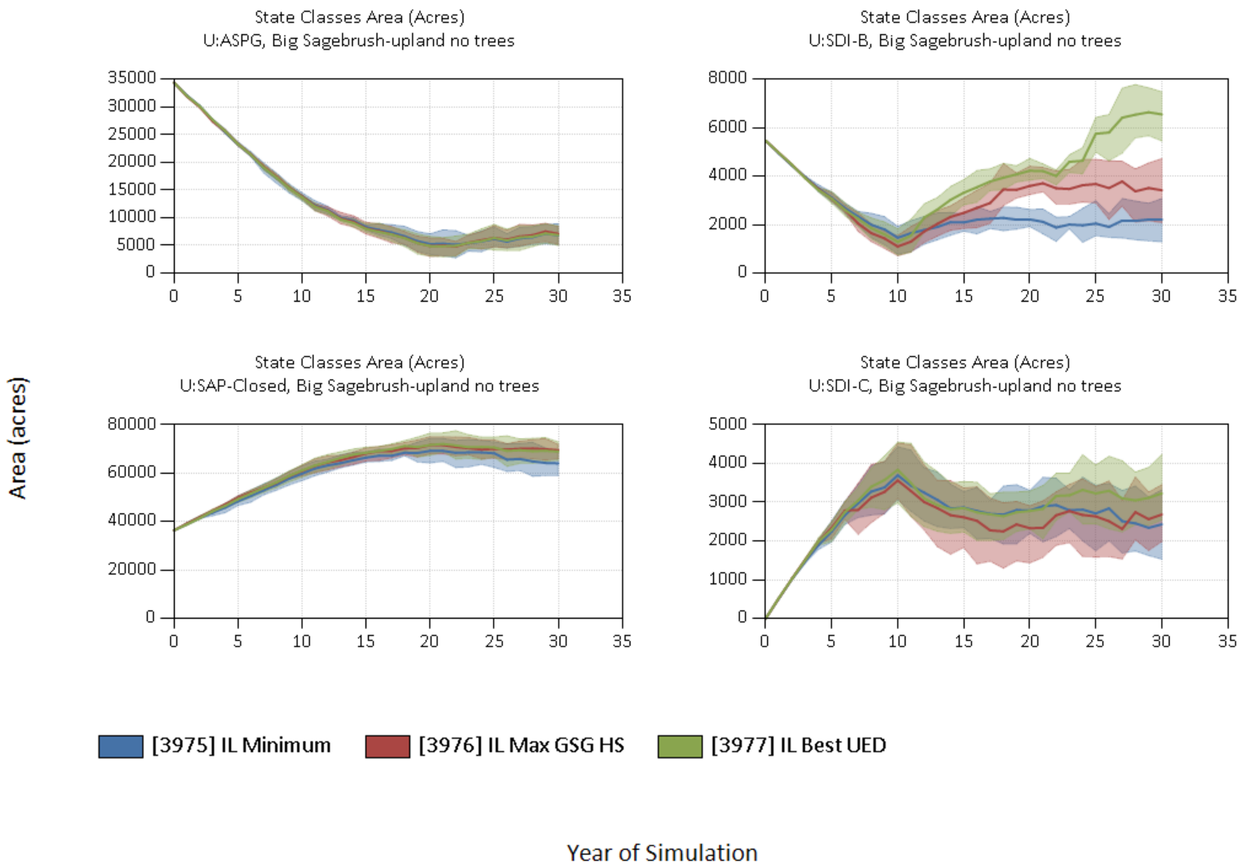


Figure 91. Area of the non-native annual species and perennial grass class (U:ASPG), shrub with non-native annual species class (U:SAP), mid-succession seeding class (U:SDI-B), and late-succession seeding class (U:SDI-C) at the IL Ranch for the three simulated scenarios averaged across the 10 replicates. These classes were dominant on the IL Ranch and explained a large fraction of the variation in sage-grouse habitat suitability.

On the TS-Horseshoe Ranches, the trend was nearly the opposite of that of Functional Acres on the IL Ranch (Table 16, Figure 92). Functional Acres rapidly increased in all scenarios until year 20, and then trended slightly downward until year 30. Over 30 years of simulation, the Minimum Management scenario produced the least amount of Functional Acres. The differences in Functional Acres between the best and second-best performing scenarios and the Minimum Management scenario, respectively, were 1,555 for the Best UED Management scenario and 1,055 for the Max GSG HS Management scenario by year 30. The overall scenario effect was statistically significant (Two-way ANOVA; $F_{2,18}$ = 15, P < 0.0002; Table 16). The Best UED Management scenarios' Functional Acres was significantly greater than those of the Minimum Management scenario, but contrast comparisons showed no differences between the Best UED Management and Max GSG HS Management scenarios. The ROIs were not significantly different between the two active scenarios (Two-way ANOVA; $F_{1,9}$ = 0.47, P > 0.5; Table 16B).

Table 16A. GSG functional acres at the TS-Horseshoe Ranches for the three simulated scenarios averaged across the 10 replicates. Based on current conditions, functional acres are estimated at 155,096.

Scenario	Year 5	Year 10	Year 15	Year 20	Year 25	Year 30	Contrast Year 30
MIN MGMT	156,601	161,737	164,788	166,080	165,663	164,584	a
MAX GSG HS	157,024	162,219	165,841	166,984	166,870	165,635	b
BEST UED-ROI	157,096	162,356	165,937	167,347	167,293	166,139	b

Table 16B. ROI for GSG functional acres at the TS-Horseshoe Ranches for the two active management scenarios averaged across the 10 replicates.

Scenario	Avg Cumulative Cost ($)	Avg ROI	ROI 95% C.I.	Two-Way ANOVA
MAX GSG HS	6,051,999	0.161	0.227	a
BEST UED	9,763,959	0.226	0.242	a

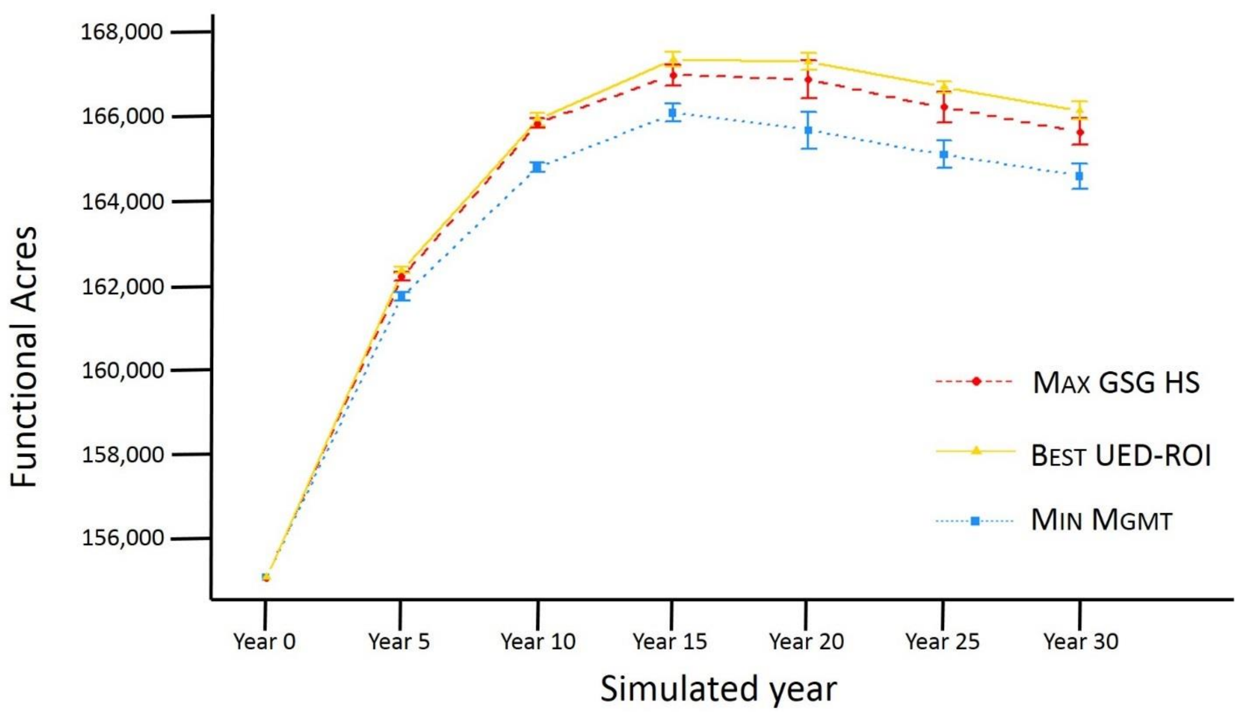


Figure 92. GSG functional acres at the TS-Horseshoe Ranch for the three simulated scenarios averaged across the 10 replicates. The error bars represent one standard error.

The primary reason for this rapid increase of Functional Acres was that many sagebrush areas of the TS-Horseshoe Ranches were in the dominant early-succession uncharacteristic classes and were maturing into mid- and late-succession classes (Figure 93). Early-succession classes decreased sage-grouse nest success (Figure 93). As a contrast, most of the IL Ranch has not burned and was covered with mature sagebrush.

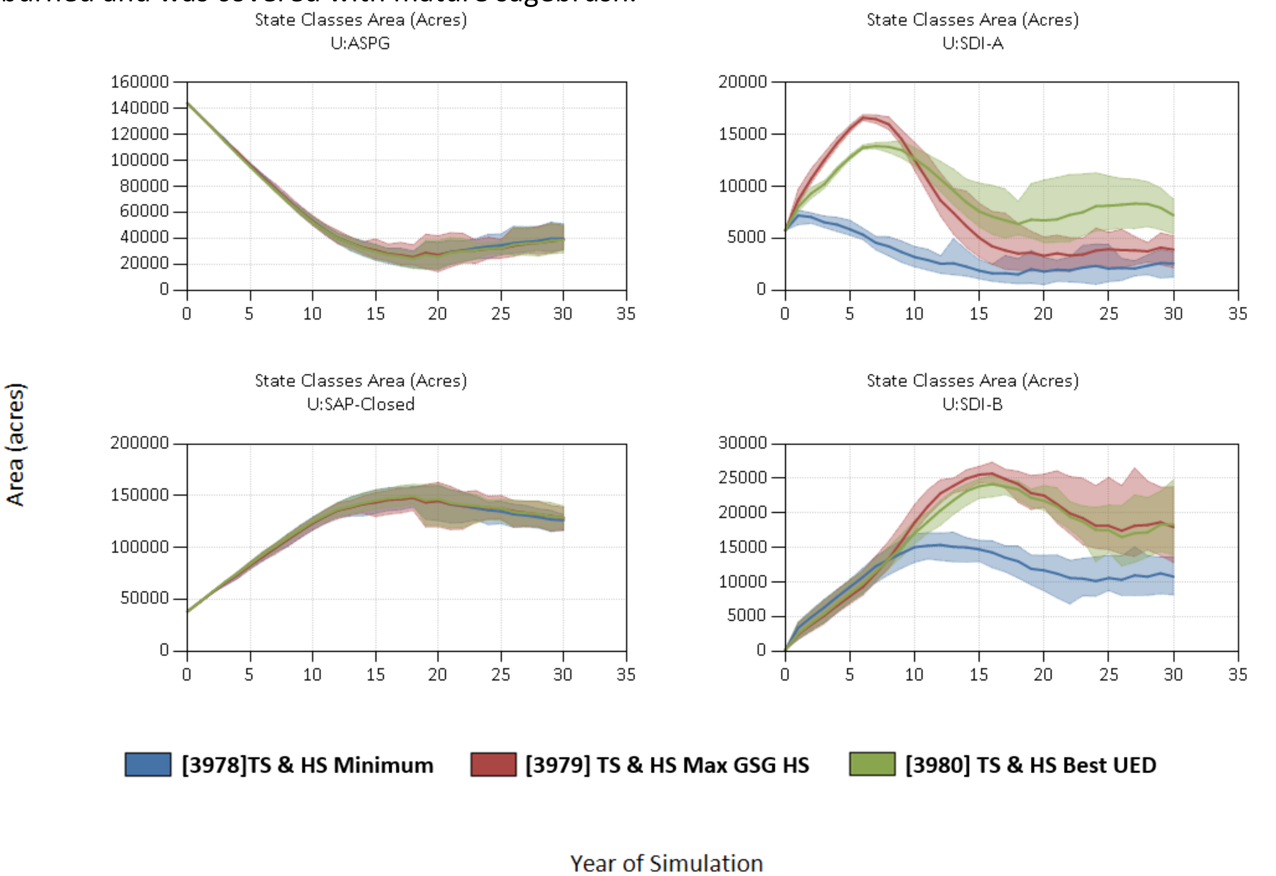


Figure 93. Area of the non-native annual species and perennial grass class (U:ASPG), shrub with non-native annual species class (U:SAP), early-succession seeded class (U:SDI-A), and mid-succession seeding class (U:SDI-B) at the TS-Horseshoe Ranches for the three simulated scenarios averaged across the 10 replicates. These classes were dominant on the IL Ranch and explained a large fraction of the variation in sage-grouse habitat suitability.

Mule Deer and Golden Eagle

The Max GSG HS Management scenario only significantly "increased" mule deer habitat suitability at the third decimal point compared to the Minimum Management scenario on the TS-Horseshoe Ranches, whereas the Best UED Management scenario was the only scenario to have a significant effect on mule deer habitat suitability by decreasing it compared to the Max GSG HS Management scenario, but not the Minimum Management scenario on the IL Ranch (Two-way ANOVA; IL Ranch, $F_{2,18} = 4$, $P < 0.032$; TS-Horseshoe Ranches, $F_{2,18} = 7$, $P < 0.0071$; Table 17). The low variability within scenarios allowed the separation of otherwise close means. This fact is informative about the mule deer habitat suitability index as it was primarily determined by physical factors that do not change with vegetation management (i.e., overall low variance); therefore, vegetation changes explained a low, but tightly determined amount of the variation (i.e., the third decimal point). This suggest that results may be ecologically significant and warrant a future revision of the mathematical structure of the index that would bring out more strongly the role of vegetation recovery. Therefore, mule deer and sage-grouse benefited most from the same restoration actions favoring sagebrush shrub maturation.

Table 17. Average mule deer habitat suitability for the IL and TS-Horseshoe Ranches across ten replicates.

Scenario	IL Ranch				TS-Horseshoe Ranches		
	Current	Year 30	Contrast		Current	Year 30	Contrast
MIN MGMT	0.3439	0.3559	a,b		0.4597	0.4733	a
MAX GSG HS	0.3439	0.3564	a		0.4597	0.4743	b
BEST UED-ROI	0.3439	0.3556	b		0.4597	0.4734	a

The BEST UED MANAGEMENT scenario showed the highest golden eagle habitat suitability on both ranches at the level of the third significant digit compared to the MINIMUM MANAGEMENT scenario (Two-way ANOVA; IL Ranch, $F_{2,18} = 5$, $P < 0.023$; TS-Horseshoe Ranches, $F_{2,18} = 129$, $P < 0.0001$; Table 18). The MAX GSG HS MANAGEMENT scenario also significantly increased golden eagle habitat suitability compared to the MINIMUM MANAGEMENT scenario only on the TS-Horseshoe Ranches. The BEST UED MANAGEMENT scenario deployed more sagebrush habitat restoration actions, including in the TS-Horseshoe Ranches' big sagebrush semi-desert, and improved montane riparian classes than the MAX GSG HS MANAGEMENT scenario. Some of these actions would not always benefit sage-grouse when degraded sagebrush was restored, but would eventually produce the habitat to support the golden eagle's alternative prey base, which is important to habitat suitability outside of deep soil communities supporting jackrabbit.

Table 18. Average golden eagle habitat suitability for the IL and TS-Horseshoe Ranches across ten replicates.

Scenario	IL Ranch				TS-Horseshoe Ranches		
	Current	Year 30	Contrast		Current	Year 30	Contrast
MIN MGMT	0.4062	0.4060	a		0.5276	0.5273	a
MAX GSG HS	0.4062	0.4054	a		0.5276	0.5292	b
BEST UED-ROI	0.4062	0.4080	b		0.5276	0.5301	c

Areas of Events and Implementation

The discussions in the preceding section on minimum and active management scenarios made reference to non-management disturbances (natural and anthropogenic) and implemented management actions that would affect vegetation classes. This section summarizes those processes and treatment selections via a set of maps.

Overall, two types of non-management disturbances were substantial or widespread enough to affect sage-grouse habitat suitability by altering nest site selection and nest success and, therefore, merit summary attention here:

1. Fire events; and
2. Aroga moth outbreaks

Table 19 shows the management actions that had substantial use in any active management scenario and were informative beyond a priori expectations:

Table 19. Management actions aimed at that revealed substantial information for the two Project Areas.

Management Action/Treatment	IL Ranch	TS-Horseshoe Ranches
Herbicide-Plateau+Native-Seed	X	X
Herbicide-Plateau+Seed	X	X
Inexpensive Floodplain Restoration	X	X
Livestock Grazing Control	X	X
Supplemental Salt Block	X	
Thin+Plateau+Native-Seed	X	X
Thin+Plateau+Seed	X	X

The maps on the following pages, Figures 94-104, display results of the spatial output of disturbances from all three scenarios and treatments, which were implemented in only the active scenarios, in Table 20, from the ST-Sim 30-year modeling runs in the two project areas. These maps show where disturbances are most likely to occur (for example, areas of greatest fire risk) and the treatment maps reveal to managers the best locations to place management actions given the constraints imposed on simulations (the higher the frequency, the better the choice of location). For example, a manager could design a current restoration project for the IL Ranch to convert an annual grassland to a seeding of mixed introduced and native species by overlapping Figure 98 with our maps of ecological systems and vegetation classes, specifically the non-native annual species class.

Table 20. Index to Figures that show management treatments within ecological systems of the two Project Areas.

Management Action/Treatment	IL Ranch	TS-Horseshoe Ranches
Fire	Figure 94	Figure 95
Aroga Moth Outbreak	Figure 96	Figure 97
Herbicide-Plateau+Native-Seed	Figure 98	Figure 99
Herbicide-Plateau+Seed	Figure 98	Figure 99
Supplemental Salt Block	Figure 100	n/a
Inexpensive Floodplain Restoration	Figure 101	Figure 102
Livestock Grazing Control	Figure 101	Figure 102
Thin+Plateau+Native-Seed	Figure 103	Figure 104
Thin+Plateau+Seed	Figure 103	Figure 104

The fuel breaks implemented by the active scenarios on the IL Ranch had a clear effect on the annual probability of fire events (Figure 90A for the time series of area burned and maps in Figures 94 B and C) compared to no fuel breaks in the MINIMUM MANAGEMENT scenario (Figure 94 A). The sharp boundary of many fires, especially on the Owyhee Allotment, corresponded to the fuel breaks. In terms of acreages burned, MINIMUM MANAGEMENT scenario (Figure 94 A) had the high extent, followed by MAX GSG HS MANAGEMENT scenario (Figure 94 B) and then BEST UED MANAGEMENT scenario (Figure 94 C, especially northwest part). The unburned areas corresponded to important nesting areas.

On the TS-Horseshoe Ranches, it proved more difficult to place fuel breaks for protection of sage-grouse nesting habitat. As a consequence, implemented fuel breaks in the active scenarios (Figures 95 C and D) were placed to reduce the annual fire probability in four localized areas compared to the MINIMUM MANAGEMENT scenario (Figure 95 A) to help protect unburned areas. Specifically, these patches were 1) in the very southern tip, 2) along the Interstate between the Beowawe and Carlin exits, 3) along the northwest edge off Boulder Valley, and 4) just west of the Carlin Trend mines in the northern part. The small, isolated nature of these breaks did little to protect the most important sage-grouse habitat from fire in the simulations.

The annual probability of Aroga moth outbreaks correlates well with mature standing sagebrush, which was unburned sagebrush or sagebrush that had not burned for at least 40 years. On the IL Ranch, few differences were observed among scenarios in Figure 96, but Aroga moth outbreaks were widespread. The few differences were higher annual probabilities in depleted sagebrush of the northern Star Ridge pasture, where the HMA is located, and immediately south of the Star Ridge pasture towards the western boundary of the IL Ranch in the MINIMUM MANAGEMENT scenario (Figure 96 A) compared to both active scenarios (Figure 96 B and C). This area of depleted sagebrush was not treated in the Star Ridge HMA, and burned more frequently in active scenarios compared to the MINIMUM MANAGEMENT scenario (Figure 95), and was thinned and seeded in the BEST UED MANAGEMENT scenario south of the Star Ridge pasture. Frequent fires and restoration remove Aroga moth food.

Aroga moth outbreaks annual probability were not visibly different among scenarios in the TS-Horseshoe Ranches (Figure 97). This was expected because most of the Ranch's sagebrush burned prior to mapping and was still in early- or mid-succession stages at mapping. Because of restoration differences between BLM and Newmont's implementation rates in semidesert and upland big sagebrush shrubland, the future availability of sagebrush for future Aroga moth consumption also varied following the checkboard pattern of ownership.

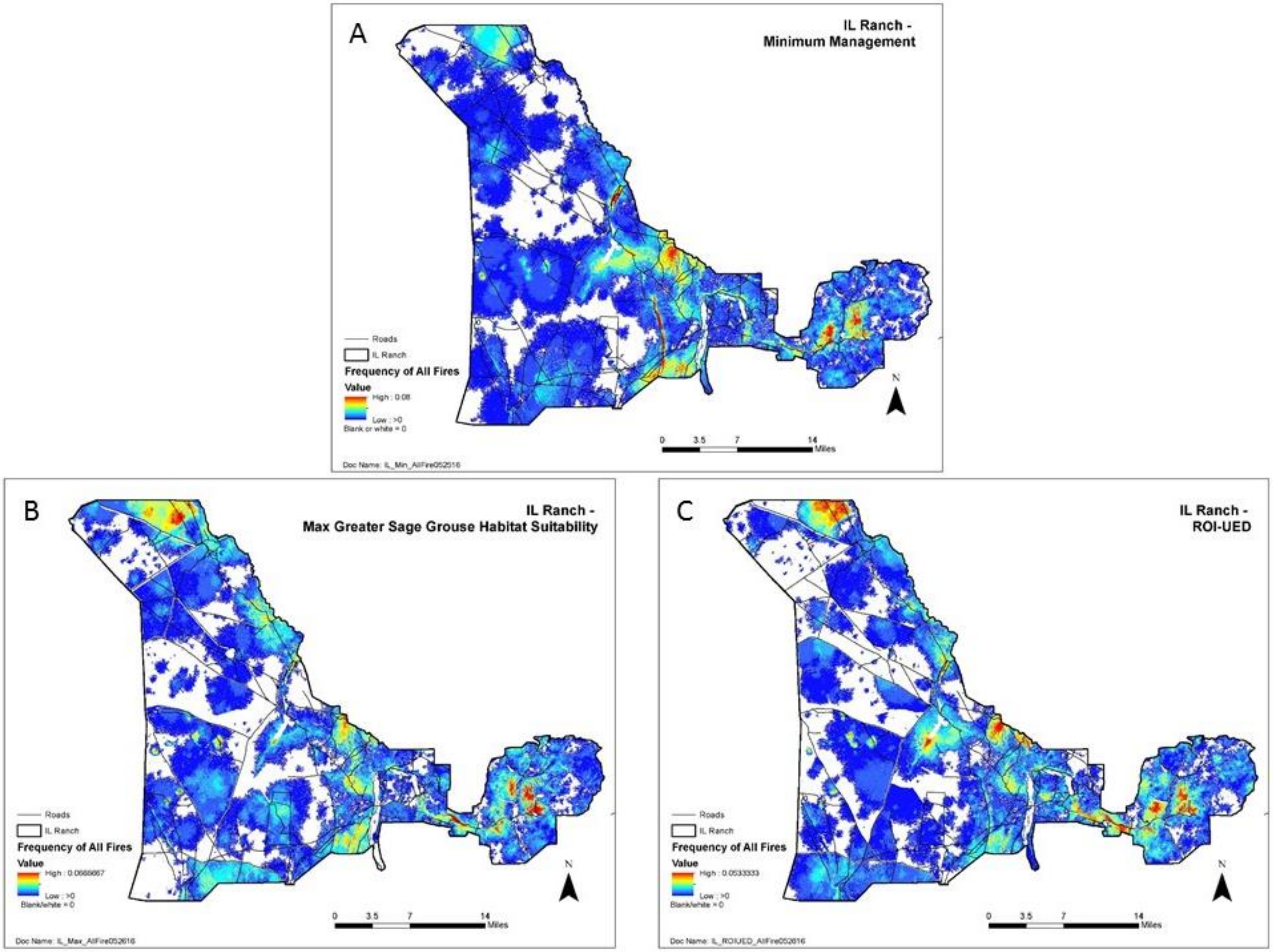


Figure 94. Annual probability of all observed fire events created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the IL Ranch. Other than no fire, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = Minimum Management, B = Max GSG HS Management, and C = Best UED Management.

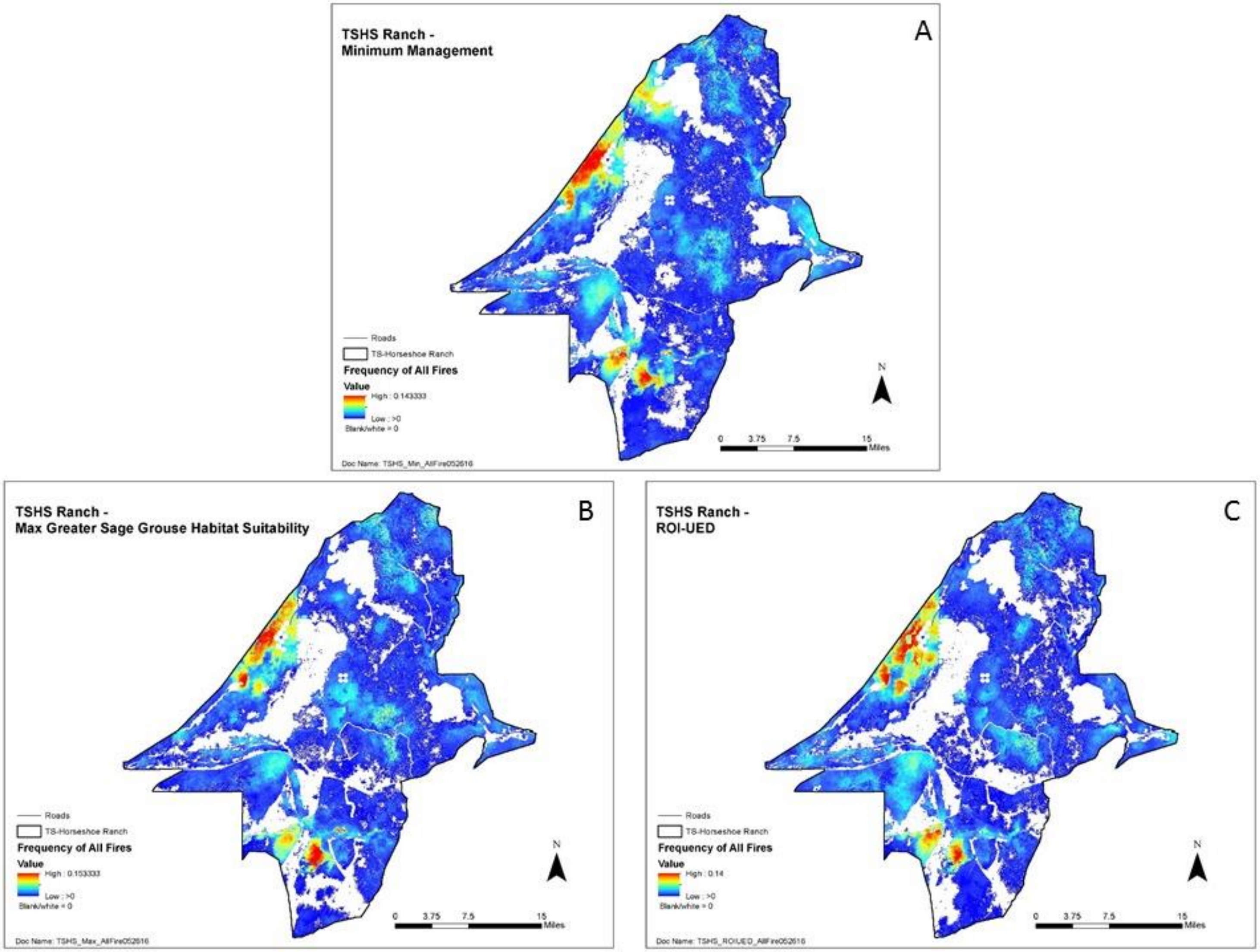


Figure 95. Annual probability of all observed fire events created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the TS-Horseshoe Ranches. Other than no fire, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = MINIMUM MANAGEMENT, B = MAX GSG HS MANAGEMENT, and C = BEST UED MANAGEMENT.

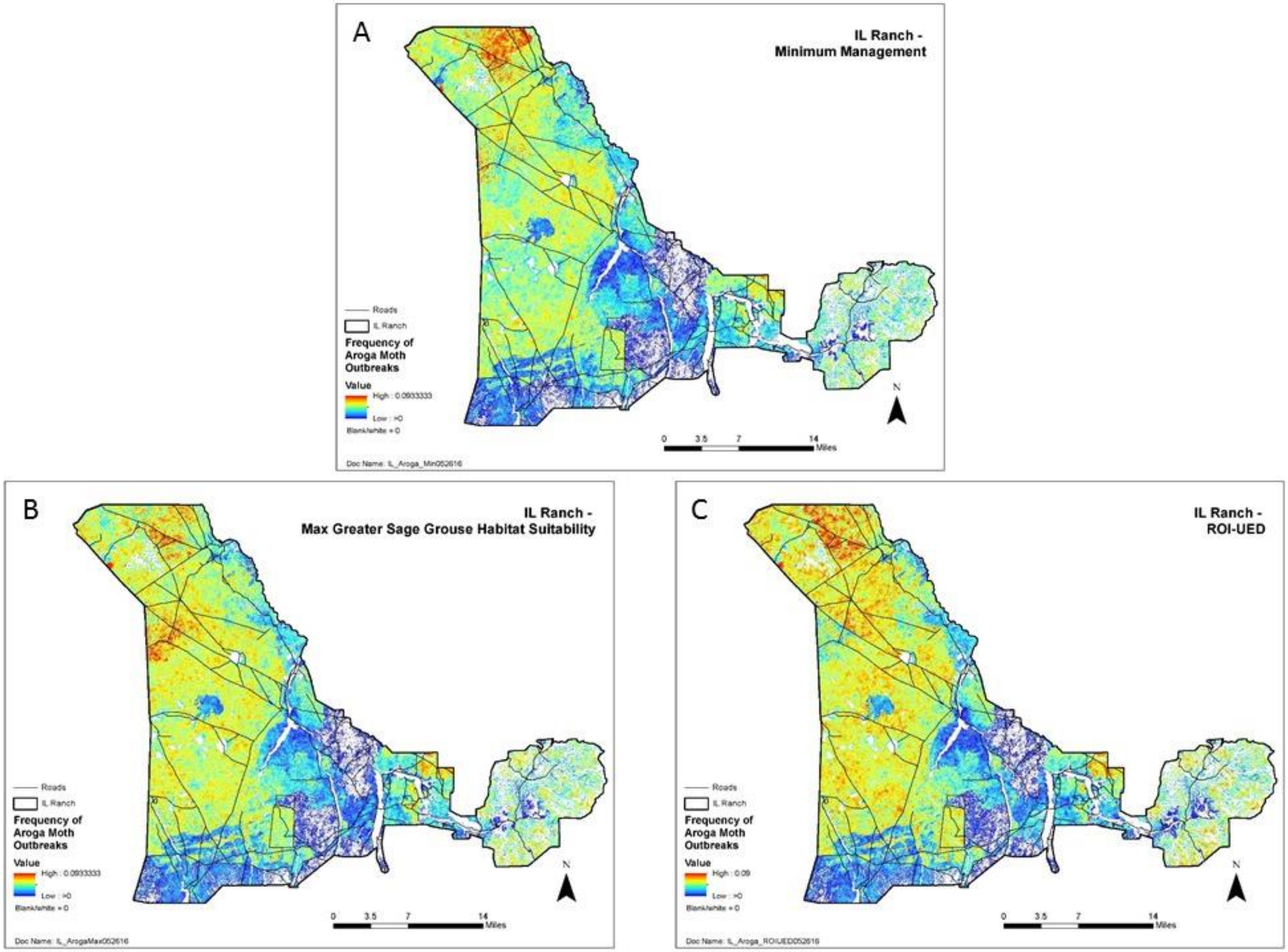


Figure 96. Annual probability of all observed Aroga moth outbreak events created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the IL Ranch. Other than no outbreaks, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = MINIMUM MANAGEMENT, B = MAX GSG HS MANAGEMENT, and C = BEST UED MANAGEMENT.

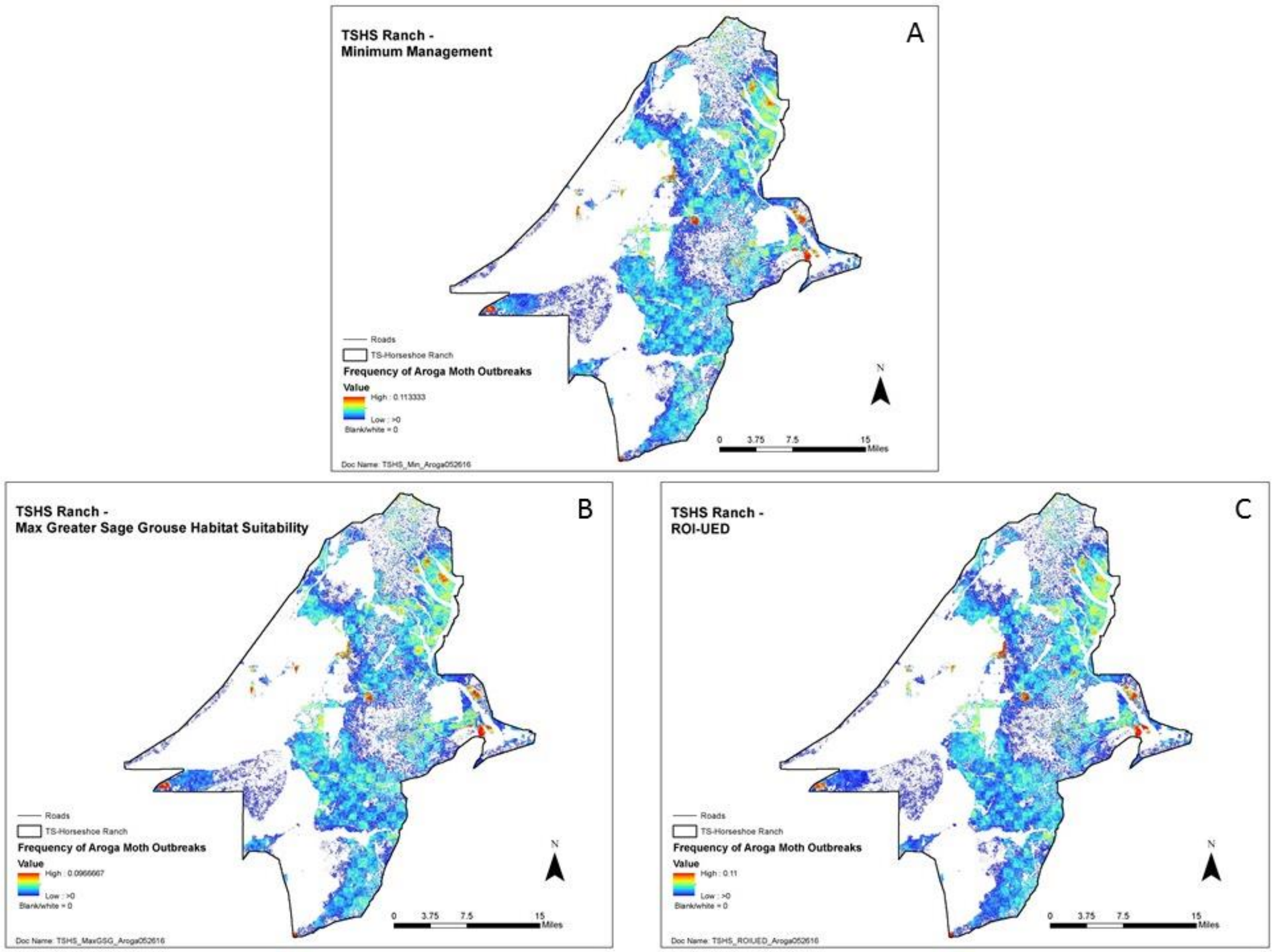


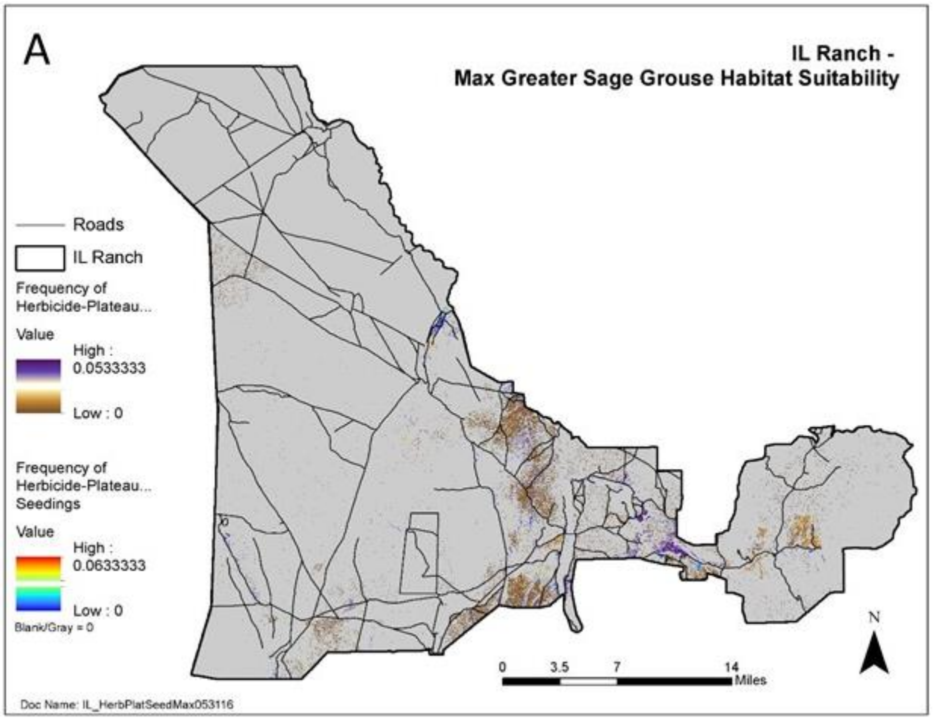
Figure 97. Annual probability of all observed Aroga moth outbreaks events created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the TS-Horseshoe Ranches. Other than no outbreaks, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = MINIMUM MANAGEMENT, B = MAX GSG HS MANAGEMENT, and C = BEST UED MANAGEMENT.

At the IL Ranch for both active scenarios, ST-Sim positioned management actions that treated the non-native annual species in class U:Annual Spp (i.e. herbicide-Plateau+native-seed for basin wildrye-montane; and herbicide-Plateau+seed for big sagebrush upland, low sagebrush, and montane sagebrush steppe) mostly in the central part of the ranch between Four-Mile Creek road and the Independence Range where older fires had previously occurred (Figure 98). These areas currently have annual grasslands or will have them after a second burn. On the TS-Horseshoe Ranches, these management actions in both active scenarios were implemented primarily east and west of the steep terrain of the Tuscarora Range, at the toe of Argenta Rim, and on the east side of Crescent Valley in the Dry Hills (Figure 99). The areas of highest implementation were situated on both sides of the Humboldt River at the south end of the Tuscarora Range and in the Dry Hills.

In order to achieve the “supplemental salt block” treatment, a “transition adjacency multiplier” was used. The result of this algorithm was that ST-Sim sprinkled small areas of shrub thinning created by temporarily (about one month) placing supplemental salt blocks within 2 km of known leks during the first 10 years of each simulation on the IL Ranch (Figure 100). About 5% of the circular area around a lek was targeted in any one replicate. The “transition adjacency multiplier” algorithm that dispersed small occurrences of supplemental salt blocks was very successful at creating maximum scatter.

Figures 101 and 102 displayed small areas, usually wet meadows and riparian areas, where inexpensive floodplain restoration (primarily small rock weirs) was applied to incised wet meadows and where livestock’s access to wet meadows and riparian areas was limited and controlled (livestock grazing control). Livestock grazing control could be several actions that accomplish the same result, but fencing riparian pastures is likely to be the most realistic for Newmont ranches. The areas that received the most focus from ST-Sim was Four-mile Creek and Winters Creek at Winters Ranch on the IL Ranch for both actions (Figure 101). On the TS-Horseshoe Ranches, actions were scattered mostly along the Tuscarora Range and the livestock grazing control action dominated (Figure 102).

Thinning sagebrush was not commonly used except when sagebrush dominated in basin wildrye montane or bottomland (TS-Horseshoe Ranches only) or for the classes with sagebrush with an understory of non-native annual species (U:SA-Closed or U:SA-Dense) in big sagebrush upland. On the IL Ranch, the thin+Plateau+native-seed action was used in basin wildrye-montane and thin+Plateau-seed action was used in big sagebrush upland-no trees in very localized areas with too much sagebrush, but only for the BEST UED MANAGEMENT scenario (Figure 103). These actions would not benefit sage-grouse, and were, therefore, not deployed in the Max GSG HS Management scenario. On the TS-Horseshoe Ranches, application to the same ecological systems was very limited; however, the major difference is the very widespread application of the thin+Plateau+native-seed to basin wildrye-bottomland in Boulder Valley for the BEST UED MANAGEMENT scenario as an effort to restore the vast grassland in the valley (Figure 104).



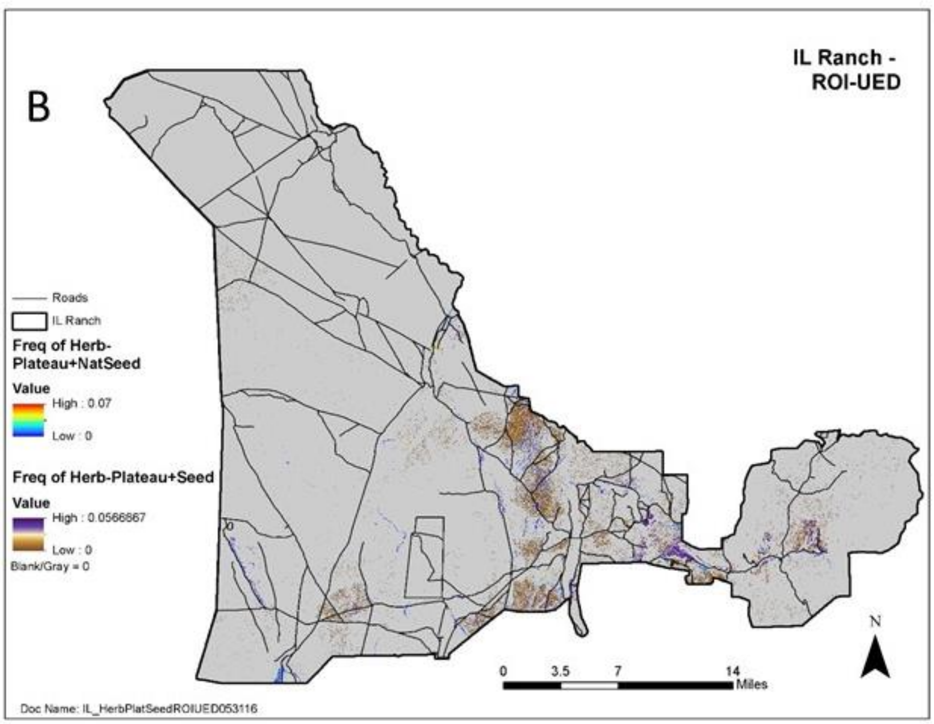


Figure 98. Annual probability of all observed events of the herbicide+Plateau+native-seed and herbicide+Plateau+seed actions created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the IL Ranch. Other than no outbreaks, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = MAX GSG HS MANAGEMENT and B = BEST UED MANAGEMENT scenarios.

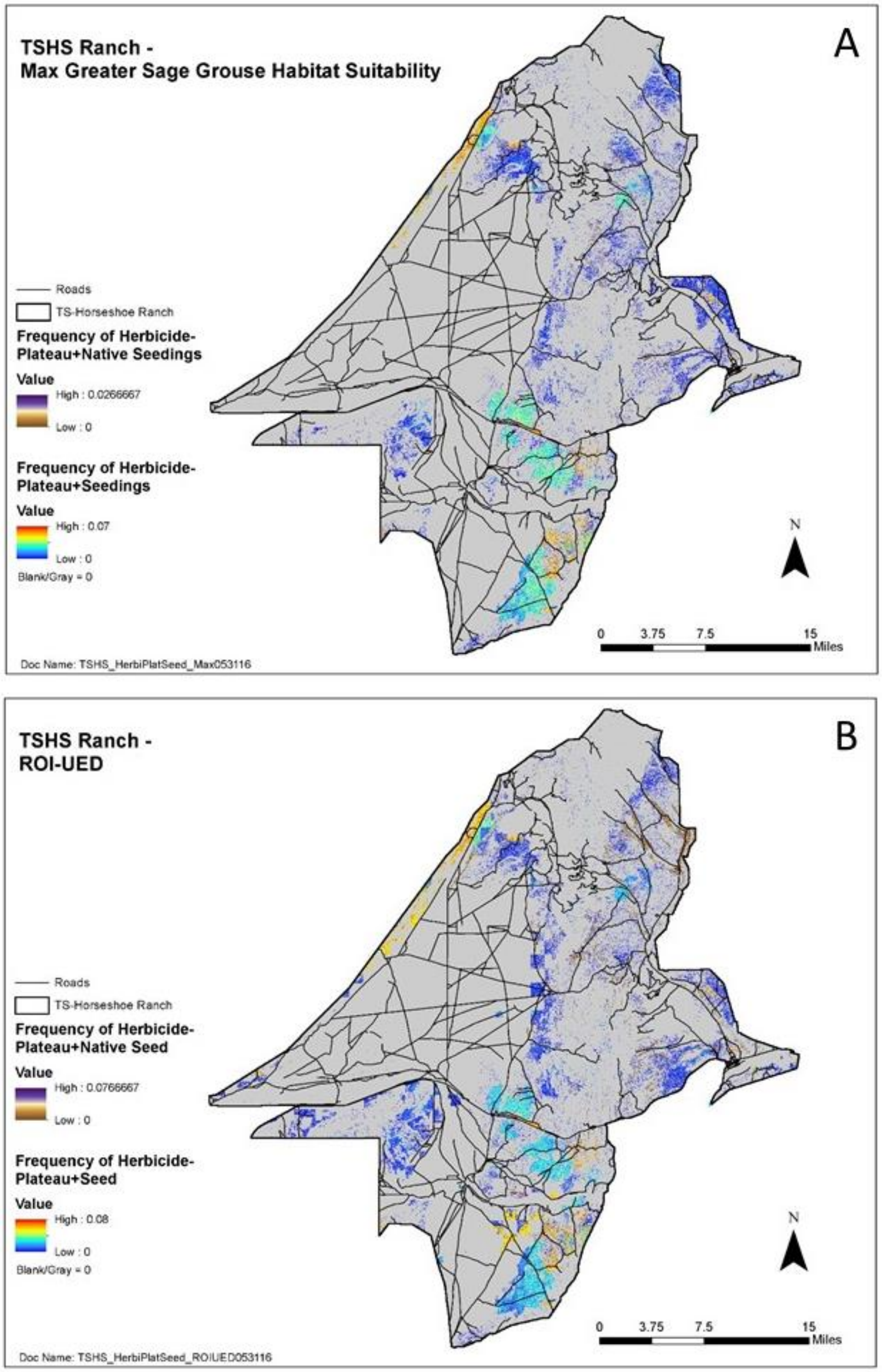


Figure 99. Annual probability of all observed events of the herbicide+Plateau+native-seed and herbicide+Plateau+seed actions created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the TS-Horseshoe Ranches. Other than no outbreaks, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = MAX GSG HS MANAGEMENT and B = BEST UED MANAGEMENT scenarios.

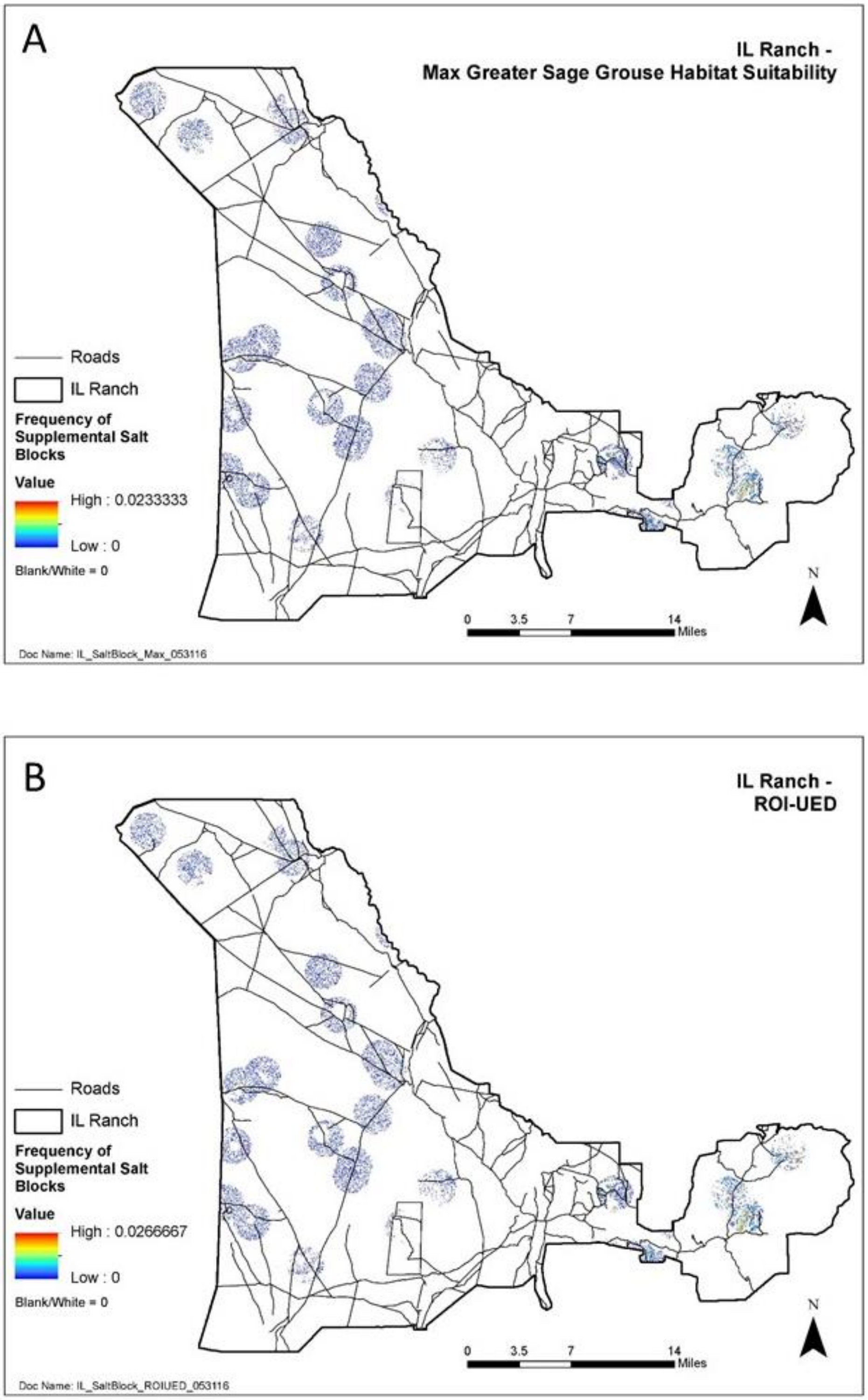


Figure 100. Annual probability of all observed events of the supplemental salt block action created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the IL Ranch. Other than no outbreaks, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = Max GSG HS Management and B = Best UED Management scenarios.

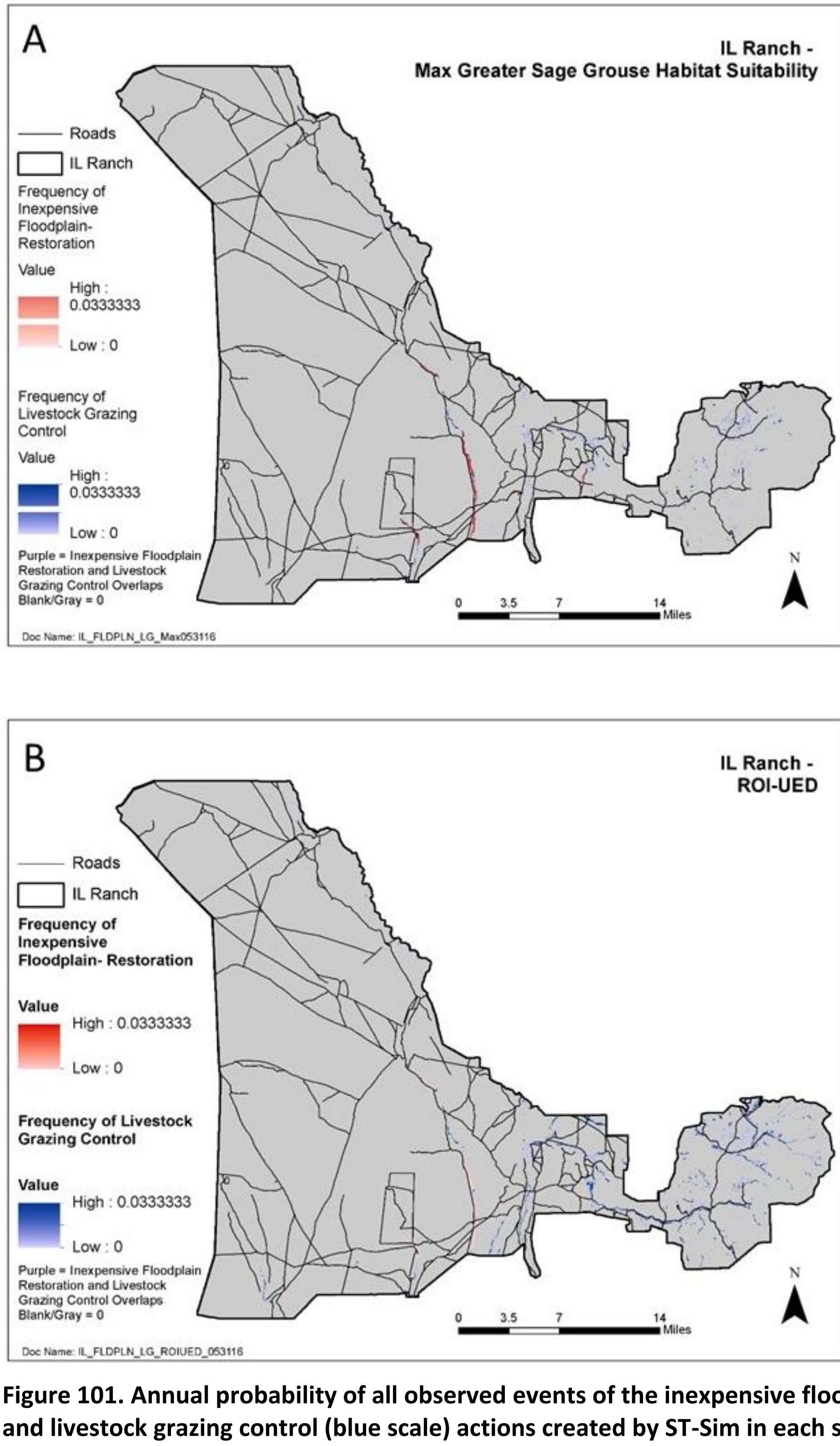


Figure 101. Annual probability of all observed events of the inexpensive floodplain restoration (red scale) and livestock grazing control (blue scale) actions created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the IL Ranch. Other than no outbreaks, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = MAX GSG HS MANAGEMENT and B = BEST UED MANAGEMENT scenarios.

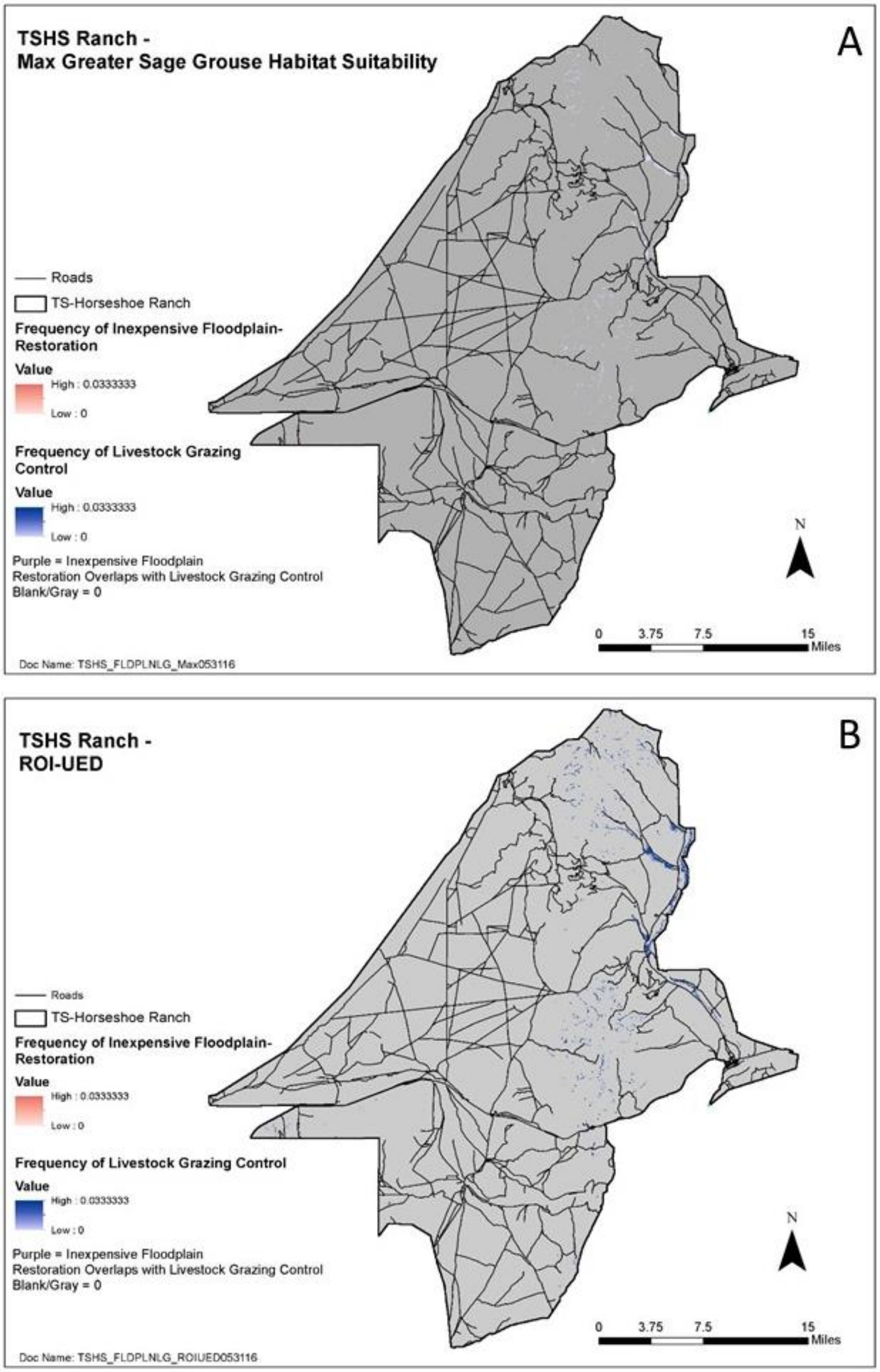


Figure 102. Annual probability of all observed events of the inexpensive floodplain restoration (red scale) and livestock grazing control (blue scale) actions created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the TS-Horseshoe Ranches. Other than no outbreaks, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = MAX GSG HS MANAGEMENT and B = BEST UED MANAGEMENT scenarios.

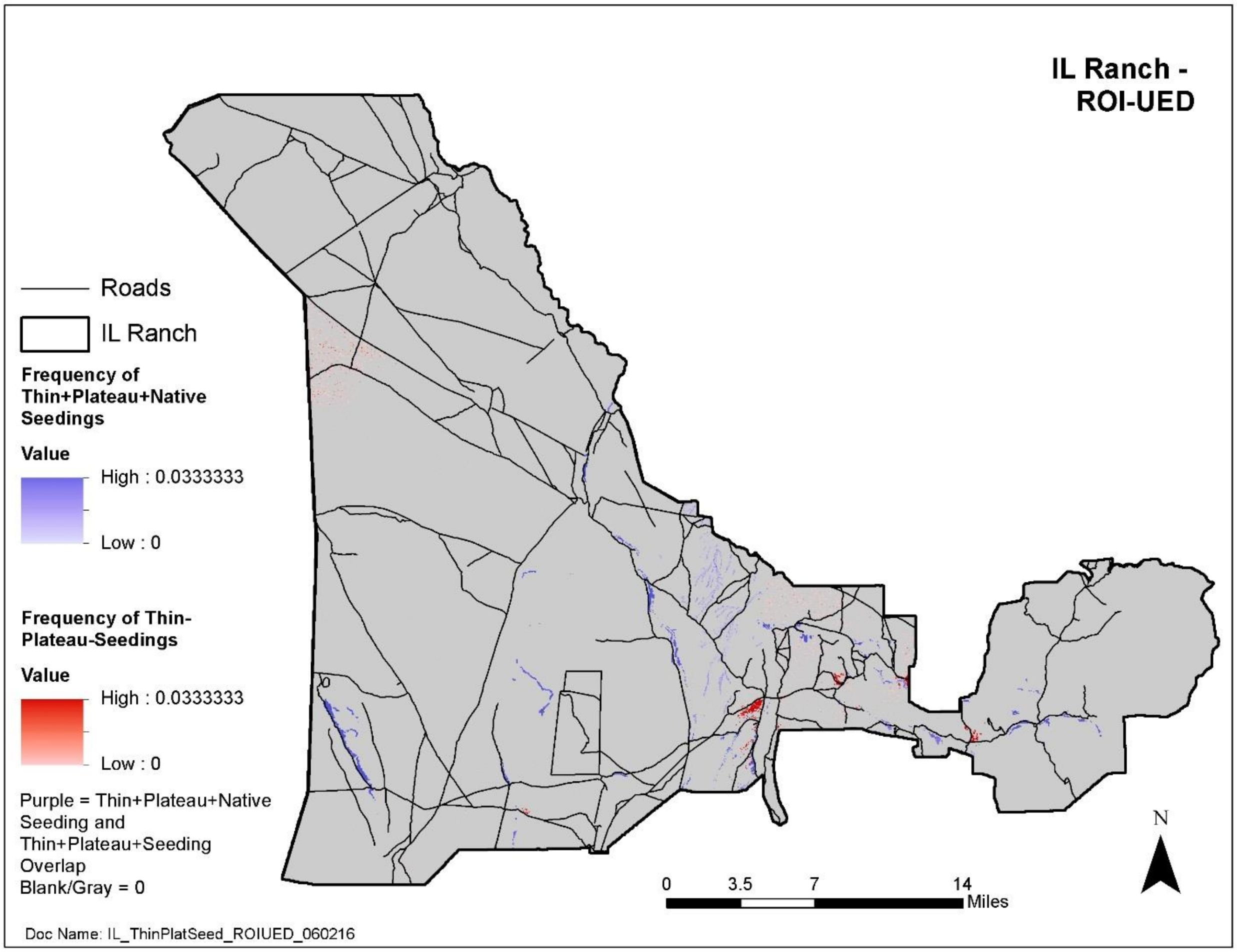


Figure 103. Annual probability of all observed events of the thin+Plateau+native-seed (purple scale) and thin+Plateau+seed (red scale) actions created by ST-Sim in each scenario calculated for 10 replicates and 30 years in the BEST UED MANAGEMENT scenario on the IL Ranch. Other than no outbreaks, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years).

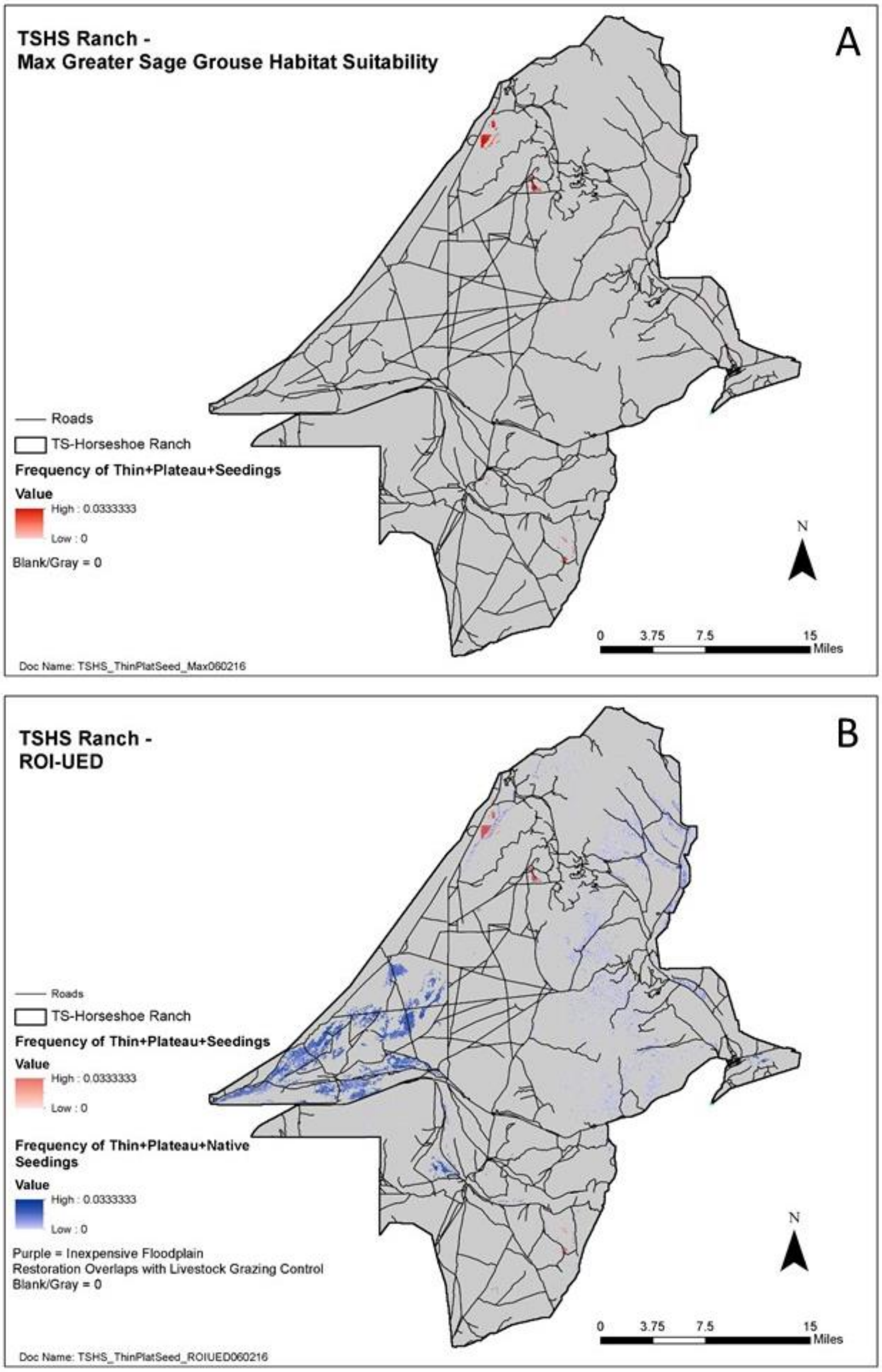


Figure 104. Annual probability of all observed events of the thin+Plateau+native-seed (red scale) and thin+Plateau+seed (purple scale) actions created by ST-Sim in each scenario calculated for 10 replicates and 30 years on the TS-Horseshoe Ranches. Other than no outbreaks, the lowest annual probability is 1 out of 300 events (300 = 10 replicates × 30 years). Legend of scenarios: A = MAX GSG HS MANAGEMENT and B = BEST UED MANAGEMENT scenarios.

Discussion

Important points of the Landscape Conservation Forecasting™ assessment for Newmont's IL Ranch and TS-Horseshoe Ranches are summarized below:

1. The IL Ranch and TS-Horseshoe Ranches, encompassing, respectively, 485,732 acres (196,569 ha) and 521,085 acres (210,876 ha), are ecologically different project areas of north-central Nevada as the former lies within the southern Columbia Plateau ecoregion and the latter occupies the northern Great Basin ecoregion. Average precipitation is greater on the IL Ranch than the TS-Horseshoe Ranches.
2. Sixteen and 19 ecological systems, respectively, were identified in the IL Ranch and TS-Horseshoe Ranches, and they and their component vegetation classes were mapped at 5-m resolution via interpretation of RapidEye satellite imagery. Big sagebrush on upland soils and montane sagebrush steppe were the dominant ecological systems on each property. Unlike the IL Ranch, the TS-Horseshoe contained the Humboldt River floodplain that supported additional low elevation mesic, saline, and sodic plant communities.
3. At present, many ecological systems in the IL Ranch are in fair to poor condition, as indicated by high values of the metric of unified ecological departure (UED) (i.e. conditions are highly departed from reference/pre-European settlement conditions), although this metric allows for a limited area of introduced-species seedings without penalty to the metric. Seven systems were highly departed from reference conditions, six moderately departed, and three showed low departure from reference conditions. Systems at lower levels of unified ecological departure were found at higher elevations and were not widespread.
4. The current condition of ecological systems of the TS-Horseshoe Ranches ranged from 11 in high departure, six at moderate departure, and one at low departure from reference conditions according to the metric unified ecological departure.
5. For the IL Ranch after 30 years of MINIMUM MANAGEMENT (no proactive management actions), UED increased in basin wildrye-montane, montane riparian, montane sagebrush steppe-subalpine, and wet meadow-montane. A few systems were stable, though remained highly departed from reference conditions: aspen woodland, aspen-mixed conifer and low sagebrush. The big sagebrush-upland system naturally recovered (i.e., lower UED) from past large fires and reference classes rebalanced through the actions of various disturbances.
6. For the TS-Horseshoe Ranches after 30 years of MINIMUM MANAGEMENT, UED significantly increased in greasewood, montane sagebrush steppe-upland, saline meadow, wet-meadow bottomland, and wet meadow-montane. A few systems remained highly departed from reference conditions, but not further deteriorating: both basin wildrye systems, big sagebrush-semidesert, and big sagebrush-upland with trees.

7. Analyses of habitat suitability were done for three species, sage-grouse, mule deer, and golden eagle, at the present time and as modeled in the future under several different types of management scenarios. For sage-grouse, habitat suitability estimation was supported by demographic data from the University of Nevada, Reno's long-term Falcon-to-Gondor study and expressed as nest site selection, nest success, chick survival, female survival, and per-capita population growth rate (λ), whereas the mule deer and golden eagle habitat suitability estimation were based on data and expert opinion resource selection functions that were combined in an overall habitat suitability functions (no λ).
8. The areas of highest sage-grouse habitat suitability were generally at higher elevations where standing sagebrush dominated vegetation structure when leks were within 10 km of any location. Mapped areas of highest habitat suitability as measured by vital rates or λ were generally the same for the current and 30-year MINIMUM MANAGEMENT scenario habitat suitability for sage-grouse; however, local changes in λ for the MINIMUM MANAGEMENT scenario were observed in formerly burned areas where mixed non-native annual species and perennial native grass species matured into a shrub phase usable as nesting habitat on both ranches. Despite similarities, habitat suitability temporally increased on the TS-Horseshoe Ranches due to recovery from fire and significantly decreased on the IL Ranch due to fires and Aroga moth outbreaks in the minimum management scenario.
9. Mule deer and golden eagle habitat suitability were largely unchanged over 30 years as resource selection functions were dominated by geomorphic, soil, topographic, and established migration corridor attributes, which do not change. For mule deer, mountainous terrain in proximity of migration corridors showed the highest habitat suitability, whereas location of deep soil supporting abundant jackrabbit populations, vegetation supporting alternative prey, locations of food subsidies from livestock birthing and Interstate roadkill were determinant for golden eagle habitat suitability.
10. Eight and 10 ecological systems, respectively, were selected for detailed modeling analyses for the IL Ranch and TS-Horseshoe Ranches based on their size, current and likely future condition (degree of ecological departure), importance to sage-grouse, and/or other features of importance to Newmont and the BLM.
11. Two management scenarios were chosen that emphasized management actions designed to either increase sage-grouse habitat suitability only in the ecological systems used by sage-grouse (MAX GSG HS MANAGEMENT scenario) or decreased unified ecological departure of all systems that were either sufficiently departed or had classes that needed special attention (BEST UED MANAGEMENT scenario). The two scenarios were proposed because several range improvements targeting degraded sagebrush conflicted with increasing sage-grouse habitat suitability in the 30-year time horizon (as per the demographic model). Both scenarios employed fuel breaks (beyond the BLM's existing or proposed fuel breaks) to protect sage-grouse nesting habitat and deployed a more distributed livestock watering system in the Owyhee Allotment.

12. Management scenario Return-On-Investment was examined on two scales: by ecological system using UED and by landscape using species habitat suitability. ROIs summarize a lot of information because they revealed (a) whether an active scenario was worth doing compared to the MINIMUM MANAGEMENT scenario (i.e., scenario's ROI > 0) and (b) if one active scenario was more effective than other active scenarios at improving metrics because ROIs are significantly different.

13. Looking at the larger scale of species habitat suitability (not UED by ecological system), no active management scenario was capable of significantly increasing sage-grouse functional acres compared to the MINIMUM MANAGEMENT scenario on the IL Ranch (average of -50 functional acres lost in the MAX GSG HS MANAGEMENT scenario and an average of 149 functional acres gained with the BEST UED MANAGEMENT scenario). The IL Ranch's vegetation was in relatively good ecological condition with few recent fires, and few areas dominated by non-native annual species; therefore, actively improving generally mature sagebrush and wet meadow communities for the benefit of sage-grouse would be difficult. The value of management on the IL Ranch is in avoiding the loss of good habitat to very large fires.

    The functional acres of the active management scenarios were greater than those of the MINIMUM MANAGEMENT scenario from years 10 to 20 in the IL Ranch with the greatest difference in the 20^{th} year. Despite fuel breaks causing less fire, major fire activity in the last decade for seven out of ten replicates, coupled with Aroga moth thinning of mature sagebrush in the Owyhee Plateau, are believed to have sufficiently transformed sage-grouse nesting habitat into early-succession sagebrush. These processes also chipped away at habitat suitability over the 30 years of the simulations in all scenarios. Early-succession sagebrush cannot be used for nesting and would decrease nest success up to a distance of 2 km. The early-succession vegetation classes would not have enough time to mature by year 30 to contribute to nesting habitat if they were created after year 10.

    On the TS-Horseshoe Ranches, habitat suitability and functional acres increased rapidly with time in all scenarios because of the maturation of higher elevation early-succession classes in sagebrush systems caused by pre-mapping fires. It is also important to note that a large fraction of the TS-Horseshoe Ranches is non-habitat for sage-grouse. The BEST UED MANAGEMENT scenario caused the significantly highest habitat suitability by year 30 (average of 1,555 functional acres gained), but ROIs showed that the higher cost of the BEST UED MANAGEMENT scenario may not be worth its habitat suitability benefits compared to MAX GSG HS MANAGEMENT scenario, which yielded an average of 1,051 functional acres.

    While sage-grouse did benefit from active management, although more strongly on the TS-Horseshoe Ranch than the IL Ranch, mule deer habitat improved most with the MAX GSG HS MANAGEMENT scenario on both ranches despite that this metric was highly determined by physical factors not responsive to vegetation management. Mule deer would benefit from the restoration of the non-native annual species classes into mature shrublands (browse and thermal cover) in proximity of migratory corridors, but it is not clear why less restoration activity in the MAX GSG HS MANAGEMENT compared to the BEST UED MANAGEMENT scenario would result in higher habitat suitability.

Golden eagle habitat suitability improved most under the BEST UED MANAGEMENT scenario, and more so in the TS-Horseshoe Ranches than the IL Ranch. Improvement of alternative prey habitat outside of the deep soil communities was thought to be the main reason for habitat improvement, because more actions causing sagebrush and riparian system improvements were conducted in the BEST UED MANAGEMENT scenario than the MAX GSG HS MANAGEMENT scenario.

14. Looking at the scale of ecological systems, active management scenarios often significantly reduced UED compared to the MINIMUM MANAGEMENT scenario. When both active scenarios were implemented for the same ecological system on the IL Ranch, the BEST UED MANAGEMENT scenario's ROI was significantly higher in three of six systems (basin wildrye-montane, big sagebrush upland, and montane riparian), higher for the MAX GSG HS MANAGEMENT scenario in montane sagebrush steppe, and not different between active scenarios in low sagebrush and wet meadow-montane. For these two last systems, implementation rates were very similar for both scenarios.

    One important result is that the implementation of any active scenario did not change UED for the largest system, big sagebrush upland without trees on the IL Ranch, which means that ROIs statistically overlapped with zero (negative ROI for MAX GSG HS MANAGEMENT scenario) or were weak and highly variable (positive ROI for BEST UED MANAGEMENT scenario yielding a 1% improvement in UED). Little change was observed in big sagebrush upland because management actions primarily created mixed introduced and native species seedings, which are uncharacteristic vegetation classes. The small proportion of these classes was below the acceptable management threshold for seedings, and, therefore, did not result in an increase in UED, but, conversely, did not reduce UED. On the IL Ranch's BLM lands, the greatest benefits of each active management scenarios were the reduction of 3,000 acres of the non-native annual species class and 700 acres of exotic forbs (mostly thistles). Additionally, only the BEST UED MANAGEMENT scenario restored the shrub with non-native annual species class (U:SAP) to a mixed introduced and native species seeding class. The cumulative costs were also substantially different between these scenarios: $2,824,034 for BEST UED MANAGEMENT scenario compared to $757,178 for the MAX GSG HS MANAGEMENT scenario. Public and Newmont managers, therefore, need to carefully consider the price tag for a rather marginal reduction in UED and non-significant effect on sage-grouse habitat suitability between active scenarios in the IL Ranch.

    Both aspen systems were only treated in the BEST UED MANAGEMENT scenario to prevent the permanent loss of aspen clones. Although ROIs were zero, thus actions were not worth doing compared to the MINIMUM MANAGEMENT scenario, the actions reduced small areas of target classes and accomplished a very narrow goal. Managers should pursue restoration of these systems regardless of UED benefits.

15. Five ecological systems only received actions specified in the BEST UED MANAGEMENT scenario for the TS-Horseshoe Ranches: aspen woodland, basin wildrye-bottomland, big sagebrush-semidesert, saline meadow, and wet meadow bottomland. Low and zero ROIs, respectively, did not justify actions in the basin wildrye-bottomland and big sagebrush-semidesert systems. Among the five other systems where both active management scenarios were simulated, ROIs were higher in the BEST UED MANAGEMENT scenario in three systems (basin wildrye-montane, montane riparian, and wet meadow-montane) and statistically equal between active scenarios for the big sagebrush upland with trees and montane sagebrush steppe systems. Overall, the BEST UED MANAGEMENT scenario appeared to be the best choice for most ecological systems with ROIs greater than zero and for wildlife habitat suitability on the TS-Horseshoe Ranches.

16. Spatial simulation maps of the 30 future years identified areas of most probable disturbance events or implementation of the more commonly used management actions. A few significant observations emerged from these maps.

    a. Fire breaks worked better in the IL Ranch than TS-Horseshoe Ranches. Less fire and smaller fires occurred with fuel breaks than without. More fuel breaks could be placed on the IL Ranch because of the flat topography of the Owyhee Allotment and IL Meadow pastures, whereas placing fuel breaks was not feasible in the rugged Tuscarora Range where the best sage-grouse habitat was found. Fuel break effects were simulated using a new option in ST-Sim that prevented the priority placement of large fires when sufficient space was in short supply. Fuel break effects did not include a reduction of the overall fire rate, which could be implemented with additional effort, as a result of staging fire suppression crews and equipment to hold fire lines at fuel breaks. Holding fires at fuel breaks appear less probable on the IL Ranch due to its remoteness, especially in the Owyhee Allotment, although it is conceivable for the TS-Horseshoe Ranches, which is close to Carlin, Battle Mountain, and Elko.

    b. Aroga moth outbreaks were more widespread than anticipated. Although outbreaks resulted in complete shrub thinning to the early-succession class for only 25% of events compared to 75% of events leading to partial thinning (i.e., remaining standing sagebrush), outbreaks remained a dominant and natural determinant of sage-grouse nest site selection, nest success, and per capita population growth rate (λ). In the absence of fire due to active fire exclusion, Aroga moth outbreaks become the dominant stand replacing disturbance in northern Nevada landscapes dominated by mature semidesert and upland sagebrush.

       Results suggested that both fire and Aroga moth outbreaks may have counteracted management actions designed to accelerate sagebrush maturation in areas that burned before mapping. In particular, these results challenge the need of placing supplemental salt blocks to improve resilience in the Owyhee Allotment where Aroga moth populations appear, and are predicted, to be most effective at defoliating sagebrush. The thinning of sagebrush near salt blocks would only add to the reduction of nest site selection and nest success already caused by Aroga moth and fire.

c. The areas of highest habitat suitability are frequently at higher elevations (Tuscarora Range, Independence Range, and Bull Run Range). These areas contribute disproportionately more to sage-grouse habitat suitability and functional acres if leks are within 10 km; therefore, restoration actions in those areas can make a large difference for habitat suitability if one or two vital rates (chick survival, female survival, nest-site selection or nest success) are dragging down the entire habitat suitability. Paradoxically, these areas are the steepest and most inaccessible to restoration equipment. As a result, simulated implementation was rarely accomplished in the mountains.

   Critical actions to restore sage-grouse habitat (for example, herbicide-Plateau+seed used in the non-native annual species class) were instead deployed by ST-Sim on the toes and alluvial benches of the steep mountain ranges where slope was ≤15% on both ranches and on the flatter areas that formerly burned in the central part of the IL Ranch. These areas can contribute large functional acres if management scenarios are carefully placed to uplift one or two failing vital rates using a dynamic spatial constraint multiplier process. The simulated results of this report incorporated a different dynamic spatial constraint multiplier process preventing accidental sagebrush thinning in high suitability areas. We do not currently have the ability to run more than one dynamic spatial multiplier process, therefore we would need to either combine the two levels of constraints (i.e., not thin sagebrush in highly suitable areas and uplift vital rates where it makes the greatest difference) or select just one of the two processes for simulation improvements. For example, restoration of incised and shrub-encroached wet meadows of Four-mile Creek and seeding mixed introduced and native species (including planting sagebrush plugs) in the non-native annual species vegetation class up to 2 km east and north-east of Four-mile Creek might be very strategic as an individual project, given analysis warrants this conclusion. This example, however, requires that we dissociate the functional acres achieved from a single project from the variation in functional acres for the entire landscape.

17. Managers may select management actions and treatment areas based upon additional factors beyond ROI values. Such additional factors could include availability of financial resources, public-safety concerns, regulatory constraints, and other multiple-use or societal objectives.

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Appendix 1-A

Descriptions of Ecological Systems (Biophysical Settings) and their Vegetation Classes For IL Ranch

Note: The Ranch overlaps with NRCS' MLRA 25.

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Aspen-Mixed Conifer (ASM) – Not GSG Habitat
1061

Overview: The Aspen-Mixed Conifer BpS is commonly called "seral aspen." Populus tremuloides *is the dominant tree species, except in late succession where prolonged fire exclusion and ungulate herbivory allow dominance by mixed conifers, such as white fir, subalpine fir, limber pine, and Engelmann spruce. The presence of even a single aspen tree in a stand provides strong evidence that the area historically supported aspen clones. This BpS typically occurs on flat to steep terrain (<80%) on all aspects. Elevation generally ranges from 1,700 m to 2,800 m (5,600' to 9,200'). Soils are highly variable, but generally cool. This type occurs above the juniper and/or sagebrush zones. Aspen stands that are difficult to "see through" are considered healthy. Shrub, forb, and grass species typical of mesic sites are very diverse and plant cover is very high.*

A (10)[1]	***Early-all*:** 10-100% cover aspen <4.9m; mountain snowberry and *Ribes* common; 0-9 yrs
B (20)	***Mid1-closed***: 40-99% cover aspen 5-9.9m; mountain snowberry and *Ribes* common; 10-39 yrs
C (31)	***Mid2-closed***: 40-99% cover aspen 10-24m; conifer saplings visible in mid-story; mountain snowberry and *Ribes* common; 40-79 yrs
D (43)	***Late1-open***: 10-39% cover aspen 10-25 m; 10-25% mixed conifer cover 5-10 m; mountain snowberry and *Ribes* common; >80 yrs
E (50)	***Late1-closed***: 40-80% cover of mixed conifer 10-50m; <40% cover of aspen 10-25m; mountain snowberry and *Ribes* present; >100 yrs
U-*NAS (1055: 10,40)*	***No-Aspen***: permanent conversion to Subalpine Spruce-Fir – 1055; >50% white fir and subalpine fir cover; aspen absent or in trace amount; dead aspen boles may be present

Aspen Woodland (ASP) – Not GSG Habitat
1011

Overview: The Aspen Woodland BpS is dominated by Populus tremuloides *and is commonly called "stable aspen." Aspen woodland is a debated BpS as it is assumed, but not proven, that soils prevent encroachment of conifers even with fire exclusion, therefore maintaining the relative cover of conifers to <25%. Where the BpS is adjacent to conifers, an occasional conifer seedling may occur, but conifers do not drive the fire regime. Elevations generally range from 1,981 m to 2,743 m (6,500'-9,000'), but occurrences can be found at lower elevations, and average annual precipitation ranges from 41 cm to >51 cm (16" to >20"). Distribution of this ecological system is limited primarily by adequate soil moisture required to meet its high evapotranspiration demand, and secondarily by the length of the growing season or low temperatures. This BpS occurs commonly as multi-storied stands. Stands are usually closed. Aspen suckers 1.5 m to 4.6 m (5-15') tall will be present in all classes (min. 500 stems/acre). The Aspen Woodland BpS typically occurs above juniper and adjacent to mountain big sagebrush. At elevations below 6,500 feet this group grades into black and narrowleaf cottonwood types along riparian corridors. Often species of tall forbs, perennial grasses and shrubs are found in the understory. The herbaceous layer may be lush and diverse.*

A (11)	***Early-closed***: 10-100% cover of aspen <5m; 0-9 yrs
B (20)	***Mid1-closed***: 40-99% cover of aspen 5-9.9m; 10-39 yrs
C (31)	***Late1-closed***: 40-99% cover of aspen 10-25m; few conifers in mid-story; >39 yrs
D (43)	***Late1-open***: 10-39% cover of aspen 10-25 m; conifers may be present but less than 25% relative cover; >99 yrs
U-*DP (103)*	***Depleted-Open***: 10-39% cover of older aspen 10-25m; no or little aspen regeneration; mountain big sagebrush common in understory; few conifers in mid-story
U-*NAS (11260: 10,22,31)*	***No-Aspen***: permanent conversion to montane sagebrush steppe - 1126; very few aspen stems present; dead clone of aspen, dead boles may be visible on the ground; 5-50% cover of mountain big sagebrush/mountain shrub; <50% herbaceous cover

[1] Remote Sensing code (Geotiff code)

Basin Wildrye (BW) – GSG Habitat
1080bw or 10801

*Overview: The Basin Wildrye BpS is a grassland dominated by basin wildrye (*Elymus cinereus*). The BpS is found at elevations from about 1,372 m to 2,134 m (4,500' to over 7.000'). Typically soils are deep to very deep with loamy to coarse loamy textures (NRCS's loamy bottom). Soils are well drained with water tables below the rooting zone of the dominant shrubs; however, basin wildrye and creeping wildrye can also be found on moist floodplains adjacent to axial valley streams on slopes <4% . Salts, if present, can increase with depth. Soils were formed through alluvial processes and typically form valley bottoms with slopes generally less than 8%, and typically between 0 and 4%. Annual precipitation ranges from 20 to 41 cm (8" to 16"). Many locations occur along valley bottoms outside of the wet meadow areas, but within zones where water tables may attain depths of 150 to 75 cm (60" to 30"). On lower precipitation sites (20 to 25 cm or 8 to 10") these locations may be positioned at the base of slopes such that water may run onto these sites. Not much is written specifically about the dynamics of this BpS. This is a grassland-shrubland mixture dominated by basin wildrye, a deep-rooted cool-season bunchgrass, with basin big sagebrush and/or greasewood or mountain big sagebrush, respectively, subdominant (<15% cover) later in succession below or above 36 cm (14") of precipitation (about 2,134 m or 7,000" of elevation). On moist floodplains, willow increases during late-succession and, although not abundant, can dominate the visual aspect. Other shrubs generally represent less than 10 % of the overall cover and include various species and subspecies of rabbitbrush. Other grasses are generally cool season bunchgrasses, with the exception of some rhizomatous grasses on the dry meadows with deep soils and high precipitation. Forbs represent less than 10 % of the herbaceous cover.*

A (13)	***Early-open***: 5-20% cover of basin wildrye; 0-10 yrs **[B]**[2]
B (20)	***Mid-closed***: 21-80% cover of basin wildrye; <11% shrub cover; 11-75 yrs **[B]**
C (43)	***Late-open***: 11-20% cover of big sagebrush and rabbitbrush; <75% cover of basin wildrye; >75 yrs **[B]**
U-*AS (100)*	***Annual-Species***: ≥5% cover of non-native annual species; <5% cover basin wildrye and other native grasses; <11% shrub cover
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% basin wildrye and other native grasses; <11% shrub cover **[B]**
U-*DP (103)*	***Depleted***: >20% cover of native shrubs, especially big sagebrush and rabbitbrush; <5% basin wildrye; >20% mineral soil and litter cover
U-*EF (108)*	***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*ES (105)*	***Early-Shrub***: >20% cover of rabbitbrush species; native grasses present; non-native annual species may be present to common
U-*PAS (119)*	***Pasture*****:** Agricultural pasture **[B]**
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass***: 5-14% cover of non-native annual species; >10% cover of native shrubs; ≥0% basin wildrye
U-*SD (135)*	***Seeded-native***: >10% seeded basin wildrye and other native grasses, forbs, and shrubs; <5% non-native annual species (if ≥5 non-native annual species, then ASPG or even AS) **[B]**
U-*SDI (127)*	***Seeded-Introduced***: >10% seeded introduced grasses, forbs, and shrubs; <5% of non-native annual species **[B]**
U-*SDI+AS (128)*	***Seeded-Introduced+Annual-Species***: >10% seeded introduced grasses, forbs, and shrubs, ≥5% cover of non-native annual species **[B]**

Big Sagebrush Shrubland-upland no trees (WSup) – GSG Habitat
1080up or 10800

Overview: The Big Sagebrush Shrubland BpS occurs on well-drained soils on foothills, terraces, slopes and plateaus. It ranges from 1,585 m to 1,981 m (5,200' – 6,500') in elevation. It is found on soil depths greater than 45 cm

[2] B = brood-rearing vegetation class, N = nesting vegetation class

*(18") and up to 152 cm (60+"). The BpS occurs from 25 cm to 35 cm (10' to 12") of annual precipitation on drier, shallower soils, and from 20 cm to 30 cm (8 to 12") of annual precipitation on deeper, more productive soils. Thus, site characteristics (e.g. aspect, drainage) should be considered in identifying this BpS. Shrub canopy cover generally ranges from 5 to 25%, but can exceed 30% at the upper elevation and precipitation zones. Big sagebrush includes basin big sagebrush and/or Wyoming big sagebrush sites. Rubber rabbitbrush may be co-dominant and antelope bitterbrush should be common. Perennial forb cover is usually <10% and perennial grass cover reaches 20 - 25% on more productive sites. Bluebunch wheatgrass and Thurber's needlegrass may be a dominant species following replacement fires and as a co-dominant after 20 years, but only in precipitation zones above 25 cm (10"). Bottlebrush squirreltail and Indian ricegrass are common on more xeric sites. Percent cover and species richness of understory are determined by site limitations. Single-leaf pinyon (*Pinus monoplylla*) and Utah juniper (*Juniperus osteosperma*) absent in this region.*

A (10) ***Early-all***: >10% herbaceous cover; <10% cover of rabbitbrush species; <10% cover of big sagebrush; 0-20 yrs **[B]**

B (22) ***Mid-open***: 11-20% cover of big sagebrush; >10% herbaceous cover; 20-39 yrs **[B,N]**

C (31) ***Late1-closed***: 20-39% cover of big sagebrush and other shrubs; >10% native herbaceous cover; 40-79 yrs; **[N]**

D (42) ***Late1-dense***: ≥40% cover of big sagebrush and other shrubs; >5% native herbaceous cover; ≥80 yrs; **[N]**

U-*AS (100)* ***Annual-Species***: >10% cover of non-native annual species; <10% cover of native shrubs, especially sagebrush

U-*ASPG (101)* ***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% native grasses; <10% shrub cover

U-*DP (103)* ***Depleted***: >20% cover of big sagebrush, and rabbitbrush; <5% native grass cover dominated by bottlebrush squirreltail and Sandberg bluegrass; <5% cover of non-native annual species; >20% mineral soil and litter cover **[N]**

U-*EF (108)* ***Exotic Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife) regardless of shrub cover

U-*ES (105)* ***Early-Shrub***: >10% cover rabbitbrush species; <5% non-native annual species; native grass may be present

U-*SA-1 (122)* ***Shrub-Annual-Species-closed***: ≥5% cover non-native annual species; 20%-39% cover of big sagebrush and other shrubs <0.5m; native grasses rare **[N?]**

U-*SA-2 (123)* ***Shrub-Annual-Species-dense***: ≥5% cover non-native annual species; ≥40% cover of big sagebrush and other shrubs <0.5m; native grasses rare **[N?]**

U-*SAP-1 (125)* ***Shrub-Annual-Species-Perennial-Grass-closed***: ≥5% cover non-native annual species; 20%-39% cover of big sagebrush and other shrubs <0.5m; 5-20% cover native grasses **[N]**

U-*SAP-2 (126)* ***Shrub-Annual-Species-Perennial-Grass-dense***: ≥5% cover non-native annual species; ≥40% cover of big sagebrush and other shrubs <0.5m; 5-20% cover native grasses **[N]**

U-*UF* (146) ***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot

U-*SD (135)* ***Seeded-Native*****:** >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover (if ≥5 non-native annual species cover, then see ASPG or AS) **[B]**

U-*SDI-A (129)* ***Seeded-Introduced-early***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of rabbitbrush species; <10% cover of Wyoming big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[B]**

U-*SDI-B (130)* ***Seeded-Introduced-Mid-open***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 11-20% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[B,N]**

U-*SDI-C (131)* ***Seeded-Introduced-Late1-closed***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 20-39% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[N]**

U-*SDI-D (132)* ***Seeded-Introduced-Late1-dense***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); >40% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[N]**

U-*SI-A+AS (138)* ***Seeded-Introduced-Early+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of rabbitbrush species; <10% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[B]**

U-*SI-B+AS* *(139)* ***Seeded-Introduced-Mid-open+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 11-20% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[B,N]**

U-*SI-C+AS* *(140)* ***Seeded-Introduced-Late1-closed+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 20-39% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[N]**

U-*SI-D+AS* *(141)* ***Seeded-Introduced-Late1-Dense+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); >40% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[N]**

Curl-leaf Mountain Mahogany (CMM) – Not GSG Habitat
1062

*Overview: The Curl-leaf Mountain Mahogany (*Cercocarpus ledifolius*) BpS is usually found on upper slopes and ridges between 2,133 m to 3,200 m (7,000' to 10,500') elevation. Most stands occur on rocky shallow soils and outcrops. Stands are assumed to reach old age, >1,000 years, without fire. The BpS is present in two distinct forms due to soil differences: 1) savannas of old and well-dispersed trees form open and often grassy woodlands (with mature stand cover between 10-55%) with a diverse understory on soils with a large proportion of boulders above and below ground; and 2) dense thickets of old shrubs (56% to 100% cover) with thick litter and little understory cover form on soils without bouldering. Curl-leaf mountain mahogany is both a primary early successional colonizer rapidly occupying bare mineral soils after disturbance and the dominant long-lived species. Seedlings require mineral soil without plant competition to reestablish after fire. Reproduction often appears dependent upon geographic variables (slope, aspect, and elevation) more than biotic factors. Where curl-leaf mountain mahogany has reestablished quickly after fire, rabbitbrush (*Chrysothamnus nauseosus*) may co-dominate. Litter and shading by woody plants inhibits establishment of curl-leaf mountain mahogany. Mountain big sagebrush (*Artemisia tridentata *spp.* vaseyana*) and mountain snowberry* (Symphoricarpos oreophilus) *are the most common shrubs, with Utah serviceberry (*Amelanchier utahensis*) and creeping barberry (*Mahonia repens*) also common. Utah juniper (*Juniperus osteosperma*) and other conifers may be present, with less than 10% total cover. In old, closed canopy stands, understory may consist largely of prickly phlox (*Leptodactylon pungens*). In savannas, the herbaceous understory can be diverse and abundant.*

A (10) ***Early-all*:** <70% cover of mountain mahogany; other shrubs (snowberry, rabbitbrush) and grasses may be present; 0-20 yrs

B (22) ***Mid-open***: 10-30% cover mountain mahogany and other shrubs; 20-60 yrs

C (20) ***Mid-closed***: 30-70% cover of mountain mahogany, other shrubs (snowberry, rabbitbrush, big sagebrush, bitterbrush, black sagebrush) abundant; 60-150 yrs

D (43) ***Late-open***: 10-30% cover of mountain mahogany; big sagebrush, black sagebrush, bitterbrush; grasses abundant; occasional mixed conifer possible; 150+ yrs

E (50) ***Late-closed***: >30% cover of mountain mahogany; 5-10% cover of Utah juniper; snowberry may be common; occasional mixed conifer possible ; 150+ yrs

U-AS (100) ***Annual-Species***: ≥10% non-native annual species cover; mountain mahogany largely absent; ≤80% cover of mineral soil, bedrock, and rock

U-*TA (145)* ***Tree-Annual-Species***: >5% cheatgrass cover; >10% cover of mountain mahogany; 40% cover of mineral soil, bedrock, and rock

Limber Pine Woodland (LB) – Not GSG Habitat
1020

Overview: The Limber BpS is often the highest subalpine forest type. Elevation ranges from 2,438 m to 3,505 m (8,000' to 11,500') on mid to upper slopes on smooth to concave mountain slopes. The BpS is found on northerly aspects at lower elevations and on all aspects at higher elevations. Slopes ranges from 8% to over 75%. The areas are typically in rain shadows, and are the dry and cold extent of tree cover. Stands occur on thin, stony soils, high windswept ridges and open slopes with minimal ground cover. Pinus flexilis *can exist separately or as mixed stands.* Pinus flexilis *is also found in association with Rocky Mountain juniper (*J. scopulorum*) on steep rocky slopes at montane and lower subalpine elevations.* Picea engelmannii *may occur incidentally highly dependent on seed-caching birds.*

A (10) ***Early-all***: ≤10% limber cover 0-5m tall and seedlings and saplings of Rocky Mountain juniper may be present to codominant; abundant mineral soil or talus cover; sparse ground cover; 0-99 yrs

B (22) ***Mid1-open***: 11-30% limber pine cover 5-10m tall and Rocky Mountain juniper may be present to codominant; abundant mineral soil or talus cover; sparse ground cover; 100-249 yrs

C (33) ***Late1-open***: very old trees; 11-35% limber pine cover 5-25m tall and Rocky Mountain juniper may be present to codominant; abundant mineral soil or talus cover; sparse ground cover; >250 yrs

Lower Montane-Valley Grassland (LMG) – GSG Habitat
1139

Overview: The Lower Montane-Valley Grassland BpS occurs in depressional areas within upland landscapes. Slopes range from 0 to 8 percent, but slope gradients of 2% to 4% are most typical. Elevations are 1,524m to 1,676 m (5,000' to 5,500'). Average annual precipitation is 20 cm to 25 cm (8" to 10"). The soils have a shallow effective rooting depth. Surface soils are modified by high amounts of cobbles and stones which occupy plant growing space. Additional moisture is received as run-in from higher landscapes. Bluebunch wheatgrass and Thurber's needlegrass are dominant. Forbs are a small proportion of the vegetation (aster, balsamroot, lupines, phlox, milkvetch, buckwheat, penstemon), and shrubs (Wyoming big sagebrush and rabbitbrush) are at most occasional.

A (10) ***Early-all***: 5-29% bluebunch wheatgrass, Thurber's needlegrass, and sedge cover; 5%-20% forb cover; abundant bare ground and rock cover; <1% shrub cover; 0-9 yrs **[B]**

B (22) ***Mid1-copen***: ≥30% bluebunch wheatgrass, Thurber's needlegrass, and sedge cover; ≤10% forb cover; <20% bare ground and rock cover; <3% shrub cover; 10-49 yrs **[B]**

C (40) ***Late-closed***: 3-10% shrub cover; ≥40% bluebunch wheatgrass, Thurber's needlegrass, and sedge cover; <20% bare ground and rock cover; ≥50 yrs **[B]**

U-*ASPG (101)* ***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% native grasses; <10% shrub cover **[B]**

U-*EF (108)* ***Exotic-Forb***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, mustard, purple loosestrife)

U-*IG (112)* ***Increaser-Grass***: ≥30% bottlebrush squirreltail, Sandberg's bluegrass; >10% phlox cover; abundant bare ground and rock cover **[B]**

U-*SE-Early (134)* ***Shrub-Encroached-early***: <30% cover of silver sagebrush; 30-50% mat muhly and other grass cover; >60% mineral soil cover; 0-55 yrs

U-*SE-Late (136)* ***Shrub-Encroached-late***: ≥30% mountain silver sagebrush; <60% mat muhly and other grass cover; >30% mineral soil cover; >55 yrs

U-*EF-ARCA (107)* ***Exotic-Forb in silver sagebrush***: >5% exotic forbs (tall whitetop, knapweed, purple loosestrife, halogeton, Russian thistle, mustards); ≥10% cover of silver sagebrush

U-*DP (103)* ***Depleted***: ≥50% silver sagebrush cover; <5% povertyweed or non-native annual species cover; <10% Nevada bluegrass cover; 10-30% cover of bare ground

U-*SA (121)* ***Shrub-Annual-Grass***: ≥5% cover of non-native annual species; <10% native grass cover; ≥10% silver sagebrush cover

U-*SAP (124)* ***Shrub-Annual-Species-Perennial-Grass***: ≥5% non-native annual species cover; ≥10% cover of silver sagebrush; ≥10% cover of native grass

Low Sagebrush (LS) – GSG Habitat
1079aa or 10790

*Overview: The Low Sagebrush BpS is found on clay soils. Low sagebrush (*Artemisia arbuscula*) is the dominant species, including early sagebrush (*A. arbuscula spp. longiloba*). Low sagebrush tends to grow where there is a clay-based root-limiting layer in the soil profile that causes a perched spring water table and poor aeration after wetting. Big sagebrush species generally occur on deeper loamy soils. Elevations range from 1,371 m to 2,438 m (4,500' to 8,000'), although the BpS is sometimes found as high as 2,895 m (9,500') on mountain ridges and summits where soil are very shallow and wind swept. Low sagebrush communities found above 2,438 m (8,000') and above 36 cm (14'") of precipitation on mountain valleys and basins are a different BpS: Low Sagebrush Steppe. The BpS mostly occurs on alluvial fans, piedmonts, bajadas, rolling hills and mountain slopes. The BpS can also be found on flats, plains, scablands. Low sagebrush generally has relatively low fuel loads with low-growing and cushion forbs and scattered bunchgrasses such as Thurber needlegrass (*Achnatherum thurberianum*), Sandberg's bluegrass* (Poa secunda), *Indian ricegrass (*Achnatherum hymenoides*), and, at higher elevations, Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). Forbs often include buckwheats*

*(*Eriogonum *spp.), fleabanes (*Erigeron *spp.), phloxes (*Phlox *spp.), paintbrushes (*Castilleja *spp.), globemallows (*Sphaeralcea *spp.), and lupines (*Lupinus *spp.).*

A (10)	***Early-all***: <10% cover rabbitbrush and other shrubs; >10% forb cover; >10% cover of grass; <50% cover mineral soil; 0-24 yrs **[B]**
B (22)	***Mid-open***: 10-19% cover of low sagebrush and rabbitbrush; >10% grass cover; <40% cover of mineral soil; 25-119 yrs **[B]**
C (31)	***Late-closed***: >20% cover of low sagebrush; >5% cover of grasses; >120 yrs **[B,N]**
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species; <10% cover of shrubs (primarily rabbitbrush and snakeweed)
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% native grasses; <10% shrub cover **[B]**
U-*EF (108)*	***Exotic-Forb***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, mustard, purple loosestrife)
U-*ES (105)*	***Early-Shrub***: >10% cover rabbitbrush and snakeweed species; <5% non-native annual species cover; native grass may be present
U-*DP (103)*	***Depleted***: >20% cover of low sagebrush; <5% native herbaceous cover; <5% non-native annual species cover **[N?]**
U-*SA (121)*	***Shrub-Annual-Species***: ≥5% non-native annual species cover; >10% cover of low sagebrush; <5% cover of native grass **[N?]**
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass***: ≥5% non-native annual species cover; >10% cover of low sagebrush; >5% cover of native grass **[N]**
U-UF (146)	***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot
U-*SD (135)*	***Seeded***: >5% seeded native grass and forb species; <10% cover of shrubs, including low sagebrush; <5% non-native annual species cover (if ≥5 non-native annual species cover, then see ASPG or AS) **[B]**
U-*SDI-A (129)*	***Seeded-Introduced-early***: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs, including low sagebrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover **[B]**
U-*SDI-B (130)*	***Seeded-Introduced-mid***: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of low sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover **[B]**
U-*SDI-C (131)*	***Seeded-Introduced-late***: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); >20% cover of low sagebrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover **[B,N]**
U-*SI-A+AS (138)*	***Seeded-Introduced-early+Annual-Species:*** >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs, including low sagebrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover **[B]**
U-*SI-B+AS (139)*	***Seeded-Introduced-mid+Annual-Species***: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of low sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover **[B]**
U-*SI-C+AS (140)*	***Seeded-Introduced-late+Annual-Species***: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); >20% cover of low sagebrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover **[B,N]**

Low Sagebrush Steppe (LSS) – GSG Habitat
1124

*Overview: The Low Sagebrush Steppe BpS is found on upper-montane to subalpine clay soils. Low sagebrush (*Artemisia arbuscula*) and Idaho fescue (*Festuca idahoensis*) are the dominant species. Low sagebrush tends to grow where there is a clay-based root-limiting layer in the soil profile that causes a perched spring water table and poor aeration after wetting. Big sagebrush species generally occur on deeper loamy soils. The BpS occurs on mountain slopes and basins. Elevation is above 2,438 m (8,000'), although the BpS is sometimes higher, where precipitation is greater than 41 cm (16"). Low sagebrush steppe has higher fuel loads than the low sagebrush BpS and, therefore, the steppe's mean fire return interval will be shorter. The dominant grass species is Idaho fescue with Cusick's bluegrass (*Poa cussikii*) subdominant. Forbs often include balsamroots (*Balsamorhiza sagittata*), buckwheats (*Eriogonum *spp.), fleabanes (*Erigeron *spp.), phloxes (*Phlox *spp.), paintbrushes (*Castilleja *spp.), globemallows (*Sphaeralcea *spp.), and lupines (*Lupinus *spp.). Utah serviceberry (*Amelanchier utahensis*) and antelope bitterbrush (*Purshia tridentata*) will* *be subdominant shrubs. Subalpine conifers may occasionally establish in low sagebrush steppe's harsh soils; however, low sagebrush does not generally support trees.*

A (10)	***Early-all***: >15% cover of grass; <10% cover rabbitbrush and other shrubs; <50% cover mineral soil; 0-24 yrs **[B]**
B (22)	***Mid-open***: 10-19% cover of low sagebrush, Utah serviceberry, snowberry, and rabbitbrush; >15% grass cover; <40% cover of mineral soil; 25-119 yrs **[B]**
C (31)	***Late-closed***: >20% cover of low sagebrush low sagebrush, Utah serviceberry, and snowberry; <3% mature conifer cover; ≤5% conifer sapling cover; 10-15% cover of grasses; >120 yrs **[B,N]**
U-*DP (103)*	***Depleted***: >10% cover of low sagebrush; <5% herbaceous cover; <3% mature conifer cover; ≤5% conifer sapling cover **[N?]**
U-*ES (105)*	***Early-Shrub***: >10% cover rabbitbrush species
U-*UF (146)*	***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot

Montane Riparian (MR) – Maybe GSG Habitat
1154 or 11540

Overview: The Montane Riparian BpS is found within a broad elevation range above 1,220 m (4,000'). Riparian communities require flooding and gravel for reestablishment. The BpS is found in low- to mid-elevation canyons and draws, on floodplains, in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff, although summer flash floods can have dramatic effects on succession. Underlying gravels may keep the water table just below ground surface, and are favored substrates for cottonwood and willow. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Surface water is generally high for variable periods. Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Codominant and diagnostic species include willow, narrowleaf cottonwood, chokecherry, sumac, Wood's rose, currant, occasional aspen, and conifers. Vegetation is very heterogeneous and diverse along river reaches. Some reaches will be dominated by narrowleaf cottonwood, whereas others are completely occupied by willow, and even cinquefoil and sagebrush on natural stream terraces (not due to incision). Lower slopes <6% favor cottonwood, whereas willow are more typically found on steeper slopes.

A (4)	***Point Bar***: >80% cover of silt, gravel, rock, and boulders; <20% recently germinated seedlings; 0-5 yrs
Bc (12)	***Early-Cottonwood***: 1-40% cover of cottonwood seedlings and saplings; grass may co-dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs **[B]**
Cc (21)	***Mid-Cottonwood***: 31-100% cover of small cottonwood trees and other tall shrubs (willows, chokecherry) and; <20% gravel, rock, and boulders; 5-19yrs
Dc (32)	***Late- Cottonwood***: 31-100% cover of cottonwood, willow, conifers and other trees 10-24m; <20% gravel, rock, and boulders; >20 yrs
Bw (14)	***Early-Willow***: 0-40% cover of willow, but cottonwood absent; grass may co-dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs **[B]**
Cw (34)	***Late-Willow***: 31-100% cover of willow and other tall shrubs (chokecherry) and cottonwood absent; <20% gravel, rock, and boulders; >5 yrs
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species on dry incised banks; < 10% shrub cover
U-*DE (104)*	***Desertified***: Incised river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush, snakeweed, rabbitbrush); >5% native grass cover **[N]**
U-*EFT (106)*	***Exotic-Forb-Tree***: >1% cover of exotic forb or tree species (knapweed, tall whitetop, thistles, purple loosestrife, salt cedar, or Russian olive)
U-*Inset-A (113)*	***Inset-Floodplain-early*:** Reformed riparian floodplain at bottom of incised creeks; 0-40% cover of willow, but cottonwood absent; grass may co-dominate or dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs
U-*Inset-B (114)*	***Inset-Floodplain-late*:** Reformed riparian floodplain at bottom of incised creeks; 31-100% cover of willow and other tall shrubs (chokecherry) and cottonwood absent; <20% gravel, rock, and boulders; >5 yrs
U-*Inset-EFT (111)*	***Inset-Floodplain-Exotic-Forb-Tree*:** Reformed riparian floodplain at bottom of incised creeks; >1% cover of exotic forb or tree species (knapweed, tall whitetop, thistles, purple loosestrife, salt cedar, or Russian olive)
U-*Inset-HU (117)*	***Inset-Floodplain-Hummocked*:** Reformed riparian floodplain at bottom of incised creeks; Trampled by ungulates; graminoids present to common in and out of holes created by ungulate hoofs

U-*Inset-SFE (118)* ***Inset-Floodplain-Shrub-Forb-Encroached*****:** Reformed riparian floodplain at bottom of incised creeks; 10-50% cover of Wood's rose, and other unpalatable forbs and shrubs in open areas or under tree canopy

U-*PAS (119)* ***Pasture*****:** Agricultural pasture **[B]**

U-*SAP (124)* ***Shrub-Annual-Species-Perennial-Grass***: Incised river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush); >5% non-native annual species cover; native grasses absent to common **[N]**

U-*SFE (137)* ***Shrub-Forb-Encroached***: 10-50% cover of Wood's rose, rabbitbrush, and/or other unpalatable forbs and shrubs in open areas or under tree canopy

U-*SDI (127)* ***Seeded-Introduced***: Incised river/creek with >20% introduced grass species cover (usually crested wheatgrass or intermediate wheatgrass) **[B]**

U-*SDI+AS (128)* ***Seeded-Introduced-Annual-Species***: Incised river/creek with >20% introduced grass species cover; >5% non-native annual species cover **[B]**

Montane Sagebrush Steppe-subalpine (MSSs) – GSG Habitat
1126s or 11261

Overview: The Montane Sagebrush Steppe subalpine BpS (a.k.a., mountain big sagebrush) is found above and inter-grades with the upland soils of montane sagebrush steppe. Precipitation is above 41 cm (16"). Elevation varies with soil depth and aspect ranging above 1981 m (6,500') on deeper and colder aspects and generally above 2,591 m (8,500') on other shallower soils or warmer aspects. In general this system shows an affinity for mild to very steep topography, fine soils, and some source of subsurface moisture. Soils generally are moderately deep to deep, well-drained, and made 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*. A variety of other shrubs can be found in some occurrences such as mountain snowberry, Utah serviceberry, antelope bitterbrush, but these are seldom dominant (if dominant, see Mountain Shrub BpS). Abundant forbs are an indicator of good range condition. Grasses are abundant, sometimes very abundant, and often diverse. As elevation or precipitation increase, spike-fescue, mountain brome, and Idaho fescue increase while bluebunch wheatgrass and Thurber's needlegrass decrease. Cheatgrass is nearly always absent from this BpS. White fir and subalpine fir may occupy this site in late-succession.*

A (10) ***Early-all***: ≥10% grass and forb cover; 0-10% canopy of mountain sage, mountain brush; 0-12 yrs **[B]**

B (22) ***Mid-open***: 11-19% cover of mountain sage, mountain shrub; >50% herbaceous cover; 13-29 yrs **[B,N]**

C (31) ***Late1-closed***: 20%-49% cover of mountain sagebrush (dominant) and mountain brush; ≥25% herbaceous cover; <10% conifer sapling cover; 30-59 yrs **[N]**

D (42) ***Late1-dense***: ≥50% cover of mountain sagebrush (dominant) and mountain brush; 25-50% herbaceous cover; <10% conifer sapling cover; ≥60 yrs **[N?]**

E (51) ***Late2-open***: 10-30% cover of mixed conifers <3m; 25-40% cover of mountain sagebrush (dominant) and mountain brush; >10% herbaceous cover; 75-149 yrs

F (62) ***Late2-closed***: >30% mixed conifers cover ≥3m; 6-20% shrub cover; >10% herbaceous cover; ≥150 yrs

U-*AS (100)* ***Annual-Species***: >10% cover of non-native annual species; <10% native grasses; snakeweed or rabbitbrush may be present

U-*ASPG (101)* ***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥10% native grasses; <10% shrub cover **[B]**

U-*DP (103)* ***Depleted***: ≥10% cover of mountain sagebrush (dominant) and mountain brush; <10% herbaceous cover; <5% cover of non-native annual species; <20% conifer sapling cover; litter and mineral soil common **[N?]**

U-*ES (105)* ***Early-Shrub***: >20% cover of snakeweed or rabbitbrush species; <5% cover of non-native annual species; native grass and forb may be present

U-*SAP-1 (125)* ***Shrub-Annual-Species-Perennial-Grass-closed***: >5% non-native annual species cover; 11-50% cover of mountain sagebrush (dominant) and mountain brush; >5% cover of native grass; <10% conifer sapling cover **[N]**

U-*SAP-2 (126)* ***Shrub-Annual-Species-Perennial-Grass-dense***: >5% non-native annual species cover; ≥50% cover of mountain sagebrush (dominant) and mountain brush; >5% cover of native grass; <10% conifer sapling cover **[N]**

U-*TEA (144)*	***Tree-Encroached or Tree –Annual-Grass***: >20% mixed conifers cover; ≥0% shrub cover; ≥0% herbaceous cover
U-*UF (146)*	***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot

Montane Sagebrush Steppe-upland (MSSup) – GSG Habitat
1126up or 11260

Overview: The Montane Sagebrush Steppe-upland BpS (a.k.a., mountain big sagebrush) is found below the subalpine montane sagebrush steppe BpS. Annual precipitation ranges from 30 cm to 41 cm (12" to 16"). Elevation is from 1,768 m (5,800') on cooler and more productive soils to 2,896 m (9,500') on steep southern slopes. In general this system shows an affinity for 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*. A variety of other shrubs can be found in some occurrences, such as antelope bitterbrush, Utah serviceberry, and black chokecherry, but these are seldom dominant. Abundant forbs are an indicator of good range condition. Grasses are abundant, sometimes very abundant, and often diverse. Common grass species are Thurber's needlegrass, bluebunch wheatgrass, and Idaho fescue.*

A (10)	***Early-all***: 10-80% grass and forb cover; 1-10% canopy of mountain sage, mountain brush; 0-12 yrs **[B]**
B (22)	***Mid-open***: 11-19% cover of mountain sage, mountain shrub; >50% herbaceous cover; 13-29 yrs **[B,N]**
C (31)	***Late-closed***: 20-50% cover of mountain sagebrush (dominant) and mountain brush; 25-50% herbaceous cover; 30-59 yrs **[N]**
D (42)	***Late-dense***: ≥50% cover of mountain sagebrush (dominant) and mountain brush; 25-50% herbaceous cover; ≥60 yrs **[N]**
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species; snakeweed or rabbitbrush may be present
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% native grasses; <10% cover of shrubs **[B]**
U-*DP (103)*	***Depleted***: >10% cover of mountain sagebrush (dominant) and mountain brush; <10% herbaceous cover; litter and mineral soil common **[N?]**
U-*ES (105)*	***Early-Shrub***: >20% cover of snakeweed or rabbitbrush species; <5% cover of non-native annual species; native grasses may be present
U-*EFT (106)*	***Exotic-Forb-Tree***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*SA-1 (122)*	***Shrub-Annual-Species-closed***: ≥5% non-native annual grass or bulbous bluegrass cover; 11-49% cover of mountain sagebrush (dominant) and mountain brush; ≤10% cover of native grass **[N?]**
U-*SA-2 (123)*	***Shrub-Annual-Species-dense***: ≥5% non-native annual grass or bulbous bluegrass cover; ≥50% cover of mountain sagebrush (dominant) and mountain brush; ≤10% cover of native grass **[N?]**
U-*SAP-1 (125)*	***Shrub-Annual-Species-Perennial-Grass-closed***: ≥5% non-native annual grass or bulbous bluegrass cover; 11-49% cover of mountain sagebrush (dominant) and mountain brush; >5% cover of native grass **[N]**
U-*SAP-2 (126)*	***Shrub-Annual-Species-Perennial-Grass-dense***: ≥5% non-native annual grass or bulbous bluegrass cover; ≥50% cover of mountain sagebrush (dominant) and mountain brush; >5% cover of native grass **[N]**
U-*UF (146)*	***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot
U-*SD (135)*	***Seeded-Native*:** >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover (if ≥5 non-native annual species cover, then see ASPG or AS) **[B]**
U-*SDI-A (129)*	***Seeded-Introduced-early-all*:** >10% seeded introduced grasses and shrubs; 0-9% canopy of mountain sage, mountain brush; native grasses present to common; <5% cover of non-native annual grass or bulbous bluegrass **[B]**

U-*SDI-B (130)* ***Seeded-Introduced-mid-open*****:** >10% seeded introduced grasses and shrubs; 10-19% cover of mountain sagebrush and mountain shrub; native grasses present to common; <5% cover of non-native annual grass or bulbous bluegrass **[B,N]**

U-*SDI-C (131)* ***Seeded-Introduced-late-closed*****:** >5% seeded introduced grasses and shrubs**;** 20%-49% cover of mountain sagebrush and mountain shrub; native grasses present to common; >5% cover of non-native annual grass or bulbous bluegrass **[N]**

U-*SDI-D (132)* ***Seeded-Introduced-late-dense*****:** >5% seeded introduced grasses and shrubs**;** ≥50% cover of mountain sagebrush and mountain shrub; native grasses present to common; <5% cover of non-native annual grass or bulbous bluegrass **[N]**

U-*SI-A+AS (138)* ***Seeded-Introduced-early-all+Annual-Species*****:** >10% seeded introduced grasses and shrubs; 0-9% canopy of mountain sage, mountain brush; native grasses present to common; ≥5% cover of non-native annual grass or bulbous bluegrass **[B]**

U-*SI-B+AS (139)* ***Seeded-Introduced-mid-open+Annual-Species*****:** >10% seeded introduced grasses and shrubs; 10-19% cover of mountain sagebrush and mountain shrub; native grasses present to common; ≥5% cover of non-native annual grass or bulbous bluegrass **[B,N]**

U-*SI-C+AS (140)* ***Seeded-Introduced-late-closed+Annual-Species*****:** >5% seeded introduced grasses and shrubs**;** 20%-49% cover of mountain sagebrush and mountain shrub; native grasses present to common; <10% conifer sapling cover; ≥5% cover of non-native annual grass or bulbous bluegrass **[N]**

U-*SI-D+AS (141)* ***Seeded-Introduced-late-dense+Annual-Species*****:** >5% seeded introduced grasses and shrubs**;** ≥50% cover of mountain sagebrush and mountain shrub; native grasses present to common; ≥5% cover of non-native annual species **[N]**

Mountain Shrub (MSh) – GSG Habitat
1106

Overview: The Mountain Shrub BpS includes several mountain shrub species that can each dominate: Utah serviceberry (Amelanchier utahensis), *mountain snowberry* (Symphoricarpos oreophilus)*, common chokecherry (*Prunus virginiana*), mountain oceanspray* (Holodiscus dumosa) *and antelope bitterbrush (*Purshia tridentata*). These shrublands occur between 1,500-2,900 m (4,921-10,000') of elevation and are usually associated with rocky substrates, shallow loamy soil on fractured bedrock, soils with high gravel and rock volumes. High volumes of rock fragments and bedrock cause soils to be well drained and dry, which limit shrub and tree growth. Sites dominated by snowberry are often associated with landform features that cause deep snow accumulation on more gentle slopes where soils contain high rock volumes or rubble. Grasses are represented as species of Idaho fescue (*Idaho festuca*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Thurber's needlegrass (*Achnatherum thurberianum*), mountain brome (*Bromus marginatus*), and slender wheatgrass (*Elymus trachycaulus)*. White fir may be found on more mesic or higher elevation sites.*)*. White fir may be found on more mesic sites.*

A (10) ***Early-all***: 10-60% canopy of mountain shrubs; 10-80% grass and forb cover; 0-4 yrs **[B]**

B (22) ***Mid-open***: 60-100% cover of fast- (mountain snowberry, Utah serviceberry) and slow- growing (antelope bitterbrush or chokecherry) mountain shrubs; >50% herbaceous cover; 5-19 yrs **[B,N]**

C (31) ***Late-closed***: 5-20% conifer cover; 31-50% cover of mountain shrubs, with a compositional increase in slower growing species (antelope bitterbrush or chokecherry); 25-50% herbaceous cover; 20-79 yrs

U-*EF (108)* ***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)

U-*ES (105)* ***Early-Shrub***: >20% cover rabbitbrush species; <5% non-native annual species cover; native grasses and forbs may be present to common

U-*DP (103)* ***Depleted***: >30% cover of less palatable shrubs and big sagebrush; <10% native grass cover; <5% non-native annual species cover; unpalatable native forbs often present to common; <10% conifer sapling cover **[N]**

U-*SAP (124)* ***Shrub-Annual-Species-Perennial-Grass***: ≥5% non-native grass cover; ≥5% cover of mountain shrubs; native herbaceous cover usually present; trees may be present **[N]**

U-*TEA (144)* ***Tree-encroached-Annual-Grass***: >20% conifer cover; <5% cover of shrubs; <55% native grass cover; non-native annual species might be present

U-*UF (146)* ***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot

Owyhee River Riparian (MRor) – Maybe GSG Habitat
1154or or 11542

Overview: The Owyhee River Riparian BpS is found in the deep volcanic canyons of the Owyhee River and its tributaries. The Owyhee River and its tributaries run through very rocky substrates and steep canyon walls. Riparian communities require flooding and gravel for reestablishment. Sites are subject to temporary flooding during spring runoff, although summer flash floods can have dramatic effects on succession. Underlying gravels may keep the water table just below ground surface, and are favored substrates for cottonwood and willow. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Surface water is generally high for variable periods. Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Codominant and diagnostic species include willow, cottonwood, chokecherry, Wood's rose, and currant. Vegetation is very heterogeneous and diverse along river reaches. Some reaches will be dominated by cottonwood, whereas the majority is completely occupied by willow, and even cinquefoil and sagebrush on natural stream terraces (not due to incision).

A (4)	***Point Bar***: >80% cover of silt, gravel, rock, and boulders; <20% recently germinated seedlings; 0-5 yrs
Bc (12)	***Early-Cottonwood***: 1-40% cover of cottonwood seedlings and saplings; grass may co-dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs **[B]**
Cc (21)	***Mid-Cottonwood***: 31-100% cover of small cottonwood trees and other tall shrubs (willows, chokecherry) and; <20% gravel, rock, and boulders; 5-19yrs
Dc (32)	***Late- Cottonwood***: 31-100% cover of cottonwood, willow, conifers and other trees 10-24m; <20% gravel, rock, and boulders; >20 yrs
Bw (14)	***Early-Willow***: 0-40% cover of willow (≤6" diameter or <3 m tall), but cottonwood absent; grass may co-dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs **[B]**
Cw (23)	***Mid-Willow***: 41-100% cover of tall (≥3m high) willow and other tall shrubs (chokecherry); cottonwood absent; <20% gravel, rock, and boulders; >5 yrs
Dw (34)	***Late-Willow***: 31-100% cover of arborescent willow and other tall shrubs (chokecherry); cottonwood absent; <20% gravel, rock, and boulders; >5 yrs
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species on dry incised banks; < 10% shrub cover
U-*DE (104)*	***Desertified***: Incised river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush, snakeweed, rabbitbrush); >5% native grass cover
U-*EFT (106)*	***Exotic-Forb-Tree***: >10% cover of exotic forb or tree species (knapweed, tall whitetop, thistles, purple loosestrife, salt cedar, or Russian olive); native canopy is usually cottonwood
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass***: Incised river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush); >5% non-native annual species cover; native grasses absent to common **[N]**
U-*Inset-A (113)*	***Inset-Floodplain-early*:** Reformed riparian floodplain at bottom of incised creeks; 0-40% cover of willow, but cottonwood absent; grass may co-dominate or dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs
U-*Inset-B (114)*	***Inset-Floodplain-late*:** Reformed riparian floodplain at bottom of incised creeks; 31-100% cover of willow and other tall shrubs (chokecherry) and cottonwood absent; <20% gravel, rock, and boulders; >5 yrs
U-*Inset-EFT (116)*	***Inset-Floodplain-Exotic-Forb-Tree*:** Reformed riparian floodplain at bottom of incised creeks; >1% cover of exotic forb or tree species (knapweed, tall whitetop, thistles, purple loosestrife, salt cedar, or Russian olive)
U-*Inset-HU (117)*	***Inset-Floodplain-Hummocked*:** Reformed riparian floodplain at bottom of incised creeks; Trampled by ungulates; graminoids present to common in and out of holes created by ungulate hoofs
U-*Inset-SFE (118)*	***Inset-Floodplain-Shrub-Forb-Encroached*:** Reformed riparian floodplain at bottom of incised creeks; 10-50% cover of Wood's rose, and other unpalatable forbs and shrubs in open areas or under tree canopy
U-*PAS (119)*	***Pasture*:** Agricultural pasture **[B]**

Subalpine Fir-Spruce (SF) – Not GSG Habitat
1055

Overview: The Subalpine Fir-Spruce BpS is found at elevations typically ranging from 2,591 m to 3,353 m (8,500-11,000') in the subalpine zone on gentle to moderately steep terrain (10-60% slopes). These forests are found on mountain slopes, high-elevation ridge tops and upper slopes, plateau like surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. Occurrences are typically found in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, such as north-facing slopes and high-elevation ravines. They can extend down in elevation below the subalpine zone in places where cold-air ponding occurs; northerly and easterly aspects predominate. The overstory is typically dominated by subalpine fir and/or Engelmann spruce. Other tree species may include aspen and limber pine. Understory shrub, forbs, and graminoid species are limited to a few high elevation species. Litter is often the dominant ground cover.

A (10) ***Early-all***: 5-100% cover of subalpine fir or Engelmann spruce seedlings/shrub/grass <5m; 0-39 yrs

B (20) ***Mid1-closed***: 40-100% cover of subalpine fir or Engelmann spruce, and aspen 5-24m pole size; 40-129yrs

C (33) ***Late1-open***: 5-39% cover of subalpine fir or Engelmann spruce, 5-24m pole size; 40-129 yrs

D (40) ***Late1-closed***: 40-100% cover of subalpine fir or Engelmann spruce 25-49m; ≥130 yrs

Subalpine-Upper Montane Grassland (SMG) – GSG Habitat
1140

*Overview: The Subalpine-Upper Montane Grassland BpS ranges from elevations of 1,676 m to over 3,048 m (5,500' to over 10,000'). Average annual precipitation is >36 cm (>14"). The soils are moderately deep to very deep to bedrock and well drained. These soils are modified by high volumes of pebbles, gravel, rock fragments through their profile. Heavy snow accumulation on this site often persists into summer and significantly reduces the potential plant growth period. Snow melt adds to the soils moisture supply. Site is medium to rapid and potential for surface erosion is moderate to high depending on slope. Graminoids dominant and species composition changes with elevation. At lower elevations, meadow barley (*Hordeum brachyantherum *), bluegrasses (*Poa *spp.), and sedges (*Carex *spp.) dominate. As elevation increases, Idaho fescue (*Festuca idahoensis*), Cusick's bluegrass (*Poa cusickii*), and bluebunch wheatgrass (*Psedoroegneria spicata*) become dominant, and mountain big sagebrush (*Artemisia tridentata *spp.* vaseyana*) is a minor shrub component. At subalpine elevation, slender wheatgrass (*Elymus trachycaulus*) and Letterman's needlegrass (*Achnatherum, lettermanii*) are dominant, whereas wyethia (*Wyethia *spp.) and lupines (*Lupinus *spp.) are sub-dominant forb species. A few shrub species are normally incidental: rabbitbrush* (Chrysothamnus spp), *mountain snowberry* (Symphoricarpos oreophilus), *Wood's rose (*Rosa woodsii*), or low sagebrush (*Artemisia arbuscula*).*

A (10) ***Early-all***: 5-19% grass and sedge cover; ≤20% forb cover; abundant bare ground and rock cover; <5% shrub cover; 0-4 yrs **[B]**

B (20) ***Mid-closed***: ≥20% graminoid cover; ≤10% forb cover; abundant bare ground and rock cover; <5% shrub cover; 5-9 yrs **[B]**

C (33) ***Late-open***: 5-10% shrub cover; ≥20% graminoid cover; common bare ground and rock cover; >10 yrs **[B]**

U-*UF (146)* ***Unpalatable-Forb***: ≥20% cover of mules'ears wyethia; native grass present to common; common bare ground and rock cover

U-*US (147)* ***Unpalatable-Shrub***: ≥10% cover of rabbitbrush, mountain snowberry, and/or Wood's rose; Mules'ears wyethia may be present to common; native grass present to common; common bare ground and rock cover **[B]**

Wet Meadow - montane (WM) – GSG Habitat
1145wm or 11450

*Overview: The Wet Meadow BpS is wetted by an elevated water table about 51 cm (20") from the surface during the growing season and adjacent to creeks or rivers, or is spring-fed. Three types are included here: true wet meadows close to mountain streams and around or below seeps and springs, clay seeps dominated by grasses and mules'ears wyethia, and dry meadows adjacent to valley axial floodplains stream terraces. Saturated soils support graminoid dominance. Elevation ranges from 1,524 m to 2,896 m (5,000' to 9,500') and annual precipitation is between 25 cm and 41 cm (10" and 16"). Tufted hairgrass (*Deschampia cespitosa*) dominates and Nevada bluegrass (*Poa nevadensis*) codominates in true wet meadows, whereas Nevada bluegrass dominates in dry meadows. Alpine* *timothy (*Phleum alpinum*) and sedges (*Carex*) are also common in both types of wet meadows. Clay seeps are dominated by Idaho fescue (Festuca idahoensis), mountain brome (*Bromus marginatus*), mules'ears wyethia (*Wyethia amplexicaulis*), and whitehead wyethia (*Wyethia helenioides*). The presence of shrubs (willow [*Salix *spp.], Wood's rose [*Rosa woodsii*], silver sagebrush [*Artemisia cana*]) at the meadow's edge increases during consecutive drought years and decreases during consecutive high water years.*

A (13)	***Early-open***: 10-60% herbaceous cover – mostly graminoids; 0-2 yrs **[B]**
B (20)	***Mid-closed***: 61-100% herbaceous cover – mostly graminoids; 3-22 yrs **[B]**
C (33)	***Late-open***: 5-10% tree-shrub (willow, Wood's rose, silver sagebrush) cover; 60-80% herbaceous cover – mostly graminoids; >22 yrs **[B]**
WW (149)	***Wallow:*** Depression of bare ground or crushed graminoids causedby elk wallowing **[B]**
U-AS (100)	***Annual-Species (on incised meadow)***: >5% cover of non-native annual species; < 10% shrub cover
U-*DE (104)*	***Desertified (= incised)***: Entrenched water table with 10-50% cover of sagebrush
U-*ES (105)*	***Early-Shrub***: >10% cover rabbitbrush species; <5% non-native annual species cover; native grasses and forbs may be present to common
U-*EF (108)*	***Exotic-Forbs***: >5% exotic forbs (knapweed, purple loosestrife, thistles)
U-*HU (110)*	***Hummocked***: Trampled by ungulates; graminoids present to common in and out of holes created by ungulate hoofs **[B]**
U-*PAS (119)*	***Pasture*****:** Agricultural pasture **[B]**
U-*SFE (137)*	***Shrub-Forb-Encroached***: >10% cover of less palatable grasses and forbs (e.g., *Iris missouriensis*) **OR** >10% shrub cover (willow, Wood's rose, silver sagebrush, rabbitbrush); 10-30% cover of bare ground
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass (on incised meadow)***: >10% cover of native shrubs; native grass may be present; 5-30% cover of non-native annual species

Appendix 1-B

Descriptions of Ecological Systems (Biophysical Settings) and their Vegetation Classes For TS-Horseshoe Ranch

Note: The Ranch overlaps with NRCS' MLRAs 24, 25, and 28. Same ecological site can be 500' lower in the northern part of the Ranch compared to the southern part.

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Aspen Woodland (ASP) – Not GSG Habitat
1011

Overview: The Aspen Woodland BpS is dominated by Populus tremuloides *and is commonly called "stable aspen." Aspen woodland is a debated BpS as it is assumed, but not proven, that soils prevent encroachment of conifers even with fire exclusion, therefore maintaining the relative cover of conifers to <25%. Where the BpS is adjacent to conifers, an occasional conifer seedling may occur, but conifers do not drive the fire regime. Elevations generally range from 1,981 m to 2,743 m (6,500'-9,000'), but occurrences can be found at lower elevations, and average annual precipitation ranges from 36 cm to >51 cm (14" to >20"). Distribution of this ecological system is limited primarily by adequate soil moisture required to meet its high evapotranspiration demand, and secondarily by the length of the growing season or low temperatures. This BpS occurs commonly as multi-storied stands. Stands are usually closed. Aspen suckers 1.5 m to 4.6 m (5-15') tall will be present in all classes (min. 500 stems/acre). The BpS also includes aspen thickets that occur on concave shoulders of mountains and plateaus on northerly aspects or on the lee-side of snow-blown plateau and mountain summits. Snow accumulation prevents full development of aspen as tall trees. The Aspen Woodland BpS typically occurs above juniper and adjacent to mountain big sagebrush. At elevations below 6,500 feet this group grades into black and narrowleaf cottonwood types along riparian corridors. Understory consists of abundant herbaceous and shrub components. Often species of tall forbs, perennial grasses and shrubs are found in the understory. The herbaceous layer may be lush and diverse.*

A (11)[3]	***Early-closed***: 10-100% cover of aspen <5m; 0-9 yrs
B (20)	***Mid1-closed***: 40-99% cover of aspen <5-9.9m (*this class also includes aspen thickets*); 10-39 yrs
C (31)	***Late1-closed***: 40-99% cover of aspen 10-25m; few conifers in mid-story; >39 yrs
D (43)	***Late1-open***: 10-39% cover of aspen 10-25 m; conifers may be present but less than 25% relative cover; >99 yrs
U-*DP (103)*	***Depleted-open***: 10-39% cover of older aspen 10-25m; no or little aspen regeneration; mountain big sagebrush common in understory; few conifers in mid-story
U-*NAS (11260: 10,22,31)*	***No-Aspen***: permanent conversion to montane sagebrush steppe - 1126; very few aspen stems present; dead clone of aspen, dead boles may be visible on the ground; 5-50% cover of mountain big sagebrush/mountain shrub; <50% herbaceous cover

Basin Wildrye-bottomland (BWb) – Not GSG Habitat
1080bwb or 10803[1]

*Overview: The Basin Wildrye-bottomland BpS is a grassland dominated by basin wildrye (*Elymus cinereus*). Many locations occur at the bottom of broad valleys and on alluvial flats at elevations of 1,219 m to 1,829 m (4,000' to 6,000') with slopes between 0-4%, although more typically <2%. Soils have water tables that may attain depths of 150 to 75 cm (60" to 30"). The BpS occurs on two sites in the landscape: (i) Dry floodplains at the outer margins of axial-stream floodplains, fan skirts and along intermittent drainages and (ii) saline bottoms on lake-plain terraces, stream terraces and on the margin of axial-stream floodplains. On lower precipitation sites, these locations may be positioned at the base of slopes such that water may run onto these sites. Typically soils are deep to very deep with loamy to coarse loamy textures. Soils are well drained with water tables below the rooting zone of the dominant shrubs. Salts, if present, can increase with depth. Annual precipitation ranges from 20 to 25 cm (6" to 10"). Not much is written specifically about the dynamics of this BpS. This is a grassland-shrubland mixture dominated by basin wildrye, a deep-rooted cool-season bunchgrass, where the dominant shrub species varies with salt content later in succession. On saline bottoms, black greasewood (*Sarcobatus vermiculatus*) is the dominant shrub with basin big sagebrush (*Artemisia tridentata *spp*. tridentata*) sub-dominant. Basin big sagebrush is the dominant shrub on less saline and more productive soils. Other shrubs generally represent less than 10 % of the overall cover and include various species and subspecies of rubber, green, and gray rabbitbrush. Other grasses are generally cool season bunchgrasses, with the exception of some rhizomatous grasses on the dry meadows with deep soils and high precipitation. Forbs represent less than 10 % of the herbaceous cover.*

[3] Remote sensing code (geotiff code)

Ch (60) ***Channel***: wet or dry channel crossing the site

A (13) ***Early-open***: 5-20% cover of basin wildrye; 0-10 yrs

B (20) ***Mid-closed***: 21-80% cover of basin wildrye; <11% shrub cover; 11-75 yrs

C (33) ***Late-open***: 11-20% cover of basin big sagebrush and/or black greasewood (generally at lower elevations), and rabbitbrush; <75% cover of basin wildrye; >75 yrs

U-*AS* (100) ***Annual-Species***: 5-40% cover of non-native annual species

U-*ASPG (101)* ***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% basin wildrye and other native grasses

U-*DP (103)* ***Depleted***: >20% cover of basin big sagebrush, and/or black greasewood, and rabbtibrush; <5% basin wildrye; >20% mineral soil and litter cover

U-*EF (108)* ***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)

U-*ES (105)* ***Early-Shrub***: >20% cover of rabbitbrush species; native grasses present

U-*SAP (124)* ***Shrub-Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; >10% cover of native shrubs; ≥0% basin wildrye

U-*SD (135)* ***Seeded-native***: >10% seeded basin wildrye, other native grasses, forbs, and shrubs; <5% non-native annual species (if ≥5 non-native annual species, then ASPG or even AS)

U-*SDI (127)* ***Seeded-Introduced***: >10% seeded introduced grasses, forbs, and shrubs; <5% of non-native annual species

U-*SDI+AS (128)* ***Seeded-Introduced+Annual-Species****:* >10% seeded introduced grasses, forbs, and shrubs, ≥5% cover of non-native annual species

Basin Wildrye-montane (BWm) – GSG Habitat
1080bwm or 10801

*Overview: The Basin Wildrye-montane BpS is a grassland dominated by basin wildrye (*Elymus cinereus*). The BpS is found at elevations from about 1,372 m to 2,134 m (4,500' to over 7,000'). Typically soils are deep to very deep with loamy to coarse loamy textures (NRCS's loamy bottom). Soils are well drained with water tables below the rooting zone of the dominant shrubs. Salts, if present, can increase with depth. Soils were formed through alluvial processes and typically form valley bottoms with slopes generally less than 8%, and typically between 0 and 4%. Annual precipitation ranges from 20 to 41 cm (8" to 16"). Many locations occur along valley bottoms outside of the wet meadow areas, but within zones where water tables may attain depths of 150 to 75 cm (60" to 30"). On lower precipitation sites (20 to 25 cm or 8 to 10") these locations may be positioned at the base of slopes such that water may run onto these sites. Not much is written specifically about the dynamics of this BpS. This is a grassland-shrubland mixture dominated by basin wildrye, a deep-rooted cool-season bunchgrass, with basin big sagebrush or mountain big sagebrush, respectively, subdominant (<15% cover) later in succession below or above 36 cm (14") of precipitation (about 2,134 m or 7,000' of elevation). Other shrubs generally represent less than 10% of the overall cover and include various species and subspecies of rabbitbrush. Other grasses are generally cool season bunchgrasses, with the exception of some rhizomatous grasses on the dry meadows with deep soils and high precipitation. Forbs represent less than 10% of the herbaceous cover.*

A (13) ***Early-open***: 5-20% cover of basin wildrye; 0-10 yrs **[B]**[4]

B (20) ***Mid-closed***: 21-80% cover of basin wildrye; <11% shrub cover; 11-75 yrs **[B]**

C (43) ***Late-open***: 11-20% cover of basin big sagebrush and/or mountain big sagebrush (at higher elevations only), and rabbitbrush; <75% cover of basin wildrye; >75 yrs **[B]**

U-*AS (100)* ***Annual-Species***: >5% cover of non-native annual species; <5% cover basin wildrye and other native grasses; <11% shrub cover

U-*ASPG (101)* ***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% basin wildrye and other native grasses **[B]**

[4] B = brood-rearing vegetation class, N = nesting vegetation class

U-*DP (103)* ***Depleted***: >20% cover of basin big sagebrush and/or mountain big sagebrush, and rabbtibrush; <5% basin wildrye; >20% mineral soil and litter cover

U-*EF (108)* ***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)

U-*ES (105)* ***Early-Shrub***: >20% cover of rabbitbrush species; native grasses present; non-native annual species may be present to common

U-*PAS (119)* ***Pasture****:* Agricultural pasture **[B]**

U-*SAP (124)* ***Shrub-Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; >10% cover of native shrubs; ≥0% basin wildrye

U-*SD (135)* ***Seeded-native***: >10% seeded basin wildrye, forbs, and shrubs; <5% non-native annual species (if ≥5 non-native annual species, then ASPG or even AS) **[B]**

U-*SDI (127)* ***Seeded-Introduced***: >10% seeded introduced grasses, forbs, and shrubs; <5% of non-native annual species **[B]**

U-*SDI+AS (128)* ***Seeded-Introduced+Annual-Species****:* >10% seeded introduced grasses, forbs, and shrubs, ≥5% cover of non-native annual species **[B]**

Big Sagebrush-semidesert (BSsd) – GSG Habitat
1080sd or 10802

Overview: The Big Sagebrush semidesert BpS occurs on well-drained and/or shallow loamy soils on foothills, terraces, slopes and plateaus. Wyoming and basin big sagebrush occupy characterize the BpS, with basin big sagebrush established on hills with deep soils. Elevation ranges from 1,280 m to 1,981 m (4,200' – 6,500'), which corresponds to annual precipitation zones from 20 cm to 30 cm (8 to 12"). The BpS is found on soil depths as shallow as 25 cm (10") and as deep as 152 cm (60+"). When Wyoming and basin big sagebrush are found on deeper soil, annual precipitation is <25 cm (<10"). The BpS is found just above the low elevation salt desert shrub typically unfavorable to tree establishment. Thus, other site characteristics (e.g. aspect, drainage) should be considered in identifying this BpS. At the precipitation extremes, this BpS generally occurs as small patches and stringers. Shrub canopy cover generally ranges from 5 to 25%, but can exceed 30% at the upper elevations, deeper soils, and precipitation zones. Wyoming big sagebrush sites have fewer understory species relative to other big sagebrush types. Rubber rabbitbrush and spiny hopsage may be co-dominant and basin big sagebrush might occur on concave sites with finer soils. Perennial forb cover is usually <10% and perennial grass cover reaches 40-60% on more productive sites. Bluebunch wheatgrass and Thurber's needlegrass may be a dominant species following replacement fires and as a co-dominant after 20 years. Bottlebrush squirreltail and Indian ricegrass are common on more xeric sites. Percent cover and species richness of understory are determined by site limitations.

A (10) ***Early-all***: ≥10% herbaceous cover; <10% cover of rabbitbrush species; <10% cover of big sagebrush; 0-20 yrs **[B]**

B (22) ***Mid-open***: 10-19% cover of big sagebrush and other shrubs; ≥10% herbaceous cover; 20-39 yrs **[B,N]**

C (31) ***Late1-closed***: 20%-39% cover of big sagebrush and other shrubs; 10-20% native herbaceous cover; 40-79 yrs **[N]**

D (42) ***Late1-dense***: ≥40% cover of big sagebrush and other shrubs; ≥5% native herbaceous cover; ≥80 yrs **[N]**

U-*AS (100)* ***Annual-Species***: >10% cover of non-native annual grass and forb species; <10% cover of shrubs

U-*ASPG (101)* ***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% native grasses; <10% cover of shrubs **[B]**

U-*DP (103)* ***Depleted***: ≥10% cover of big sagebrush, and rabbitbrush; <5% native grass cover dominated by bottlebrush squirreltail and Sandberg bluegrass; <5% non-native annual species; >20% mineral soil and litter cover **[N?]**

U-*EF (108)* ***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)

U-*ES (105)* ***Early-Shrub***: >10% cover rabbitbrush species; <5% non-native annual species; native grass may be present

U-*SA-1 (122)* ***Shrub-Annual-Species-Closed***: ≥5% cover non-native annual species; 10%-39% cover of big sagebrush and other shrubs <0.5m; native grasses rare **[N?]**

U-*SA-2 (123)* ***Shrub-Annual-Species-Dense***: ≥5% cover non-native annual species ; ≥40% cover of big sagebrush and other shrubs <0.5m; native grasses rare **[N?]**

U-*SAP-1 (125)* ***Shrub-Annual-Species-Perennial-Grass-Closed***: ≥5% cover non-native annual species; 10%-39% cover of big sagebrush and other shrubs <0.5m; ≥5% cover native grasses **[N]**

U-*SAP-2 (126)* ***Shrub-Annual-Species-Perennial-Grass-Dense***: ≥5% cover non-native annual species ; ≥40% cover of big sagebrush and other shrubs <0.5m; ≥5% cover native grasses **[N]**

U-*SDI-A (129)* ***Seeded-Introduced-Early***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of rabbitbrush species; <10% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[B]**

U-*SDI-B (130)* ***Seeded-Introduced-Mid-open***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[B,N]**

U-*SDI-C (131)* ***Seeded-Introduced-Late1-closed***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 20-39% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[N]**

U-*SDI-D (132)* ***Seeded-Introduced-Late1-dense***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); ≥40% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[N]**

U-*SI-A+AS (138)* ***Seeded-Introduced-Early+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of rabbitbrush species; <10% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[B]**

U-*SI-B+AS (139)* ***Seeded-Introduced-Mid-open+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[B,N]**

U-*SI-C+AS (140)* ***Seeded-Introduced-Late1-closed+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 20-39% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[N]**

U-*SI-D+AS (141)* ***Seeded-Introduced-Late1-dense+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); ≥40% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[N]**

Big Sagebrush Shrubland-upland with trees (WSup) – GSG Habitat
1080up or 10804

*Overview: The Big Sagebrush Shrubland BpS occurs on well-drained soils on foothills, terraces, slopes and plateaus. It ranges from 1,524 m to 2,134 m (5,000' – 7,000') in elevation. It is found on soil depths greater than 45 cm (18") and up to 152 cm (60+"). The BpS occurs from 25 cm to 36 cm (10" to 14") of annual precipitation on drier, shallower soils, and from 20 cm to 30 cm (8 to 12") of annual precipitation on deeper, more productive soils. Thus, site characteristics (e.g. aspect, drainage) should be considered in identifying this BpS. Shrub canopy cover generally ranges from 5 to 25%, but can exceed 30% at the upper elevation and precipitation zones. Big sagebrush includes basin big sagebrush and/or Wyoming big sagebrush sites. Rubber rabbitbrush may be co-dominant and antelope bitterbrush should be common. Perennial forb cover is usually <10% and perennial grass cover reaches 20 - 25% on more productive sites. Bluebunch wheatgrass and Thurber's needlegrass may be a dominant species following replacement fires and as a co-dominant after 20 years, but only in precipitation zones above 25 cm (10"). Bottlebrush squirreltail and Indian ricegrass are common on more xeric sites. Percent cover and species richness of understory are determined by site limitations. Utah juniper (*Juniperus osteosperma*) can be present, occasionally reaching 50% canopy cover in areas that have escaped fire.*

A (10) ***Early-all***: ≥10% herbaceous cover; <10% cover of rabbitbrush species; <10% cover of big sagebrush; 0-20 yrs **[B]**

B (22) ***Mid-open***: 10-19% cover of big sagebrush; ≥10% herbaceous cover; 20-39 yrs **[B,N]**

C (31) ***Late1-closed***: 20-39% cover of big sagebrush and other shrubs; ≥10% native herbaceous cover; 40-79 yrs; **[N]**

D (42) ***Late1-dense***: ≥40% cover of big sagebrush and other shrubs; ≥5% native herbaceous cover; ≥80 yrs; **[N]**

E (51)	***Late2-open***: 5-15% juniper sapling <5m tall; 10-25% cover of big sagebrush; <15% native herbaceous cover; 75-149 yrs; **[N?]**
F (62)	***Late2-dense***: >20% juniper cover <10m tall; <10% cover of big sagebrush; ~5% native herbaceous cover; ≥150 yrs
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species; <10% cover of native shrubs, especially sagebrush
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% native grasses; <10% shrub cover **[B]**
U-*DP (103)*	***Depleted***: ≥10% cover of big sagebrush, and rabbitbrush; <5% native grass cover dominated by bottlebrush squirreltail and Sandberg bluegrass; <5% cover of non-native annual species; >20% mineral soil and litter cover **[N?]**
U-*EF (108)*	***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*ES (105)*	***Early-Shrub***: >10% cover rabbitbrush species; <5% non-native annual species; native grass may be present
U-*SA-1 (122)*	***Shrub-Annual-Species-Closed***: ≥5% cover non-native annual species; 10-39% big sagebrush and other shrubs <0.5m; scattered juniper saplings may be present; native grasses rare **[N?]**
U-*SA-2 (123)*	***Shrub-Annual-Species-Dense***: ≥5% cover non-native annual species; ≥40% big sagebrush and other shrubs <0.5m; scattered juniper saplings may be present; native grasses rare **[N?]**
U-*SAP-1 (125)*	***Shrub-Annual-Species-Perennial-Grass-Closed***: ≥5% cover non-native annual species; 10-39% big sagebrush and other shrubs <0.5m; ≥5% cover native grasses; scattered juniper saplings may be present **[N]**
U-*SAP-2 (126)*	***Shrub-Annual-Species-Perennial-Grass-Dense***: ≥5% cover non-native annual species; ≥40% big sagebrush and other shrubs <0.5m; ≥5% cover native grasses; scattered juniper saplings may be present **[N]**
U-*TEA (144)*	***Tree-Encroached-Annual-Species***: 11-60% cover of trees 5-9m; non-native annual species may be present to abundant; native grasses absent or trace amounts
U-*UF (146)*	***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot
U-*SD (135)*	***Seeded-Native*:** >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover (if ≥5 non-native annual species cover, then see ASPG or AS) **[B]**
U-*SDI-A (129)*	***Seeded-Introduced-Early***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of rabbitbrush species; <10% cover of Wyoming big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[B]**
U-*SDI-B (130)*	***Seeded-Introduced-Mid-open***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[B,N]**
U-*SDI-C (131)*	***Seeded-Introduced-Late1-closed***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 20-39% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[N]**
U-*SDI-D (132)*	***Seeded-Introduced-Late1-dense***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); ≥40% cover of big sagebrush; native grass may be present to common; <5% cover of non-native annual species **[N]**
U-*SI-A+AS (138)*	***Seeded-Introduced-Early+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of rabbitbrush species; <10% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[B]**
U-*SI-B+AS (139)*	***Seeded-Introduced-Mid-open+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[B,N]**
U-*SI-C+AS (140)*	***Seeded-Introduced-Late1-closed+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia); 20-39% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[N]**
U-*SI-D+AS (141)*	***Seeded-Introduced-Late1-dense+Annual-Species***: ≥10% cover of introduced forage species (e.g., crested wheatgrass, intermediate wheatgrass, or forage kochia; 10-25% cover of big sagebrush; native grass may be present to common; ≥5% cover of non-native annual species **[N]**

Black Sagebrush (BS) – GSG Habitat
1079an or 10791

Overview: The Black Sagebrush BpS is found on shallow calcareous or shallow clay loamy/sandy soils. Soil differences and widely ranging elevations create a variety of communities. Artemisia nova *is the dominant shrub species. Black sagebrush tends to grow where there is a calcite-based root-limiting layer in the soil profile; however, a shallow clay-based root-restricting layer also supports black sagebrush in northern Nevada. Wyoming big sagebrush and basin big sagebrush generally occur with black sagebrush on moderately deep to deep soils that are well-drained. Elevations range from 1,524 m to 2,896 m (5,000' to 9,500'). Average annual precipitation varies between 20 cm to over 41 cm (8" to over 16"). The BpS mostly occurs on alluvial fans, piedmonts, bajadas, rolling hills and moderate to steep mountain slopes, and warmer slopes of basalt slopes. The BpS can also be found on flats and plains. Soils typically contain high volumes of gravel and rock fragments. Black sagebrush generally has relatively low fuel loads with low-growing and cushion forbs and scattered bunchgrasses. The lower elevation black sagebrush community shares many species with mixed salt desert communities, such as Sandberg's bluegrass* (Poa secunda)*, Indian ricegrass (*Achnatherum hymenoides*), bottlebrush squireltail (*Elymus elymoides*), bud sagebrush (*Picrothamnus desertorum*), winterfat (*Krascheninnikovia lanata*), spiny hopsage (*Grayia spinosa*), and shadscale (*Atriplex confertifolia*). With increasing elevation, Thurber needlegrass (*Achnatherum thurberianum), *Sandberg's bluegrass*, *Indian ricegrass, bluebunch wheatgrass (*Pseudoroegneria spicata*), and Idaho fescue (Festuca idahoensis) become dominant. Antelope bitterbrush (*Purshia tridentata*) also increases with elevation. At even higher elevations >36 cm (>14") precipitation on shallow calcareous soils, Utah serviceberry (*Amelanchier utahensis*), mountain snowberry (*Symphoricarpos oreophilus)*, and antelope bitterbrush become sub-dominant to black sagebrush. Forbs often include buckwheats (*Eriogonum *spp.), fleabanes (*Erigeron *spp.), phloxes (*Phlox *spp.), paintbrushes (*Castilleja *spp.), globemallows (*Sphaeralcea *spp.), and lupines (*Lupinus *spp.). Because the mean fire return interval is long and soils harsh, old scattered Utah juniper can be present.*

A (10)	***Early***: <10% cover rabbitbrush; ≥10% cover of native grass; <50% cover mineral soil; 0-35 yrs **[B]**
B (22)	***Mid-open***: 10-19% cover of black sagebrush and rabbitbrush; ≥10% native grass cover; <40% cover of mineral soil; 25-119 yrs **[B,N]**
C (31)	***Late-closed***: ≥20% cover of black sagebrush and rabbitbrush; 10-30% cover of native grasses; 120-194 yrs **[N]**
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species; <10% cover of shrubs
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% native grasses; <10% cover of shrubs **[B]**
U-*DP (103)*	***Depleted***: ≥10% cover of black sagebrush; <5% native herbaceous cover; <10% juniper sapling cover **[N?]**
U-*EF 108)*	***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*ES (105)*	***Early-Shrub***: ≥10% cover rabbitbrush species; ≤5% non-native annual species cover; native grasses may be present
U-*SA (121)*	***Shrub-Annual-Species***: ≥5% non-native annual species cover; ≥10% cover of black sagebrush; <5% cover of native grass **[N?]**
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass***: ≥5% non-native annual species cover; ≥10% cover of black sagebrush; >5% cover of native grass **[N]**
U-*SD (135)*	***Seeded***: >10% seeded native grasses, black sagebrush, other shrubs, and forbs. **[B]**
U-*SDI-A (129)*	***Seeded-Introduced-Early***: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; <5% non-native annual species cover **[B]**
U-*SDI-B (130)*	***Seeded-Introduced-Mid***: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of black sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover **[B,N]**
U-*SDI-C (131)*	***Seeded-Introduced-Late***: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 20-30% cover of black sagebrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover **[N]**
U-*SI-A+AS (138)*	***Seeded-Introduced-Early+Annual-Species:*** >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover **[B]**

U-*SI-B+AS* *(139)* ***Seeded-Introduced-Mid+Annual-Species***: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of black sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover **[B,N]**

U-*SI-C+AS* *(140)* ***Seeded-Introduced-Late+Annual-Species***: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); ≥20% cover of black sagebrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover **[N]**

Channel (Ch)
1005

Main or well-defined secondary channel in Humboldt floodplain. Note that channels are sometimes noted directly in ecological systems.

Ch (152) ***Channel***

U-EFT (153) ***Exotic-Forb-Tree***: >10% cover of exotic forb or tree species (knapweed, tall whitetop, thistles, purple loosestrife, mustards, salt cedar, or Russian olive)

Desert Wash (DW) – Maybe GSG Habitat
1154dw or 11544

Overview: The Desert Wash BpS comprises intermittent to dry desert drainages with mostly subsurface flow whose banks are deeply incised. Flash-flooding is the major disturbance in this BpS. Gravels and desert shrub species dominate the system with shrub cover increasing with time since last flood. Common species include desert almond, bursage, bladdersage, burrobrush, big sagebrush, Anderson's wolfberry, snakeweed, rabbitbrush, big galleta, bush muhly, Indian ricegrass, and squirreltail.

A (10) ***Early-all***: 20-50% cover may be gravel, sands, and/or flood debris; 10-19% cover of desert almond, burrobrush, rabbitbrush, desert willows present; 5-15% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); forbs present to abundant; 0-5 yrs **[B]**

B (20) ***Mid-closed***: 20-50% cover of desert almond, bursage, bladdersage, burrobrush, big sagebrush, Anderson's wolfberry, rabbitbrush; 5-10% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); forbs present to abundant; <30% of gravel and rocks; 5-19 yrs **[B]**

C (31) ***Late-closed***: 30-50% cover of bursage, burrobrush, desert almond, bladdersage, big sagebrush, Anderson's wolfberry, rabbitbrush, 5-10% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); forbs present to abundant; <10% of gravel and rocks; >20 yrs

U-***SAP*** (124) ***Shrub-Annual-Grass-Perennial-Grass***: 5-14% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; 0-50% small trees and shrubs, ≥5% cover of grasses (big galleta, bush muhly, Indian ricegrass, squirreltail); mineral soil may be common **[B]**

U-***SA*** (121) ***Shrub-Annual-Grass***: 5-14% exotic species (*Bromus rubens, Bromus tectorum*, *Erodium cicutarium*) cover; 0-50% small trees and shrubs; <5% cover of native grasses; mineral soil may be common

U-*ES* (105) ***Early-Shrub***: >20% cover of cholla, snakeweed or rabbitbrush species

U-*EFT* (106) ***Exotic-Forb-Tree:*** >5% cover of salt cedar or exotic forbs (knapweed, tall whitetop); 0-50% cover of bursage, burrobrush, big sagebrush, Anderson's wolfberry, rabbitbrush, desert almond.

U-*BG* (102) ***Bare-Ground***: mineral soil exposed by human-caused disturbances

Four-wing Saltbush (FWS) – Not GSG Habitat
1081fws or 10811

*The Four-Wing Saltbush BpS occurs from 1,524 – 1,585 m (5,000' – 5,200'). It is part of the Mixed Salt Desert community, but the high stature and high density of four-wing saltbush (*Atriplex canescens*) makes it stand apart. Soils are alkaline, made of loamy fine sand, highly permeable, and very deep (>152 cm or >60"). Many soils are derived from eolian deposits and often associated with dunes. Average annual precipitation ranges from 0-25.4 cm (0 to 10"). This system generally occurs as small patches and stringers. Summers are hot and dry with many days reaching 30 degrees C (100 degrees F). Spring is the only dependable growing season with moisture both from winter and spring precipitation. Cool springs can delay the onset of plant growth and drought can curtail the length of active spring growth. Four-wing saltbush are tall shrubs found at high density (3-5 plants per sq. m) interspersed with low to mid-height bunch grasses. Other shrubs include basin big sagebrush (*Artemisia tridentata *ssp*. tridentata*) and rubber rabbitbrush (*Ericameria nauseosa*). Common bunch grass species are Indian ricegrass (*Achnatherum hymenoides*), needle-and-thread (*Hesperostipa comata*), and, where monsoonal influences are present, rhizomatous/sod forming grasses such as galleta grass (*Pleuraphis jamesii*) and sand dropseed (*Sporobolus cryptandrus*). The biophysical setting has not evolved with fire and fire is absent from the reference condition.*

A (13)	***Early-open*:** ≥10% Indian ricegrass, galleta grass, needle-and-thread, or bottlebrush cover; <5% young four-wing saltbush or rubber rabbitbrush cover; mineral soil common to abundant; 0-5 yrs
B (22)	***Mid-closed*:** 5-20% four-wing saltbush, basin big sagebrush, or rabbitbrush cover; >10% Indian ricegrass, galleta grass, needle-and-thread, or bottlebrush cover; mineral soil common to abundant; 6-19 yrs
C (31)	***Late-open***: >20% four-wing saltbush and basin big sagebrush cover >1m tall; 10-20% Indian ricegrass, needle-and-thread, or bottlebrush cover; ≥20 years
U-*AS (100)*	***Annual-Species***: ≥10% non-native annual species cover; <5% shrub cover; native grass may be present to common
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% native grasses; <5% shrub cover
U-*DP (103)*	***Depleted***: 5-20% cover of four-wing saltbush, basin big sagebrush, or rabbitbrush; <10% native grass; <5% non-native annual species cover
U-*EF (108)*	***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass***: ≥5% non-native annual species cover; ≥5% cover of four-wing saltbush, basin big sagebrush, or rabbitbrush; native grass may be present to common
U-*SD (135)*	***Seeded-Native***: >10% native grass and four-wing saltbush seed mix cover; <5% non-native annual species cover

Greasewood (GW) – Not GSG Habitat
1153

Overview: *The Greasewood BpS occurs on alluvial flats or lake plains usually adjacent to playas. Sites typically have saline to sodic soils, shallow water table, and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations. Slope gradients of less than 2 percent are most typical. Elevations range from 1,067 to 1,768 m (3,500' to 5,800'). Average annual precipitation is 13 to 25 cm (5" to 10"); and average growing season is 100 to 120 days. The surface layer normally crusts over, inhibiting water infiltration and seedling emergence. This BpS sometimes occurs as a mosaic of multiple communities, with open to moderately-dense shrublands dominated or co-dominated by* Sarcobatus vermiculatus *(greasewood).* Artimesia tridentata spp. tridentata *(Basin big sagebrush),* Atriplex confertifolia *(shadscale) may be present or co-dominant. An herbaceous layer, if present, is usually dominated by salt-tolerant graminoids. There may be inclusions of* Sporobolus airoides *(alkali sacaton),* Distichilis spicata *(saltgrass), and* Elymus cinereus *(basin wildrye). Vegetation on this site is normally restricted to coppice mound areas that are surrounded by playa-like depressions or nearly level, usually barren, inner spaces. As ecological condition declines, herbaceous understory is reduced or eliminated and the site becomes a community of halophytic shrubs dominated by greasewood.*

A (10)	***Early-all*:** >5% herbaceous cover of inland salt grass, alkali sacaton, or basin wildrye; ≤5% young or resprouting greasewood; >25% mineral soil; flood debris may be abundant; 0-4 years
B (31)	***Late-closed*:** >5% cover of mature greasewood with other shrubs possible (basin big sagebrush); >0% herbaceous cover of inland salt grass, alkali sacaton, or basin wildrye; mineral soil may be common; >4 years
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species; <5% cover of mature greasewood and other shrubs
U-*EF (108)*	***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*SA (121)*	***Shrub-Annual-Species***: ≥5% non-native annual species cover; >5% cover of mature greasewood or basin big sagebrush; native grasses may be present to common; >4 years
U-*SDI (127)*	***Seeded-Introduced***: >10% seeded introduced grasses (usually Russian wheatgrass), forbs, and shrubs; greasewood and other shrubs may be present to common; <5% non-native annual species cover
U-*SDI+AS (128)*	***Seeded-Introduced+Annual-Species***: >10% seeded introduced grasses (usually Russian wheatgrass), forbs, and shrubs; greasewood and other shrubs may be present to common; ≥5% non-native annual species cover

Juniper Woodland (JW) – Not GSG Habitat
1019

Overview: The Juniper Woodland BpS is typically found from 1,600-2,743 m (5,250'-9,000') above the 25 cm (10") precipitation zone. This BpS generally occurs on most soils and landforms, especially fire-safe sites of steep (8% to 75% slopes) and rocky slopes. Soils supporting this system are generally skeletal and vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. Woodlands comprising this system are dominated by Juniperus osteosperma*. Typical understory layers are variable and include big sagebrush, antelope bitterbrush, black sagebrush, and curl-leaf mountain mahogany. Grass and shrub species are often diverse and common, although not abundant.*

A (13)	***Early-open***: 5-20% herbaceous cover; charred stumps and trunks; 0-9 yrs **[B]**
B (22)	***Mid1-open***: 11-30% cover big sagebrush or bitterbrush <1.0m; 10-40% herbaceous cover; 10-29 yrs **[B,N]**
C (36)	***Mid2-open***: 11-20% cover of young (<100 yrs old) juniper <5m; 10-20% shrub cover; <20% herbaceous cover; 30-99 yrs
D (43)	***Late-open***: 21-60% cover of juniper <5m-9m; 10-40% shrub cover; <20% herbaceous cover; ≥100 yrs
U-*AS (100)*	***Annual-Species***: >10% non-native annual grasses cover; dead juniper visible
U-*EF (108)*	***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*TA (145)*	***Tree-Annual-Species***: 20-60% cover of juniper <5m-9m; 10-40% shrub cover; >5% non-native annual species cover; ≥30 yrs
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass***: >5% non-native annual species; 11-30% cover big sagebrush or bitterbrush <1.0m; <40% herbaceous cover **[N]**

Low Sagebrush (LS) – GSG Habitat
1079aa or 10790

*Overview: The Low Sagebrush BpS is found on clay soils. Low sagebrush (*Artemisia arbuscula*) is the dominant species, including Lahontan sagebrush (*A. arbuscula spp. longicaulis*) and early sagebrush (*A. arbuscula spp. longiloba*). Low sagebrush tends to grow where there is a clay-based root-limiting layer in the soil profile that causes a perched spring water table and poor aeration after wetting. Big sagebrush species generally occur on deeper loamy soils. Elevations range from 1,371 m to 2,438 m (5,500' to 8,000') in MLRA 25 and from 1,981 m to 2,591 m (6,500' to 8,500') in MLRA 24. The BpS is sometimes found as high as 2,895 m (9,500') on mountain ridges and summits where soils are very shallow and wind swept. Low sagebrush communities found above the 36 cm (14'") of precipitation on mountain valleys and basins are a different BpS: Low Sagebrush Steppe. The BpS mostly occurs on alluvial fans, piedmonts, bajadas, rolling hills and mountain slopes. The BpS can also be found on flats, plains, scablands. Low sagebrush generally has relatively low fuel loads with low-growing and cushion forbs and scattered bunchgrasses such as Thurber needlegrass (*Achnatherum thurberianum), *Sandberg's bluegrass* (Poa secunda), *Indian ricegrass (*Achnatherum hymenoides*), and, at higher elevations, Idaho fescue (*Festuca idahoensis*), and bluebunch wheatgrass (*Pseudoroegneria spicata*). Forbs often include buckwheats (*Eriogonum *spp.), fleabanes (*Erigeron *spp.), phloxes (*Phlox *spp.), paintbrushes (*Castilleja *spp.), globemallows (*Sphaeralcea *spp.), and lupines (*Lupinus *spp.).*

A (10)	***Early-all***: <10% cover rabbitbrush and other shrubs; >10% cover of native grass; <50% cover mineral soil; 0-24 yrs **[B]**
B (22)	***Mid-open***: 10-19% cover of low sagebrush and rabbitbrush; >10% native grass cover; <40% cover of mineral soil; 25-119 yrs **[B]**
C (31)	***Late-closed***: >20% cover of low sagebrush; >5% cover of native grasses; >120 yrs **[B,N]**
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species; <10% cover of shrubs (primarily rabbitbrush and snakeweed)
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥5% native grasses; <10% cover of shrubs **[B]**
U-*EF (108)*	***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*ES (105)*	***Early-Shrub***: >10% cover rabbitbrush species; <5% cover of non-native annual species; native grasses may be present
U-*DP (103)*	***Depleted***: >20% cover of low sagebrush; <5% native herbaceous cover;<5% cover of non-native annual species **[N?]**
U-*SA (121)*	***Shrub-Annual-Species***: ≥5% non-native annual species cover; >10% cover of low sagebrush; <5% cover of native grass **[N?]**

U-*SAP (124)* ***Shrub-Annual-Species-Perennial-Grass***: ≥5% non-native annual species cover; >10% cover of low sagebrush; >5% cover of native grass **[N]**

U-UF (146) ***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot

U-*SD (135)* ***Seeded***: >5% seeded native grass and forb species; <10% cover of shrubs; <5% non-native annual species cover (if ≥5 non-native annual species cover, then see ASPG or AS) **[B]**

U-*SDI-A (129)* ***Seeded-Introduced-Early***: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; <5% non-native annual species cover **[B]**

U-*SDI-B (130)* ***Seeded-Introduced-Mid***: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of low sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover **[B,N]**

U-*SDI-C (131)* ***Seeded-Introduced-Late***: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass. or forage kochia); >20% cover of low sagebrush; native grasses and forbs may be present to abundant; <5% non-native annual species cover **[N]**

U-*SI-A+AS (138)* ***Seeded-Introduced-Early+Annual-Species:*** >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); <10% cover of shrubs; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover **[B]**

U-*SI-B+AS (139)* ***Seeded-Introduced-Mid+Annual-Species***: >10% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); 10-19% cover of low sagebrush and rabbitbrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover **[B,N]**

U-*SI-C+AS (140)* ***Seeded-Introduced-Late+Annual-Species***: >5% seeded introduced species (crested wheatgrass, intermediate wheatgrass, or forage kochia); >20% cover of low sagebrush; native grasses and forbs may be present to abundant; ≥5% non-native annual species cover **[N]**

Mixed Salt Desert (MSD) – Not GSG Habitat
1081 or 10810

Overview: *The Mixed Salt Desert occurs from lower slopes to valley bottoms ranging in elevation from 1,067 – 1981 m (3,500' - 6,500'). Soils are often alkaline or calcareous. Soil permeability ranges from high to low, with more impermeable soils occurring in valley bottoms. Water ponds on alkaline bottoms. Texture is variable becoming finer toward valley bottoms. Many soils are derived from alluvium. Average annual precipitation ranges from 7.5-25.4 cm (3" to 10"); however, this system is in 12.7 - 30.3 cm (5"-8") of effective moisture within this broader range. Thus, other site characteristics (e.g. aspect, drainage, soil type) should be considered in identifying this biophysical setting. At the precipitation extremes, this system generally occurs as small patches and stringers. Summers are hot and dry with many days reaching 30 degrees C (100 degrees F). Spring is the only dependable growing season with moisture both from winter and spring precipitation. Cool springs can delay the onset of plant growth and drought can curtail the length of active spring growth. Freezing temperatures are common from November through April. Mixed Salt Desert generally lies above playas, lakes, and greasewood communities. Up slope the BpS is bordered by low elevation big sagebrush groups, commonly Wyoming big sagebrush, low sagebrush, and black sagebrush communities. Mixed Salt Desert includes low (<0.91 m or 3') and medium-sized shrubs found widely scattered (often 6.1 - 9.1 m [20'-30'] apart) to high density (3-5 plants per sq. m) shrubs interspersed with low to mid-height bunch grasses. Common shrubs are shadscale, greasewood, winterfat, budsage, Nevada ephedra, horsebrush, low rabbitbrush, broom snakeweed, and spiny hopsage. Shrub dominance is highly dependent on the site. Some of these shrubs will be present. Common bunch grass species are Indian ricegrass, needle-and-thread, purple three-awn, and bottlebrush squirreltail. Globemallows are the most common and widespread forbs. The understory grasses and forbs are salt-tolerant, not particularly drought tolerant, and are variably abundant. The relative abundance of species may vary in a patchwork pattern across the landscape in relation to subtle differences in soils (e.g., sand sheets or other surface textural differences) and reflect variation in disturbance history. Total cover rarely exceeds 25% and annual precipitation is closely linked to prior 12 months precipitation. Stand-replacing disturbances (insects, extended wet periods and drought) shift dominance between shrub and grass species. Following drought coupled with insect infestations, the system will tend more toward bud sagebrush dominance. The biophysical setting has not evolved with fire and fire is absent from the reference condition.*

A (10) ***Early-all***: 0-5% cover of young *Atriplex* spp. or other shrubs; Indian ricegrass and squirreltail common; 0-5 yrs

B (43)	***Late1-open***: >5% cover *Atriplex* spp. or other shrubs; Indian ricegrass and squirreltail present to common; ≥6 yrs
C (33)	***Late2-open***: >5% cover budsage <0.25m; Indian ricegrass and squirreltail present to common; ≥6 years
U-*AS (100)*	***Annual-Species***: ≥5% non-native annual species cover; <5% shrub cover
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% non-native annual species cover; ≥5% native grass species cover; <5% shrub cover
U-*EF (108)*	***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*SA(121)*	***Shrub-Annual-Species***: ≥5% non-native annual species cover; ≥5% cover of *Atriplex* spp. or other shrubs; native grasses may be present
U-*SD (135)*	***Seeded-Native***: >10% native seed mix cover; <5% non-native annual species cover (if ≥5% non-native annual species cover, then see ASPG or AS)
U-*SDI (127)*	***Seeded-Introduced***: >10% seeded introduced grasses, forbs, and shrubs; <5% non-native annual species cover; shrubs may be present to common
U-SDI+AS (128)	***Seeded-Introduced+Annual-Species:*** >10% seeded introduced grasses and shrubs; ≥5% non-native annual species cover; shrubs may be present to common

Moist Floodplain (MF) – GSG Habitat
1154mf or 11541

Overview: The Moist Floodplain BpS is found in lower gradient valleys often as axial valley waterways or rivers in broad valleys sometimes cutting through mountains ranges. The Humboldt River and some of its low gradient tributaries (Maggie Creek) fall into this group. The BpS is the primary riparian community adjacent to rivers. Species require flooding and gravel for growth and reestablishment. Sites are subject to temporary flooding during spring runoff, although summer flash floods can have dramatic effects on succession. Severe flood events can alter the potential of the local floodplain to support the Moist Floodplain BpS, thus causing a shift in BpS. Underlying gravels may keep the water table just below the ground surface, and are favored substrates for willow, and if applicable, cottonwood germination. Surface water is generally high for variable periods. Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Vegetation is predominantly herbaceous with species composition varying with salt tolerance and alluvial deposits. Riparian shrubs are found at the river's edge as willows or distributed in clumps farther away from the channel in wetter areas. Codominant and diagnostic species include 1creeping wildrye and basin wildrye. Other common species are tufted hairgrass, Nevada bluegrass, sedges, alkali sacaton, inland saltgrass, willow, black greasewood, basin big sagebrush, and silver buffaloberry. Cottonwood is occasional.

W (148)	***Water***: Water in mainstem and secondary channels
Ch (60)	***Channel***: wet or dry channel crossing site that is not mainstem river (i.e., water)
A (4)	***Gravel-Sand-Bar***: >80% cover of silt, gravel, rock, and boulders; <20% very recently germinated seedlings; 0-5 yrs **[B]**
Bw (14)	***Early-Willow***: 30%-50% cover of creeping wildrye and basin wildrye codominant with other graminoids subdominant (Nevada bluegrass, and/or sedges); <5% cover of willow seedlings and sapling in clumps or at the river's edge <1.5m high; <1% cottonwood cover; 50-70% cover of gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs **[B]**
Cw (23)	***Mid-Willow***: 50-90% cover of creeping wildrye and basin wildrye codominant with other graminoids subdominant (Nevada bluegrass, and/or sedges); 5-10% cover of large but not arborescent willow (≤6" diameter and <3m high) and other shrubs in clumps or at the river's edge; <1% cottonwood cover; <50% gravel, rock, and boulders; 5-74 yrs **[B]**
Dw (34)	***Late-Willow***: 10-15% cover of large diameter (>6" and ≥3m high) arborescent willow and other tall shrubs in clumps or at the river's edge; 50-80% cover of creeping wildrye and basin wildrye codominant with other graminoids subdominant (Nevada bluegrass, and/or sedges); <1% cottonwood cover; <10% gravel, rock, and boulders; >75 yrs **[B]**
Bc (12)	***Early-Cottonwood***: 0-40% cover of cottonwood seedlings and saplings <1.5m height; creeping wildrye and/or basin wildrye may co-dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs **[B]**

Cc (21)	***Mid-Cottonwood***: 31-100% cover of small pole-sized cottonwood trees (≥1.5m and <10m height) and other tall shrubs (willows, buffaloberry); creping wildrye and basin wildrye dominate the understory<20% gravel, rock, and boulders; 5-19yrs
Dc (32)	***Late-Cottonwood***: 31-100% cover of cottonwood trees 10-24m high; creeping wildrye and basin wildrye dominate herbaceous layer; willow and other shrubs in mid-story; <20% gravel, rock, and boulders; >20 yrs
U-*AS (100)*	***Annual-Species***: dry incised banks with >10% cover of non-native annual species; <10% shrub cover
U-*DE (104)*	***Desertified***: Incised river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush, snakeweed, rabbitbrush, Wood's Rose, silver buffaloberry); >5% native grass cover **[N]**
U-*EFT (106)*	***Exotic-Forb-Tree***: >5% cover of exotic forb species (knapweed, tall whitetop, thistles, or purple loosestrife); native shrub or tree cover variable
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass***: Incised river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush snakeweed, rabbitbrush, Wood's Rose, silver buffaloberry); >5% non-native annual species cover; native upland grasses absent to common **[N]**
U-*SFE (137)*	***Shrub-Forb-Encroached***: 10-50% cover of irises, Wood's rose, rabbitbrush, or other unpalatable forbs and shrubs in open areas or under tree canopy
U-*PAS (119)*	***Pasture***: Irrigated, sub-irrigated, or fallow pasture or alfalfa field **[B]**

Montane Riparian (MR) – Maybe GSG Habitat
1154 or 11540

Overview: The Montane Riparian BpS is found within a broad elevation range above 1,220 m (4,000'). Riparian communities require flooding and gravel for reestablishment. The BpS is found in low- to mid-elevation canyons and draws, on montane floodplains, in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff, although summer flash floods can have dramatic effects on succession. Underlying gravels may keep the water table just below ground surface, and are favored substrates for cottonwood and willow. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Surface water is generally high for variable periods. Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Codominant and diagnostic species include willow, cottonwood, chokecherry, sumac, Wood's rose, currant, occasional aspen, and conifers. Vegetation is very heterogeneous and diverse along river reaches. Some reaches will be dominated by cottonwood, whereas others are completely occupied by willow, and even cinquefoil and sagebrush on natural stream terraces (not due to incision). Lower slopes <6% favor cottonwood, whereas willow are more typically found on steeper slopes.

A (4)	***Point Bar***: >80% cover of silt, gravel, rock, and boulders; <20% recently germinated seedlings; 0-5 yrs
Bc (12)	***Early-Cottonwood***: 0-40% cover of cottonwood seedlings and saplings; grass may co-dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs **[B]**
Cc (21)	***Mid-Cottonwood***: 31-100% cover of small cottonwood trees and other tall shrubs (willows, chokecherry) and; <20% gravel, rock, and boulders; 5-19 yrs
Dc (32)	***Late- Cottonwood***: 31-100% cover of cottonwood, willow, conifers and other trees 10-24m; <20% gravel, rock, and boulders; >20 yrs
Bw (14)	***Early-Willow***: 0-40% cover of willow, but cottonwood absent; grass may co-dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs **[B]**
Cw (34)	***Late-Willow***: 41-100% cover of willow and other tall shrubs (chokecherry) and cottonwood absent; <20% gravel, rock, and boulders; >5 yrs
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species on dry **incised** banks; <10% shrub cover
U-*DE (104)*	***Desertified***: Incised river/creek with ≥10% cover of upland shrubs (e.g., big sagebrush, snakeweed, rabbitbrush); >5% native grass cover **[N]**
U-*EFT (106)*	***Exotic-Forb-Tree***: >10% cover of exotic forb or tree species (knapweed, tall whitetop, thistles, purple loosestrife, salt cedar, or Russian olive); native canopy is usually cottonwood
U-*Inset-A (113)*	***Inset-Floodplain-early*:** Reformed riparian floodplain at bottom of incised creeks; 0-40% cover of willow, but cottonwood absent; grass may co-dominate or dominate; <50% cover gravel, rock, and boulders, although this may be highly variable by reach; 0-5 yrs

U-*Inset-B (114)*	***Inset-Floodplain-late*:** Reformed riparian floodplain at bottom of incised creeks; 31-100% cover of willow and other tall shrubs (chokecherry) and cottonwood absent; <20% gravel, rock, and boulders; >5 yrs
U-*Inset-EFT (111)*	***Inset-Floodplain-Exotic-Forb-Tree*:** Reformed riparian floodplain at bottom of incised creeks; >1% cover of exotic forb or tree species (knapweed, tall whitetop, thistles, purple loosestrife, salt cedar, or Russian olive)
U-*Inset-HU (117)*	***Inset-Floodplain-Hummocked*:** Reformed riparian floodplain at bottom of incised creeks; Trampled by ungulates; graminoids present to common in and out of holes created by ungulate hoofs
U-*Inset-SFE (118)*	***Inset-Floodplain-Shrub-Forb-Encroached*:** Reformed riparian floodplain at bottom of incised creeks; 10-50% cover of Wood's rose, and other unpalatable forbs and shrubs in open areas or under tree canopy
U-*SFE (137)*	***Shrub-Forb-Encroached***: 10-50% cover of Wood's rose, sumac, or other unpalatable forbs and shrubs in open areas or under tree canopy
U-*PAS (119)*	***Pasture*:** Agricultural pasture **[B]**
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass***: Incised river/creek with 10-50% cover of upland shrubs (e.g., big sagebrush); >5% non-native annual species cover; native grasses absent to common; **[N]**
U-*SDI (127)*	***Seeded-Introduced***: Incised river/creek with >20% introduced grass species cover (usually crested wheatgrass or intermediate wheatgrass) **[B]**
U-*SDI+AS (128)*	***Seeded-Introduced-Annual-Species***: Incised river/creek with >20% introduced grass species cover; >5% non-native annual species cover **[B]**

Montane Sagebrush Steppe (MSS) – GSG Habitat
1126 or 11260

Overview: The Montane Sagebrush Steppe BpS (a.k.a., mountain big sagebrush) is found on deep soil to stony flats, ridges, nearly flat ridge tops, and mountain slopes. Annual precipitation ranges from 30 cm to 41 cm (12" to 16"). Elevation is from 1,768 m (5,800') on cooler and more productive soils to 2,743 m (9,000') on steep southern slopes. In general this system shows an affinity for fine soils and some source of subsurface moisture. Soils generally are moderately deep to deep, well-drained, and made 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. Vegetation types are usually dominated by Artemisia tridentata *ssp.* vaseyana*. A variety of other shrubs can be found in some occurrences, such as antelope bitterbrush, Utah serviceberry, and black chokecherry, but these are seldom dominant (if dominant, see Mountain Shrub BpS). Abundant forbs are an indicator of good range condition. Grasses are abundant, sometimes very abundant, and often diverse. Common grass species are Thurber's needlegrass, bluebunch wheatgrass, and, at higher elevations, Idaho fescue, Cusick's blugrass, and basin wildrye. Conifers usually absent from area.*

A (10)	***Early***: ≥10% grass and forb cover; 0-10% canopy of mountain sage, mountain brush; 0-12 yrs **[B]**
B (22)	***Mid-open***: 11-20% cover of mountain sage, mountain shrub; >50% herbaceous cover; 13-29 yrs **[B,N]**
C (31)	***Mid-closed***: 20-49% cover of mountain sagebrush (dominant) and mountain brush; ≥25% herbaceous cover; 30-59 yrs **[N]**
D (42)	***Mid-dense***: ≥50% cover of mountain sagebrush (dominant) and mountain brush; ≥25% herbaceous cover; ≥60 yrs **[N]**
U-*AS (100)*	***Annual-Species***: >10% cover of non-native annual species; snakeweed or rabbitbrush may be present
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥10% native grasses; <10% shrub cover **[B]**
U-*DP (103)*	***Depleted***: >10% cover of mountain sagebrush (dominant) and mountain brush; <10% herbaceous cover; <5% cover of non-native annual species ; <20% conifer sapling cover; litter and mineral soil common **[N?]**
U-*EFT (106)*	***Exotic-Forb-Tree***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)
U-*ES (105)*	***Early-Shrub***: >20% cover of snakeweed or rabbitbrush species; <5% cover of non-native annual species; native grasses may be present

U-*SA-1* *(122)*	***Shrub-Annual-Species-Closed***: ≥5% non-native annual species cover; ≥10-49% cover of mountain sagebrush (dominant) and mountain brush; ≤10% cover of native grass **[N?]**
U-*SA-2* *(123)*	***Shrub-Annual-Species-Dense***: ≥5% non-native annual species cover; ≥50% cover of mountain sagebrush (dominant) and mountain brush; ≤10% cover of native grass **[N?]**
U-*SAP-1* *(125)*	***Shrub-Annual-Species-Perennial-Grass-Closed***: ≥5% non-native annual species cover; 11-49% cover of mountain sagebrush (dominant) and mountain brush; >10% cover of native grass **[N]**
U-*SAP-2* *(126)*	***Shrub-Annual-Species-Perennial-Grass-Dense***: ≥5% non-native annual species cover; ≥50% cover of mountain sagebrush (dominant) and mountain brush; >10% cover of native grass **[N]**
U-*UF (146)*	***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot
U-*SD (135)*	***Seeded-Native*****:** >10% seeded native grasses, forbs, and shrubs; <5% non-native annual species cover (if ≥5% non-native annual species cover, then see ASPG or AS) **[B]**
U-*SDI-A (129)*	***Seeded-Introduced-Early*****:** >10% seeded introduced grasses and shrubs; <10% canopy of mountain sage, mountain brush; native grasses present to common; <5% cover of non-native annual species **[B]**
U-*SDI-B (130)*	***Seeded-Introduced-Mid-open*****:** >10% seeded introduced grasses and shrubs; 10-19% cover of mountain sagebrush and mountain shrub; native grasses present to common; <5% cover of non-native annual species **[B,N]**
U-*SDI-C (131)*	***Seeded-Introduced-Mid-closed*****:** >5% seeded introduced grasses and shrubs**;** 20-49% cover of mountain sagebrush and mountain shrub; native grasses present to common; <5% cover of non-native annual species **[N]**
U-*SDI-D (132)*	***Seeded-Introduced-Late-dense*****:** >5% seeded introduced grasses and shrubs; ≥50% cover of mountain sagebrush and mountain shrub; native grasses present to common; <5% cover of non-native annual species **[N]**
U-*SI-A+AS* *(138)*	***Seeded-Introduced-Early+Annual-Species*****:** >10% seeded introduced grasses and shrubs; <10% canopy of mountain sage, mountain brush; native grasses present to common; ≥5% cover of non-native annual species **[B]**
U-*SI-B+AS* *(139)*	***Seeded-Introduced-Mid-Open+Annual-Species*** **:** >10% seeded introduced grasses and shrubs; 10-19% cover of mountain sage and mountain shrub; native grasses present to common; ≥5% cover of non-native annual species **[B,N]**
U-*SI-C+AS* *(140)*	***Seeded-Introduced-Mid-Closed+Annual-Species*****:** >5% seeded introduced grasses and shrubs**;** 20-49% cover of mountain sage and mountain shrub; native grasses present to common; ≥5% cover of non-native annual species **[N]**
U-*SI-D+AS* *(141)*	***Seeded-Introduced-Late-Dense+Annual-Species*****:** >5% seeded introduced grasses and shrubs; ≥50% cover of mountain sage and mountain shrub; native grasses present to common; ≥5% cover of non-native annual species **[N]**

Mountain Shrub (MSh) – GSG Habitat
1106

Overview: The Mountain Shrub BpS includes several mountain shrub species that can each dominate: Utah serviceberry (Amelanchier utahensis), *mountain snowberry* (Symphoricarpos oreophilus)*, common chokecherry (*Prunus virginiana*), mountain oceanspray* (Holodiscus dumosa) *and antelope bitterbrush (*Purshia tridentata*). These shrublands occur between 1,981 m and 2,581 m (6,500' and 8,500') of elevation and are usually associated on smooth to usually concave mountain side slopes on all aspects. The site is typically associated with talus and rubbleland lying below areas of rock outcrop and on fractured bedrock covered with shallow soil. Sites dominated by snowberry are often associated with landform features that cause deep snow accumulation on more gentle slopes where soils contain high rock volumes or rubble. Annual precipitation ranges from 35.5 cm and 46 cm(14" and 18"). Grasses are represented as species of Idaho fescue (*Idaho festuca*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Thurber's needlegrass (*Achnatherum thurberianum*), mountain brome (*Bromus marginatus*), and slender wheatgrass (*Elymus trachycaulus*).*

A (10)	***Early-all***: 10-59% cover of mountain shrubs; ≥10% grass and forb cover; 0-4 yrs **[B]**
B (22)	***Mid-open***: 60-100% cover of fast and slow growing mountain shrubs (mountain snowberry, Utah serviceberry, chokecherry); >50% herbaceous cover; 5-19 yrs **[B,N]**
U-*EF (108)*	***Exotic-Forbs***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)

U-*ES (105)* ***Early-Shrub***: >20% cover rabbitbrush species; <5% non-native annual species cover; native grasses and forbs may be present to common

U-*DP (103)* ***Depleted***: >30% cover of less palatable shrubs and big sagebrush; <10% native grass cover; <5% non-native annual species cover; unpalatable native forbs often present to common **[N]**

U-*SAP (124)* ***Shrub-Annual-Species-Perennial-Grass***: ≥5% non-native annual species cover; ≥5% cover of mountain shrubs; native herbaceous cover usually present **[N]**

U-*UF (146)* ***Unpalatable-Forb***: >75% Increaser forb cover, such as mules'ears wyethia or narrowleaf balsamroot

Saline Meadow (SM) – Not GSG Habitat
1145sm or 11451

*Overview: The Saline Meadow BpS is found at the bottom of broad valleys and on alluvial flats at elevations of 1,219 m to 1,829 m (4,000' to 6,000') with slopes between 0-4%, although more typically <2%, usually surrounded by salt tolerant plant communities. The BpS is wetted by an elevated water table at a depth of 102 cm (40") on saline soils and between 51-102 cm (20" to 40") on sodic floodplains that periodically rise to the surface during the spring or is spring-fed in broad valley bottoms. Saturated soils support graminoid dominance. Soils are deep saline and often calcareous or sodic and made of alluvium of mixed origins. Average annual precipitation ranges from 15 to 25 cm (6" to 10"). Alkali sacaton (*Sporobolus airoides*) and alkali muhly (*Muhlenbergia asperifolia*) dominate, although inland saltgrass (*Distichlis spicata*), and alkali cordgrass (*Spartina gracilis*) may co-dominate. Inland saltgrass dominates on sodic soils. Black greasewood (*Sarcobatus vermiculatus*), iodine bush (*Allenrolfea occidentalis*), silver buffaloberry (*Shepherdia argentea*), alkali rabbitbrush (*Chrysothamnus albidus*), and willow (*Salix *spp.) may be present at low abundance. As the sodium concentration in the soil increases, vegetation cover decreases from <70% to <15%.*

Ch (60) ***Channel***: wet or dry channel crossing site

A (13) ***Early-open***: 10-39% alkali sacaton and other salt-tolerant grasses cover; >60% mineral soil cover; 0-2 yrs

B (20) ***Mid-closed***: ≥40% alkali sacaton and other salt-tolerant grasses cover; >30% mineral soil cover; <5% shrub cover; 3-22 yrs

C (33) ***Late-open***: 5-10% shrub (greasewood and other shrubs) cover; ≥40% alkali sacaton and other salt-tolerant grasses cover; >50% mineral soil cover; >22 yrs

U-*AS (100)* ***Annual-Species***: ≥10% cover of non-native annual species; <10% inland saltgrass, Baltic rush cover, and other salt-tolerant grasses cover; <10% shrub cover; >30% mineral soil cover

U-*ASPG (101)* ***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥10% inland saltgrass, Baltic rush cover, and other salt-tolerant grasses cover; <10% cover of native shrubs; >20% mineral soil cover

U-*EF (108)* ***Exotic-Forb***: 5-100% exotic forbs (knapweed, tall whitetop, thistles, halogeton, purple loosestrife)

U-*SAP (124)* ***Shrub-Annual-Species-Perennial-Grass***: ≥10% cover of native shrubs; >10% inland saltgrass and Baltic rush cover; ≥5 non-native annual species cover; >10% mineral soil cover

U-*DP (103)* ***Depleted***: ≥10% shrub cover (greasewood and other shrubs); <60% of inland saltgrass and Baltic rush cover; 10-30% cover of bare ground

Wet Meadow-bottomland (WMb) – Not GSG Habitat
1145wmb or 11452

*Overview: The Wet Meadow-bottomland BpS is found in bottomland floodplains or adjacent to valley axial streams, such as the Humboldt River and lower Maggie Creek. Slope is typically less than 2%. The BpS is wetted by an elevated water table about 51 cm (20") from the surface during the growing season and adjacent to rivers, or is spring-fed. Saturated soils support graminoid dominance. Elevation is generally below 1,524 m (5,000') and annual precipitation is between 15 cm and 25 cm (6" and 10"). Being in a floodplain away from the main channel, bottomland wet meadows can experience large flood events and fine sediment accumulation. Above 20 cm (8") of annual precipitation, tufted hairgrass (*Deschampia cespitosa*) dominates and Nevada bluegrass (*Poa nevadensis*) codominates, whereas Alkali bluegrass (*Poa juncifolia*) dominates and alkali sacaton (*Sporobolus airoides*) codominates below 20 cm (8") of annual precipitation. Baltic rush* (Juncus balticus), *inland saltgrass (*Distichlis spicata*), and alkali cordgrass (*Spartina gracilis) *are also common, especially as soil become more saline or sodic. The presence of shrubs (willow [*Salix *spp.], Wood's* *rose [*Rosa woodsii*], silver buffaloberry [*Shepherdia argenta*]) at the meadow's edge increases during consecutive drought years and decreases during consecutive high water years.*

Ch (60)	***Channel***: wet or dry channel crossing wet meadow
A (13)	***Early-open***: 10-60% herbaceous cover – mostly graminoids; 0-2 yrs
B (20)	***Mid-closed***: 61-100% herbaceous cover – mostly graminoids; 3-22 yrs
C (33)	***Late-open***: 5-10% tree-shrub (willow, Wood's rose, silver sagebrush) cover; 60-80% herbaceous cover – mostly graminoids; >22 yrs
U-*AS (100)*	***Annual-Species (on incised meadow)***: >5% cover of non-native annual species; < 10% shrub cover
U-*EF (108)*	***Exotic-Forbs***: ≥5% exotic forbs (knapweed, purple loosestrife, thistles)
U-*DE (104)*	***Desertified (= incised)***: Entrenched water table with 10-50% cover of sagebrush
U-*HU (110)*	***Hummucked***: Trampled by ungulates; graminoids present to common in and out of holes created by ungulate hoofs
U-*SFE (137)*	***Shrub-Forb-Encroached***: >10% cover of less palatable grasses and forbs (e.g., *Iris missouriensis*) **OR** >10% shrub cover (willow, Wood's rose, silver sagebrush); 10-30% cover of bare ground
U-*SA (121)*	***Shrub-Annual-Species (on incised meadow)***: >10% cover of native shrubs; <5% native grass cover; ≥5% cover of non-native annual species

Wet Meadow-montane (WMm) – GSG Habitat
1145wmm or 11450

*Overview: The Wet Meadow BpS is wetted by an elevated water table about 51 cm (20") from the surface during the growing season and adjacent to creeks or rivers, or is spring-fed. Three types are included here: true wet meadows close to mountain streams and around or below seeps and springs, clay seeps dominated by grasses and mules' ears wyethia, and dry meadows adjacent to valley axial floodplains stream terraces. Saturated soils support graminoid dominance. Elevation ranges from 1,524 m to 2,896 m (5,000' to 9,500') and annual precipitation is between 25 cm and 41 cm (10" and 16"). Slopes are <15%, although typically <4%. Tufted hairgrass (*Deschampia cespitosa*) dominates and Nevada bluegrass (*Poa nevadensis*) codominates in true wet meadows, whereas Nevada bluegrass dominates in dry meadows. Alpine timothy (*Phleum alpinum*) and sedges (*Carex*) are also common in both types of wet meadows. Clay seeps are dominated by Idaho fescue (Festuca idahoensis), mountain brome (*Bromus marginatus*), mules'ears wyethia (*Wyethia amplexicaulis*), and whitehead wyethia (*Wyethia helenioides*). The presence of shrubs (willow [*Salix *spp.], Wood's rose [*Rosa woodsii*], silver sagebrush [*Artemisia cana*]) at the meadow's edge increases during consecutive drought years and decreases during consecutive high water years.*

A (13)	***Early-open***: 10-60% herbaceous cover – mostly graminoids; 0-2 yrs **[B]**
B (20)	***Mid-closed***: 61-100% herbaceous cover – mostly graminoids; 3-22 yrs **[B]**
C (33)	***Late-open***: 5-10% tree-shrub (willow, Wood's rose, silver sagebrush) cover; 60-80% herbaceous cover – mostly graminoids; >22 yrs **[B]**
U-AS (100)	***Annual-Species (on incised meadow)***: >5% cover of non-native annual species; < 10% shrub cover
U-*DE (104)*	***Desertified (= incised)***: Entrenched water table with 10-50% cover of sagebrush
U-*ES (105)*	***Early-Shrub***: >10% cover rabbitbrush species; <5% non-native annual species cover; native grasses and forbs may be present to common
U-*SFE (137)*	***Shrub-Forb-Encroached***: >10% cover of less palatable grasses and forbs (e.g., *Iris missouriensis*) **OR** >10% shrub cover (willow, Wood's rose, silver sagebrush); 10-30% cover of bare ground
U-*EF (108)*	***Exotic-Forbs***: ≥5% exotic forbs (knapweed, purple loosestrife, thistles, tall whitetop, halogeton)
U-*HU (110)*	***Hummocked***: Trampled by ungulates; graminoids present to common in and out of holes created by ungulate hoofs **[B]**
U-*PAS (119)*	***Pasture*:** Agricultural pasture **[B]**
U-*SAP (124)*	***Shrub-Annual-Grass (on incised meadow)***: >10% cover of native shrubs; native grass cover may be present; ≥5% cover of non-native annual species

Wetland – Not GSG Habitat

1001wl or 11543	

Overview: The Wetland BpS is found in bottomland floodplains or adjacent to valley axial streams, such as the Humboldt River and lower Maggie Creek. Wetlands are generally formed by flood events cutting river meanders and creating backwater wetlands or created by beaver activity.

W (148)	***Water***: Open water with <5% emergent vegetation cover
A (10)	***Early-all***: 5%-24% emergent vegetation cover; remaining area is water
B (30)	***Late-all:*** ≥25% emergent vegetation cover; remaining area is water
U-*EFT (106)*	***Exotic-Forb-Tree***: >1% noxious non-native forbs, tamarisk, or Russian olive

Winterfat (WF) – Not GSG Habitat

1081wl or 10812

*Overview: The winterfat BpS is generally considered part of the mixed salt desert scrub communities. Winterfat communities occupy saline silty or gravelly silty soils on shallow slopes between 1,219 – 1,829 m (4,000' - 6,000'). Such sites are often found in shallow washes with slopes typically <4%. Average annual precipitation ranges from 10 cm to 20 cm (4" to 8"). Winterfat (*Kraschenninnikovia lanata*) is the dominant shrub, often monotypic. Shadscale (*Atriplex confertifolia*), budsage (Artemisia spinescens), snakeweed (*Gutierrezia *spp.), rabbitbrush (*Chrysothamnus *spp.) also can be common shrubs. Common grasses are Indian ricegrass, bottlebrush, squirreltail, and needle-and-thread.*

A (10)	***Early-all***: >10% Indian ricegrass, squirreltail, other native grasses; ≤5% cover of rabbitbrush, snakeweed, and other salt desert shrubs; <60% mineral soil <0.5m; 0-49 yrs
B (22)	***Mid1*-open**: 5-20% cover winterfat, budsage, rabbitbrush, and other desert shrubs <0.5m; >10% native grass cover; 50-149 yrs
C (31)	***Late1-closed****:* >20% cover winterfat, budsage, rabbitbrush, and other salt desert shrubs; >5% native grass cover; *>150 yrs*
U-*AS (100)*	***Annual-Species***: >10% non-native annual species cover; <5% cover of native shrubs
U-*ASPG (101)*	***Annual-Species-Perennial-Grass***: ≥5% cover of non-native annual species; ≥10% native grass cover; <10% shrub cover
U-*EF (108)*	***Exotic-Forbs****:* >5% cover halogeton or exotic mustards; <10% cover of non-native annual species; >50% mineral soil
U-*SAP (124)*	***Shrub-Annual-Species-Perennial-Grass***: ≥5% non-native annual species cover; >5% cover of winterfat or other shrubs; >5% non-native annual species cover
U-*SD (135)*	***Seeded***: ≥10% native grass species seed mix cover; <5% non-native annual species cover (if ≥5% non-native annual species cover, then see ASPG or AS)
U-*SDI (127)*	***Seeded-Introduced***: ≥5% introduced species (crested wheatgrass, forage kochia) seed mix cover; <5% non-native annual species cover
U-*SDI+AS (128)*	***Seeded-Introduced+Annual-Species***: ≥5% introduced species (crested wheatgrass, forage kochia) seed mix cover; ≥5% non-native annual species cover

Appendix 2

Crosswalk from TNC's ecological systems to NRCS ecological sites for both the IL and TS-Horseshoe Ranches

BPS name	BPS Code	Ecological Site Name	MRLA Code	MRLA
Aspen Woodland (ASP)	10110	Aspen Thicket POTR5 WSG:1R1707 POTR5 WSG:2W1710	024XY036NV 025XY065NV 025XY064NV	24/25
Basin Wildrye-bottomland (BWb)	10803	Deep Sodic Fan (atypical) Dry Floodplain Saline Bottom Saline Floodplain (atypical)	024XY015NV 024XY006NV 024XY007NV 024XY063NV	24
Basin Wildrye (BW) Basin Wildrye-montane (BWm)	10801	Deep Loamy 14+"P.Z. (atypical) Loamy Bottom 14+"P.Z. Loamy Bottom 8-14"P.Z.	025XY029NV 025XY081NV 025XY003NV	25
Big Sagebrush Shrubland-upland (WSup)	10800	Ashy Loam 10-12"P.Z. Churning Clay 8-12"P.Z. (atypical) Loamy 10-12"P.Z. Loamy Fan 8-10"P.Z Shallow Loam 8-12"P.Z. South Slope 8-12"P.Z. Stony Bottom (atypical)	025XY066NV 025XY013NV 025XY014NV 025XY070NV 025XY021NV 025XY015NV 025XY050NV	25
Big Sagebrush Shrubland-upland with trees (WSup)	10804	Ashy Loam 10-12"P.Z. Churning Clay 8-12"P.Z. (atypical) Loamy 10-12" P.Z. Loamy 10-12" P.Z. Loamy Fan 8-10"P.Z Shallow Loam 8-12"P.Z. Shallow Loam 10-14"P.Z. South Slope 8-12"P.Z. Steep North Slope 10-12"P.Z.	025XY066NV 024XY028NV 025XY014NV 024XY013NV 025xy070NV 025XY021NV 024XY035NV 025XY015NV 024XY033NV	24 25
Big Sagebrush-semidesert (BSsd)	10802	Ashy Loam 8-10" P.Z. Droughty Loam 8-10"P.Z. Eroded Slope 6-10" P.Z. Gravelly Fan Loamy 8-10"P.Z. Sandy 8-10"P.Z. Sandy Loam 8-10"P.Z. (atypical) Shallow Loam 8-10"P.Z. (atypical) Stony Slope 6-10"P.Z.	025XY066NV 024xy020NV 024xy045NV 024XY041NV 025XY019NV 024XY017NV 024XY058NV 024XY047NV 024XY026NV	24 25
Channel (Ch)	10050	Various floodplain sites		
Curl-leaf Mountain Mahogany (CMM)	10620	Mahogany Savanna 14-16" P.Z. Mahogany Savanna 16+"P.Z. Mahogany Thicket Stony Mahogany Savanna	025XY071NV 025XY075NV 025XY030NV 025XY031NV	25
Desert Wash (DW)	11544	None in MLRAs 24 or 25		
Four-wing Saltbush (FWS)	10811	Gravelly Sand 5-8" P.Z.	024XY069NV	24

Greasewood (GW)	11530	Sodic Dunes Sodic Flat 6-8"P.Z. Sodic Flat 8-10" P.Z. Sodic terrace 6-8"P.Z. (atypical) Sodic Terrace 8-10"P.Z.	024XY066NV 024XY011NV 024XY008NV 024XY003NV 024XY022NV	24
Juniper Woodland (JW)	10190	JUOS WSG:0R0402 JUOS WSG:0R0404 PIMO WSG:1R0601 (atypical) PIMO WSG:0R0601 (atypical) PIMO-JUOS WSG:0R0501 PIMO-JUOS WSG:0R0502	025XY059NV 025XY060NV 025XY061NV 024XY054NV 024XY049NV 024XY050NV	24 25
Limber Pine Woodland (LB)	10200	JUSC WSG:OR2901 (found JUSC and PIFL2 co-dominant on very steep stony slope) PIFL2 WSG:0R1007	025XY068NV 025XY073NV	25
Low Sagebrush (LS)	10790	Clayey 12-14:P.Z. (atypical) Claypan 10-12P.Z. Claypan 10-12P.Z. Claypan 12-16"P.Z. Claypan 12-16"P.Z. Cobbly Claypan 8-12"P.Z. Clay Seep (atypical) Clay Slope 8-12"P.Z. Eroded Claypan 12-16"P.Z. Mountain Ridge Mountain Ridge Channery Hill (atypical)	025XY054NV 025XY018NV 024XY018NV 025XY017NV 024XY027NV 025XY022NV 025XY047NV 025XY083NV 025XY051NV 025XY024NV 024XY016NV 024XY057NV	24 25
Low sagebrush Steppe (LSS)	11240	Claypan 16+"P.Z.	025XY032NV	25
Lower Montane-Valley Grassland (LMG)	11390	Clay Basin Subirrigated Clay Basin Wet Clay Basin	025XY048NV 025XY069NV 025XY005NV	25
Mixed Salt Desert (MSD)	10810	Droughty Loam 5-8"P.Z. Gravelly Loam 5-8"P.Z. Loamy 5-8"P.Z. Loamy Slope5-8"P.Z. Saline Terrace 6-8"P.Z. Sandy 5-8"P.Z. (atypical) Shallow Silty 5-8" P.Z. Shallow Silty 8-10"P.Z. Sodic terrace 6-8"P.Z. (atypical)	024XY068NV 024XY065NV 024XY002NV 024XY025NV 024XY012NV 024XY055NV 024XY067NV 024XY060NV 024XY003NV	24
Moist Floodplain (MF)	11541	Moist Floodplain	025XY001NV	25
Montane Riparian (MR)	11540	POAN3 WSG:6W1410 POBAT WSG:6W1610 Stream Terrace Streambank	025XY053NV 025XY074NV 025XY062NV 025XY079NV	25
Montane Sagebrush Steppe (MSS)	11260	Clay Seep (atypical) Gravelly North Slope Loamy 12-14"P.Z. Loamy 14-16"P.Z. Loamy Slope 12-14"P.Z.	025XY047NV 024XY046NV 025XY027NV 025XY056NV 024XY021NV	24 25

		Loamy slope 12-16"P.Z. Loamy Slope 14+"P.Z. North Slope 14+P.Z. Pocket Meadow (atypical) Shallow Loam 14-16"P.Z. South Slope 12-14"P.Z. South Slope 12-16"P.Z. South Slope 14-18"P.Z. Steep North Slope (atypical) Stony Loam 12-14"P.Z.	025XY012NV 024XY032NV 024XY023NV 025XY063NV 025XY042NV 025XY009NV 024XY029NV 025XY016NV 025XY010NV 025XY082NV	
Montane Sagebrush Steppe-subalpine (MSSs)	11261	Loamy Slope 16+P.Z. Shallow Loam 16+"P.Z.	025XY012NV 025XY076NV	24 25
Montane Sagebrush Steppe-upland (MSSup)	11260	Clay Seep (atypical) Loamy 12-14"P.Z. Loamy 14-16"P.Z Loamy slope 12-16"P.Z. Pocket Meadow (atypical) Shallow Loam 14-16"P.Z. South Slope 12-14"P.Z. South Slope 14-18"P.Z. Steep North Slope (atypical) Stony Loam 12-14"P.Z.	025XY047NV 025XY027NV 025XY056NV 025XY012NV 025XY063NV 025XY042NV 025XY009NV 025XY016NV 025XY010NV 025XY082NV	25
Mountain Shrub (MSh)	11060	Bouldery Loam Ceanothus Thicket Fractured Stony Loam 14+"P.Z. Gravelly Claypan 12-16"P.Z. Gravelly Loam 16+"P.Z. Snowfield Stony Loam14+"P.Z.	025XY058NV 025XY052NV 025XY046NV 025XY023NV 025XY072NV 025XY080NV 024XY034NV	24 25
Owyhee River Riparian	11542	POBAT WSG:6W1610 Stream Terrace	025XY074NV 025XY062NV	25
Saline Meadow (SM)	11451	Saline Meadow Sodic Floodplain Wet Sodic Flat	024XY009NV 024XY010NV 024XY044NV	24
Subalpine Fir-Spruce (SF)	10550	ABLA WSG:4R2207	025XY078NV	
Subalpine-Upper Montane Grassland	11400	Snowpocket Subalpine Snowpocket	025XY028NV 025XY077NV	25
Wet Meadow (WM) (montane)	11450	Dry Meadow Wet Meadow	025XY006NV 025XY005NV	25
Wet Meadow-bottomland (WMb)	11452	Wet Meadow 6-8" P.Z.	024XY043NV	24 25
Wet Meadow-montane (WMm)	11450	Dry Meadow Wet Meadow	025XY006NV 025XY005NV	25
Wetland	11543	None		
Winterfat (WF)	10812	Coarse silty 4-8"P.Z Silty 4-8"P.Z. Silty 8-10"P.Z.	024XY014NV 024XY004NV 024XY059NV	24

Appendix 3
Python resampling script for 5m to 60m raster resolution

```
#-------------------------------------------------------------------------------
# Name:        Newmont_Resampling
# Purpose:     Resample land cover raster from 5-m to 60-m resolution, while prioritizing/preserving
select systems and classes.
# Author:      nwelch
# Modified:    2015/04/06
#-------------------------------------------------------------------------------

# Import ArcGIS modules
import arcpy
from arcpy import env
from arcpy.sa import *

# Make sure the Spatial Analyst extension is on
arcpy.CheckOutExtension("spatial")

# Set environment settings
env.workspace = r"K:\GIS3\Projects\Sage_Grouse\Geodata\Scripts\tempnwelch"
Workspace = env.workspace
env.overwriteOutput = True

# Cast rasters and set local variables
orig_rast = arcpy.Raster("tshs_5m_sysxcla_20150330_old.tif")
rule_table = "tshs_5m_ranks_20150406.dbf"
mask_60m = arcpy.Raster("tshs_mask_20150330.tif")

# Create and save a new raster based on the Ecological System x Vegetation Class field
orig_lu = arcpy.sa.Lookup(orig_rast, "SYSXCLA")
orig_lu.save("orig_lu")

# Join raster with table holding priority codes
arcpy.JoinField_management("orig_lu", "SYSXCLA", rule_table, "SYSXCLA", ["PRIOR"])

# Create and save a new raster based on the priority code field
prior_lu = arcpy.sa.Lookup("orig_lu", "PRIOR")
prior_lu.save("prior_lu")

# Extract values with non-zero priority codes, execute block statistics (maximum) with 60-m window,
and resample at 60 m resolution
priorityExtract = ExtractByAttributes("prior_lu", "VALUE > 0")
priorityExtract.save("prior_extr")
nbr = NbrRectangle(12,12,"CELL")
priorityBlockStat = BlockStatistics("prior_extr", nbr, "MAXIMUM", "DATA")
priorityBlockStat.save("prior_blst")
arcpy.Resample_management("prior_blst", "prior_resamp", "60", "NEAREST")
arcpy.JoinField_management("prior_resamp", "Value", "orig_lu", "PRIOR", ["VALUE"])
```

```
prior_lu2 = arcpy.sa.Lookup("prior_resamp", "VALUE_1")
prior_lu2.save("prior_resamp2")
# Run Majority Filter on original raster w/o regard to PRIORITY codes, then resample at 60-m
resolution
outMajFilt = MajorityFilter("orig_lu", "FOUR", "MAJORITY")
outMajFilt.save("orig_majfil")
arcpy.Resample_management("orig_majfil", "orig_resamp", "60", "NEAREST")

# Mosaic resampled rasters (order is important), join other fields, and extract with 60-m mask
arcpy.MosaicToNewRaster_management("prior_resamp2; orig_resamp", Workspace, "mosaic_60m",
"", "32_BIT_SIGNED", 60, 1, "FIRST", "")
arcpy.JoinField_management("mosaic_60m", "Value", "orig_lu", "Value", ["SYSXCLA"])
arcpy.JoinField_management("mosaic_60m", "SYSXCLA", orig_rast, "SYSXCLA", ["SYS_NAME",
"SYS_CODE", "CLA_NAME", "CLA_CODE"])
outExtractByMask = ExtractByMask("mosaic_60m", mask_60m)
outExtractByMask.save("SYSXCLA_60m.tif")
```

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

From Vegetation Type	From Class	To Class	Transition Type	Prob	Propn	Age Min	Age Max	Age Shift	Age Reset	TST Min	TST Max
Aspen Woodland	1-Early:Closed	1-Early:Closed	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990	3			Yes	12	
Aspen Woodland	1-Early:Closed	1-Early:Closed	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990	3			Yes	12	
Aspen Woodland	1-Early:Closed	1-Early:Closed	Fence	0.0100					No	11	
Aspen Woodland	1-Early:Closed	1-Early:Closed	Late-Cattle-Grazing_0dd-Yr	0.0400	0.9995	3			Yes	12	
Aspen Woodland	1-Early:Closed	1-Early:Closed	Late-Cattle-Grazing_Even-Yr	0.0400	0.9995	3			Yes	12	
Aspen Woodland	1-Early:Closed	1-Early:Closed	NativeGrazing	0.0020					Yes		
Aspen Woodland	1-Early:Closed	1-Early:Closed	ReplacementFire	0.0200	0.2000				Yes		
Aspen Woodland	1-Early:Closed	U:ASP->MSS	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010	3			No	12	
Aspen Woodland	1-Early:Closed	U:ASP->MSS	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010	3			No	12	
Aspen Woodland	1-Early:Closed	U:ASP->MSS	Late-Cattle-Grazing_0dd-Yr	0.0400	0.0005	3			No	12	
Aspen Woodland	1-Early:Closed	U:ASP->MSS	Late-Cattle-Grazing_Even-Yr	0.0400	0.0005	3			No	12	
Aspen Woodland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010			1	No	12	
Aspen Woodland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990				No	12	
Aspen Woodland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010			1	No	12	
Aspen Woodland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990				No	12	
Aspen Woodland	2-Mid:Closed	1-Early:Closed	ReplacementFire	0.0200	0.2000				Yes		
Aspen Woodland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.0400	0.0005			0	No	12	
Aspen Woodland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.0400	0.9995				No	12	
Aspen Woodland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0400	0.0005			0	No	12	
Aspen Woodland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0400	0.9995				No	12	
Aspen Woodland	3-Late:Closed	1-Early:Closed	Chainsaw-Thinning	0.0100		60			Yes		
Aspen Woodland	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010			1	No	12	
Aspen Woodland	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990				No	12	
Aspen Woodland	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010			1	No	12	
Aspen Woodland	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990				No	12	
Aspen Woodland	3-Late:Closed	1-Early:Closed	Insect/Disease	0.0050	0.2000				Yes		
Aspen Woodland	3-Late:Closed	1-Early:Closed	ReplacementFire	0.0200	0.5000				Yes		
Aspen Woodland	3-Late:Closed	3-Late:Closed	Insect/Disease	0.0050	0.8000			-1	No		
Aspen Woodland	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0400	0.0005			0	No	12	
Aspen Woodland	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0400	0.9995				No	12	
Aspen Woodland	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0400	0.0005			0	No	12	
Aspen Woodland	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0400	0.9995				No	12	
Aspen Woodland	4-Late:Open	1-Early:Closed	Chainsaw-Thinning	0.0100					Yes		
Aspen Woodland	4-Late:Open	1-Early:Closed	Senescence	0.0100		150			Yes		
Aspen Woodland	4-Late:Open	4-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990				No	12	
Aspen Woodland	4-Late:Open	4-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990				No	12	
Aspen Woodland	4-Late:Open	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010				No	12	
Aspen Woodland	4-Late:Open	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010				No	12	
Aspen Woodland	4-Late:Open	1-Early:Closed	ReplacementFire	0.0200	0.5000				Yes		
Aspen Woodland	4-Late:Open	1-Early:Closed	RxFire	0.0100	0.7000				Yes		
Aspen Woodland	4-Late:Open	3-Late:Closed	Insect/Disease	0.0030					Yes		
Aspen Woodland	4-Late:Open	4-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0400	0.9995				No	12	
Aspen Woodland	4-Late:Open	4-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0400	0.9995				No	12	
Aspen Woodland	4-Late:Open	4-Late:Open	MixedFire	0.0020					Yes		
Aspen Woodland	4-Late:Open	4-Late:Open	RxFire	0.0100	0.3000				No		
Aspen Woodland	4-Late:Open	U:Depleted	Late-Cattle-Grazing_0dd-Yr	0.0400	0.0005				No	12	
Aspen Woodland	4-Late:Open	U:Depleted	Late-Cattle-Grazing_Even-Yr	0.0400	0.0005				No	12	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Aspen Woodland	U:Depleted	2-Mid:Closed	Natural-Recovery	1.0000	0.5000			Yes	10
Aspen Woodland	U:Depleted	3-Late:Closed	Natural-Recovery	1.0000	0.5000			Yes	10
Aspen Woodland	U:Depleted	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990			No	12
Aspen Woodland	U:Depleted	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990			No	12
Aspen Woodland	U:Depleted	U:Depleted	Fence	0.0100				No	11
Aspen Woodland	U:Depleted	1-Early:Closed	Chainsaw-Thinning	0.0000	0.7000			Yes	
Aspen Woodland	U:Depleted	1-Early:Closed	Insect/Disease	0.0033	0.8000			Yes	
Aspen Woodland	U:Depleted	1-Early:Closed	ReplacementFire	0.0200	0.7000			Yes	
Aspen Woodland	U:Depleted	1-Early:Closed	RxFire	0.0100	0.5000			Yes	
Aspen Woodland	U:Depleted	1-Early:Closed	Severe-Drought	0.0070	0.1000			Yes	
Aspen Woodland	U:Depleted	U:ASP->MSS	Chainsaw-Thinning	0.0000	0.0750		10	Yes	
Aspen Woodland	U:Depleted	U:ASP->MSS	Chainsaw-Thinning	0.0000	0.1500		5	Yes	
Aspen Woodland	U:Depleted	U:ASP->MSS	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010		5	Yes	12
Aspen Woodland	U:Depleted	U:ASP->MSS	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010		5	Yes	12
Aspen Woodland	U:Depleted	U:ASP->MSS	Insect/Disease	0.0033	0.1000		10	Yes	
Aspen Woodland	U:Depleted	U:ASP->MSS	Late-Cattle-Grazing_0dd-Yr	0.0400	0.0005		5	Yes	12
Aspen Woodland	U:Depleted	U:ASP->MSS	Late-Cattle-Grazing_Even-Yr	0.0400	0.0005		5	Yes	12
Aspen Woodland	U:Depleted	U:ASP->MSS	LosingClone	0.1000	1.0000	250	40	Yes	
Aspen Woodland	U:Depleted	U:ASP->MSS	ReplacementFire	0.0200	0.1500			Yes	
Aspen Woodland	U:Depleted	U:ASP->MSS	RxFire	0.0100	0.1000			Yes	
Aspen Woodland	U:Depleted	U:ASP->MSS	Severe-Drought	0.0070	0.4500		10	Yes	
Aspen Woodland	U:Depleted	U:Depleted	Late-Cattle-Grazing_0dd-Yr	0.0400	0.9995			No	12
Aspen Woodland	U:Depleted	U:Depleted	Late-Cattle-Grazing_Even-Yr	0.0400	0.9995			No	12
Aspen Woodland	U:Depleted	U:Depleted	RxFire	0.0100	0.3000			No	
Aspen-Mixed Conifer	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0090	0.9990	3	1	No	12
Aspen-Mixed Conifer	1-Early:All	1-Early:All	ReplacementFire	0.0200	0.1000			Yes	
Aspen-Mixed Conifer	1-Early:All	1-Early:All	Avalanches	0.1400	0.0010			Yes	
Aspen-Mixed Conifer	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0090	0.9990	3	1	No	12
Aspen-Mixed Conifer	1-Early:All	1-Early:All	Fence	0.0100				No	11
Aspen-Mixed Conifer	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0100	0.9995	3	0	No	12
Aspen-Mixed Conifer	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0100	0.9995	3	0	No	12
Aspen-Mixed Conifer	1-Early:All	1-Early:All	NativeGrazing	0.0020	0.9500			Yes	
Aspen-Mixed Conifer	1-Early:All	U:ASM->SF	Early-Cattle-Grazing_0dd-Yr	0.0090	0.0010	3		No	12
Aspen-Mixed Conifer	1-Early:All	U:ASM->SF	Early-Cattle-Grazing_Even-Yr	0.0090	0.0010	3		No	12
Aspen-Mixed Conifer	1-Early:All	U:ASM->SF	Late-Cattle-Grazing_0dd-Yr	0.0100	0.0005	3		No	12
Aspen-Mixed Conifer	1-Early:All	U:ASM->SF	Late-Cattle-Grazing_Even-Yr	0.0100	0.0005	3		No	12
Aspen-Mixed Conifer	1-Early:All	U:ASM->SF	NativeGrazing	0.0020	0.0500			Yes	
Aspen-Mixed Conifer	2-Mid:Closed	1-Early:All	ReplacementFire	0.0200	0.2500			Yes	
Aspen-Mixed Conifer	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.0090	0.0010		1	No	12
Aspen-Mixed Conifer	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.0090	0.9990			No	12
Aspen-Mixed Conifer	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0090	0.0010		1	No	12
Aspen-Mixed Conifer	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0090	0.9990			No	12
Aspen-Mixed Conifer	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.0100	0.0005		0	No	12
Aspen-Mixed Conifer	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.0100	0.9995			No	12
Aspen-Mixed Conifer	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0100	0.0005		0	No	12
Aspen-Mixed Conifer	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0100	0.9995			No	12
Aspen-Mixed Conifer	2-Mid:Closed	1-Early:All	Avalanches	0.1400	0.0010			Yes	0
Aspen-Mixed Conifer	3-Late:Closed	1-Early:All	ReplacementFire	0.0200	0.5000				
Aspen-Mixed Conifer	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0090	0.0010		1	No	12

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Aspen-Mixed Conifer	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Odd-Yr	0.0090	0.9990			No	12
Aspen-Mixed Conifer	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0090	0.0010		1	No	12
Aspen-Mixed Conifer	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0090	0.9990			No	12
Aspen-Mixed Conifer	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Odd-Yr	0.0100	0.0005		0	No	12
Aspen-Mixed Conifer	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Odd-Yr	0.0100	0.9995			No	12
Aspen-Mixed Conifer	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0100	0.0005		0	No	12
Aspen-Mixed Conifer	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0100	0.9995			No	12
Aspen-Mixed Conifer	3-Late:Closed	1-Early:All	Avalanches	0.1400	0.0010			Yes	
Aspen-Mixed Conifer	3-Late:Closed	1-Early:All	Insect/Disease	0.0050	0.2000			Yes	
Aspen-Mixed Conifer	3-Late:Closed	2-Mid:Closed	MixedFire	0.0150				Yes	
Aspen-Mixed Conifer	3-Late:Closed	3-Late:Closed	Insect/Disease	0.0050	0.8000		-1	No	
Aspen-Mixed Conifer	4-Late:Open	4-Late:Open	Competition	0.0010			-10	No	
Aspen-Mixed Conifer	4-Late:Open	4-Late:Open	Insect/Disease	0.0020				Yes	
Aspen-Mixed Conifer	4-Late:Open	1-Early:All	Avalanches	0.1400	0.0010			Yes	
Aspen-Mixed Conifer	4-Late:Open	1-Early:All	ReplacementFire	0.0200				Yes	
Aspen-Mixed Conifer	4-Late:Open	1-Early:All	RxFire	0.0100	0.7000			Yes	
Aspen-Mixed Conifer	4-Late:Open	3-Late:Closed	Chainsaw-Thinning	0.0100				Yes	
Aspen-Mixed Conifer	4-Late:Open	4-Late:Open	RxFire	0.0100	0.3000			No	
Aspen-Mixed Conifer	4-Late:Open	4-Late:Open	SurfaceFire	0.0024				No	
Aspen-Mixed Conifer	5-Late:Closed	4-Late:Open	Severe-Drought	0.0070				Yes	
Aspen-Mixed Conifer	5-Late:Closed	5-Late:Closed	SurfaceFire	0.0014				No	
Aspen-Mixed Conifer	5-Late:Closed	1-Early:All	Avalanches	0.1400	0.0010			Yes	
Aspen-Mixed Conifer	5-Late:Closed	1-Early:All	Chainsaw-Thinning	0.0100	0.6700	150		Yes	
Aspen-Mixed Conifer	5-Late:Closed	1-Early:All	Insect/Disease	0.0040				Yes	
Aspen-Mixed Conifer	5-Late:Closed	1-Early:All	ReplacementFire	0.0200				Yes	
Aspen-Mixed Conifer	5-Late:Closed	1-Early:All	RxFire	0.0100	0.7000			Yes	
Aspen-Mixed Conifer	5-Late:Closed	5-Late:Closed	RxFire	0.0100	0.3000			No	
Aspen-Mixed Conifer	5-Late:Closed	U:ASM->SF	LosingClone	0.0100		250	130	Yes	
Basin Wildrye-bottomland	1-Early:Open	1-Early:Open	Flooding-100yr	0.0100			5	Yes	
Basin Wildrye-bottomland	1-Early:Open	1-Early:Open	Severe-Drought	0.0070				Yes	
Basin Wildrye-bottomland	1-Early:Open	1-Early:Open	Early-Cattle-Grazing_Odd-Yr	0.0290	0.9990	3	1	No	
Basin Wildrye-bottomland	1-Early:Open	1-Early:Open	Early-Cattle-Grazing_Even-Yr	0.0290	0.9990	3	1	No	
Basin Wildrye-bottomland	1-Early:Open	1-Early:Open	Late-Cattle-Grazing_Odd-Yr	0.0330		3	0	No	
Basin Wildrye-bottomland	1-Early:Open	1-Early:Open	Late-Cattle-Grazing_Even-Yr	0.0330		3	0	No	
Basin Wildrye-bottomland	1-Early:Open	1-Early:Open	ReplacementFire	0.0200				Yes	
Basin Wildrye-bottomland	1-Early:Open	1-Early:Open	Weed-Inventory+Spot-Treat	0.0100				No	3
Basin Wildrye-bottomland	1-Early:Open	U:Early Shrub	Early-Cattle-Grazing_Odd-Yr	0.0290	0.0010	3		No	
Basin Wildrye-bottomland	1-Early:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0290	0.0010	3		No	
Basin Wildrye-bottomland	1-Early:Open	U:Exotic Forbs	Exotic-Invasion	0.0010		5		Yes	5
Basin Wildrye-bottomland	2-Mid:Closed	1-Early:Open	Flooding-100yr	0.0100			5	Yes	
Basin Wildrye-bottomland	2-Mid:Closed	1-Early:Open	ReplacementFire	0.0250				Yes	
Basin Wildrye-bottomland	2-Mid:Closed	1-Early:Open	Severe-Drought	0.0070			5	Yes	
Basin Wildrye-bottomland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Odd-Yr	0.0290	0.9990		1	No	
Basin Wildrye-bottomland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0290	0.9990		1	No	
Basin Wildrye-bottomland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Odd-Yr	0.0330			0	No	
Basin Wildrye-bottomland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0330			0	No	
Basin Wildrye-bottomland	2-Mid:Closed	2-Mid:Closed	Weed-Inventory+Spot-Treat	0.0100				No	3
Basin Wildrye-bottomland	2-Mid:Closed	U:ASPG	AS-Invasion	0.0010				No	
Basin Wildrye-bottomland	2-Mid:Closed	U:Early Shrub	Early-Cattle-Grazing_Odd-Yr	0.0290	0.0010			No	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Basin Wildrye-bottomland	2-Mid:Closed	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0290	0.0010			No	
Basin Wildrye-bottomland	2-Mid:Closed	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes	5
Basin Wildrye-bottomland	3-Late:Open	1-Early:Open	Flooding-100yr	0.0100			5	Yes	
Basin Wildrye-bottomland	3-Late:Open	1-Early:Open	ReplacementFire	0.0150				Yes	
Basin Wildrye-bottomland	3-Late:Open	1-Early:Open	RxFire	0.0100				Yes	
Basin Wildrye-bottomland	3-Late:Open	2-Mid:Closed	Severe-Drought	0.0070	0.1000			Yes	
Basin Wildrye-bottomland	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0290	0.9990		1	No	
Basin Wildrye-bottomland	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0290	0.9990		1	No	
Basin Wildrye-bottomland	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0330			0	No	
Basin Wildrye-bottomland	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0330			0	No	
Basin Wildrye-bottomland	3-Late:Open	3-Late:Open	Severe-Drought	0.0070	0.9000			Yes	
Basin Wildrye-bottomland	3-Late:Open	3-Late:Open	Weed-Inventory+Spot-Treat	0.0100				No	3
Basin Wildrye-bottomland	3-Late:Open	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0290	0.0010			No	
Basin Wildrye-bottomland	3-Late:Open	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0290	0.0010			No	
Basin Wildrye-bottomland	3-Late:Open	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes	5
Basin Wildrye-bottomland	3-Late:Open	U:SAP	AS-Invasion	0.0025				No	
Basin Wildrye-bottomland	U:Annual Spp	U:Annual Spp	Flooding-100yr	0.0100				Yes	
Basin Wildrye-bottomland	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Seed	0.0100	0.2000			Yes	
Basin Wildrye-bottomland	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000				Yes	2
Basin Wildrye-bottomland	U:Annual Spp	U:Annual Spp	Weed-Inventory+Spot-Treat	0.0100				No	3
Basin Wildrye-bottomland	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes	5
Basin Wildrye-bottomland	U:Annual Spp	U:Seeded Native	Herbicide-Plateau+Seed	0.0100	0.8000			Yes	
Basin Wildrye-bottomland	U:ASPG	1-Early:Open	Herbicide-Plateau+Seed	0.0100	0.8000			Yes	
Basin Wildrye-bottomland	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0290	0.9990	3	1	No	
Basin Wildrye-bottomland	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0290	0.9990	3	1	No	
Basin Wildrye-bottomland	U:ASPG	U:ASPG	Flooding-100yr	0.0100			5	Yes	
Basin Wildrye-bottomland	U:ASPG	U:ASPG	Herbicide-Plateau+Seed	0.0100	0.2000			Yes	
Basin Wildrye-bottomland	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0330		3	0	No	
Basin Wildrye-bottomland	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0330		3	0	No	
Basin Wildrye-bottomland	U:ASPG	U:ASPG	ReplacementFire	0.0400				Yes	2
Basin Wildrye-bottomland	U:ASPG	U:ASPG	Severe-Drought	0.0070			5	Yes	
Basin Wildrye-bottomland	U:ASPG	U:ASPG	Weed-Inventory+Spot-Treat	0.0100				No	3
Basin Wildrye-bottomland	U:ASPG	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0290	0.0010	3		No	
Basin Wildrye-bottomland	U:ASPG	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0290	0.0010	3		No	
Basin Wildrye-bottomland	U:ASPG	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes	5
Basin Wildrye-bottomland	U:Depleted	U:Depleted	Weed-Inventory+Spot-Treat	0.0100				No	3
Basin Wildrye-bottomland	U:Depleted	U:Early Shrub	Flooding-100yr	0.0100				Yes	
Basin Wildrye-bottomland	U:Depleted	U:Early Shrub	Masticate+Plateau+NativeSeed	0.0100	0.3000			Yes	
Basin Wildrye-bottomland	U:Depleted	U:Early Shrub	ReplacementFire	0.0100				Yes	
Basin Wildrye-bottomland	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes	5
Basin Wildrye-bottomland	U:Depleted	U:SAP	AS-Invasion	0.0050				No	
Basin Wildrye-bottomland	U:Depleted	U:Seeded Native	Masticate+Plateau+NativeSeed	0.0100	0.7000			Yes	
Basin Wildrye-bottomland	U:Early Shrub	1-Early:Open	ReplacementFire	0.0150	0.0500			Yes	
Basin Wildrye-bottomland	U:Early Shrub	U:Annual Spp	Masticate+24D+Plateau+NativeSeed	0.0100	0.1000			Yes	
Basin Wildrye-bottomland	U:Early Shrub	U:Annual Spp	Severe-Drought	0.0070	0.1000			Yes	
Basin Wildrye-bottomland	U:Early Shrub	U:Early Shrub	Masticate+24D+Plateau+NativeSeed	0.0100	0.1000			Yes	
Basin Wildrye-bottomland	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0150	0.9500			Yes	
Basin Wildrye-bottomland	U:Early Shrub	U:Early Shrub	Severe-Drought	0.0070	0.9000			Yes	
Basin Wildrye-bottomland	U:Early Shrub	U:Early Shrub	Weed-Inventory+Spot-Treat	0.0100				No	3

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Basin Wildrye-bottomland	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5	
Basin Wildrye-bottomland	U:Early Shrub	U:Seeded Native	Masticate+24D+Plateau+NativeSeed	0.0100	0.8000				Yes		
Basin Wildrye-bottomland	U:Exotic Forbs	1-Early:Open	Exotic-Control	0.0100	0.5000				Yes		20
Basin Wildrye-bottomland	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0290				1	No		
Basin Wildrye-bottomland	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0290				1	No		
Basin Wildrye-bottomland	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.5000				Yes		20
Basin Wildrye-bottomland	U:Exotic Forbs	U:Exotic Forbs	Flooding-100yr	0.0100				5	Yes		
Basin Wildrye-bottomland	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0330				0	No		
Basin Wildrye-bottomland	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0330				0	No		
Basin Wildrye-bottomland	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0200					Yes		
Basin Wildrye-bottomland	U:Exotic Forbs	U:Exotic Forbs	Wild-Horse-Grazing	0.0330				1	No		
Basin Wildrye-bottomland	U:SAP	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0290	0.0010				Yes		
Basin Wildrye-bottomland	U:SAP	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0290	0.0010				Yes		
Basin Wildrye-bottomland	U:SAP	U:Annual Spp	Masticate+Plateau+NativeSeed	0.0100	0.1000				Yes		
Basin Wildrye-bottomland	U:SAP	U:Annual Spp	ReplacementFire	0.0250	0.5000				Yes		
Basin Wildrye-bottomland	U:SAP	U:Annual Spp	Severe-Drought	0.0070	0.0500				Yes		
Basin Wildrye-bottomland	U:SAP	U:Annual Spp	Thin+Seed	0.0100	0.1000				Yes		
Basin Wildrye-bottomland	U:SAP	U:ASPG	Flooding-100yr	0.0100				5	Yes		
Basin Wildrye-bottomland	U:SAP	U:ASPG	Masticate+Plateau+NativeSeed	0.0100	0.1000				Yes		
Basin Wildrye-bottomland	U:SAP	U:ASPG	ReplacementFire	0.0250	0.5000				Yes		
Basin Wildrye-bottomland	U:SAP	U:ASPG	Severe-Drought	0.0070	0.0500				Yes		
Basin Wildrye-bottomland	U:SAP	U:ASPG	Thin+Seed	0.0100	0.1000				Yes		
Basin Wildrye-bottomland	U:SAP	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5	
Basin Wildrye-bottomland	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0290	0.9990			1	No		
Basin Wildrye-bottomland	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0290	0.9990			1	No		
Basin Wildrye-bottomland	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0330				0	No		
Basin Wildrye-bottomland	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0330				0	No		
Basin Wildrye-bottomland	U:SAP	U:SAP	Severe-Drought	0.0070	0.9000				Yes		
Basin Wildrye-bottomland	U:SAP	U:SAP	Weed-Inventory+Spot-Treat	0.0100					No	3	
Basin Wildrye-bottomland	U:SAP	U:SDI	Thin+Seed	0.0100	0.8000				Yes		
Basin Wildrye-bottomland	U:SAP	U:Seeded Native	Masticate+Plateau+NativeSeed	0.0100	0.8000				Yes		
Basin Wildrye-bottomland	U:SDI	2-Mid:Closed	Natural-Recovery	0.0010		10	74		No	10	
Basin Wildrye-bottomland	U:SDI	3-Late:Open	Natural-Recovery	0.0100		75			No	10	
Basin Wildrye-bottomland	U:SDI	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5	
Basin Wildrye-bottomland	U:SDI	U:SDI	Early-Cattle-Grazing_0dd-Yr	0.0290		3		1	No		
Basin Wildrye-bottomland	U:SDI	U:SDI	Early-Cattle-Grazing_Even-Yr	0.0290		3		1	No		
Basin Wildrye-bottomland	U:SDI	U:SDI	Flooding-100yr	0.0100				5	Yes		
Basin Wildrye-bottomland	U:SDI	U:SDI	Late-Cattle-Grazing_0dd-Yr	0.0330		3		0	No		
Basin Wildrye-bottomland	U:SDI	U:SDI	Late-Cattle-Grazing_Even-Yr	0.0330		3		0	No		
Basin Wildrye-bottomland	U:SDI	U:SDI	ReplacementFire	0.0010					Yes		
Basin Wildrye-bottomland	U:SDI	U:SDI	Weed-Inventory+Spot-Treat	0.0100					No	3	
Basin Wildrye-bottomland	U:SDI	U:SDI+AS	AS-Invasion	0.0010					No		
Basin Wildrye-bottomland	U:SDI+AS	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5	
Basin Wildrye-bottomland	U:SDI+AS	U:SDI	Competition	0.3300					No	3	
Basin Wildrye-bottomland	U:SDI+AS	U:SDI	Herbicide-Plateau+Seed	0.0100	0.8000				No		
Basin Wildrye-bottomland	U:SDI+AS	U:SDI+AS	Early-Cattle-Grazing_0dd-Yr	0.0290				1	No		
Basin Wildrye-bottomland	U:SDI+AS	U:SDI+AS	Early-Cattle-Grazing_Even-Yr	0.0290				1	No		
Basin Wildrye-bottomland	U:SDI+AS	U:SDI+AS	Flooding-100yr	0.0100				5	Yes		
Basin Wildrye-bottomland	U:SDI+AS	U:SDI+AS	Herbicide-Plateau+Seed	0.0100	0.2000				No		

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Basin Wildrye-bottomland	U:SDI+AS	U:SDI+AS	Late-Cattle-Grazing_0dd-Yr	0.0330				0	No	
Basin Wildrye-bottomland	U:SDI+AS	U:SDI+AS	Late-Cattle-Grazing_Even-Yr	0.0330				0	No	
Basin Wildrye-bottomland	U:SDI+AS	U:SDI+AS	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-bottomland	U:SDI+AS	U:SDI+AS	Wet-Year	0.0670					No	
Basin Wildrye-bottomland	U:Seeded Native	1-Early:Open	Natural-Recovery	0.3300			9		No	5
Basin Wildrye-bottomland	U:Seeded Native	2-Mid:Closed	Natural-Recovery	0.3300		10	74		No	5
Basin Wildrye-bottomland	U:Seeded Native	3-Late:Open	Natural-Recovery	0.3300		75			No	5
Basin Wildrye-bottomland	U:Seeded Native	U:ASPG	AS-Invasion	0.0050					No	
Basin Wildrye-bottomland	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0290	0.0010	3			Yes	
Basin Wildrye-bottomland	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0290	0.0010	3			Yes	
Basin Wildrye-bottomland	U:Seeded Native	U:Early Shrub	Severe-Drought	0.0070	0.1000		9		Yes	
Basin Wildrye-bottomland	U:Seeded Native	U:Exotic Forbs	Exotic-Invasion	0.0010		5			No	5
Basin Wildrye-bottomland	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_0dd-Yr	0.0290	0.9990	3		1	No	
Basin Wildrye-bottomland	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Even-Yr	0.0290	0.9990	3		1	No	
Basin Wildrye-bottomland	U:Seeded Native	U:Seeded Native	Flooding-100yr	0.0100				5	Yes	
Basin Wildrye-bottomland	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_0dd-Yr	0.0330		3		0	No	
Basin Wildrye-bottomland	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Even-Yr	0.0330		3		0	No	
Basin Wildrye-bottomland	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0050					Yes	
Basin Wildrye-bottomland	U:Seeded Native	U:Seeded Native	Severe-Drought	0.0070		10		10	Yes	
Basin Wildrye-bottomland	U:Seeded Native	U:Seeded Native	Severe-Drought	0.0070	0.9000		9		Yes	
Basin Wildrye-bottomland	U:Seeded Native	U:Seeded Native	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-montane	1-Early:Open	1-Early:Open	Severe-Drought	0.0070					Yes	
Basin Wildrye-montane	1-Early:Open	1-Early:Open	Wild-Horse-Grazing	0.1000	0.9990			1	No	
Basin Wildrye-montane	1-Early:Open	U:Early Shrub	Wild-Horse-Grazing	0.1000	0.0010				Yes	
Basin Wildrye-montane	1-Early:Open	1-Early:Open	Early-Cattle-Grazing_0dd-Yr	0.0880	0.9990	3		1	No	
Basin Wildrye-montane	1-Early:Open	1-Early:Open	Early-Cattle-Grazing_Even-Yr	0.0880	0.9990	3		1	No	
Basin Wildrye-montane	1-Early:Open	1-Early:Open	Late-Cattle-Grazing_0dd-Yr	0.1000		3		0	No	
Basin Wildrye-montane	1-Early:Open	1-Early:Open	Late-Cattle-Grazing_Even-Yr	0.1000		3		0	No	
Basin Wildrye-montane	1-Early:Open	1-Early:Open	ReplacementFire	0.0200					Yes	
Basin Wildrye-montane	1-Early:Open	1-Early:Open	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-montane	1-Early:Open	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0880	0.0010	3			No	
Basin Wildrye-montane	1-Early:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0880	0.0010	3			No	
Basin Wildrye-montane	1-Early:Open	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5
Basin Wildrye-montane	2-Mid:Closed	2-Mid:Closed	Wild-Horse-Grazing	0.1000	0.9990			1	No	
Basin Wildrye-montane	2-Mid:Closed	U:Early Shrub	Wild-Horse-Grazing	0.1000	0.0010				Yes	
Basin Wildrye-montane	2-Mid:Closed	1-Early:Open	ReplacementFire	0.0250					Yes	
Basin Wildrye-montane	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.0880	0.9990			1	No	
Basin Wildrye-montane	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0880	0.9990			1	No	
Basin Wildrye-montane	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.1000				0	No	
Basin Wildrye-montane	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.1000				0	No	
Basin Wildrye-montane	2-Mid:Closed	2-Mid:Closed	Severe-Drought	0.0070					Yes	
Basin Wildrye-montane	2-Mid:Closed	2-Mid:Closed	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-montane	2-Mid:Closed	U:ASPG	AS-Invasion	0.0010					No	
Basin Wildrye-montane	2-Mid:Closed	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0880	0.0010				No	
Basin Wildrye-montane	2-Mid:Closed	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0880	0.0010				No	
Basin Wildrye-montane	2-Mid:Closed	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5
Basin Wildrye-montane	4-Late:Open	4-Late:Open	Wild-Horse-Grazing	0.1000	0.9990			1	No	
Basin Wildrye-montane	4-Late:Open	U:Depleted	Wild-Horse-Grazing	0.1000	0.0010				Yes	
Basin Wildrye-montane	4-Late:Open	1-Early:Open	ReplacementFire	0.0150					Yes	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Basin Wildrye-montane	4-Late:Open	1-Early:Open	RxFire	0.0100					Yes	
Basin Wildrye-montane	4-Late:Open	2-Mid:Closed	Severe-Drought	0.0070	0.1000				Yes	
Basin Wildrye-montane	4-Late:Open	2-Mid:Closed	Thin+Native-Seed	0.0100		100			Yes	
Basin Wildrye-montane	4-Late:Open	4-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0880	0.9990			1	No	
Basin Wildrye-montane	4-Late:Open	4-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0880	0.9990			1	No	
Basin Wildrye-montane	4-Late:Open	4-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.1000				0	No	
Basin Wildrye-montane	4-Late:Open	4-Late:Open	Late-Cattle-Grazing_Even-Yr	0.1000				0	No	
Basin Wildrye-montane	4-Late:Open	4-Late:Open	Severe-Drought	0.0070	0.9000				Yes	
Basin Wildrye-montane	4-Late:Open	4-Late:Open	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-montane	4-Late:Open	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0880	0.0010				No	
Basin Wildrye-montane	4-Late:Open	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0880	0.0010				No	
Basin Wildrye-montane	4-Late:Open	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5
Basin Wildrye-montane	4-Late:Open	U:SAP	AS-Invasion	0.0025					No	
Basin Wildrye-montane	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0880				1	No	
Basin Wildrye-montane	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0880				1	No	
Basin Wildrye-montane	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Seed	0.0100	0.0500				Yes	
Basin Wildrye-montane	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.1000				0	No	
Basin Wildrye-montane	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.1000				0	No	
Basin Wildrye-montane	U:Annual Spp	U:Annual Spp	Wild-Horse-Grazing	0.1000				1	No	
Basin Wildrye-montane	U:Annual Spp	U:SDI	Herbicide-Plateau+Seed	0.0100	0.9000				Yes	
Basin Wildrye-montane	U:Annual Spp	U:SDI+AS	Herbicide-Plateau+Seed	0.0100	0.0500				Yes	
Basin Wildrye-montane	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Native-Seed	0.0100	0.2000				Yes	
Basin Wildrye-montane	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes	2
Basin Wildrye-montane	U:Annual Spp	U:Annual Spp	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-montane	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5
Basin Wildrye-montane	U:Annual Spp	U:Seeded Native	Herbicide-Plateau+Native-Seed	0.0100	0.8000				Yes	
Basin Wildrye-montane	U:ASPG	U:Annual Spp	Wild-Horse-Grazing	0.1000	0.0010				Yes	
Basin Wildrye-montane	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0880	0.9990			1	No	
Basin Wildrye-montane	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0880	0.9990			1	No	
Basin Wildrye-montane	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.1000				0	No	
Basin Wildrye-montane	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.1000				0	No	
Basin Wildrye-montane	U:ASPG	U:ASPG	Severe-Drought	0.0070			9		Yes	
Basin Wildrye-montane	U:ASPG	U:ASPG	Wild-Horse-Grazing	0.1000	0.9990			1	No	
Basin Wildrye-montane	U:ASPG	1-Early:Open	Herbicide-Plateau+Native-Seed	0.0100	0.8000				Yes	
Basin Wildrye-montane	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0880	0.0010				Yes	
Basin Wildrye-montane	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0880	0.0010				Yes	
Basin Wildrye-montane	U:ASPG	U:ASPG	Herbicide-Plateau+Native-Seed	0.0100	0.2000				Yes	
Basin Wildrye-montane	U:ASPG	U:ASPG	ReplacementFire	0.0400					Yes	2
Basin Wildrye-montane	U:ASPG	U:ASPG	Severe-Drought	0.0070		10		10	Yes	
Basin Wildrye-montane	U:ASPG	U:ASPG	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-montane	U:ASPG	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5
Basin Wildrye-montane	U:Depleted	U:Depleted	Severe-Drought	0.0070	0.9000				Yes	
Basin Wildrye-montane	U:Depleted	U:Depleted	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-montane	U:Depleted	U:Early Shrub	Severe-Drought	0.0070	0.1000				Yes	
Basin Wildrye-montane	U:Depleted	U:Early Shrub	Thin+Plateau+Native-Seed	0.0100	0.2000				Yes	
Basin Wildrye-montane	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5
Basin Wildrye-montane	U:Depleted	U:Seeded Native	Thin+Plateau+Native-Seed	0.0100	0.8000				Yes	
Basin Wildrye-montane	U:Depleted	U:Early Shrub	Masticate+Plateau+NativeSeed	0.0100	0.2000				Yes	
Basin Wildrye-montane	U:Depleted	U:Early Shrub	ReplacementFire	0.0100					Yes	

Basin Wildrye-montane	U:Depleted	U:SAP	AS-Invasion	0.0050			No		
Basin Wildrye-montane	U:Depleted	U:Seeded Native	Masticate+Plateau+NativeSeed	0.0100	0.8000		Yes		
Basin Wildrye-montane	U:Early Shrub	U:Annual Spp	Thin+24D+Plateau+NativeSeed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:Early Shrub	U:Early Shrub	Thin+24D+Plateau+NativeSeed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:Early Shrub	U:Seeded Native	Thin+24D+Plateau+NativeSeed	0.0100	0.8000				
Basin Wildrye-montane	U:Early Shrub	U:Annual Spp	Masticate+24D+Plateau+NativeSeed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:Early Shrub	U:Annual Spp	Severe-Drought	0.0070	0.1000		Yes		
Basin Wildrye-montane	U:Early Shrub	U:Early Shrub	Masticate+24D+Plateau+NativeSeed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0150			Yes		
Basin Wildrye-montane	U:Early Shrub	U:Early Shrub	Severe-Drought	0.0070	0.9000		Yes		
Basin Wildrye-montane	U:Early Shrub	U:Early Shrub	Weed-Inventory+Spot-Treat	0.0100			No	3	
Basin Wildrye-montane	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0010			Yes	5	
Basin Wildrye-montane	U:Early Shrub	U:Seeded Native	Masticate+24D+Plateau+NativeSeed	0.0100	0.8000		Yes		
Basin Wildrye-montane	U:Exotic Forbs	U:Exotic Forbs	Wild-Horse-Grazing	0.1000		1	No		
Basin Wildrye-montane	U:Exotic Forbs	1-Early:Open	Exotic-Control	0.0100	0.5000		Yes		20
Basin Wildrye-montane	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0880		1	No		
Basin Wildrye-montane	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0880		1	No		
Basin Wildrye-montane	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.5000		Yes		20
Basin Wildrye-montane	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.1000		0	No		
Basin Wildrye-montane	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.1000		0	No		
Basin Wildrye-montane	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0200			Yes		
Basin Wildrye-montane	U:SAP	U:Annual Spp	Thin+Plateau+Native-Seed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:SAP	U:Annual Spp	Wild-Horse-Grazing	0.1000	0.0010		Yes		
Basin Wildrye-montane	U:SAP	U:ASPG	Masticate+Plateau+NativeSeed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:SAP	U:ASPG	ReplacementFire	0.0250	0.5000		Yes		
Basin Wildrye-montane	U:SAP	U:ASPG	Severe-Drought	0.0070	0.0500		Yes		
Basin Wildrye-montane	U:SAP	U:ASPG	Thin+Plateau+Native-Seed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:SAP	U:ASPG	Thin+Seed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:SAP	U:SAP	Wild-Horse-Grazing	0.1000	0.9990	1	No		
Basin Wildrye-montane	U:SAP	U:Seeded Native	Thin+Plateau+Native-Seed	0.0100	0.8000		Yes		
Basin Wildrye-montane	U:SAP	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0880	0.0010		Yes		
Basin Wildrye-montane	U:SAP	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0880	0.0010		Yes		
Basin Wildrye-montane	U:SAP	U:Annual Spp	Masticate+Plateau+NativeSeed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:SAP	U:Annual Spp	ReplacementFire	0.0250	0.5000		Yes		
Basin Wildrye-montane	U:SAP	U:Annual Spp	Severe-Drought	0.0070	0.0500		Yes		
Basin Wildrye-montane	U:SAP	U:Annual Spp	Thin+Seed	0.0100	0.1000		Yes		
Basin Wildrye-montane	U:SAP	U:Exotic Forbs	Exotic-Invasion	0.0010			Yes	5	
Basin Wildrye-montane	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0880	0.9990	1	No		
Basin Wildrye-montane	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0880	0.9990	1	No		
Basin Wildrye-montane	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.1000		0	No		
Basin Wildrye-montane	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.1000		0	No		
Basin Wildrye-montane	U:SAP	U:SAP	Severe-Drought	0.0070	0.9000		Yes		
Basin Wildrye-montane	U:SAP	U:SAP	Weed-Inventory+Spot-Treat	0.0100			No	3	
Basin Wildrye-montane	U:SAP	U:SDI	Thin+Seed	0.0100	0.8000		Yes		
Basin Wildrye-montane	U:SAP	U:Seeded Native	Masticate+Plateau+NativeSeed	0.0100	0.8000		Yes		
Basin Wildrye-montane	U:SDI	U:SDI	Wild-Horse-Grazing	0.1000		1	No		
Basin Wildrye-montane	U:SDI	U:Exotic Forbs	Exotic-Invasion	0.0010			Yes	5	
Basin Wildrye-montane	U:SDI	U:SDI	Early-Cattle-Grazing_0dd-Yr	0.0880		1	No		
Basin Wildrye-montane	U:SDI	U:SDI	Early-Cattle-Grazing_Even-Yr	0.0880		1	No		

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Basin Wildrye-montane	U:SDI	U:SDI	Late-Cattle-Grazing_0dd-Yr	0.1000				0	No	
Basin Wildrye-montane	U:SDI	U:SDI	Late-Cattle-Grazing_Even-Yr	0.1000				0	No	
Basin Wildrye-montane	U:SDI	U:SDI	ReplacementFire	0.0010					Yes	
Basin Wildrye-montane	U:SDI	U:SDI	Thin+Seed	0.0100		75			Yes	
Basin Wildrye-montane	U:SDI	U:SDI	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-montane	U:SDI	U:SDI+AS	AS-Invasion	0.0010					No	
Basin Wildrye-montane	U:SDI+AS	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5
Basin Wildrye-montane	U:SDI+AS	U:SDI	Competition	0.3300					No	3
Basin Wildrye-montane	U:SDI+AS	U:SDI	Herbicide-Plateau+Seed	0.0100	0.8000				No	
Basin Wildrye-montane	U:SDI+AS	U:SDI+AS	Early-Cattle-Grazing_0dd-Yr	0.0880				1	No	
Basin Wildrye-montane	U:SDI+AS	U:SDI+AS	Early-Cattle-Grazing_Even-Yr	0.0880				1	No	
Basin Wildrye-montane	U:SDI+AS	U:SDI+AS	Herbicide-Plateau+Seed	0.0100	0.2000				No	
Basin Wildrye-montane	U:SDI+AS	U:SDI+AS	Late-Cattle-Grazing_0dd-Yr	0.1000				0	No	
Basin Wildrye-montane	U:SDI+AS	U:SDI+AS	Late-Cattle-Grazing_Even-Yr	0.1000				0	No	
Basin Wildrye-montane	U:SDI+AS	U:SDI+AS	Weed-Inventory+Spot-Treat	0.0100					No	3
Basin Wildrye-montane	U:SDI+AS	U:SDI+AS	Wet-Year	0.0670					No	
Basin Wildrye-montane	U:SDI+AS	U:SDI+AS	Wild-Horse-Grazing	0.1000				1	No	
Basin Wildrye-montane	U:Seeded Native	U:Early Shrub	Severe-Drought	0.0070	0.1000		9		Yes	
Basin Wildrye-montane	U:Seeded Native	U:Early Shrub	Wild-Horse-Grazing	0.1000	0.0010				Yes	
Basin Wildrye-montane	U:Seeded Native	U:Seeded Native	Severe-Drought	0.0070		10		10	Yes	
Basin Wildrye-montane	U:Seeded Native	U:Seeded Native	Severe-Drought	0.0070	0.9000		9		Yes	
Basin Wildrye-montane	U:Seeded Native	U:Seeded Native	Wild-Horse-Grazing	0.1000	0.9990			1	No	
Basin Wildrye-montane	U:Seeded Native	1-Early:Open	Natural-Recovery	0.3300			9		No	5
Basin Wildrye-montane	U:Seeded Native	2-Mid:Closed	Natural-Recovery	0.3300		10	74		No	5
Basin Wildrye-montane	U:Seeded Native	4-Late:Open	Natural-Recovery	0.3300		75			No	5
Basin Wildrye-montane	U:Seeded Native	U:Annual Spp	AS-Invasion	0.0050					No	
Basin Wildrye-montane	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0880	0.0010	3			Yes	
Basin Wildrye-montane	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0880	0.0010	3			Yes	
Basin Wildrye-montane	U:Seeded Native	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5
Basin Wildrye-montane	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_0dd-Yr	0.0880	0.9990	3		1	No	
Basin Wildrye-montane	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Even-Yr	0.0880	0.9990	3		1	No	
Basin Wildrye-montane	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_0dd-Yr	0.1000		3		0	No	
Basin Wildrye-montane	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Even-Yr	0.1000		3		0	No	
Basin Wildrye-montane	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0050					Yes	
Basin Wildrye-montane	U:Seeded Native	U:Seeded Native	Weed-Inventory+Spot-Treat	0.0100					No	3
Big Sagebrush-semidesert	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990	3		1	No	
Big Sagebrush-semidesert	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990	3		1	No	
Big Sagebrush-semidesert	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0044		3		0	No	
Big Sagebrush-semidesert	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0044		3		0	No	
Big Sagebrush-semidesert	1-Early:All	1-Early:All	ReplacementFire	0.0040					Yes	
Big Sagebrush-semidesert	1-Early:All	U:ASPG	AS-Invasion	0.0025					No	
Big Sagebrush-semidesert	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010	3			No	
Big Sagebrush-semidesert	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010	3			No	
Big Sagebrush-semidesert	2-Mid:Open	1-Early:All	ReplacementFire	0.0083					Yes	
Big Sagebrush-semidesert	2-Mid:Open	1-Early:All	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-semidesert	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990			1	No	
Big Sagebrush-semidesert	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990			1	No	
Big Sagebrush-semidesert	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_0dd-Yr	0.0044				0	No	
Big Sagebrush-semidesert	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0044				0	No	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-semidesert	2-Mid:Open	2-Mid:Open	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-semidesert	2-Mid:Open	4-Late:Dense	Alternate-Succession	0.0001		38		Yes	
Big Sagebrush-semidesert	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010			No	
Big Sagebrush-semidesert	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010			No	
Big Sagebrush-semidesert	2-Mid:Open	U:SAP-Closed	AS-Invasion	0.0025				No	
Big Sagebrush-semidesert	3-Late:Closed	1-Early:All	Aroga-Outbreak	0.0670	0.2500		5	Yes	
Big Sagebrush-semidesert	3-Late:Closed	1-Early:All	ReplacementFire	0.0083				Yes	
Big Sagebrush-semidesert	3-Late:Closed	1-Early:All	Supplemental-Salt-Block	0.0100			5	Yes	
Big Sagebrush-semidesert	3-Late:Closed	2-Mid:Open	Aroga-Outbreak	0.0670	0.7500			Yes	
Big Sagebrush-semidesert	3-Late:Closed	2-Mid:Open	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-semidesert	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990		1	No	
Big Sagebrush-semidesert	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990		1	No	
Big Sagebrush-semidesert	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0044			0	No	
Big Sagebrush-semidesert	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0044			0	No	
Big Sagebrush-semidesert	3-Late:Closed	3-Late:Closed	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-semidesert	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010			No	
Big Sagebrush-semidesert	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010			No	
Big Sagebrush-semidesert	3-Late:Closed	U:SAP-Closed	AS-Invasion	0.0025				No	
Big Sagebrush-semidesert	4-Late:Dense	1-Early:All	Aroga-Outbreak	0.0670	0.2500		1	Yes	
Big Sagebrush-semidesert	4-Late:Dense	1-Early:All	ReplacementFire	0.0083				Yes	
Big Sagebrush-semidesert	4-Late:Dense	1-Early:All	Supplemental-Salt-Block	0.0100			5	Yes	
Big Sagebrush-semidesert	4-Late:Dense	2-Mid:Open	Aroga-Outbreak	0.0670	0.7500			Yes	
Big Sagebrush-semidesert	4-Late:Dense	3-Late:Closed	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-semidesert	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990		1	No	
Big Sagebrush-semidesert	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990		1	No	
Big Sagebrush-semidesert	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_0dd-Yr	0.0044			0	No	
Big Sagebrush-semidesert	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_Even-Yr	0.0044			0	No	
Big Sagebrush-semidesert	4-Late:Dense	4-Late:Dense	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-semidesert	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010			No	
Big Sagebrush-semidesert	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010			No	
Big Sagebrush-semidesert	4-Late:Dense	U:SAP-Dense	AS-Invasion	0.0025				No	
Big Sagebrush-semidesert	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Seed	0.0100	0.1500			No	
Big Sagebrush-semidesert	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000				Yes	2
Big Sagebrush-semidesert	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005				No	
Big Sagebrush-semidesert	U:Annual Spp	U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.7000			Yes	
Big Sagebrush-semidesert	U:Annual Spp	U:SI-A+AS	Herbicide-Plateau+Seed	0.0100	0.1500			Yes	
Big Sagebrush-semidesert	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010			No	
Big Sagebrush-semidesert	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010			No	
Big Sagebrush-semidesert	U:ASPG	U:Annual Spp	ReplacementFire	0.0100	0.5000			Yes	2
Big Sagebrush-semidesert	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990		1	No	
Big Sagebrush-semidesert	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990		1	No	
Big Sagebrush-semidesert	U:ASPG	U:ASPG	Exotic-Invasion	0.0005				No	
Big Sagebrush-semidesert	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:ASPG	U:ASPG	ReplacementFire	0.0100	0.5000			Yes	2

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-semidesert	U:ASPG	U:ASPG	Severe-Drought	0.0070	0.1000				Yes		
Big Sagebrush-semidesert	U:ASPG	U:ASPG	Severe-Drought	0.0070	0.9000			-1	No		
Big Sagebrush-semidesert	U:Depleted	U:Depleted	Aroga-Outbreak	0.0670	0.7500				Yes		
Big Sagebrush-semidesert	U:Depleted	U:Depleted	Severe-Drought	0.0070	0.9000				Yes		
Big Sagebrush-semidesert	U:Depleted	U:Early Shrub	Aroga-Outbreak	0.0670	0.2500				Yes		
Big Sagebrush-semidesert	U:Depleted	U:Early Shrub	ReplacementFire	0.0083					Yes		
Big Sagebrush-semidesert	U:Depleted	U:Early Shrub	Severe-Drought	0.0070	0.1000				No		
Big Sagebrush-semidesert	U:Depleted	U:Early Shrub	Thin+Seed	0.0100	0.2000				Yes		
Big Sagebrush-semidesert	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-semidesert	U:Depleted	U:SA-Closed	AS-Invasion	0.0050		40	79		No		
Big Sagebrush-semidesert	U:Depleted	U:SA-Dense	AS-Invasion	0.0050		80			No		
Big Sagebrush-semidesert	U:Depleted	U:SDI-A	Thin+Seed	0.0100	0.8000				Yes		
Big Sagebrush-semidesert	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0083					Yes		
Big Sagebrush-semidesert	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-semidesert	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0350				1	No		
Big Sagebrush-semidesert	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0350				1	No		
Big Sagebrush-semidesert	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.2000				Yes		20
Big Sagebrush-semidesert	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0044				0	No		
Big Sagebrush-semidesert	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0044				0	No		
Big Sagebrush-semidesert	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0100					Yes		
Big Sagebrush-semidesert	U:Exotic Forbs	U:SDI-A	Exotic-Control	0.0100	0.8000				Yes		20
Big Sagebrush-semidesert	U:SA-Closed	U:Annual Spp	Aroga-Outbreak	0.0670	0.2500	40			Yes		
Big Sagebrush-semidesert	U:SA-Closed	U:Annual Spp	ReplacementFire	0.0100			39		Yes	2	
Big Sagebrush-semidesert	U:SA-Closed	U:Annual Spp	ReplacementFire	0.0100		40			Yes		
Big Sagebrush-semidesert	U:SA-Closed	U:Annual Spp	Severe-Drought	0.0070	0.1000				No		
Big Sagebrush-semidesert	U:SA-Closed	U:Annual Spp	Thin-Plateau-Seed	0.0100	0.1000				Yes		
Big Sagebrush-semidesert	U:SA-Closed	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-semidesert	U:SA-Closed	U:SA-Closed	Aroga-Outbreak	0.0670	0.7500	40			Yes		
Big Sagebrush-semidesert	U:SA-Closed	U:SA-Closed	Early-Cattle-Grazing_0dd-Yr	0.0350				1	No		
Big Sagebrush-semidesert	U:SA-Closed	U:SA-Closed	Early-Cattle-Grazing_Even-Yr	0.0350				1	No		
Big Sagebrush-semidesert	U:SA-Closed	U:SA-Closed	Late-Cattle-Grazing_0dd-Yr	0.0044				0	No		
Big Sagebrush-semidesert	U:SA-Closed	U:SA-Closed	Late-Cattle-Grazing_Even-Yr	0.0044				0	No		
Big Sagebrush-semidesert	U:SA-Closed	U:SA-Closed	Severe-Drought	0.0070	0.9000			1	No		
Big Sagebrush-semidesert	U:SA-Closed	U:SA-Dense	Alternate-Succession	0.0001		38	39		Yes		
Big Sagebrush-semidesert	U:SA-Closed	U:SDI-A	Thin-Plateau-Seed	0.0100	0.8000				Yes		
Big Sagebrush-semidesert	U:SA-Closed	U:SI-A+AS	Thin-Plateau-Seed	0.0100	0.1000				Yes		
Big Sagebrush-semidesert	U:SA-Dense	U:Annual Spp	Aroga-Outbreak	0.0670	0.2500			1	Yes		
Big Sagebrush-semidesert	U:SA-Dense	U:Annual Spp	ReplacementFire	0.0100					Yes		
Big Sagebrush-semidesert	U:SA-Dense	U:Annual Spp	Severe-Drought	0.0070	0.0100				Yes		
Big Sagebrush-semidesert	U:SA-Dense	U:Annual Spp	Thin-Plateau-Seed	0.0100	0.1000				Yes		
Big Sagebrush-semidesert	U:SA-Dense	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-semidesert	U:SA-Dense	U:SA-Closed	Aroga-Outbreak	0.0670	0.7500			40	Yes		
Big Sagebrush-semidesert	U:SA-Dense	U:SA-Closed	Severe-Drought	0.0070	0.0900				Yes		
Big Sagebrush-semidesert	U:SA-Dense	U:SA-Dense	Early-Cattle-Grazing_0dd-Yr	0.0350				1	No		
Big Sagebrush-semidesert	U:SA-Dense	U:SA-Dense	Early-Cattle-Grazing_Even-Yr	0.0350				1	No		
Big Sagebrush-semidesert	U:SA-Dense	U:SA-Dense	Late-Cattle-Grazing_0dd-Yr	0.0044				0	No		
Big Sagebrush-semidesert	U:SA-Dense	U:SA-Dense	Late-Cattle-Grazing_Even-Yr	0.0044				0	No		
Big Sagebrush-semidesert	U:SA-Dense	U:SA-Dense	Severe-Drought	0.0070	0.9000				Yes		
Big Sagebrush-semidesert	U:SA-Dense	U:SDI-A	Thin-Plateau-Seed	0.0100	0.8000				Yes		

Big Sagebrush-semidesert	U:SA-Dense	U:SI-A+AS	Thin-Plateau-Seed	0.0100	0.1000				Yes	
Big Sagebrush-semidesert	U:SAP-Closed	1-Early:All	Supplemental-Salt-Block	0.0100	0.7000			5	Yes	
Big Sagebrush-semidesert	U:SAP-Closed	U:ASPG	Aroga-Outbreak	0.0670	0.2500	40		5	Yes	
Big Sagebrush-semidesert	U:SAP-Closed	U:ASPG	ReplacementFire	0.0100			39		Yes	2
Big Sagebrush-semidesert	U:SAP-Closed	U:ASPG	ReplacementFire	0.0100		40			Yes	
Big Sagebrush-semidesert	U:SAP-Closed	U:ASPG	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-semidesert	U:SAP-Closed	U:ASPG	Supplemental-Salt-Block	0.0100	0.3000			5	Yes	
Big Sagebrush-semidesert	U:SAP-Closed	U:Exotic Forbs	Exotic-Invasion	0.0005					No	
Big Sagebrush-semidesert	U:SAP-Closed	U:SA-Closed	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010			1	No	
Big Sagebrush-semidesert	U:SAP-Closed	U:SA-Closed	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010			1	No	
Big Sagebrush-semidesert	U:SAP-Closed	U:SAP-Closed	Aroga-Outbreak	0.0670	0.7500	40			Yes	
Big Sagebrush-semidesert	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990			1	No	
Big Sagebrush-semidesert	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990			1	No	
Big Sagebrush-semidesert	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_0dd-Yr	0.0044				0	No	
Big Sagebrush-semidesert	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_Even-Yr	0.0044				0	No	
Big Sagebrush-semidesert	U:SAP-Closed	U:SAP-Closed	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-semidesert	U:SAP-Closed	U:SAP-Dense	Alternate-Succession	0.0001		38	39		Yes	
Big Sagebrush-semidesert	U:SAP-Dense	1-Early:All	Supplemental-Salt-Block	0.0100	0.6000			5	Yes	
Big Sagebrush-semidesert	U:SAP-Dense	U:ASPG	Aroga-Outbreak	0.0670	0.2500			1	Yes	
Big Sagebrush-semidesert	U:SAP-Dense	U:ASPG	ReplacementFire	0.0100					Yes	
Big Sagebrush-semidesert	U:SAP-Dense	U:ASPG	Severe-Drought	0.0070	0.0100				Yes	
Big Sagebrush-semidesert	U:SAP-Dense	U:ASPG	Supplemental-Salt-Block	0.0100	0.4000			5	Yes	
Big Sagebrush-semidesert	U:SAP-Dense	U:Exotic Forbs	Exotic-Invasion	0.0005					No	
Big Sagebrush-semidesert	U:SAP-Dense	U:SA-Dense	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010			1	No	
Big Sagebrush-semidesert	U:SAP-Dense	U:SA-Dense	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010			1	No	
Big Sagebrush-semidesert	U:SAP-Dense	U:SAP-Closed	Aroga-Outbreak	0.0670	0.7500				Yes	
Big Sagebrush-semidesert	U:SAP-Dense	U:SAP-Closed	Severe-Drought	0.0070	0.0900				Yes	
Big Sagebrush-semidesert	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990			1	No	
Big Sagebrush-semidesert	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990			1	No	
Big Sagebrush-semidesert	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_0dd-Yr	0.0044				0	No	
Big Sagebrush-semidesert	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_Even-Yr	0.0044				0	No	
Big Sagebrush-semidesert	U:SAP-Dense	U:SAP-Dense	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-semidesert	U:SDI-A	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010	3			No	
Big Sagebrush-semidesert	U:SDI-A	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010	3			No	
Big Sagebrush-semidesert	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990	3		1	No	
Big Sagebrush-semidesert	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990	3		1	No	
Big Sagebrush-semidesert	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_0dd-Yr	0.0044		3		0	No	
Big Sagebrush-semidesert	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_Even-Yr	0.0044		3		0	No	
Big Sagebrush-semidesert	U:SDI-A	U:SDI-A	ReplacementFire	0.0020		1			Yes	
Big Sagebrush-semidesert	U:SDI-A	U:SDI-A	Severe-Drought	0.0070	0.1000	1			Yes	
Big Sagebrush-semidesert	U:SDI-A	U:SDI-A	Severe-Drought	0.0070	0.9000	1		-1	No	
Big Sagebrush-semidesert	U:SDI-A	U:SI-A+AS	AS-Invasion	0.0010		1			No	
Big Sagebrush-semidesert	U:SDI-B	2-Mid:Open	Natural-Recovery	0.0010					No	10
Big Sagebrush-semidesert	U:SDI-B	U:SDI-A	ReplacementFire	0.0020					Yes	
Big Sagebrush-semidesert	U:SDI-B	U:SDI-A	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-semidesert	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_0dd-Yr	0.0350				1	No	
Big Sagebrush-semidesert	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_Even-Yr	0.0350				1	No	
Big Sagebrush-semidesert	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_0dd-Yr	0.0044				0	No	
Big Sagebrush-semidesert	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_Even-Yr	0.0044				0	No	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-semidesert	U:SDI-B	U:SDI-B	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-semidesert	U:SDI-B	U:SDI-D	Alternate-Succession	0.0001		38		Yes	
Big Sagebrush-semidesert	U:SDI-B	U:SI-B+AS	AS-Invasion	0.0010				No	
Big Sagebrush-semidesert	U:SDI-C	3-Late:Closed	Natural-Recovery	0.0100				No	10
Big Sagebrush-semidesert	U:SDI-C	U:SDI-A	Aroga-Outbreak	0.0670	0.2500		5	Yes	
Big Sagebrush-semidesert	U:SDI-C	U:SDI-A	ReplacementFire	0.0020				Yes	
Big Sagebrush-semidesert	U:SDI-C	U:SDI-B	Aroga-Outbreak	0.0670	0.7500			Yes	
Big Sagebrush-semidesert	U:SDI-C	U:SDI-B	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-semidesert	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_0dd-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_Even-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_0dd-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_Even-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SDI-C	U:SDI-C	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-semidesert	U:SDI-C	U:SI-C+AS	AS-Invasion	0.0010				No	
Big Sagebrush-semidesert	U:SDI-D	4-Late:Dense	Natural-Recovery	0.1000				No	10
Big Sagebrush-semidesert	U:SDI-D	U:SDI-A	Aroga-Outbreak	0.0670	0.2500		5	Yes	
Big Sagebrush-semidesert	U:SDI-D	U:SDI-A	ReplacementFire	0.0020				Yes	
Big Sagebrush-semidesert	U:SDI-D	U:SDI-B	Aroga-Outbreak	0.0670	0.7500			Yes	
Big Sagebrush-semidesert	U:SDI-D	U:SDI-C	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-semidesert	U:SDI-D	U:SDI-D	Early-Cattle-Grazing_0dd-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SDI-D	U:SDI-D	Early-Cattle-Grazing_Even-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SDI-D	U:SDI-D	Late-Cattle-Grazing_0dd-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SDI-D	U:SDI-D	Late-Cattle-Grazing_Even-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SDI-D	U:SDI-D	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-semidesert	U:SDI-D	U:SI-D+AS	AS-Invasion	0.0010				No	
Big Sagebrush-semidesert	U:SI-A+AS	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0350	0.0010	3		No	
Big Sagebrush-semidesert	U:SI-A+AS	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0350	0.0010	3		No	
Big Sagebrush-semidesert	U:SI-A+AS	U:SDI-A	Competition	0.3330				No	3
Big Sagebrush-semidesert	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_0dd-Yr	0.0350	0.9990	3	1	No	
Big Sagebrush-semidesert	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_Even-Yr	0.0350	0.9990	3	1	No	
Big Sagebrush-semidesert	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_0dd-Yr	0.0044		3	0	No	
Big Sagebrush-semidesert	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_Even-Yr	0.0044		3	0	No	
Big Sagebrush-semidesert	U:SI-A+AS	U:SI-A+AS	ReplacementFire	0.0050				Yes	2
Big Sagebrush-semidesert	U:SI-A+AS	U:SI-A+AS	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-semidesert	U:SI-A+AS	U:SI-A+AS	Severe-Drought	0.0070	0.9000		-1	No	
Big Sagebrush-semidesert	U:SI-A+AS	U:SI-A+AS	Wet-Year	0.0670				No	
Big Sagebrush-semidesert	U:SI-B+AS	U:SDI-B	Competition	0.3330				No	3
Big Sagebrush-semidesert	U:SI-B+AS	U:SI-A+AS	ReplacementFire	0.0050				Yes	2
Big Sagebrush-semidesert	U:SI-B+AS	U:SI-A+AS	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-semidesert	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_0dd-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_Even-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_0dd-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_Even-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SI-B+AS	U:SI-B+AS	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-semidesert	U:SI-B+AS	U:SI-B+AS	Wet-Year	0.0670				No	
Big Sagebrush-semidesert	U:SI-B+AS	U:SI-D+AS	Alternate-Succession	0.0001		38		Yes	
Big Sagebrush-semidesert	U:SI-C+AS	U:SDI-C	Competition	0.3330				No	3
Big Sagebrush-semidesert	U:SI-C+AS	U:SI-A+AS	Aroga-Outbreak	0.0670	0.2500		5	Yes	
Big Sagebrush-semidesert	U:SI-C+AS	U:SI-A+AS	ReplacementFire	0.0050				Yes	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-semidesert	U:SI-C+AS	U:SI-B+AS	Aroga-Outbreak	0.0670	0.7500			Yes	
Big Sagebrush-semidesert	U:SI-C+AS	U:SI-B+AS	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-semidesert	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_0dd-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_Even-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_0dd-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_Even-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SI-C+AS	U:SI-C+AS	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-semidesert	U:SI-C+AS	U:SI-C+AS	Wet-Year	0.0670				No	
Big Sagebrush-semidesert	U:SI-D+AS	U:SDI-D	Competition	0.3330				No	3
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-A+AS	Aroga-Outbreak	0.0670	0.2500		1	Yes	
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-A+AS	ReplacementFire	0.0050				Yes	
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-B+AS	Aroga-Outbreak	0.0670	0.7500			Yes	
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-C+AS	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-D+AS	Early-Cattle-Grazing_0dd-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-D+AS	Early-Cattle-Grazing_Even-Yr	0.0350			1	No	
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-D+AS	Late-Cattle-Grazing_0dd-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-D+AS	Late-Cattle-Grazing_Even-Yr	0.0044			0	No	
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-D+AS	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-semidesert	U:SI-D+AS	U:SI-D+AS	Wet-Year	0.0670				No	
Big Sagebrush-upland no trees	1-Early:All	1-Early:All	Wild-Horse-Grazing	0.0190	0.9990	3	1	No	
Big Sagebrush-upland no trees	1-Early:All	U:Early Shrub	Wild-Horse-Grazing	0.0190	0.0010	3		No	
Big Sagebrush-upland no trees	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	3	1	No	
Big Sagebrush-upland no trees	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3	1	No	
Big Sagebrush-upland no trees	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0063		3	0	No	
Big Sagebrush-upland no trees	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0063		3	0	No	
Big Sagebrush-upland no trees	1-Early:All	1-Early:All	ReplacementFire	0.0040				Yes	
Big Sagebrush-upland no trees	1-Early:All	U:ASPG	AS-Invasion	0.0025	1.0000			No	
Big Sagebrush-upland no trees	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	3		No	
Big Sagebrush-upland no trees	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3		No	
Big Sagebrush-upland no trees	2-Mid:Open	2-Mid:Open	Wild-Horse-Grazing	0.0190	0.9990		1	No	
Big Sagebrush-upland no trees	2-Mid:Open	4-Late:Dense	Alternate-Succession	0.0001		38		Yes	
Big Sagebrush-upland no trees	2-Mid:Open	U:Early Shrub	Wild-Horse-Grazing	0.0190	0.0010			No	
Big Sagebrush-upland no trees	2-Mid:Open	1-Early:All	ReplacementFire	0.0100				Yes	
Big Sagebrush-upland no trees	2-Mid:Open	1-Early:All	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-upland no trees	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990		1	No	

Big Sagebrush-upland no trees	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	1	No
Big Sagebrush-upland no trees	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_0dd-Yr	0.0063		0	No
Big Sagebrush-upland no trees	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0063		0	No
Big Sagebrush-upland no trees	2-Mid:Open	2-Mid:Open	Severe-Drought	0.0070	0.9000		Yes
Big Sagebrush-upland no trees	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010		No
Big Sagebrush-upland no trees	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010		No
Big Sagebrush-upland no trees	2-Mid:Open	U:SAP-Closed	AS-Invasion	0.0025			No
Big Sagebrush-upland no trees	3-Late:Closed	1-Early:All	Aroga-Outbreak	0.0670	0.2500	5	Yes
Big Sagebrush-upland no trees	3-Late:Closed	1-Early:All	Supplemental-Salt-Block	0.0100		5	Yes
Big Sagebrush-upland no trees	3-Late:Closed	2-Mid:Open	Aroga-Outbreak	0.0670	0.7500		Yes
Big Sagebrush-upland no trees	3-Late:Closed	1-Early:All	ReplacementFire	0.0100			Yes
Big Sagebrush-upland no trees	3-Late:Closed	2-Mid:Open	Severe-Drought	0.0070	0.1000		Yes
Big Sagebrush-upland no trees	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	1	No
Big Sagebrush-upland no trees	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	1	No
Big Sagebrush-upland no trees	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0063		0	No
Big Sagebrush-upland no trees	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0063		0	No
Big Sagebrush-upland no trees	3-Late:Closed	3-Late:Closed	Severe-Drought	0.0070	0.9000		Yes
Big Sagebrush-upland no trees	3-Late:Closed	3-Late:Closed	Wild-Horse-Grazing	0.0190	0.9999	1	No
Big Sagebrush-upland no trees	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010		No
Big Sagebrush-upland no trees	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010		No
Big Sagebrush-upland no trees	3-Late:Closed	U:Depleted	Wild-Horse-Grazing	0.0190	0.0010		No
Big Sagebrush-upland no trees	3-Late:Closed	U:SAP-Closed	AS-Invasion	0.0025			No
Big Sagebrush-upland no trees	4-Late:Dense	1-Early:All	Aroga-Outbreak	0.0670	0.2500	1	Yes
Big Sagebrush-upland no trees	4-Late:Dense	1-Early:All	ReplacementFire	0.0100			Yes
Big Sagebrush-upland no trees	4-Late:Dense	1-Early:All	Supplemental-Salt-Block	0.0100		5	Yes
Big Sagebrush-upland no trees	4-Late:Dense	2-Mid:Open	Aroga-Outbreak	0.0670	0.7500		Yes

Big Sagebrush-upland no trees	4-Late:Dense	3-Late:Closed	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-upland no trees	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990		1	No	
Big Sagebrush-upland no trees	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990		1	No	
Big Sagebrush-upland no trees	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_0dd-Yr	0.0063			0	No	
Big Sagebrush-upland no trees	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_Even-Yr	0.0063			0	No	
Big Sagebrush-upland no trees	4-Late:Dense	4-Late:Dense	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-upland no trees	4-Late:Dense	4-Late:Dense	Wild-Horse-Grazing	0.0190	0.9990		1	No	
Big Sagebrush-upland no trees	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010			No	
Big Sagebrush-upland no trees	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010			No	
Big Sagebrush-upland no trees	4-Late:Dense	U:Depleted	Wild-Horse-Grazing	0.0190	0.0010			No	
Big Sagebrush-upland no trees	4-Late:Dense	U:SAP-Dense	AS-Invasion	0.0025				No	
Big Sagebrush-upland no trees	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0500		3	1	No	
Big Sagebrush-upland no trees	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0500		3	1	No	
Big Sagebrush-upland no trees	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Seed	0.0100	0.1000			Yes	
Big Sagebrush-upland no trees	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0063		3	0	No	
Big Sagebrush-upland no trees	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0063		3	0	No	
Big Sagebrush-upland no trees	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000				Yes	2
Big Sagebrush-upland no trees	U:Annual Spp	U:Annual Spp	Wild-Horse-Grazing	0.0190			1	No	
Big Sagebrush-upland no trees	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005				No	
Big Sagebrush-upland no trees	U:Annual Spp	U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.8000			Yes	
Big Sagebrush-upland no trees	U:Annual Spp	U:SI-A+AS	Herbicide-Plateau+Seed	0.0100	0.1000			Yes	
Big Sagebrush-upland no trees	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	3		No	
Big Sagebrush-upland no trees	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3		No	
Big Sagebrush-upland no trees	U:ASPG	U:Annual Spp	ReplacementFire	0.0125	0.5000			Yes	2
Big Sagebrush-upland no trees	U:ASPG	U:Annual Spp	Wild-Horse-Grazing	0.0190	0.0010			No	
Big Sagebrush-upland no trees	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	3	1	No	

Big Sagebrush-upland no trees	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3		1	No		
Big Sagebrush-upland no trees	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0063		3		0	No		
Big Sagebrush-upland no trees	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0063		3		0	No		
Big Sagebrush-upland no trees	U:ASPG	U:ASPG	ReplacementFire	0.0125	0.5000				Yes	2	
Big Sagebrush-upland no trees	U:ASPG	U:ASPG	Severe-Drought	0.0070	0.1000				Yes		
Big Sagebrush-upland no trees	U:ASPG	U:ASPG	Severe-Drought	0.0070	0.9000			-1	No		
Big Sagebrush-upland no trees	U:ASPG	U:ASPG	Wild-Horse-Grazing	0.0190	0.9990			1	No		
Big Sagebrush-upland no trees	U:Depleted	U:Depleted	Aroga-Outbreak	0.0670	0.7500				Yes		
Big Sagebrush-upland no trees	U:Depleted	U:Early Shrub	Aroga-Outbreak	0.0670	0.2500				Yes		
Big Sagebrush-upland no trees	U:Depleted	U:Early Shrub	Thin+Native-Seed	0.0100	0.4000				Yes		
Big Sagebrush-upland no trees	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-upland no trees	U:Depleted	U:SA-Dense	AS-Invasion	0.0050		80			No		
Big Sagebrush-upland no trees	U:Depleted	U:Seeded Native	Thin+Native-Seed	0.0100	0.6000				Yes		
Big Sagebrush-upland no trees	U:Depleted	U:Depleted	Severe-Drought	0.0070	0.9000				Yes		
Big Sagebrush-upland no trees	U:Depleted	U:Early Shrub	ReplacementFire	0.0100					Yes		
Big Sagebrush-upland no trees	U:Depleted	U:Early Shrub	Severe-Drought	0.0070	0.1000				Yes		
Big Sagebrush-upland no trees	U:Depleted	U:Early Shrub	Thin+Seed	0.0100	0.2000				Yes		
Big Sagebrush-upland no trees	U:Depleted	U:SA-Closed	AS-Invasion	0.0050		20	79		No		
Big Sagebrush-upland no trees	U:Depleted	U:SDI-A	Thin+Seed	0.0100	0.8000				Yes		
Big Sagebrush-upland no trees	U:Early Shrub	U:Early Shrub	Thin+24D+Seed	0.0100	0.3000				Yes		
Big Sagebrush-upland no trees	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-upland no trees	U:Early Shrub	U:SDI-A	Thin+24D+Seed	0.0100	0.7000				Yes		
Big Sagebrush-upland no trees	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0150					Yes		
Big Sagebrush-upland no trees	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No		
Big Sagebrush-upland no trees	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0500				1	No		
Big Sagebrush-upland no trees	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.3000				Yes		20

Big Sagebrush-upland no trees	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No		
Big Sagebrush-upland no trees	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0063				0	No		
Big Sagebrush-upland no trees	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0100					Yes		
Big Sagebrush-upland no trees	U:Exotic Forbs	U:Exotic Forbs	Wild-Horse-Grazing	0.0190				2	No		
Big Sagebrush-upland no trees	U:Exotic Forbs	U:SDI-A	Exotic-Control	0.0100	0.7000				Yes		20
Big Sagebrush-upland no trees	U:SA-Closed	U:Annual Spp	Aroga-Outbreak	0.0670	0.2500	40			Yes		
Big Sagebrush-upland no trees	U:SA-Closed	U:Annual Spp	ReplacementFire	0.0150			39		Yes	2	
Big Sagebrush-upland no trees	U:SA-Closed	U:Annual Spp	ReplacementFire	0.0150		40			Yes		
Big Sagebrush-upland no trees	U:SA-Closed	U:Annual Spp	Severe-Drought	0.0070	0.1000				Yes		
Big Sagebrush-upland no trees	U:SA-Closed	U:Annual Spp	Thin-Plateau-Seed	0.0100	0.1500						
Big Sagebrush-upland no trees	U:SA-Closed	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-upland no trees	U:SA-Closed	U:SA-Closed	Aroga-Outbreak	0.0670	0.7500	40			Yes		
Big Sagebrush-upland no trees	U:SA-Closed	U:SA-Closed	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No		
Big Sagebrush-upland no trees	U:SA-Closed	U:SA-Closed	Early-Cattle-Grazing_Even-Yr	0.0500				1	No		
Big Sagebrush-upland no trees	U:SA-Closed	U:SA-Closed	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No		
Big Sagebrush-upland no trees	U:SA-Closed	U:SA-Closed	Late-Cattle-Grazing_Even-Yr	0.0063				0	No		
Big Sagebrush-upland no trees	U:SA-Closed	U:SA-Closed	Severe-Drought	0.0070	0.9000				Yes		
Big Sagebrush-upland no trees	U:SA-Closed	U:SA-Closed	Wild-Horse-Grazing	0.0190				1	No		
Big Sagebrush-upland no trees	U:SA-Closed	U:SA-Dense	Alternate-Succession	0.0001		38	39		Yes		
Big Sagebrush-upland no trees	U:SA-Closed	U:SDI-A	Thin-Plateau-Seed	0.0100	0.7000				Yes		
Big Sagebrush-upland no trees	U:SA-Closed	U:SI-A+AS	Thin-Plateau-Seed	0.0100	0.1500				Yes		
Big Sagebrush-upland no trees	U:SA-Dense	U:Annual Spp	Aroga-Outbreak	0.0670	0.2500				Yes		
Big Sagebrush-upland no trees	U:SA-Dense	U:Annual Spp	ReplacementFire	0.0150					Yes		
Big Sagebrush-upland no trees	U:SA-Dense	U:Annual Spp	Severe-Drought	0.0070	0.0100				Yes		
Big Sagebrush-upland no trees	U:SA-Dense	U:Annual Spp	Thin-Plateau-Seed	0.0100	0.1500				Yes		
Big Sagebrush-upland no trees	U:SA-Dense	U:Exotic Forbs	Exotic-Invasion	0.0005					No		

Big Sagebrush-upland no trees	U:SA-Dense	U:SA-Closed	Aroga-Outbreak	0.0670	0.7500				Yes	
Big Sagebrush-upland no trees	U:SA-Dense	U:SA-Closed	Severe-Drought	0.0070	0.0900				Yes	
Big Sagebrush-upland no trees	U:SA-Dense	U:SA-Dense	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland no trees	U:SA-Dense	U:SA-Dense	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland no trees	U:SA-Dense	U:SA-Dense	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SA-Dense	U:SA-Dense	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SA-Dense	U:SA-Dense	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland no trees	U:SA-Dense	U:SA-Dense	Wild-Horse-Grazing	0.0190				1	No	
Big Sagebrush-upland no trees	U:SA-Dense	U:SDI-A	Thin-Plateau-Seed	0.0100	0.7000				Yes	
Big Sagebrush-upland no trees	U:SA-Dense	U:SI-A+AS	Thin-Plateau-Seed	0.0100	0.1500				Yes	
Big Sagebrush-upland no trees	U:SAP-Closed	1-Early:All	Supplemental-Salt-Block	0.0100	0.8000			5	Yes	
Big Sagebrush-upland no trees	U:SAP-Closed	U:ASPG	Aroga-Outbreak	0.0670	0.2500	40		5	Yes	
Big Sagebrush-upland no trees	U:SAP-Closed	U:ASPG	Supplemental-Salt-Block	0.0100	0.2000			5	Yes	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SA-Closed	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010				No	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SA-Closed	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010				No	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SA-Closed	Wild-Horse-Grazing	0.0190	0.0010				No	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SAP-Closed	Aroga-Outbreak	0.0670	0.7500	40			Yes	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SAP-Dense	Alternate-Succession	0.0001		38	39		Yes	
Big Sagebrush-upland no trees	U:SAP-Closed	1-Early:All	ReplacementFire	0.0150			39		Yes	2
Big Sagebrush-upland no trees	U:SAP-Closed	1-Early:All	ReplacementFire	0.0150		40			Yes	
Big Sagebrush-upland no trees	U:SAP-Closed	U:ASPG	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SAP-Closed	U:SAP-Closed	Severe-Drought	0.0070	0.9000				Yes	

Big Sagebrush-upland no trees	U:SAP-Closed	U:SAP-Closed	Wild-Horse-Grazing	0.0190	0.9990		1	No
Big Sagebrush-upland no trees	U:SAP-Dense	1-Early:All	Supplemental-Salt-Block	0.0100	0.7000		2	Yes
Big Sagebrush-upland no trees	U:SAP-Dense	U:ASPG	Aroga-Outbreak	0.0670	0.2500		1	Yes
Big Sagebrush-upland no trees	U:SAP-Dense	U:ASPG	ReplacementFire	0.0150				Yes
Big Sagebrush-upland no trees	U:SAP-Dense	U:ASPG	Severe-Drought	0.0070	0.0100			Yes
Big Sagebrush-upland no trees	U:SAP-Dense	U:ASPG	Supplemental-Salt-Block	0.0100	0.3000		2	Yes
Big Sagebrush-upland no trees	U:SAP-Dense	U:SA-Dense	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010			No
Big Sagebrush-upland no trees	U:SAP-Dense	U:SA-Dense	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010			No
Big Sagebrush-upland no trees	U:SAP-Dense	U:SA-Dense	Wild-Horse-Grazing	0.0190	0.0010			No
Big Sagebrush-upland no trees	U:SAP-Dense	U:SAP-Closed	Aroga-Outbreak	0.0670	0.7500			Yes
Big Sagebrush-upland no trees	U:SAP-Dense	U:SAP-Closed	Severe-Drought	0.0070	0.0900			Yes
Big Sagebrush-upland no trees	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990		1	No
Big Sagebrush-upland no trees	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990		1	No
Big Sagebrush-upland no trees	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_0dd-Yr	0.0063			0	No
Big Sagebrush-upland no trees	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_Even-Yr	0.0063			0	No
Big Sagebrush-upland no trees	U:SAP-Dense	U:SAP-Dense	Severe-Drought	0.0070	0.9000			Yes
Big Sagebrush-upland no trees	U:SAP-Dense	U:SAP-Dense	Wild-Horse-Grazing	0.0190	0.9990		1	No
Big Sagebrush-upland no trees	U:SDI-A	U:Early Shrub	Wild-Horse-Grazing	0.0190	0.0010			No
Big Sagebrush-upland no trees	U:SDI-A	U:SDI-A	Wild-Horse-Grazing	0.0190	0.9990		1	No
Big Sagebrush-upland no trees	U:SDI-A	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	3		Yes
Big Sagebrush-upland no trees	U:SDI-A	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3		Yes
Big Sagebrush-upland no trees	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	3	1	No
Big Sagebrush-upland no trees	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3	1	No
Big Sagebrush-upland no trees	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_0dd-Yr	0.0063		3	0	No
Big Sagebrush-upland no trees	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_Even-Yr	0.0063		3	0	No
Big Sagebrush-upland no trees	U:SDI-A	U:SDI-A	ReplacementFire	0.0020				Yes

Big Sagebrush-upland no trees	U:SDI-A	U:SDI-A	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland no trees	U:SDI-A	U:SDI-A	Severe-Drought	0.0070	0.9000			-1	No	
Big Sagebrush-upland no trees	U:SDI-A	U:SI-A+AS	AS-Invasion	0.0010					No	
Big Sagebrush-upland no trees	U:SDI-B	U:SDI-B	Wild-Horse-Grazing	0.0190				1	No	
Big Sagebrush-upland no trees	U:SDI-B	U:SDI-D	Alternate-Succession	0.0001		38	39		Yes	
Big Sagebrush-upland no trees	U:SDI-B	U:SDI-A	ReplacementFire	0.0020					Yes	
Big Sagebrush-upland no trees	U:SDI-B	U:SDI-A	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland no trees	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland no trees	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland no trees	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SDI-B	U:SDI-B	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland no trees	U:SDI-B	U:SI-B+AS	AS-Invasion	0.0010					No	
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-A	Aroga-Outbreak	0.0670	0.2500			5	Yes	
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-B	Aroga-Outbreak	0.0670	0.7500				Yes	
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-C	Wild-Horse-Grazing	0.0190				1	No	
Big Sagebrush-upland no trees	U:SDI-C	3-Late:Closed	Natural-Recovery	0.0100					No	10
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-A	ReplacementFire	0.0020					Yes	
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-B	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SDI-C	U:SDI-C	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland no trees	U:SDI-C	U:SI-C+AS	AS-Invasion	0.0010					No	
Big Sagebrush-upland no trees	U:SDI-D	4-Late:Dense	Natural-Recovery	0.0010					No	10

Big Sagebrush-upland no trees	U:SDI-D	U:SDI-A	Aroga-Outbreak	0.0670	0.2500			1	Yes	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-A	ReplacementFire	0.0020					Yes	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-B	Aroga-Outbreak	0.0670	0.7500				Yes	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-C	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-D	AS-Invasion	0.0010					No	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-D	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-D	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-D	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-D	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-D	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland no trees	U:SDI-D	U:SDI-D	Wild-Horse-Grazing	0.0190				1	No	
Big Sagebrush-upland no trees	U:Seeded Native	4-Late:Dense	Natural-Recovery	0.3300		80			No	5
Big Sagebrush-upland no trees	U:Seeded Native	U:ASPG	AS-Invasion	0.0050			19		No	
Big Sagebrush-upland no trees	U:Seeded Native	U:Early Shrub	Wild-Horse-Grazing	0.0190		3	5		No	
Big Sagebrush-upland no trees	U:Seeded Native	U:Early Shrub	Wild-Horse-Grazing	0.0190	0.0010	6			Yes	
Big Sagebrush-upland no trees	U:Seeded Native	U:SAP-Dense	AS-Invasion	0.0050		80			No	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	Aroga-Outbreak	0.0670	0.2500	40		5	Yes	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	Aroga-Outbreak	0.0670	0.7500	40		20	Yes	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0100		20			Yes	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	Wild-Horse-Grazing	0.0190	0.9990	6		1	No	
Big Sagebrush-upland no trees	U:Seeded Native	1-Early:All	Natural-Recovery	0.3300			19		No	5
Big Sagebrush-upland no trees	U:Seeded Native	2-Mid:Open	Natural-Recovery	0.3300		20	39		No	5
Big Sagebrush-upland no trees	U:Seeded Native	3-Late:Closed	Natural-Recovery	0.3300		40	79		No	5
Big Sagebrush-upland no trees	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	3			Yes	
Big Sagebrush-upland no trees	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3			Yes	
Big Sagebrush-upland no trees	U:Seeded Native	U:Early Shrub	Severe-Drought	0.0070	0.1000				No	

Big Sagebrush-upland no trees	U:Seeded Native	U:SAP-Closed	AS-Invasion	0.0050		20	79		No	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_0dd-Yr	0.0063		3		0	No	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Even-Yr	0.0063		3		0	No	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0020			19		Yes	
Big Sagebrush-upland no trees	U:Seeded Native	U:Seeded Native	Severe-Drought	0.0070	0.9000			-1	No	
Big Sagebrush-upland no trees	U:SI-A+AS	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	3			Yes	
Big Sagebrush-upland no trees	U:SI-A+AS	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3			Yes	
Big Sagebrush-upland no trees	U:SI-A+AS	U:Annual Spp	Wild-Horse-Grazing	0.0190	0.0010				No	
Big Sagebrush-upland no trees	U:SI-A+AS	U:SI-A+AS	Wet-Year	0.0670					No	
Big Sagebrush-upland no trees	U:SI-A+AS	U:SI-A+AS	Wild-Horse-Grazing	0.0190	0.9990			1	No	
Big Sagebrush-upland no trees	U:SI-A+AS	U:SDI-A	Competition	0.3330					No	3
Big Sagebrush-upland no trees	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland no trees	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland no trees	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_0dd-Yr	0.0063		3		0	No	
Big Sagebrush-upland no trees	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_Even-Yr	0.0063		3		0	No	
Big Sagebrush-upland no trees	U:SI-A+AS	U:SI-A+AS	ReplacementFire	0.0050					Yes	2
Big Sagebrush-upland no trees	U:SI-A+AS	U:SI-A+AS	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland no trees	U:SI-A+AS	U:SI-A+AS	Severe-Drought	0.0070	0.9000			-1	No	
Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-B+AS	Wet-Year	0.0670					No	
Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-B+AS	Wild-Horse-Grazing	0.0190				1	No	
Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-D+AS	Alternate-Succession	0.0001		38			Yes	
Big Sagebrush-upland no trees	U:SI-B+AS	U:SDI-B	Competition	0.3330					No	3
Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-A+AS	ReplacementFire	0.0050					Yes	2
Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-A+AS	Severe-Drought	0.0070	0.1000				Yes	

Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_Odd-Yr	0.0500		1	No	
Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_Even-Yr	0.0500		1	No	
Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_Odd-Yr	0.0063		0	No	
Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_Even-Yr	0.0063		0	No	
Big Sagebrush-upland no trees	U:SI-B+AS	U:SI-B+AS	Severe-Drought	0.0070	0.9000		Yes	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-A+AS	Aroga-Outbreak	0.0670	0.2500	5	Yes	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-B+AS	Aroga-Outbreak	0.0670	0.7500		Yes	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-C+AS	Wet-Year	0.0670			No	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-C+AS	Wild-Horse-Grazing	0.0190		1	No	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SDI-C	Competition	0.3330			No	3
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-A+AS	ReplacementFire	0.0050			Yes	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-B+AS	Severe-Drought	0.0070	0.1000		Yes	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_Odd-Yr	0.0500		1	No	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_Even-Yr	0.0500		1	No	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_Odd-Yr	0.0063		0	No	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_Even-Yr	0.0063		0	No	
Big Sagebrush-upland no trees	U:SI-C+AS	U:SI-C+AS	Severe-Drought	0.0070	0.9000		Yes	
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-A+AS	Aroga-Outbreak	0.0670	0.2500	1	Yes	
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-A+AS	ReplacementFire	0.0050			Yes	
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-B+AS	Aroga-Outbreak	0.0670	0.7500		Yes	
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-C+AS	Severe-Drought	0.0070	0.1000		Yes	
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-D+AS	Competition	0.3330			No	3
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-D+AS	Early-Cattle-Grazing_Odd-Yr	0.0500		1	No	
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-D+AS	Early-Cattle-Grazing_Even-Yr	0.0500		1	No	
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-D+AS	Late-Cattle-Grazing_Odd-Yr	0.0063		0	No	
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-D+AS	Late-Cattle-Grazing_Even-Yr	0.0063		0	No	

Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-D+AS	Severe-Drought	0.0070	0.9000				Yes
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-D+AS	Wet-Year	0.0670					No
Big Sagebrush-upland no trees	U:SI-D+AS	U:SI-D+AS	Wild-Horse-Grazing	0.0190				1	No
Big Sagebrush-upland no trees	U:Unpalat. Forb	U:SDI-A	Thin+24D+Seed	0.0000	0.9000				Yes
Big Sagebrush-upland no trees	U:Unpalat. Forb	U:Unpalat. Forb	ReplacementFire	0.0200					Yes
Big Sagebrush-upland no trees	U:Unpalat. Forb	U:Unpalat. Forb	Thin+24D+Seed	0.0000	0.1000				Yes
Big Sagebrush-upland+trees	1-Early:All	U:ASPG	AS-Invasion	0.0025					No
Big Sagebrush-upland+trees	1-Early:All	1-Early:All	Early-Cattle-Grazing_Odd-Yr	0.0500	0.9990	3		1	No
Big Sagebrush-upland+trees	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3		1	No
Big Sagebrush-upland+trees	1-Early:All	1-Early:All	Late-Cattle-Grazing_Odd-Yr	0.0063		3		0	No
Big Sagebrush-upland+trees	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0063		3		0	No
Big Sagebrush-upland+trees	1-Early:All	1-Early:All	ReplacementFire	0.0040					Yes
Big Sagebrush-upland+trees	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Odd-Yr	0.0500	0.0010	3			No
Big Sagebrush-upland+trees	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3			No
Big Sagebrush-upland+trees	2-Mid:Open	1-Early:All	ReplacementFire	0.0100					Yes
Big Sagebrush-upland+trees	2-Mid:Open	1-Early:All	Severe-Drought	0.0070	0.1000				Yes
Big Sagebrush-upland+trees	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Odd-Yr	0.0500	0.9990			1	No
Big Sagebrush-upland+trees	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990			1	No
Big Sagebrush-upland+trees	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Odd-Yr	0.0063				0	No
Big Sagebrush-upland+trees	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0063				0	No
Big Sagebrush-upland+trees	2-Mid:Open	2-Mid:Open	Severe-Drought	0.0070	0.9000				Yes
Big Sagebrush-upland+trees	2-Mid:Open	4-Late:Dense	Alternate-Succession	0.0001		38	39		Yes
Big Sagebrush-upland+trees	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_Odd-Yr	0.0500	0.0010				No
Big Sagebrush-upland+trees	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010				No
Big Sagebrush-upland+trees	2-Mid:Open	U:SAP-Closed	AS-Invasion	0.0025					No
Big Sagebrush-upland+trees	3-Late:Closed	1-Early:All	Aroga-Outbreak	0.0670	0.2500			5	Yes
Big Sagebrush-upland+trees	3-Late:Closed	1-Early:All	ReplacementFire	0.0100					Yes
Big Sagebrush-upland+trees	3-Late:Closed	1-Early:All	Severe-Drought	0.0070	0.1000				Yes
Big Sagebrush-upland+trees	3-Late:Closed	1-Early:All	Supplemental-Salt-Block	0.0100				5	Yes
Big Sagebrush-upland+trees	3-Late:Closed	2-Mid:Open	Aroga-Outbreak	0.0670	0.7500				Yes
Big Sagebrush-upland+trees	3-Late:Closed	2-Mid:Open	Severe-Drought	0.0070	0.9000				Yes
Big Sagebrush-upland+trees	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Odd-Yr	0.0500	0.9990			1	No
Big Sagebrush-upland+trees	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990			1	No
Big Sagebrush-upland+trees	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Odd-Yr	0.0063				0	No
Big Sagebrush-upland+trees	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0063				0	No
Big Sagebrush-upland+trees	3-Late:Closed	5-Late:Open	Tree-Invasion	0.0001		100			Yes
Big Sagebrush-upland+trees	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_Odd-Yr	0.0500	0.0010				No
Big Sagebrush-upland+trees	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010				No
Big Sagebrush-upland+trees	3-Late:Closed	U:SAP-Closed	AS-Invasion	0.0025					No
Big Sagebrush-upland+trees	4-Late:Dense	1-Early:All	Aroga-Outbreak	0.0670	0.2500			1	Yes
Big Sagebrush-upland+trees	4-Late:Dense	1-Early:All	ReplacementFire	0.0100					Yes
Big Sagebrush-upland+trees	4-Late:Dense	1-Early:All	Supplemental-Salt-Block	0.0100				5	Yes
Big Sagebrush-upland+trees	4-Late:Dense	2-Mid:Open	Aroga-Outbreak	0.0670	0.7500				Yes
Big Sagebrush-upland+trees	4-Late:Dense	2-Mid:Open	Severe-Drought	0.0070	0.1000				Yes

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-upland+trees	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland+trees	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland+trees	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	4-Late:Dense	4-Late:Dense	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland+trees	4-Late:Dense	5-Late:Open	Tree-Invasion	0.0001		100			Yes	
Big Sagebrush-upland+trees	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010				No	
Big Sagebrush-upland+trees	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010				No	
Big Sagebrush-upland+trees	4-Late:Dense	U:SAP-Dense	AS-Invasion	0.0025					No	
Big Sagebrush-upland+trees	5-Late:Open	1-Early:All	ReplacementFire	0.0100					Yes	
Big Sagebrush-upland+trees	5-Late:Open	4-Late:Dense	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	5-Late:Open	4-Late:Dense	Small-Tree-Lopping	0.0100			124		Yes	
Big Sagebrush-upland+trees	5-Late:Open	5-Late:Open	Aroga-Outbreak	0.0670				5	No	
Big Sagebrush-upland+trees	5-Late:Open	5-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland+trees	5-Late:Open	5-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland+trees	5-Late:Open	5-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	5-Late:Open	5-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	5-Late:Open	5-Late:Open	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland+trees	5-Late:Open	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010		124		No	
Big Sagebrush-upland+trees	5-Late:Open	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010		124		No	
Big Sagebrush-upland+trees	5-Late:Open	U:SAP-Dense	AS-Invasion	0.0025			124		No	
Big Sagebrush-upland+trees	5-Late:Open	U:TEA	AS-Invasion	0.0025		125			No	
Big Sagebrush-upland+trees	5-Late:Open	U:TEA	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	125			No	
Big Sagebrush-upland+trees	5-Late:Open	U:TEA	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	125			No	
Big Sagebrush-upland+trees	6-Late:Dense	1-Early:All	Masticate+Native-Seed	0.0100		200			Yes	
Big Sagebrush-upland+trees	6-Late:Dense	1-Early:All	ReplacementFire	0.0080					Yes	
Big Sagebrush-upland+trees	6-Late:Dense	5-Late:Open	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	6-Late:Dense	6-Late:Dense	Severe-Drought	0.0070	0.9000		199		Yes	
Big Sagebrush-upland+trees	6-Late:Dense	6-Late:Dense	Severe-Drought	0.0070	0.9000	200		5	No	
Big Sagebrush-upland+trees	6-Late:Dense	U:TEA	AS-Invasion	0.0025					No	
Big Sagebrush-upland+trees	6-Late:Dense	U:TEA	Tree-Encroachment	0.0200		200			No	
Big Sagebrush-upland+trees	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0500		3		1	No	
Big Sagebrush-upland+trees	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0500		3		1	No	
Big Sagebrush-upland+trees	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Seed	0.0100	0.1500				Yes	
Big Sagebrush-upland+trees	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0063		3		0	No	
Big Sagebrush-upland+trees	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0063		3		0	No	
Big Sagebrush-upland+trees	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes	2
Big Sagebrush-upland+trees	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005					No	
Big Sagebrush-upland+trees	U:Annual Spp	U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.7000				Yes	
Big Sagebrush-upland+trees	U:Annual Spp	U:SI-A+AS	Herbicide-Plateau+Seed	0.0100	0.1500				Yes	
Big Sagebrush-upland+trees	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	3			No	
Big Sagebrush-upland+trees	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3			No	
Big Sagebrush-upland+trees	U:ASPG	U:Annual Spp	ReplacementFire	0.0125	0.5000				Yes	2
Big Sagebrush-upland+trees	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland+trees	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland+trees	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0063		3		0	No	
Big Sagebrush-upland+trees	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0063		3		0	No	
Big Sagebrush-upland+trees	U:ASPG	U:ASPG	ReplacementFire	0.0125	0.5000				Yes	2
Big Sagebrush-upland+trees	U:ASPG	U:ASPG	Severe-Drought	0.0070	0.1000				Yes	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-upland+trees	U:ASPG	U:ASPG	Severe-Drought	0.0070	0.9000			-1	No		
Big Sagebrush-upland+trees	U:ASPG	U:Early Shrub	Exotic-Invasion	0.0005					No		
Big Sagebrush-upland+trees	U:Depleted	U:Depleted	Aroga-Outbreak	0.0670	0.7500				Yes		
Big Sagebrush-upland+trees	U:Depleted	U:Depleted	Severe-Drought	0.0070	0.9000				Yes		
Big Sagebrush-upland+trees	U:Depleted	U:Depleted	Small-Tree-Lopping	0.0100		100			Yes		
Big Sagebrush-upland+trees	U:Depleted	U:Early Shrub	Aroga-Outbreak	0.0670	0.2500				Yes		
Big Sagebrush-upland+trees	U:Depleted	U:Early Shrub	ReplacementFire	0.0100					Yes		
Big Sagebrush-upland+trees	U:Depleted	U:Early Shrub	Severe-Drought	0.0070	0.1000				Yes		
Big Sagebrush-upland+trees	U:Depleted	U:Early Shrub	Thin+Native-Seed	0.0100	0.4000				Yes		
Big Sagebrush-upland+trees	U:Depleted	U:Early Shrub	Thin+Seed	0.0100	0.2000				Yes		
Big Sagebrush-upland+trees	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-upland+trees	U:Depleted	U:SA-Closed	AS-Invasion	0.0050			79		No		
Big Sagebrush-upland+trees	U:Depleted	U:SA-Dense	AS-Invasion	0.0050		80			No		
Big Sagebrush-upland+trees	U:Depleted	U:SDI-A	Thin+Seed	0.0100	0.8000				Yes		
Big Sagebrush-upland+trees	U:Depleted	U:Seeded Native	Thin+Native-Seed	0.0100	0.6000				Yes		
Big Sagebrush-upland+trees	U:Depleted	U:TEA	Tree-Invasion	0.0001		100			Yes		
Big Sagebrush-upland+trees	U:Early Shrub	U:Early Shrub	Thin+24D+Seed	0.0100	0.1500				Yes		
Big Sagebrush-upland+trees	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-upland+trees	U:Early Shrub	U:SDI-A	Thin+24D+Seed	0.0100	0.7500				Yes		
Big Sagebrush-upland+trees	U:Early Shrub	U:SI-A+AS	Thin+24D+Seed	0.0100	0.1000				Yes		
Big Sagebrush-upland+trees	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0150					Yes		
Big Sagebrush-upland+trees	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No		
Big Sagebrush-upland+trees	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0500				1	No		
Big Sagebrush-upland+trees	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.3000				Yes		20
Big Sagebrush-upland+trees	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No		
Big Sagebrush-upland+trees	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0063				0	No		
Big Sagebrush-upland+trees	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0020		1	19		Yes		
Big Sagebrush-upland+trees	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0100		20			Yes		
Big Sagebrush-upland+trees	U:Exotic Forbs	U:SDI-A	Exotic-Control	0.0100	0.7000				Yes		20
Big Sagebrush-upland+trees	U:SA-Closed	U:Annual Spp	Aroga-Outbreak	0.0670	0.2500	40			Yes		
Big Sagebrush-upland+trees	U:SA-Closed	U:Annual Spp	ReplacementFire	0.0150			39		Yes	2	
Big Sagebrush-upland+trees	U:SA-Closed	U:Annual Spp	ReplacementFire	0.0150		40			Yes		
Big Sagebrush-upland+trees	U:SA-Closed	U:Annual Spp	Severe-Drought	0.0070	0.1000				Yes		
Big Sagebrush-upland+trees	U:SA-Closed	U:Annual Spp	Thin-Plateau-Seed	0.0100	0.1500				Yes		
Big Sagebrush-upland+trees	U:SA-Closed	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Big Sagebrush-upland+trees	U:SA-Closed	U:SA-Closed	Aroga-Outbreak	0.0670	0.7500	40			Yes		
Big Sagebrush-upland+trees	U:SA-Closed	U:SA-Closed	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No		
Big Sagebrush-upland+trees	U:SA-Closed	U:SA-Closed	Early-Cattle-Grazing_Even-Yr	0.0500				1	No		
Big Sagebrush-upland+trees	U:SA-Closed	U:SA-Closed	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No		
Big Sagebrush-upland+trees	U:SA-Closed	U:SA-Closed	Late-Cattle-Grazing_Even-Yr	0.0063				0	No		
Big Sagebrush-upland+trees	U:SA-Closed	U:SA-Closed	Severe-Drought	0.0070	0.9000				Yes		
Big Sagebrush-upland+trees	U:SA-Closed	U:SA-Dense	Alternate-Succession	0.0001		38	39		Yes		
Big Sagebrush-upland+trees	U:SA-Closed	U:SDI-A	Thin-Plateau-Seed	0.0100	0.7000				Yes		
Big Sagebrush-upland+trees	U:SA-Closed	U:SI-A+AS	Thin-Plateau-Seed	0.0100	0.1500				Yes		
Big Sagebrush-upland+trees	U:SA-Closed	U:TEA	Tree-Invasion	0.0001		100			Yes		
Big Sagebrush-upland+trees	U:SA-Dense	U:Annual Spp	Aroga-Outbreak	0.0670	0.2500			1	Yes		
Big Sagebrush-upland+trees	U:SA-Dense	U:Annual Spp	ReplacementFire	0.0150					Yes		
Big Sagebrush-upland+trees	U:SA-Dense	U:Annual Spp	Severe-Drought	0.0070	0.0100				Yes		
Big Sagebrush-upland+trees	U:SA-Dense	U:Annual Spp	Thin-Plateau-Seed	0.0100	0.1500				Yes		

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-upland+trees	U:SA-Dense	U:Exotic Forbs	Exotic-Invasion	0.0005					No	
Big Sagebrush-upland+trees	U:SA-Dense	U:SA-Closed	Aroga-Outbreak	0.0670	0.7500				Yes	
Big Sagebrush-upland+trees	U:SA-Dense	U:SA-Closed	Severe-Drought	0.0070	0.0900				Yes	
Big Sagebrush-upland+trees	U:SA-Dense	U:SA-Dense	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SA-Dense	U:SA-Dense	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SA-Dense	U:SA-Dense	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SA-Dense	U:SA-Dense	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SA-Dense	U:SA-Dense	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland+trees	U:SA-Dense	U:SA-Dense	Small-Tree-Lopping	0.0100		100			Yes	
Big Sagebrush-upland+trees	U:SA-Dense	U:SDI-A	Thin-Plateau-Seed	0.0100	0.7000				Yes	
Big Sagebrush-upland+trees	U:SA-Dense	U:SI-A+AS	Thin-Plateau-Seed	0.0100	0.1500				Yes	
Big Sagebrush-upland+trees	U:SA-Dense	U:TEA	Tree-Invasion	0.0001		100			Yes	
Big Sagebrush-upland+trees	U:SAP-Closed	1-Early:All	Supplemental-Salt-Block	0.0100	0.8000			5	Yes	
Big Sagebrush-upland+trees	U:SAP-Closed	U:ASPG	Aroga-Outbreak	0.0670	0.2500	40		5	Yes	
Big Sagebrush-upland+trees	U:SAP-Closed	U:ASPG	ReplacementFire	0.0150			39		Yes	2
Big Sagebrush-upland+trees	U:SAP-Closed	U:ASPG	ReplacementFire	0.0150		40			Yes	
Big Sagebrush-upland+trees	U:SAP-Closed	U:ASPG	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SAP-Closed	U:ASPG	Supplemental-Salt-Block	0.0100	0.2000			5	Yes	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SA-Closed	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010				No	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SA-Closed	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010				No	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SA-Closed	Exotic-Invasion	0.0005					No	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SAP-Closed	Aroga-Outbreak	0.0670	0.7500	40			Yes	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SAP-Closed	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SAP-Closed	Tree-Invasion	0.0001		100			Yes	
Big Sagebrush-upland+trees	U:SAP-Closed	U:SAP-Dense	Alternate-Succession	0.0001		38	39		Yes	
Big Sagebrush-upland+trees	U:SAP-Dense	1-Early:All	Supplemental-Salt-Block	0.0100	0.7000			2	Yes	
Big Sagebrush-upland+trees	U:SAP-Dense	U:ASPG	Aroga-Outbreak	0.0670	0.2500			5	Yes	
Big Sagebrush-upland+trees	U:SAP-Dense	U:ASPG	ReplacementFire	0.0150					Yes	
Big Sagebrush-upland+trees	U:SAP-Dense	U:ASPG	Supplemental-Salt-Block	0.0100	0.3000			2	Yes	
Big Sagebrush-upland+trees	U:SAP-Dense	U:Exotic Forbs	Exotic-Invasion	0.0005					No	
Big Sagebrush-upland+trees	U:SAP-Dense	U:SA-Dense	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010				No	
Big Sagebrush-upland+trees	U:SAP-Dense	U:SA-Dense	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010				No	
Big Sagebrush-upland+trees	U:SAP-Dense	U:SAP-Closed	Aroga-Outbreak	0.0670	0.7500				Yes	
Big Sagebrush-upland+trees	U:SAP-Dense	U:SAP-Closed	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland+trees	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990			1	No	
Big Sagebrush-upland+trees	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SAP-Dense	U:SAP-Dense	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland+trees	U:SAP-Dense	U:TEA	Tree-Invasion	0.0001		100			Yes	
Big Sagebrush-upland+trees	U:SDI-A	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	3			Yes	
Big Sagebrush-upland+trees	U:SDI-A	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3			Yes	
Big Sagebrush-upland+trees	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland+trees	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland+trees	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_0dd-Yr	0.0063		3		0	No	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-upland+trees	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_Even-Yr	0.0063		3		0	No	
Big Sagebrush-upland+trees	U:SDI-A	U:SDI-A	ReplacementFire	0.0020					Yes	
Big Sagebrush-upland+trees	U:SDI-A	U:SDI-A	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SDI-A	U:SDI-A	Severe-Drought	0.0070	0.9000			-1	No	
Big Sagebrush-upland+trees	U:SDI-A	U:SI-A+AS	AS-Invasion	0.0010					No	
Big Sagebrush-upland+trees	U:SDI-B	2-Mid:Open	Natural-Recovery	0.0010					No	10
Big Sagebrush-upland+trees	U:SDI-B	U:SDI-A	ReplacementFire	0.0020					Yes	
Big Sagebrush-upland+trees	U:SDI-B	U:SDI-A	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SDI-B	U:SDI-B	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland+trees	U:SDI-B	U:SDI-D	Alternate-Succession	0.0001		38	39		Yes	
Big Sagebrush-upland+trees	U:SDI-B	U:SI-B+AS	AS-Invasion	0.0010					No	
Big Sagebrush-upland+trees	U:SDI-C	3-Late:Closed	Natural-Recovery	0.0100					No	10
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-A	Aroga-Outbreak	0.0670	0.2500			5	Yes	
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-A	ReplacementFire	0.0020					Yes	
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-B	Aroga-Outbreak	0.0670	0.7500				Yes	
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-B	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-C	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland+trees	U:SDI-C	U:SDI-E	Tree-Invasion	0.0001		100			Yes	
Big Sagebrush-upland+trees	U:SDI-C	U:SI-C+AS	AS-Invasion	0.0010					No	
Big Sagebrush-upland+trees	U:SDI-D	4-Late:Dense	Natural-Recovery	0.1000					No	10
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-A	Aroga-Outbreak	0.0670	0.2500			1	Yes	
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-A	ReplacementFire	0.0020					Yes	
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-B	Aroga-Outbreak	0.0670	0.7500				Yes	
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-C	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-D	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-D	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-D	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-D	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-D	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland+trees	U:SDI-D	U:SDI-E	Tree-Invasion	0.0001		100			Yes	
Big Sagebrush-upland+trees	U:SDI-D	U:SI-D+AS	AS-Invasion	0.0010					No	
Big Sagebrush-upland+trees	U:SDI-E	5-Late:Open	Natural-Recovery	0.1000					No	10
Big Sagebrush-upland+trees	U:SDI-E	U:SDI-A	ReplacementFire	0.0020					Yes	
Big Sagebrush-upland+trees	U:SDI-E	U:SDI-D	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SDI-E	U:SDI-D	Small-Tree-Lopping	0.0100					Yes	
Big Sagebrush-upland+trees	U:SDI-E	U:SDI-E	Aroga-Outbreak	0.0670				5	No	
Big Sagebrush-upland+trees	U:SDI-E	U:SDI-E	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SDI-E	U:SDI-E	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SDI-E	U:SDI-E	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SDI-E	U:SDI-E	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SDI-E	U:SDI-E	Severe-Drought	0.0070	0.9000				Yes	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-upland+trees	U:SDI-E	U:SI-E+AS	AS-Invasion	0.0010					No	
Big Sagebrush-upland+trees	U:Seeded Native	1-Early:All	Natural-Recovery	0.3300			19		No	5
Big Sagebrush-upland+trees	U:Seeded Native	1-Early:All	Natural-Recovery	0.3300		20	39		No	5
Big Sagebrush-upland+trees	U:Seeded Native	3-Late:Closed	Natural-Recovery	0.3300		40	79		No	5
Big Sagebrush-upland+trees	U:Seeded Native	4-Late:Dense	Natural-Recovery	0.3300		80	100		No	5
Big Sagebrush-upland+trees	U:Seeded Native	5-Late:Open	Natural-Recovery	0.3300		100			No	5
Big Sagebrush-upland+trees	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	3			Yes	
Big Sagebrush-upland+trees	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3			Yes	
Big Sagebrush-upland+trees	U:Seeded Native	U:Early Shrub	Severe-Drought	0.0070	0.1000				No	
Big Sagebrush-upland+trees	U:Seeded Native	U:SAP-Closed	AS-Invasion	0.0050					No	
Big Sagebrush-upland+trees	U:Seeded Native	U:Seeded Native	Aroga-Outbreak	0.0670	0.2500			5	Yes	
Big Sagebrush-upland+trees	U:Seeded Native	U:Seeded Native	Aroga-Outbreak	0.0670	0.7500			20	Yes	
Big Sagebrush-upland+trees	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland+trees	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland+trees	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_0dd-Yr	0.0063		3		0	No	
Big Sagebrush-upland+trees	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Even-Yr	0.0063		3		0	No	
Big Sagebrush-upland+trees	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0020			19		Yes	
Big Sagebrush-upland+trees	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0100		20			Yes	
Big Sagebrush-upland+trees	U:Seeded Native	U:Seeded Native	Severe-Drought	0.0070	0.9000			-1	No	
Big Sagebrush-upland+trees	U:SI-A+AS	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0500	0.0010	3			No	
Big Sagebrush-upland+trees	U:SI-A+AS	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0500	0.0010	3			No	
Big Sagebrush-upland+trees	U:SI-A+AS	U:SDI-A	Competition	0.3330					No	3
Big Sagebrush-upland+trees	U:SI-A+AS	U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.9000					
Big Sagebrush-upland+trees	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_0dd-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland+trees	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_Even-Yr	0.0500	0.9990	3		1	No	
Big Sagebrush-upland+trees	U:SI-A+AS	U:SI-A+AS	Herbicide-Plateau+Seed	0.0100	0.1000				Yes	
Big Sagebrush-upland+trees	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_0dd-Yr	0.0063		3		0	No	
Big Sagebrush-upland+trees	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_Even-Yr	0.0063		3		0	No	
Big Sagebrush-upland+trees	U:SI-A+AS	U:SI-A+AS	ReplacementFire	0.0050					Yes	2
Big Sagebrush-upland+trees	U:SI-A+AS	U:SI-A+AS	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SI-A+AS	U:SI-A+AS	Severe-Drought	0.0070	0.9000			-1	No	
Big Sagebrush-upland+trees	U:SI-A+AS	U:SI-A+AS	Wet-Year	0.0670					Yes	
Big Sagebrush-upland+trees	U:SI-B+AS	U:SDI-B	Competition	0.3300					No	3
Big Sagebrush-upland+trees	U:SI-B+AS	U:SI-A+AS	ReplacementFire	0.0050					Yes	2
Big Sagebrush-upland+trees	U:SI-B+AS	U:SI-A+AS	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_Even-Yr	0.0063				0	No	
Big Sagebrush-upland+trees	U:SI-B+AS	U:SI-B+AS	Severe-Drought	0.0070	0.9000				Yes	
Big Sagebrush-upland+trees	U:SI-B+AS	U:SI-B+AS	Wet-Year	0.0670					No	
Big Sagebrush-upland+trees	U:SI-B+AS	U:SI-D+AS	Alternate-Succession	0.0001		38	39		Yes	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SDI-C	Competition	0.3300					No	3
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-A+AS	Aroga-Outbreak	0.0670	0.2500			5	Yes	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-B+AS	Aroga-Outbreak	0.0670	0.7500				Yes	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-B+AS	Severe-Drought	0.0070	0.1000				Yes	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_0dd-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_Even-Yr	0.0500				1	No	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_0dd-Yr	0.0063				0	No	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_Even-Yr	0.0063			0	No	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-C+AS	ReplacementFire	0.0050				Yes	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-C+AS	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-C+AS	Wet-Year	0.0670				No	
Big Sagebrush-upland+trees	U:SI-C+AS	U:SI-E+AS	Tree-Invasion	0.0001		100		Yes	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SDI-D	Competition	0.3330				No	3
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-A+AS	Aroga-Outbreak	0.0670	0.2500		1	Yes	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-A+AS	ReplacementFire	0.0050				Yes	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-B+AS	Aroga-Outbreak	0.0670	0.7500			Yes	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-C+AS	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-D+AS	Early-Cattle-Grazing_0dd-Yr	0.0500			1	No	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-D+AS	Early-Cattle-Grazing_Even-Yr	0.0500			1	No	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-D+AS	Late-Cattle-Grazing_0dd-Yr	0.0063			0	No	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-D+AS	Late-Cattle-Grazing_Even-Yr	0.0063			0	No	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-D+AS	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-D+AS	Wet-Year	0.0670				Yes	
Big Sagebrush-upland+trees	U:SI-D+AS	U:SI-E+AS	Tree-Invasion	0.0001		100		Yes	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SDI-E	Competition	0.3300				No	3
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-A+AS	ReplacementFire	0.0050				Yes	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-D+AS	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-D+AS	Small-Tree-Lopping	0.0100				Yes	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-E+AS	Aroga-Outbreak	0.0670			5	No	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-E+AS	Early-Cattle-Grazing_0dd-Yr	0.0500			1	No	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-E+AS	Early-Cattle-Grazing_Even-Yr	0.0500			1	No	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-E+AS	Late-Cattle-Grazing_0dd-Yr	0.0063			0	No	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-E+AS	Late-Cattle-Grazing_Even-Yr	0.0063			0	No	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-E+AS	Severe-Drought	0.0070	0.9000			No	
Big Sagebrush-upland+trees	U:SI-E+AS	U:SI-E+AS	Wet-Year	0.0670				No	
Big Sagebrush-upland+trees	U:TEA	U:Annual Spp	Masticate+Native-Seed	0.0100	0.1000			Yes	
Big Sagebrush-upland+trees	U:TEA	U:Annual Spp	ReplacementFire	0.0080				Yes	
Big Sagebrush-upland+trees	U:TEA	U:Annual Spp	Severe-Drought	0.0070	0.1000			Yes	
Big Sagebrush-upland+trees	U:TEA	U:SDI-A	Masticate+Native-Seed	0.0100	0.8000			Yes	
Big Sagebrush-upland+trees	U:TEA	U:SI-A+AS	Masticate+Native-Seed	0.0100	0.1000			Yes	
Big Sagebrush-upland+trees	U:TEA	U:TEA	Severe-Drought	0.0070	0.9000			Yes	
Big Sagebrush-upland+trees	U:Unpalat. Forb	U:SDI-A	Thin+24D+Seed	0.0000	0.9000			Yes	
Big Sagebrush-upland+trees	U:Unpalat. Forb	U:Unpalat. Forb	ReplacementFire	0.0200				Yes	
Big Sagebrush-upland+trees	U:Unpalat. Forb	U:Unpalat. Forb	Thin+24D+Seed	0.0000	0.1000			Yes	
Channel	Channel:Channel	Channel:Channel	Early-Cattle-Grazing_0dd-Yr	0.0340	0.9990		1	No	
Channel	Channel:Channel	Channel:Channel	Early-Cattle-Grazing_Even-Yr	0.0340	0.9990		1	No	
Channel	Channel:Channel	Channel:Channel	Late-Cattle-Grazing_0dd-Yr	0.0390			0	No	
Channel	Channel:Channel	Channel:Channel	Late-Cattle-Grazing_Even-Yr	0.0390			0	No	
Channel	Channel:Channel	Channel:Channel	Weed-Inventory+Spot-Treat	0.0100				No	3
Channel	Channel:Channel	Channel:Channel	Wild-Horse-Grazing	0.0390	0.9990		2	No	
Channel	Channel:Channel	Channel:Exotic Forb&Tree	Early-Cattle-Grazing_0dd-Yr	0.0340	0.0010			Yes	
Channel	Channel:Channel	Channel:Exotic Forb&Tree	Early-Cattle-Grazing_Even-Yr	0.0340	0.0010			Yes	
Channel	Channel:Channel	Channel:Exotic Forb&Tree	Exotic-Invasion	0.0050				No	5

Channel	Channel:Channel	Channel:Exotic Forb&Tree	Wild-Horse-Grazing	0.0390	0.0010				Yes
Channel	Channel:Exotic Forb&Tree	Channel:Exotic Forb&Tree	Early-Cattle-Grazing_Odd-Yr	0.0340				1	No
Channel	Channel:Exotic Forb&Tree	Channel:Exotic Forb&Tree	Early-Cattle-Grazing_Even-Yr	0.0340				1	No
Channel	Channel:Exotic Forb&Tree	Channel:Exotic Forb&Tree	Late-Cattle-Grazing_Odd-Yr	0.0390				0	No
Channel	Channel:Exotic Forb&Tree	Channel:Exotic Forb&Tree	Late-Cattle-Grazing_Even-Yr	0.0390				0	No
Channel	Channel:Exotic Forb&Tree	Channel:Exotic Forb&Tree	Wild-Horse-Grazing	0.0390				2	No
Curl-leaf Mountain Mahogany	1-Early:All	1-Early:All	Early-Cattle-Grazing_Odd-Yr	0.0487		3		1	No
Curl-leaf Mountain Mahogany	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0487		3		1	No
Curl-leaf Mountain Mahogany	1-Early:All	1-Early:All	Late-Cattle-Grazing_Odd-Yr	0.0062		3		0	No
Curl-leaf Mountain Mahogany	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0062		3		0	No
Curl-leaf Mountain Mahogany	1-Early:All	1-Early:All	NativeGrazing	0.0200					Yes
Curl-leaf Mountain Mahogany	1-Early:All	1-Early:All	ReplacementFire	0.0020					Yes
Curl-leaf Mountain Mahogany	2-Mid:Open	1-Early:All	ReplacementFire	0.0070					Yes
Curl-leaf Mountain Mahogany	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Odd-Yr	0.0487				1	No
Curl-leaf Mountain Mahogany	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0487				1	No
Curl-leaf Mountain Mahogany	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Odd-Yr	0.0062				0	No
Curl-leaf Mountain Mahogany	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0062				0	No
Curl-leaf Mountain Mahogany	2-Mid:Open	2-Mid:Open	NativeGrazing	0.0100				-1	No
Curl-leaf Mountain Mahogany	3-Mid:Closed	1-Early:All	ReplacementFire	0.0070		60	149		Yes
Curl-leaf Mountain Mahogany	3-Mid:Closed	3-Mid:Closed	Early-Cattle-Grazing_Odd-Yr	0.0487				1	No
Curl-leaf Mountain Mahogany	3-Mid:Closed	3-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0487				1	No
Curl-leaf Mountain Mahogany	3-Mid:Closed	3-Mid:Closed	Late-Cattle-Grazing_Odd-Yr	0.0062				0	No
Curl-leaf Mountain Mahogany	3-Mid:Closed	3-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0062				0	No
Curl-leaf Mountain Mahogany	3-Mid:Closed	4-Late:Open	AlternateBpS-CMM	0.0050		60	149		No
Curl-leaf Mountain Mahogany	4-Late:Open	1-Early:All	ReplacementFire	0.0030					Yes
Curl-leaf Mountain Mahogany	4-Late:Open	4-Late:Open	Early-Cattle-Grazing_Odd-Yr	0.0487				1	No

Curl-leaf Mountain Mahogany	4-Late:Open	4-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0487			1	No	
Curl-leaf Mountain Mahogany	4-Late:Open	4-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0062			0	No	
Curl-leaf Mountain Mahogany	4-Late:Open	4-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0062			0	No	
Curl-leaf Mountain Mahogany	4-Late:Open	U:Tree Ann Spp	AS-Invasion	0.0025				No	
Curl-leaf Mountain Mahogany	5-Late:Closed	1-Early:All	ReplacementFire	0.0020				Yes	
Curl-leaf Mountain Mahogany	5-Late:Closed	5-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0487			1	No	
Curl-leaf Mountain Mahogany	5-Late:Closed	5-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0487			1	No	
Curl-leaf Mountain Mahogany	5-Late:Closed	5-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0062			0	No	
Curl-leaf Mountain Mahogany	5-Late:Closed	5-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0062			0	No	
Curl-leaf Mountain Mahogany	5-Late:Closed	U:Tree Ann Spp	AS-Invasion	0.0010				No	
Curl-leaf Mountain Mahogany	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0487			1	No	2
Curl-leaf Mountain Mahogany	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0487			1	No	2
Curl-leaf Mountain Mahogany	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0062			0	No	2
Curl-leaf Mountain Mahogany	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0062			0	No	2
Curl-leaf Mountain Mahogany	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000				Yes	
Curl-leaf Mountain Mahogany	U:Tree Ann Spp	U:Annual Spp	ReplacementFire	0.0070		60		Yes	
Curl-leaf Mountain Mahogany	U:Tree Ann Spp	U:Tree Ann Spp	Early-Cattle-Grazing_0dd-Yr	0.0487			1	No	
Curl-leaf Mountain Mahogany	U:Tree Ann Spp	U:Tree Ann Spp	Early-Cattle-Grazing_Even-Yr	0.0487			1	No	
Curl-leaf Mountain Mahogany	U:Tree Ann Spp	U:Tree Ann Spp	Late-Cattle-Grazing_0dd-Yr	0.0062			0	No	
Curl-leaf Mountain Mahogany	U:Tree Ann Spp	U:Tree Ann Spp	Late-Cattle-Grazing_Even-Yr	0.0062			0	No	
Desert Wash	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0410	0.9990	3	1	No	
Desert Wash	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0410	0.9990	3	1	No	
Desert Wash	1-Early:All	1-Early:All	Flash-Flooding	0.0075				Yes	
Desert Wash	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0052		3	0	No	
Desert Wash	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0052		3	0	No	
Desert Wash	1-Early:All	1-Early:All	Weed-Inventory+Spot-Treat	0.0100				No	3
Desert Wash	1-Early:All	U:Bare Ground	OHV	0.0001				Yes	
Desert Wash	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0410	0.0010	3		No	
Desert Wash	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0410	0.0010	3		No	
Desert Wash	1-Early:All	U:Exotic Forb&Tree	Exotic-Invasion	0.0050				No	5
Desert Wash	1-Early:All	U:SAP	AS-Invasion	0.0050				No	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Desert Wash	2-Mid:Closed	1-Early:All	Flash-Flooding	0.0075					Yes	
Desert Wash	2-Mid:Closed	1-Early:All	ReplacementFire	0.0001					Yes	
Desert Wash	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.0410	0.9990			1	No	
Desert Wash	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0410	0.9990			1	No	
Desert Wash	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.0052				0	No	
Desert Wash	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0052				0	No	
Desert Wash	2-Mid:Closed	2-Mid:Closed	Weed-Inventory+Spot-Treat	0.0100					No	3
Desert Wash	2-Mid:Closed	U:Bare Ground	OHV	0.0001					Yes	
Desert Wash	2-Mid:Closed	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0410	0.0010				No	
Desert Wash	2-Mid:Closed	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0410	0.0010				No	
Desert Wash	2-Mid:Closed	U:Exotic Forb&Tree	Exotic-Invasion	0.0050					No	5
Desert Wash	2-Mid:Closed	U:SAP	AS-Invasion	0.0050					No	
Desert Wash	3-Late:Closed	1-Early:All	Flash-Flooding	0.0075					Yes	
Desert Wash	3-Late:Closed	1-Early:All	ReplacementFire	0.0001					Yes	
Desert Wash	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0410	0.9990			1	No	
Desert Wash	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0410	0.9990			1	No	
Desert Wash	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0052				0	No	
Desert Wash	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0052				0	No	
Desert Wash	3-Late:Closed	3-Late:Closed	Weed-Inventory+Spot-Treat	0.0100					No	3
Desert Wash	3-Late:Closed	U:Bare Ground	OHV	0.0001					Yes	
Desert Wash	3-Late:Closed	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0410	0.0010				No	
Desert Wash	3-Late:Closed	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0410	0.0010				No	
Desert Wash	3-Late:Closed	U:Exotic Forb&Tree	Exotic-Invasion	0.0050					No	5
Desert Wash	3-Late:Closed	U:SAP	AS-Invasion	0.0050					No	
Desert Wash	U:Bare Ground	U:Bare Ground	OHV	0.0001					Yes	
Desert Wash	U:Bare Ground	U:Bare Ground	Weed-Inventory+Spot-Treat	0.0100					No	3
Desert Wash	U:Bare Ground	U:Early Shrub	Alternate-Succession	0.1000		20			Yes	
Desert Wash	U:Bare Ground	U:Exotic Forb&Tree	Exotic-Invasion	0.0050					Yes	5
Desert Wash	U:Bare Ground	U:SA	AS-Invasion	0.0050					No	
Desert Wash	U:Early Shrub	U:Bare Ground	OHV	0.0001					Yes	
Desert Wash	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0001					Yes	
Desert Wash	U:Early Shrub	U:Early Shrub	Weed-Inventory+Spot-Treat	0.0100					No	3
Desert Wash	U:Early Shrub	U:Exotic Forb&Tree	Exotic-Invasion	0.0050					No	5
Desert Wash	U:Exotic Forb&Tree	1-Early:All	Exotic-Control	0.0100	0.6000		4		Yes	
Desert Wash	U:Exotic Forb&Tree	1-Early:All	Tamarisk-Beetle	0.2500	0.9000		4		No	
Desert Wash	U:Exotic Forb&Tree	2-Mid:Closed	Exotic-Control	0.0100	0.6000	5	19		Yes	
Desert Wash	U:Exotic Forb&Tree	2-Mid:Closed	Tamarisk-Beetle	0.2500	0.9000	5	19		No	
Desert Wash	U:Exotic Forb&Tree	3-Late:Closed	Exotic-Control	0.0100	0.6000	20			Yes	
Desert Wash	U:Exotic Forb&Tree	3-Late:Closed	Tamarisk-Beetle	0.2500	0.9000	20			No	
Desert Wash	U:Exotic Forb&Tree	U:Bare Ground	OHV	0.0001					Yes	
Desert Wash	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Exotic-Control	0.0100	0.4000				Yes	

Desert Wash	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Flash-Flooding	0.0075					Yes	
Desert Wash	U:Exotic Forb&Tree	U:Exotic Forb&Tree	ReplacementFire	0.0001					Yes	
Desert Wash	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Tamarisk-Beetle	0.2500	0.1000				No	
Desert Wash	U:SA	U:Bare Ground	OHV	0.0001					Yes	
Desert Wash	U:SA	U:Exotic Forb&Tree	Exotic-Invasion	0.0050					No	5
Desert Wash	U:SA	U:SA	Early-Cattle-Grazing_0dd-Yr	0.0410				1	No	
Desert Wash	U:SA	U:SA	Early-Cattle-Grazing_Even-Yr	0.0410				1	No	
Desert Wash	U:SA	U:SA	Late-Cattle-Grazing_0dd-Yr	0.0052				0	No	
Desert Wash	U:SA	U:SA	Late-Cattle-Grazing_Even-Yr	0.0052				0	No	
Desert Wash	U:SA	U:SA	ReplacementFire	0.0001			19		Yes	2
Desert Wash	U:SA	U:SA	ReplacementFire	0.0001		20			Yes	
Desert Wash	U:SA	U:SA	Weed-Inventory+Spot-Treat	0.0100					No	3
Desert Wash	U:SAP	U:Bare Ground	OHV	0.0001					Yes	
Desert Wash	U:SAP	U:Exotic Forb&Tree	Exotic-Invasion	0.0050					No	5
Desert Wash	U:SAP	U:SA	Early-Cattle-Grazing_0dd-Yr	0.0410	0.0010				No	
Desert Wash	U:SAP	U:SA	Early-Cattle-Grazing_Even-Yr	0.0410	0.0010				No	
Desert Wash	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0410	0.9990			1	No	
Desert Wash	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0410	0.9990			1	No	
Desert Wash	U:SAP	U:SAP	Flash-Flooding	0.0075					Yes	
Desert Wash	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0052				0	No	
Desert Wash	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0052				0	No	
Desert Wash	U:SAP	U:SAP	ReplacementFire	0.0001			19		Yes	2
Desert Wash	U:SAP	U:SAP	ReplacementFire	0.0001		20			Yes	
Desert Wash	U:SAP	U:SAP	Weed-Inventory+Spot-Treat	0.0100					No	3
Four-Wing Saltbush	1-Early:Open	1-Early:Open	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990	3		1	No	
Four-Wing Saltbush	1-Early:Open	1-Early:Open	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990	3		1	No	
Four-Wing Saltbush	1-Early:Open	1-Early:Open	Late-Cattle-Grazing_0dd-Yr	0.0027		3			No	
Four-Wing Saltbush	1-Early:Open	1-Early:Open	Late-Cattle-Grazing_Even-Yr	0.0027		3			No	
Four-Wing Saltbush	1-Early:Open	1-Early:Open	Very-Wet-Year	0.0181					Yes	
Four-Wing Saltbush	1-Early:Open	U:ASPG	AS-Invasion	0.0025					No	
Four-Wing Saltbush	1-Early:Open	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010	3			Yes	
Four-Wing Saltbush	1-Early:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010	3			Yes	
Four-Wing Saltbush	2-Mid:Open	1-Early:Open	ReplacementFire	0.0010					Yes	
Four-Wing Saltbush	2-Mid:Open	1-Early:Open	Very-Wet-Year	0.0181					Yes	
Four-Wing Saltbush	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990			1	No	
Four-Wing Saltbush	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990			1	No	
Four-Wing Saltbush	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_0dd-Yr	0.0027					No	
Four-Wing Saltbush	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0027					No	
Four-Wing Saltbush	2-Mid:Open	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010				No	
Four-Wing Saltbush	2-Mid:Open	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010				No	
Four-Wing Saltbush	2-Mid:Open	U:SAP	AS-Invasion	0.0025					No	
Four-Wing Saltbush	3-Late:Closed	1-Early:Open	ReplacementFire	0.0010					Yes	
Four-Wing Saltbush	3-Late:Closed	1-Early:Open	Very-Wet-Year	0.0181	1.0000				Yes	
Four-Wing Saltbush	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990			1	No	
Four-Wing Saltbush	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990			1	No	
Four-Wing Saltbush	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0027					No	
Four-Wing Saltbush	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0027					No	

Four-Wing Saltbush	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010				No		
Four-Wing Saltbush	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010				No		
Four-Wing Saltbush	3-Late:Closed	U:SAP	AS-Invasion	0.0025					No		
Four-Wing Saltbush	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0210				1	No		
Four-Wing Saltbush	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0210				1	No		
Four-Wing Saltbush	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Native-Seed	0.0100	0.4000				Yes		
Four-Wing Saltbush	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0027					No		
Four-Wing Saltbush	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0027					No		
Four-Wing Saltbush	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes	2	
Four-Wing Saltbush	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Four-Wing Saltbush	U:Annual Spp	U:Seeded Native	Herbicide-Plateau+Native-Seed	0.0100	0.6000				Yes		
Four-Wing Saltbush	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010				Yes		
Four-Wing Saltbush	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010				Yes		
Four-Wing Saltbush	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990			1	No		
Four-Wing Saltbush	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990			1	No		
Four-Wing Saltbush	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0027					No		
Four-Wing Saltbush	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0027					No		
Four-Wing Saltbush	U:ASPG	U:ASPG	ReplacementFire	0.0100					Yes	2	
Four-Wing Saltbush	U:ASPG	U:ASPG	Very-Wet-Year	0.0181					Yes		
Four-Wing Saltbush	U:ASPG	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Four-Wing Saltbush	U:Depleted	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990			1	No		
Four-Wing Saltbush	U:Depleted	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990			1	No		
Four-Wing Saltbush	U:Depleted	U:Depleted	Late-Cattle-Grazing_0dd-Yr	0.0027					No		
Four-Wing Saltbush	U:Depleted	U:Depleted	Late-Cattle-Grazing_Even-Yr	0.0027					No		
Four-Wing Saltbush	U:Depleted	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010				Yes		
Four-Wing Saltbush	U:Depleted	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010				Yes		
Four-Wing Saltbush	U:Depleted	U:Early Shrub	ReplacementFire	0.0010					Yes		
Four-Wing Saltbush	U:Depleted	U:Early Shrub	Thin+Native-Seed	0.0100	0.3000				Yes		
Four-Wing Saltbush	U:Depleted	U:Early Shrub	Very-Wet-Year	0.0181					Yes		
Four-Wing Saltbush	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Four-Wing Saltbush	U:Depleted	U:SAP	AS-Invasion	0.0050					No		
Four-Wing Saltbush	U:Depleted	U:Seeded Native	Thin+Native-Seed	0.0100	0.7000				Yes		
Four-Wing Saltbush	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Four-Wing Saltbush	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.4000				Yes	0	20
Four-Wing Saltbush	U:Exotic Forbs	U:Seeded Native	Exotic-Control	0.0100	0.6000				Yes	0	20
Four-Wing Saltbush	U:SAP	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010				Yes		
Four-Wing Saltbush	U:SAP	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010				Yes		
Four-Wing Saltbush	U:SAP	U:Annual Spp	ReplacementFire	0.0100			19		Yes	2	
Four-Wing Saltbush	U:SAP	U:Annual Spp	ReplacementFire	0.0100		20			Yes		
Four-Wing Saltbush	U:SAP	U:Annual Spp	Very-Wet-Year	0.0181					Yes		
Four-Wing Saltbush	U:SAP	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Four-Wing Saltbush	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990			1	No		
Four-Wing Saltbush	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990			1	No		
Four-Wing Saltbush	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0027					No		
Four-Wing Saltbush	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0027					No		
Four-Wing Saltbush	U:Seeded Native	1-Early:Open	Natural-Recovery	0.3330			5		No	5	
Four-Wing Saltbush	U:Seeded Native	2-Mid:Open	Natural-Recovery	0.3330		6	19		No	5	
Four-Wing Saltbush	U:Seeded Native	3-Late:Closed	Natural-Recovery	0.3330		20			No	5	
Four-Wing Saltbush	U:Seeded Native	U:ASPG	AS-Invasion	0.0050			5		No		

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Four-Wing Saltbush	U:Seeded Native	U:Depleted	Early-Cattle-Grazing_Odd-Yr	0.0210	0.0010	3			No		
Four-Wing Saltbush	U:Seeded Native	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010	3			No		
Four-Wing Saltbush	U:Seeded Native	U:SAP	AS-Invasion	0.0050		6			No		
Four-Wing Saltbush	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Odd-Yr	0.0210	0.9990	3		1	No		
Four-Wing Saltbush	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990	3		1	No		
Four-Wing Saltbush	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Odd-Yr	0.0027		3			No		
Four-Wing Saltbush	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Even-Yr	0.0027		3			No		
Four-Wing Saltbush	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0010		6	19		Yes		
Four-Wing Saltbush	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0010		20			Yes		
Four-Wing Saltbush	U:Seeded Native	U:Seeded Native	Very-Wet-Year	0.0181					Yes		
Greasewood	1-Early:All	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Greasewood	1-Early:All	1-Early:All	Late-Cattle-Grazing_Odd-Yr	0.0010		3		0	No		
Greasewood	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0010		3		0	No		
Greasewood	1-Early:All	U:Annual Spp	AS-Invasion	0.0025					No		
Greasewood	3-Late:Closed	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Greasewood	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Odd-Yr	0.0010				0	No		
Greasewood	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0010				0	No		
Greasewood	3-Late:Closed	U:SA	AS-Invasion	0.0025					No		
Greasewood	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Odd-Yr	0.0010				0	No		
Greasewood	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0010				0	No		
Greasewood	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Greasewood	U:Annual Spp	U:SDI+AS	Herbicide-Plateau+Seed	0.0100	0.2500				Yes		
Greasewood	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Seed	0.0100	0.2500				Yes		
Greasewood	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes	2	
Greasewood	U:Annual Spp	U:SDI	Herbicide-Plateau+Seed	0.0100	0.5000				Yes		
Greasewood	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.5000				Yes	0	20
Greasewood	U:Exotic Forbs	U:SDI	Exotic-Control	0.0100	0.5000				Yes	0	20
Greasewood	U:Pasture	U:Pasture	Early-Cattle-Grazing_Odd-Yr	0.0090				1	No		
Greasewood	U:Pasture	U:Pasture	Early-Cattle-Grazing_Even-Yr	0.0090				1	No		
Greasewood	U:Pasture	U:Pasture	Late-Cattle-Grazing_Odd-Yr	0.0010				0	No		
Greasewood	U:Pasture	U:Pasture	Late-Cattle-Grazing_Even-Yr	0.0010				0	No		
Greasewood	U:SA	U:Annual Spp	ReplacementFire	0.0030					Yes	2	
Greasewood	U:SA	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Greasewood	U:SA	U:SA	Late-Cattle-Grazing_Odd-Yr	0.0010				0	No		
Greasewood	U:SA	U:SA	Late-Cattle-Grazing_Even-Yr	0.0010				0	No		
Greasewood	U:SA	U:SA	SurfaceFire	0.0033					Yes	2	
Greasewood	U:SDI	3-Late:Closed	Natural-Recovery	0.0010		5	29		No	10	
Greasewood	U:SDI	U:SDI	Late-Cattle-Grazing_Odd-Yr	0.0010		3		0	No		
Greasewood	U:SDI	U:SDI	Late-Cattle-Grazing_Even-Yr	0.0010		3		0	No		
Greasewood	U:SDI	U:SDI+AS	AS-Invasion	0.0010		5			No		
Greasewood	U:SDI+AS	U:SDI+AS	Wet-Year	0.0670					No		
Greasewood	U:SDI+AS	U:SDI	Competition	0.3300					No	3	
Greasewood	U:SDI+AS	U:SDI+AS	Late-Cattle-Grazing_Odd-Yr	0.0010		3		0	No	0	
Greasewood	U:SDI+AS	U:SDI+AS	Late-Cattle-Grazing_Even-Yr	0.0010		3		0	No	0	
Greasewood	U:SDI+AS	U:SDI+AS	ReplacementFire	0.0010					Yes	2	
Juniper Woodland	1-Early:Open	1-Early:Open	ReplacementFire	0.0050					Yes		
Juniper Woodland	1-Early:Open	U:Annual Spp	AS-Invasion	0.0025					No		
Juniper Woodland	2-Mid:Open	1-Early:Open	ReplacementFire	0.0050					Yes		
Juniper Woodland	2-Mid:Open	U:SAP	AS-Invasion	0.0025					No		

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Juniper Woodland	3-Mid:Open	1-Early:Open	ReplacementFire	0.0050					Yes		
Juniper Woodland	3-Mid:Open	2-Mid:Open	Severe-Drought	0.0070	0.1000				Yes		
Juniper Woodland	3-Mid:Open	3-Mid:Open	Severe-Drought	0.0070	0.9000				Yes		
Juniper Woodland	3-Mid:Open	U:Tree Ann Spp	AS-Invasion	0.0025					No		
Juniper Woodland	4-Late:Open	1-Early:Open	ReplacementFire	0.0020					Yes		
Juniper Woodland	4-Late:Open	1-Early:Open	Senescence	0.0100		2000			Yes		
Juniper Woodland	4-Late:Open	2-Mid:Open	Insect/Disease	0.0167	0.0100				Yes		
Juniper Woodland	4-Late:Open	3-Mid:Open	Insect/Disease	0.0167	0.0900				Yes		
Juniper Woodland	4-Late:Open	4-Late:Open	Insect/Disease	0.0167	0.9000				Yes		
Juniper Woodland	4-Late:Open	4-Late:Open	SurfaceFire	0.0010					No		
Juniper Woodland	4-Late:Open	U:Tree Ann Spp	AS-Invasion	0.0010					No		
Juniper Woodland	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes		
Juniper Woodland	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Juniper Woodland	U:Exotic Forbs	1-Early:Open	Exotic-Control	0.0100	0.6000				Yes		20
Juniper Woodland	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.4000				Yes		20
Juniper Woodland	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0050					Yes		
Juniper Woodland	U:SAP	U:Annual Spp	ReplacementFire	0.0100			29		Yes	2	
Juniper Woodland	U:SAP	U:Annual Spp	ReplacementFire	0.0100		30			Yes		
Juniper Woodland	U:SAP	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Juniper Woodland	U:Tree Ann Spp	1-Early:Open	ReplacementFire	0.0050					Yes		
Juniper Woodland	U:Tree Ann Spp	U:Annual Spp	Senescence	0.0100		2000					
Juniper Woodland	U:Tree Ann Spp	U:Annual Spp	Severe-Drought	0.0070	0.1000				Yes		
Juniper Woodland	U:Tree Ann Spp	U:Tree Ann Spp	Severe-Drought	0.0070	0.9000				Yes		
Limber Pine Woodland	1-Early:All	1-Early:All	ReplacementFire	0.0010					Yes		
Limber Pine Woodland	1-Early:All	1-Early:All	Severe-Drought	0.0070				-5	No		
Limber Pine Woodland	1-Early:All	1-Early:All	SurfaceFire	0.0010					No		
Limber Pine Woodland	2-Mid:Open	1-Early:All	ReplacementFire	0.0010					Yes		
Limber Pine Woodland	2-Mid:Open	2-Mid:Open	SurfaceFire	0.0020					No		
Limber Pine Woodland	3-Late:Open	1-Early:All	ReplacementFire	0.0010					Yes		
Limber Pine Woodland	3-Late:Open	3-Late:Open	SurfaceFire	0.0020					No		
Low Sagebrush	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0440	0.9990	3		1	No		
Low Sagebrush	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0440	0.9990	3		1	No		
Low Sagebrush	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0060		3		0	No		
Low Sagebrush	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0060		3		0	No		
Low Sagebrush	1-Early:All	1-Early:All	ReplacementFire	0.0040					Yes		
Low Sagebrush	1-Early:All	1-Early:All	Severe-Drought	0.0070				-1	No		
Low Sagebrush	1-Early:All	1-Early:All	Wild-Horse-Grazing	0.0120	0.9990			1	No		
Low Sagebrush	1-Early:All	U:ASPG	AS-Invasion	0.0010					No		
Low Sagebrush	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0440	0.0010	3			No		
Low Sagebrush	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0440	0.0010	3			No		
Low Sagebrush	1-Early:All	U:Early Shrub	Wild-Horse-Grazing	0.0120	0.0010				No		
Low Sagebrush	2-Mid:Open	1-Early:All	ReplacementFire	0.0040					Yes		
Low Sagebrush	2-Mid:Open	1-Early:All	Severe-Drought	0.0070	0.1000				Yes		
Low Sagebrush	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_0dd-Yr	0.0440	0.9990			1	No		
Low Sagebrush	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0440	0.9990			1	No		
Low Sagebrush	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_0dd-Yr	0.0060				0	No		
Low Sagebrush	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0060				0	No		
Low Sagebrush	2-Mid:Open	2-Mid:Open	Severe-Drought	0.0070	0.9000				Yes		
Low Sagebrush	2-Mid:Open	2-Mid:Open	Wild-Horse-Grazing	0.0120	0.9990			1	No		

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Low Sagebrush	2-Mid:Open	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0440	0.0010		No	
Low Sagebrush	2-Mid:Open	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0440	0.0010		No	
Low Sagebrush	2-Mid:Open	U:Depleted	Wild-Horse-Grazing	0.0120	0.0010		No	
Low Sagebrush	2-Mid:Open	U:SAP	AS-Invasion	0.0010			No	
Low Sagebrush	3-Late:Closed	1-Early:All	ReplacementFire	0.0040			Yes	
Low Sagebrush	3-Late:Closed	2-Mid:Open	Severe-Drought	0.0070	0.1000		Yes	
Low Sagebrush	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0440	0.9990	1	No	
Low Sagebrush	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0440	0.9990	1	No	
Low Sagebrush	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0060		0	No	
Low Sagebrush	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0060		0	No	
Low Sagebrush	3-Late:Closed	3-Late:Closed	Severe-Drought	0.0070	0.9000		Yes	
Low Sagebrush	3-Late:Closed	3-Late:Closed	Wild-Horse-Grazing	0.0120	0.9990	1	No	
Low Sagebrush	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0440	0.0010		No	
Low Sagebrush	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0440	0.0010		No	
Low Sagebrush	3-Late:Closed	U:Depleted	Wild-Horse-Grazing	0.0120	0.0010		No	
Low Sagebrush	3-Late:Closed	U:SAP	AS-Invasion	0.0010			No	
Low Sagebrush	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0440		1	No	
Low Sagebrush	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0440		1	No	
Low Sagebrush	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Seed	0.0100	0.1500		Yes	
Low Sagebrush	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0060		0	No	
Low Sagebrush	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0060		0	No	
Low Sagebrush	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000			Yes	2
Low Sagebrush	U:Annual Spp	U:Annual Spp	Wild-Horse-Grazing	0.0120		1	No	
Low Sagebrush	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005			No	
Low Sagebrush	U:Annual Spp	U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.7000		Yes	
Low Sagebrush	U:Annual Spp	U:SI-A+AS	Herbicide-Plateau+Seed	0.0100	0.1500		Yes	
Low Sagebrush	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0440	0.0010		No	
Low Sagebrush	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0440	0.0010		No	
Low Sagebrush	U:ASPG	U:Annual Spp	ReplacementFire	0.0067	0.5000		Yes	2
Low Sagebrush	U:ASPG	U:Annual Spp	ReplacementFire	0.0067	0.5000		Yes	2
Low Sagebrush	U:ASPG	U:Annual Spp	Severe-Drought	0.0070	0.1000		Yes	
Low Sagebrush	U:ASPG	U:Annual Spp	Wild-Horse-Grazing	0.0120	0.0010		No	
Low Sagebrush	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0440	0.9990	1	No	
Low Sagebrush	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0440	0.9990	1	No	
Low Sagebrush	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0060		0	No	
Low Sagebrush	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0060		0	No	
Low Sagebrush	U:ASPG	U:ASPG	Severe-Drought	0.0070	0.9000		Yes	
Low Sagebrush	U:ASPG	U:ASPG	Wild-Horse-Grazing	0.0120	0.9990	1	No	
Low Sagebrush	U:ASPG	U:Exotic Forbs	Exotic-Control	0.0010			No	
Low Sagebrush	U:Depleted	U:Depleted	Severe-Drought	0.0070	0.9000		Yes	
Low Sagebrush	U:Depleted	U:Early Shrub	ReplacementFire	0.0020			Yes	
Low Sagebrush	U:Depleted	U:Early Shrub	Severe-Drought	0.0070	0.1000		Yes	
Low Sagebrush	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0005			No	
Low Sagebrush	U:Depleted	U:SA	AS-Invasion	0.0050			No	
Low Sagebrush	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0040			No	
Low Sagebrush	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0440		1	No	
Low Sagebrush	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0440		1	No	
Low Sagebrush	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.2000		Yes	
Low Sagebrush	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0060		0	No	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Low Sagebrush	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0060				0	No	
Low Sagebrush	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0050					Yes	
Low Sagebrush	U:Exotic Forbs	U:Exotic Forbs	Wild-Horse-Grazing	0.0120				2	No	
Low Sagebrush	U:Exotic Forbs	U:SDI-A	Exotic-Control	0.0100	0.8000				Yes	
Low Sagebrush	U:SA	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0440	0.0010				No	
Low Sagebrush	U:SA	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0440	0.0010				No	
Low Sagebrush	U:SA	U:Annual Spp	ReplacementFire	0.0067			119		Yes	2
Low Sagebrush	U:SA	U:Annual Spp	ReplacementFire	0.0067		120			Yes	
Low Sagebrush	U:SA	U:Annual Spp	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush	U:SA	U:Annual Spp	Wild-Horse-Grazing	0.0120	0.0010				No	
Low Sagebrush	U:SA	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes	
Low Sagebrush	U:SA	U:SA	Early-Cattle-Grazing_0dd-Yr	0.0440	0.9990			1	No	
Low Sagebrush	U:SA	U:SA	Early-Cattle-Grazing_Even-Yr	0.0440	0.9990			1	No	
Low Sagebrush	U:SA	U:SA	Late-Cattle-Grazing_0dd-Yr	0.0060				0	No	
Low Sagebrush	U:SA	U:SA	Late-Cattle-Grazing_Even-Yr	0.0060				0	No	
Low Sagebrush	U:SA	U:SA	Severe-Drought	0.0070	0.9000				Yes	
Low Sagebrush	U:SA	U:SA	Wild-Horse-Grazing	0.0120	0.9990			1	No	
Low Sagebrush	U:SA	U:Unpalat. Forb	Wet-Year	0.0670					No	
Low Sagebrush	U:SAP	U:Annual Spp	ReplacementFire	0.0100	0.9500		119		Yes	2
Low Sagebrush	U:SAP	U:Annual Spp	ReplacementFire	0.0100	0.9500	120			Yes	
Low Sagebrush	U:SAP	U:ASPG	ReplacementFire	0.0100	0.0500		119		Yes	2
Low Sagebrush	U:SAP	U:ASPG	ReplacementFire	0.0100	0.0500	120			Yes	
Low Sagebrush	U:SAP	U:ASPG	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush	U:SAP	U:Exotic Forbs	Exotic-Invasion	0.0005					No	
Low Sagebrush	U:SAP	U:SA	Early-Cattle-Grazing_0dd-Yr	0.0440	0.0010				No	
Low Sagebrush	U:SAP	U:SA	Early-Cattle-Grazing_Even-Yr	0.0440	0.0010				No	
Low Sagebrush	U:SAP	U:SA	Wild-Horse-Grazing	0.0120	0.0010				No	
Low Sagebrush	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0440	0.9990			1	No	
Low Sagebrush	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0440	0.9990			1	No	
Low Sagebrush	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0060				0	No	
Low Sagebrush	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0060				0	No	
Low Sagebrush	U:SAP	U:SAP	Severe-Drought	0.0070	0.9000				Yes	
Low Sagebrush	U:SAP	U:SAP	Wild-Horse-Grazing	0.0120	0.9990			1	No	
Low Sagebrush	U:SDI-A	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0440	0.0010	3			Yes	
Low Sagebrush	U:SDI-A	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0440	0.0010	3			Yes	
Low Sagebrush	U:SDI-A	U:Early Shrub	Wild-Horse-Grazing	0.0120	0.0010				Yes	
Low Sagebrush	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_0dd-Yr	0.0440	0.9990	3		1	No	
Low Sagebrush	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_Even-Yr	0.0440	0.9990	3		1	No	
Low Sagebrush	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_0dd-Yr	0.0060		3		0	No	
Low Sagebrush	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_Even-Yr	0.0060		3		0	No	
Low Sagebrush	U:SDI-A	U:SDI-A	ReplacementFire	0.0010					Yes	
Low Sagebrush	U:SDI-A	U:SDI-A	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush	U:SDI-A	U:SDI-A	Severe-Drought	0.0070	0.9000			-1	No	
Low Sagebrush	U:SDI-A	U:SDI-A	Wild-Horse-Grazing	0.0120	0.9990			1	No	
Low Sagebrush	U:SDI-A	U:SI-A+AS	AS-Invasion	0.0010					No	
Low Sagebrush	U:SDI-B	2-Mid:Open	Natural-Recovery	0.0010					No	10
Low Sagebrush	U:SDI-B	U:SDI-A	ReplacementFire	0.0010					Yes	
Low Sagebrush	U:SDI-B	U:SDI-A	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_0dd-Yr	0.0440				1	No	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Low Sagebrush	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_Even-Yr	0.0440				1	No	
Low Sagebrush	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_0dd-Yr	0.0060				0	No	
Low Sagebrush	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_Even-Yr	0.0060				0	No	
Low Sagebrush	U:SDI-B	U:SDI-B	Severe-Drought	0.0070	0.9000				Yes	
Low Sagebrush	U:SDI-B	U:SDI-B	Wild-Horse-Grazing	0.0120				1	No	
Low Sagebrush	U:SDI-B	U:SI-B+AS	AS-Invasion	0.0010					No	
Low Sagebrush	U:SDI-C	3-Late:Closed	Natural-Recovery	0.0100					No	10
Low Sagebrush	U:SDI-C	U:SDI-A	ReplacementFire	0.0010					Yes	
Low Sagebrush	U:SDI-C	U:SDI-B	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_0dd-Yr	0.0440				1	No	
Low Sagebrush	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_Even-Yr	0.0440				1	No	
Low Sagebrush	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_0dd-Yr	0.0060				0	No	
Low Sagebrush	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_Even-Yr	0.0060				0	No	
Low Sagebrush	U:SDI-C	U:SDI-C	Severe-Drought	0.0070	0.9000				Yes	
Low Sagebrush	U:SDI-C	U:SDI-C	Wild-Horse-Grazing	0.0120				1	No	
Low Sagebrush	U:SDI-C	U:SI-C+AS	AS-Invasion	0.0010					No	
Low Sagebrush	U:Seeded Native	1-Early:All	Natural-Recovery	0.3330			24		No	5
Low Sagebrush	U:Seeded Native	2-Mid:Open	Natural-Recovery	0.3330		25	149		No	5
Low Sagebrush	U:Seeded Native	3-Late:Closed	Natural-Recovery	0.3330		150			No	5
Low Sagebrush	U:Seeded Native	U:ASPG	AS-Invasion	0.0050			24		No	
Low Sagebrush	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0440	0.0010	3			No	
Low Sagebrush	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0440	0.0010	3			No	
Low Sagebrush	U:Seeded Native	U:Early Shrub	Wild-Horse-Grazing	0.0120	0.0010	3			No	
Low Sagebrush	U:Seeded Native	U:SAP	AS-Invasion	0.0050		25			No	
Low Sagebrush	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_0dd-Yr	0.0440	0.9990	3		1	No	
Low Sagebrush	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Even-Yr	0.0440	0.9990	3		1	No	
Low Sagebrush	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_0dd-Yr	0.0060		3		0	No	
Low Sagebrush	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Even-Yr	0.0060		3		0	No	
Low Sagebrush	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0040					Yes	
Low Sagebrush	U:Seeded Native	U:Seeded Native	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush	U:Seeded Native	U:Seeded Native	Severe-Drought	0.0070	0.9000		24	-1	No	
Low Sagebrush	U:Seeded Native	U:Seeded Native	Severe-Drought	0.0070	0.9000	25		25	Yes	
Low Sagebrush	U:Seeded Native	U:Seeded Native	Wild-Horse-Grazing	0.0120	0.9990			1	No	
Low Sagebrush	U:SI-A+AS	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0440	0.0010	3			Yes	
Low Sagebrush	U:SI-A+AS	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0440	0.0010	3			Yes	
Low Sagebrush	U:SI-A+AS	U:Annual Spp	Wild-Horse-Grazing	0.0120	0.0010				Yes	
Low Sagebrush	U:SI-A+AS	U:SDI-A	Competition	0.3300					No	3
Low Sagebrush	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_0dd-Yr	0.0440	0.9990	3		1	No	
Low Sagebrush	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_Even-Yr	0.0440	0.9990	3		1	No	
Low Sagebrush	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_0dd-Yr	0.0060		3		0	No	
Low Sagebrush	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_Even-Yr	0.0060		3		0	No	
Low Sagebrush	U:SI-A+AS	U:SI-A+AS	ReplacementFire	0.0050					Yes	2
Low Sagebrush	U:SI-A+AS	U:SI-A+AS	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush	U:SI-A+AS	U:SI-A+AS	Severe-Drought	0.0070	0.9000			-1	No	
Low Sagebrush	U:SI-A+AS	U:SI-A+AS	Wet-Year	0.0670					No	
Low Sagebrush	U:SI-A+AS	U:SI-A+AS	Wild-Horse-Grazing	0.0120	0.9990			1	No	
Low Sagebrush	U:SI-B+AS	U:SDI-B	Competition	0.3300					No	3
Low Sagebrush	U:SI-B+AS	U:SI-A+AS	ReplacementFire	0.0050					Yes	2
Low Sagebrush	U:SI-B+AS	U:SI-A+AS	Severe-Drought	0.0070	0.1000				Yes	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Low Sagebrush	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_0dd-Yr	0.0440				1	No	
Low Sagebrush	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_Even-Yr	0.0440				1	No	
Low Sagebrush	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_0dd-Yr	0.0060				0	No	
Low Sagebrush	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_Even-Yr	0.0060				0	No	
Low Sagebrush	U:SI-B+AS	U:SI-B+AS	Severe-Drought	0.0070	0.9000				Yes	
Low Sagebrush	U:SI-B+AS	U:SI-B+AS	Wild-Horse-Grazing	0.0120				1	No	
Low Sagebrush	U:SI-C+AS	U:SDI-C	Competition	0.3300					No	3
Low Sagebrush	U:SI-C+AS	U:SI-A+AS	ReplacementFire	0.0050			119		Yes	2
Low Sagebrush	U:SI-C+AS	U:SI-A+AS	ReplacementFire	0.0050		120			Yes	
Low Sagebrush	U:SI-C+AS	U:SI-B+AS	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_0dd-Yr	0.0440				1	No	
Low Sagebrush	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_Even-Yr	0.0440				1	No	
Low Sagebrush	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_0dd-Yr	0.0060				0	No	
Low Sagebrush	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_Even-Yr	0.0060				0	No	
Low Sagebrush	U:SI-C+AS	U:SI-C+AS	Severe-Drought	0.0070	0.9000				Yes	
Low Sagebrush	U:SI-C+AS	U:SI-C+AS	Wet-Year	0.0670					No	
Low Sagebrush	U:SI-C+AS	U:SI-C+AS	Wild-Horse-Grazing	0.0120				1	No	
Low Sagebrush	U:Unpalat. Forb	U:SDI-A	Thin+24D+Seed	0.0000	0.7000				Yes	
Low Sagebrush	U:Unpalat. Forb	U:Unpalat. Forb	ReplacementFire	0.0100					Yes	
Low Sagebrush	U:Unpalat. Forb	U:Unpalat. Forb	Thin+24D+Seed	0.0000	0.3000				Yes	
Low Sagebrush Steppe	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0400	0.9990	3		1	No	
Low Sagebrush Steppe	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0400	0.9990	3		1	No	
Low Sagebrush Steppe	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0050		3		0	No	
Low Sagebrush Steppe	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0050		3		0	No	
Low Sagebrush Steppe	1-Early:All	1-Early:All	ReplacementFire	0.0040					Yes	
Low Sagebrush Steppe	1-Early:All	1-Early:All	Severe-Drought	0.0070				-1	No	
Low Sagebrush Steppe	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0400	0.0010	3			No	
Low Sagebrush Steppe	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0400	0.0010	3			No	
Low Sagebrush Steppe	2-Mid:Open	1-Early:All	ReplacementFire	0.0110					Yes	
Low Sagebrush Steppe	2-Mid:Open	1-Early:All	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush Steppe	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_0dd-Yr	0.0400	0.9990			1	No	
Low Sagebrush Steppe	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0400	0.9990			1	No	
Low Sagebrush Steppe	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_0dd-Yr	0.0050				0	No	
Low Sagebrush Steppe	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0050				0	No	
Low Sagebrush Steppe	2-Mid:Open	2-Mid:Open	Severe-Drought	0.0070	0.9000				Yes	
Low Sagebrush Steppe	2-Mid:Open	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0400	0.0010				No	
Low Sagebrush Steppe	2-Mid:Open	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0400	0.0010				No	
Low Sagebrush Steppe	3-Late:Closed	1-Early:All	ReplacementFire	0.0110					Yes	
Low Sagebrush Steppe	3-Late:Closed	2-Mid:Open	Severe-Drought	0.0070	0.1000				Yes	
Low Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0400	0.0010			1	No	
Low Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0400	0.9990			1	No	
Low Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0050				0	No	
Low Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0050				0	No	
Low Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Severe-Drought	0.0070	0.9000				Yes	
Low Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Small-Tree-Lopping	0.0100		200			Yes	
Low Sagebrush Steppe	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0400	0.0010				No	
Low Sagebrush Steppe	U:Depleted	U:Depleted	Severe-Drought	0.0070	0.9000				Yes	
Low Sagebrush Steppe	U:Depleted	U:Early Shrub	ReplacementFire	0.0040					Yes	
Low Sagebrush Steppe	U:Depleted	U:Early Shrub	Severe-Drought	0.0070	0.1000				Yes	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Low Sagebrush Steppe	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0110				Yes	
Low Sagebrush Steppe	U:Unpalat. Forb	U:Unpalat. Forb	ReplacementFire	0.0100				Yes	
Lower Montane-Valley Grassland	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0990	0.9990	3	1	No	
Lower Montane-Valley Grassland	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0990	0.9990	3	1	No	
Lower Montane-Valley Grassland	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0130		3	0	No	
Lower Montane-Valley Grassland	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0130		3	0	No	
Lower Montane-Valley Grassland	1-Early:All	1-Early:All	NativeGrazing	0.0200			-1	No	
Lower Montane-Valley Grassland	1-Early:All	1-Early:All	ReplacementFire	0.0100				Yes	2
Lower Montane-Valley Grassland	1-Early:All	1-Early:All	Very-Wet-Year	0.0181			1	Yes	
Lower Montane-Valley Grassland	1-Early:All	1-Early:All	Wild-Horse-Grazing	0.0380	0.9990		1	No	
Lower Montane-Valley Grassland	1-Early:All	U:ASPG	AS-Invasion	0.0025				No	
Lower Montane-Valley Grassland	1-Early:All	U:Increaser Grass	Early-Cattle-Grazing_0dd-Yr	0.0990	0.0010	3		Yes	
Lower Montane-Valley Grassland	1-Early:All	U:Increaser Grass	Early-Cattle-Grazing_Even-Yr	0.0990	0.0010	3		Yes	
Lower Montane-Valley Grassland	1-Early:All	U:Increaser Grass	Wild-Horse-Grazing	0.0380	0.0010			No	
Lower Montane-Valley Grassland	2-Mid:Open	1-Early:All	ReplacementFire	0.0200				Yes	2
Lower Montane-Valley Grassland	2-Mid:Open	1-Early:All	Very-Wet-Year	0.0181				Yes	
Lower Montane-Valley Grassland	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_0dd-Yr	0.0990	0.9990		1	No	
Lower Montane-Valley Grassland	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0990	0.9990		1	No	
Lower Montane-Valley Grassland	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_0dd-Yr	0.0130			0	No	
Lower Montane-Valley Grassland	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0130			0	No	
Lower Montane-Valley Grassland	2-Mid:Open	2-Mid:Open	Wet-Year	0.0670				Yes	
Lower Montane-Valley Grassland	2-Mid:Open	2-Mid:Open	Wild-Horse-Grazing	0.0380	0.9990		1	No	
Lower Montane-Valley Grassland	2-Mid:Open	U:ASPG	AS-Invasion	0.0025				No	
Lower Montane-Valley Grassland	2-Mid:Open	U:Increaser Grass	Early-Cattle-Grazing_0dd-Yr	0.0990	0.0010			Yes	
Lower Montane-Valley Grassland	2-Mid:Open	U:Increaser Grass	Early-Cattle-Grazing_Even-Yr	0.0990	0.0010			Yes	
Lower Montane-Valley Grassland	2-Mid:Open	U:Increaser Grass	Wild-Horse-Grazing	0.0380	0.0010			No	

Lower Montane-Valley Grassland	4-Late:Closed	1-Early:All	ReplacementFire	0.0200					Yes	2
Lower Montane-Valley Grassland	4-Late:Closed	1-Early:All	Very-Wet-Year	0.0181					Yes	
Lower Montane-Valley Grassland	4-Late:Closed	2-Mid:Open	Wet-Year	0.0670					Yes	
Lower Montane-Valley Grassland	4-Late:Closed	4-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0990	0.9990			1	No	
Lower Montane-Valley Grassland	4-Late:Closed	4-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0990	0.9990			1	No	
Lower Montane-Valley Grassland	4-Late:Closed	4-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0130				0	No	
Lower Montane-Valley Grassland	4-Late:Closed	4-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0130				0	No	
Lower Montane-Valley Grassland	4-Late:Closed	4-Late:Closed	Wild-Horse-Grazing	0.0380	0.9990			1	No	
Lower Montane-Valley Grassland	4-Late:Closed	U:ASPG	AS-Invasion	0.0025					No	
Lower Montane-Valley Grassland	4-Late:Closed	U:SE-Early	Early-Cattle-Grazing_0dd-Yr	0.0990	0.0010				Yes	
Lower Montane-Valley Grassland	4-Late:Closed	U:SE-Early	Early-Cattle-Grazing_Even-Yr	0.0990	0.0010				Yes	
Lower Montane-Valley Grassland	4-Late:Closed	U:SE-Early	Wild-Horse-Grazing	0.0380	0.0010				No	
Lower Montane-Valley Grassland	U:ASPG	1-Early:All	Herbicide-Plateau+Native-Seed	0.0100	0.7000				Yes	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0990	0.0010	3			Yes	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0990	0.9990	3		1	No	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0990	0.0010	3			Yes	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0990	0.9990	3		1	No	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Herbicide-Plateau+Native-Seed	0.0100	0.3000				Yes	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0130		3		0	No	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0130		3		0	No	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	ReplacementFire	0.0250					Yes	2
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Very-Wet-Year	0.0181				1	No	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Wet-Year	0.0670		10	49	10	Yes	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Wet-Year	0.0670		50		50	Yes	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Wild-Horse-Grazing	0.0380	0.0010				Yes	
Lower Montane-Valley Grassland	U:ASPG	U:ASPG	Wild-Horse-Grazing	0.0380	0.9990			1	No	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Lower Montane-Valley Grassland	U:ASPG	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes
Lower Montane-Valley Grassland	U:Bare Ground	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes
Lower Montane-Valley Grassland	U:Depleted	1-Early:All	Inexpensive-Floodplain-Restoration	0.0100	0.9000			Yes
Lower Montane-Valley Grassland	U:Depleted	1-Early:All	Spike+Plateau+Native-Seed	0.0100	0.7000			Yes
Lower Montane-Valley Grassland	U:Depleted	U:Depleted	ReplacementFire	0.0100				Yes
Lower Montane-Valley Grassland	U:Depleted	U:Depleted	Spike+Plateau+Native-Seed	0.0100	0.3000			Yes
Lower Montane-Valley Grassland	U:Depleted	U:Depleted	Very-Wet-Year	0.0181				Yes
Lower Montane-Valley Grassland	U:Depleted	U:Exotic Forb-ARCA	Exotic-Invasion	0.0010		9		No
Lower Montane-Valley Grassland	U:Depleted	U:SA	AS-Invasion	0.0050				No
Lower Montane-Valley Grassland	U:Depleted	U:SE-Early	Inexpensive-Floodplain-Restoration	0.0100	0.1000			Yes
Lower Montane-Valley Grassland	U:Exotic Forb-ARCA	1-Early:All	Exotic-Control	0.0100	0.9000			Yes
Lower Montane-Valley Grassland	U:Exotic Forb-ARCA	1-Early:All	Inexpensive-Floodplain-Restoration	0.0100	0.9000			Yes
Lower Montane-Valley Grassland	U:Exotic Forb-ARCA	U:Exotic Forb-ARCA	Exotic-Control	0.0100	0.1000			Yes
Lower Montane-Valley Grassland	U:Exotic Forb-ARCA	U:Exotic Forb-ARCA	ReplacementFire	0.0100				Yes
Lower Montane-Valley Grassland	U:Exotic Forb-ARCA	U:Exotic Forb-ARCA	Very-Wet-Year	0.0181				Yes
Lower Montane-Valley Grassland	U:Exotic Forb-ARCA	U:Exotic Forbs	Inexpensive-Floodplain-Restoration	0.0100	0.1000			Yes
Lower Montane-Valley Grassland	U:Exotic Forbs	1-Early:All	Exotic-Control	0.0100	0.5000			Yes
Lower Montane-Valley Grassland	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.5000			Yes
Lower Montane-Valley Grassland	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0010				Yes
Lower Montane-Valley Grassland	U:Exotic Forbs	U:Exotic Forbs	Very-Wet-Year	0.0181				Yes
Lower Montane-Valley Grassland	U:Increaser Grass	U:ASPG	AS-Invasion	0.0050				No
Lower Montane-Valley Grassland	U:Increaser Grass	U:Exotic Forbs	Exotic-Invasion	0.0010				No
Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	Early-Cattle-Grazing_0dd-Yr	0.0990	0.9990		1	No
Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	Early-Cattle-Grazing_Even-Yr	0.0990	0.9990		1	No
Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	Late-Cattle-Grazing_0dd-Yr	0.0130			0	No
Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	Late-Cattle-Grazing_Even-Yr	0.0130			0	No

Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	ReplacementFire	0.0100			9		Yes
Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	ReplacementFire	0.0200		10			Yes
Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	Very-Wet-Year	0.0181				1	No
Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	Wet-Year	0.0670		10	49	10	Yes
Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	Wet-Year	0.0670		50		50	Yes
Lower Montane-Valley Grassland	U:Increaser Grass	U:Increaser Grass	Wild-Horse-Grazing	0.0380	0.9990			1	No
Lower Montane-Valley Grassland	U:Increaser Grass	U:SE-Early	Early-Cattle-Grazing_0dd-Yr	0.0990	0.0010				Yes
Lower Montane-Valley Grassland	U:Increaser Grass	U:SE-Early	Early-Cattle-Grazing_Even-Yr	0.0990	0.0010				Yes
Lower Montane-Valley Grassland	U:Increaser Grass	U:SE-Early	Wild-Horse-Grazing	0.0380	0.0010				Yes
Lower Montane-Valley Grassland	U:SA	1-Early:All	Inexpensive-Floodplain-Restoration	0.0100	0.9000				Yes
Lower Montane-Valley Grassland	U:SA	1-Early:All	Spike+Plateau+Native-Seed	0.0100	0.6000				Yes
Lower Montane-Valley Grassland	U:SA	U:Exotic Forb-ARCA	Exotic-Invasion	0.0010			9		No
Lower Montane-Valley Grassland	U:SA	U:SA	Early-Cattle-Grazing_0dd-Yr	0.0990		3		1	No
Lower Montane-Valley Grassland	U:SA	U:SA	Early-Cattle-Grazing_Even-Yr	0.0990		3		1	No
Lower Montane-Valley Grassland	U:SA	U:SA	Inexpensive-Floodplain-Restoration	0.0100	0.1000				Yes
Lower Montane-Valley Grassland	U:SA	U:SA	Late-Cattle-Grazing_0dd-Yr	0.0130		3		0	No
Lower Montane-Valley Grassland	U:SA	U:SA	Late-Cattle-Grazing_Even-Yr	0.0130		3		0	No
Lower Montane-Valley Grassland	U:SA	U:SA	ReplacementFire	0.0250					Yes
Lower Montane-Valley Grassland	U:SA	U:SA	Spike+Plateau+Native-Seed	0.0100	0.4000				Yes
Lower Montane-Valley Grassland	U:SA	U:SA	Very-Wet-Year	0.0181					Yes
Lower Montane-Valley Grassland	U:SA	U:SA	Wild-Horse-Grazing	0.0380				1	No
Lower Montane-Valley Grassland	U:SAP	1-Early:All	Inexpensive-Floodplain-Restoration	0.0100	0.9000				Yes
Lower Montane-Valley Grassland	U:SAP	1-Early:All	Spike+Plateau+Native-Seed	0.0100	0.7000				Yes
Lower Montane-Valley Grassland	U:SAP	U:ASPG	Inexpensive-Floodplain-Restoration	0.0100	0.1000				Yes
Lower Montane-Valley Grassland	U:SAP	U:Exotic Forb-ARCA	Exotic-Invasion	0.0010			9		No
Lower Montane-Valley Grassland	U:SAP	U:SA	Early-Cattle-Grazing_0dd-Yr	0.0990	0.0010	3			No

Lower Montane-Valley Grassland	U:SAP	U:SA	Early-Cattle-Grazing_Even-Yr	0.0990	0.0010	3		No
Lower Montane-Valley Grassland	U:SAP	U:SA	Wild-Horse-Grazing	0.0380	0.0010			No
Lower Montane-Valley Grassland	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0990	0.9990	3	1	No
Lower Montane-Valley Grassland	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0990	0.9990	3	1	No
Lower Montane-Valley Grassland	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0130		3	0	No
Lower Montane-Valley Grassland	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0130		3	0	No
Lower Montane-Valley Grassland	U:SAP	U:SAP	ReplacementFire	0.0250				Yes
Lower Montane-Valley Grassland	U:SAP	U:SAP	Spike+Plateau+Native-Seed	0.0100	0.3000			Yes
Lower Montane-Valley Grassland	U:SAP	U:SAP	Very-Wet-Year	0.0181				Yes
Lower Montane-Valley Grassland	U:SAP	U:SAP	Wild-Horse-Grazing	0.0380	0.9990		1	No
Lower Montane-Valley Grassland	U:SE-Early	1-Early:All	Inexpensive-Floodplain-Restoration	0.0100	0.9000			Yes
Lower Montane-Valley Grassland	U:SE-Early	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0990	0.0010	3		No
Lower Montane-Valley Grassland	U:SE-Early	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0990	0.0010	3		No
Lower Montane-Valley Grassland	U:SE-Early	U:Depleted	Wild-Horse-Grazing	0.0380	0.0010			No
Lower Montane-Valley Grassland	U:SE-Early	U:Exotic Forb-ARCA	Exotic-Invasion	0.0010				No
Lower Montane-Valley Grassland	U:SE-Early	U:SAP	AS-Invasion	0.0050				No
Lower Montane-Valley Grassland	U:SE-Early	U:SE-Early	Early-Cattle-Grazing_0dd-Yr	0.0990	0.9990	3	1	No
Lower Montane-Valley Grassland	U:SE-Early	U:SE-Early	Early-Cattle-Grazing_Even-Yr	0.0990	0.9990	3	1	No
Lower Montane-Valley Grassland	U:SE-Early	U:SE-Early	Inexpensive-Floodplain-Restoration	0.0100	0.1000			Yes
Lower Montane-Valley Grassland	U:SE-Early	U:SE-Early	Late-Cattle-Grazing_0dd-Yr	0.0130		3	0	No
Lower Montane-Valley Grassland	U:SE-Early	U:SE-Early	Late-Cattle-Grazing_Even-Yr	0.0130		3	0	No
Lower Montane-Valley Grassland	U:SE-Early	U:SE-Early	ReplacementFire	0.0100				Yes
Lower Montane-Valley Grassland	U:SE-Early	U:SE-Early	Very-Wet-Year	0.0181			8	Yes
Lower Montane-Valley Grassland	U:SE-Early	U:SE-Early	Wild-Horse-Grazing	0.0380	0.9990		1	No
Lower Montane-Valley Grassland	U:SE-Late	1-Early:All	Spike+Plateau+Native-Seed	0.0100	0.7000			Yes
Lower Montane-Valley Grassland	U:SE-Late	4-Late:Closed	Inexpensive-Floodplain-Restoration	0.0100	0.9000			Yes

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Lower Montane-Valley Grassland	U:SE-Late	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0990	0.0010			No
Lower Montane-Valley Grassland	U:SE-Late	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0990	0.0010			No
Lower Montane-Valley Grassland	U:SE-Late	U:Depleted	Wild-Horse-Grazing	0.0380	0.0010			No
Lower Montane-Valley Grassland	U:SE-Late	U:SAP	AS-Invasion	0.0050				No
Lower Montane-Valley Grassland	U:SE-Late	U:SE-Early	Inexpensive-Floodplain-Restoration	0.0100	0.1000			Yes
Lower Montane-Valley Grassland	U:SE-Late	U:SE-Early	ReplacementFire	0.0100				Yes
Lower Montane-Valley Grassland	U:SE-Late	U:SE-Early	Very-Wet-Year	0.0181				Yes
Lower Montane-Valley Grassland	U:SE-Late	U:SE-Late	Early-Cattle-Grazing_0dd-Yr	0.0990	0.9990		1	No
Lower Montane-Valley Grassland	U:SE-Late	U:SE-Late	Early-Cattle-Grazing_Even-Yr	0.0990	0.9990		1	No
Lower Montane-Valley Grassland	U:SE-Late	U:SE-Late	Late-Cattle-Grazing_0dd-Yr	0.0130			0	No
Lower Montane-Valley Grassland	U:SE-Late	U:SE-Late	Late-Cattle-Grazing_Even-Yr	0.0130			0	No
Lower Montane-Valley Grassland	U:SE-Late	U:SE-Late	Spike+Plateau+Native-Seed	0.0100	0.3000			Yes
Lower Montane-Valley Grassland	U:SE-Late	U:SE-Late	Wild-Horse-Grazing	0.0380	0.9990		1	No
Lower Montane-Valley Grassland	U:Stock Tank	1-Early:All	Inexpensive-Floodplain-Restoration	0.0100	0.9000			Yes
Lower Montane-Valley Grassland	U:Stock Tank	U:Bare Ground	Inexpensive-Floodplain-Restoration	0.0100	0.1000			Yes
Mixed Salt Desert	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0110	0.9990	3	1	No
Mixed Salt Desert	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0110	0.9990	3	1	No
Mixed Salt Desert	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0010		3	0	No
Mixed Salt Desert	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0010		3	0	No
Mixed Salt Desert	1-Early:All	1-Early:All	Very-Wet-Year	0.0181				Yes
Mixed Salt Desert	1-Early:All	U:Annual Spp	AS-Invasion	0.0025				No
Mixed Salt Desert	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0110	0.0010	3		No
Mixed Salt Desert	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0110	0.0010	3		No
Mixed Salt Desert	3-Late:Open	1-Early:All	Very-Wet-Year	0.0181				Yes
Mixed Salt Desert	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0110	0.9990		1	No
Mixed Salt Desert	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0110	0.9990		1	No
Mixed Salt Desert	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0010			0	No
Mixed Salt Desert	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0010			0	No
Mixed Salt Desert	3-Late:Open	3-Late:Open	Severe-Drought	0.0070				Yes
Mixed Salt Desert	3-Late:Open	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0110	0.0010			Yes
Mixed Salt Desert	3-Late:Open	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0110	0.0010			Yes
Mixed Salt Desert	3-Late:Open	U:SA	AS-Invasion	0.0025				No
Mixed Salt Desert	4-Late:Open	1-Early:All	Very-Wet-Year	0.0181				Yes
Mixed Salt Desert	4-Late:Open	3-Late:Open	Severe-Drought	0.0070				Yes
Mixed Salt Desert	4-Late:Open	4-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0110	0.9990		1	No
Mixed Salt Desert	4-Late:Open	4-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0110	0.9990		1	No

Mixed Salt Desert	4-Late:Open	4-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0010				0	No		
Mixed Salt Desert	4-Late:Open	4-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0010				0	No		
Mixed Salt Desert	4-Late:Open	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0110	0.0010				No		
Mixed Salt Desert	4-Late:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0110	0.0010				No		
Mixed Salt Desert	4-Late:Open	U:SA	AS-Invasion	0.0025					No		
Mixed Salt Desert	U:Annual Spp	1-Early:All	Herbicide-Plateau+Seed	0.0100	0.6000				Yes		
Mixed Salt Desert	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0110				1	No		
Mixed Salt Desert	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0110				1	No		
Mixed Salt Desert	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Seed	0.0100	0.2000				Yes		
Mixed Salt Desert	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0010				0	No		
Mixed Salt Desert	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0010				0	No		
Mixed Salt Desert	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes	2	
Mixed Salt Desert	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes		
Mixed Salt Desert	U:Annual Spp	U:SDI+AS	Herbicide-Plateau+Seed	0.0100	0.2000				Yes		
Mixed Salt Desert	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0110	0.0010				Yes		
Mixed Salt Desert	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0110	0.0010				Yes		
Mixed Salt Desert	U:ASPG	U:Annual Spp	ReplacementFire	0.0100					Yes	2	
Mixed Salt Desert	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0110	0.9990			1	No		
Mixed Salt Desert	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0110	0.9990			1	No		
Mixed Salt Desert	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0010				0	No		
Mixed Salt Desert	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0010				0	No		
Mixed Salt Desert	U:ASPG	U:ASPG	Very-Wet-Year	0.0181					Yes		
Mixed Salt Desert	U:ASPG	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Mixed Salt Desert	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes		
Mixed Salt Desert	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.5000				Yes		20
Mixed Salt Desert	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0010					Yes		
Mixed Salt Desert	U:Exotic Forbs	U:SDI	Exotic-Control	0.0100	0.5000				Yes		20
Mixed Salt Desert	U:SA	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0110	0.0010				Yes		
Mixed Salt Desert	U:SA	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0110	0.0010				Yes		
Mixed Salt Desert	U:SA	U:Annual Spp	ReplacementFire	0.0250			19		Yes	2	
Mixed Salt Desert	U:SA	U:Annual Spp	ReplacementFire	0.0250		20			Yes		
Mixed Salt Desert	U:SA	U:Annual Spp	Very-Wet-Year	0.0181					Yes		
Mixed Salt Desert	U:SA	U:Exotic Forbs	Exotic-Invasion	0.0005					No		
Mixed Salt Desert	U:SA	U:SA	Early-Cattle-Grazing_0dd-Yr	0.0110	0.9990			1	No		
Mixed Salt Desert	U:SA	U:SA	Early-Cattle-Grazing_Even-Yr	0.0110	0.9990			1	No		
Mixed Salt Desert	U:SA	U:SA	Late-Cattle-Grazing_0dd-Yr	0.0010				0	No		
Mixed Salt Desert	U:SA	U:SA	Late-Cattle-Grazing_Even-Yr	0.0010				0	No		
Mixed Salt Desert	U:SDI	3-Late:Open	Natural-Recovery	0.0010		6			No	10	
Mixed Salt Desert	U:SDI	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0110	0.0010	3			Yes		
Mixed Salt Desert	U:SDI	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0110	0.0010	3			Yes		
Mixed Salt Desert	U:SDI	U:SDI	Early-Cattle-Grazing_0dd-Yr	0.0110	0.9990	3		1	No		
Mixed Salt Desert	U:SDI	U:SDI	Early-Cattle-Grazing_Even-Yr	0.0110	0.9990	3		1	No		
Mixed Salt Desert	U:SDI	U:SDI	Late-Cattle-Grazing_0dd-Yr	0.0010		3		0	No		
Mixed Salt Desert	U:SDI	U:SDI	Late-Cattle-Grazing_Even-Yr	0.0010		3		0	No		
Mixed Salt Desert	U:SDI	U:SDI	Very-Wet-Year	0.0181					Yes		
Mixed Salt Desert	U:SDI	U:SDI+AS	AS-Invasion	0.0010					No		
Mixed Salt Desert	U:SDI+AS	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0110	0.0010	3	5		No		
Mixed Salt Desert	U:SDI+AS	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0110	0.0010	3	5		No		
Mixed Salt Desert	U:SDI+AS	U:SA	Early-Cattle-Grazing_0dd-Yr	0.0110	0.0010	6			No		

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Mixed Salt Desert	U:SDI+AS	U:SA	Early-Cattle-Grazing_Even-Yr	0.0110	0.0010	6			No	
Mixed Salt Desert	U:SDI+AS	U:SDI	Competition	0.3300					No	3
Mixed Salt Desert	U:SDI+AS	U:SDI	Herbicide-Plateau	0.0100	0.8000				No	
Mixed Salt Desert	U:SDI+AS	U:SDI+AS	Early-Cattle-Grazing_0dd-Yr	0.0110	0.9990	3		1	No	
Mixed Salt Desert	U:SDI+AS	U:SDI+AS	Early-Cattle-Grazing_Even-Yr	0.0110	0.9990	3		1	No	
Mixed Salt Desert	U:SDI+AS	U:SDI+AS	Herbicide-Plateau	0.0100	0.2000				No	
Mixed Salt Desert	U:SDI+AS	U:SDI+AS	Late-Cattle-Grazing_0dd-Yr	0.0010		3		0	No	
Mixed Salt Desert	U:SDI+AS	U:SDI+AS	Late-Cattle-Grazing_Even-Yr	0.0010		3		0	No	
Mixed Salt Desert	U:SDI+AS	U:SDI+AS	ReplacementFire	0.0010			19		Yes	2
Mixed Salt Desert	U:SDI+AS	U:SDI+AS	ReplacementFire	0.0010		20			Yes	
Mixed Salt Desert	U:SDI+AS	U:SDI+AS	Very-Wet-Year	0.0181		6			Yes	
Mixed Salt Desert	U:SDI+AS	U:SDI+AS	Wet-Year	0.0670			5		No	
Mixed Salt Desert	U:Seeded Native	1-Early:All	Natural-Recovery	0.3330			5		No	5
Mixed Salt Desert	U:Seeded Native	3-Late:Open	Natural-Recovery	0.3330		6			No	5
Mixed Salt Desert	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0110	0.0010	3			No	
Mixed Salt Desert	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0110	0.0010	3			No	
Mixed Salt Desert	U:Seeded Native	U:SA	AS-Invasion	0.0050					No	
Mixed Salt Desert	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_0dd-Yr	0.0110	0.9990	3		1	No	
Mixed Salt Desert	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Even-Yr	0.0110	0.9990	3		1	No	
Mixed Salt Desert	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_0dd-Yr	0.0010		3		0	No	
Mixed Salt Desert	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Even-Yr	0.0010		3		0	No	
Mixed Salt Desert	U:Seeded Native	U:Seeded Native	Very-Wet-Year	0.0181					Yes	
Moist Floodplain	1-Early:Cottonwood	1-Early:Cottonwood	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990			1	No	20
Moist Floodplain	1-Early:Cottonwood	1-Early:Cottonwood	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990			1	No	20
Moist Floodplain	1-Early:Cottonwood	1-Early:Cottonwood	Fence	0.0100					No	19
Moist Floodplain	1-Early:Cottonwood	1-Early:Cottonwood	Flooding-7yr	0.1400					Yes	
Moist Floodplain	1-Early:Cottonwood	1-Early:Cottonwood	Late-Cattle-Grazing_0dd-Yr	0.0670	0.9995			0	No	20
Moist Floodplain	1-Early:Cottonwood	1-Early:Cottonwood	Late-Cattle-Grazing_Even-Yr	0.0670	0.9995			0	No	20
Moist Floodplain	1-Early:Cottonwood	1-Early:Cottonwood	Weed-Inventory+Spot-Treat	0.0100					No	3
Moist Floodplain	1-Early:Cottonwood	1-Early:Cottonwood	Wild-Horse-Grazing	0.0670	0.9990			1	No	20
Moist Floodplain	1-Early:Cottonwood	U:Desertified	Wild-Horse-Grazing	0.0670	0.0010				No	20
Moist Floodplain	1-Early:Cottonwood	U:Exotic Forb&Tree	Exotic-Invasion	0.0010					Yes	5
Moist Floodplain	1-Early:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010				No	20
Moist Floodplain	1-Early:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010				No	20
Moist Floodplain	1-Early:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0670	0.0005				No	20
Moist Floodplain	1-Early:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0670	0.0005				No	20
Moist Floodplain	1-Early:Willow	1-Early:Willow	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990	3			Yes	20

Moist Floodplain	1-Early:Willow	1-Early:Willow	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990	3		Yes	20
Moist Floodplain	1-Early:Willow	1-Early:Willow	Fence	0.0100				No	19
Moist Floodplain	1-Early:Willow	1-Early:Willow	Flooding-7yr	0.1400				Yes	
Moist Floodplain	1-Early:Willow	1-Early:Willow	Late-Cattle-Grazing_0dd-Yr	0.0670	0.9995	3		Yes	20
Moist Floodplain	1-Early:Willow	1-Early:Willow	Late-Cattle-Grazing_Even-Yr	0.0670	0.9995	3		Yes	20
Moist Floodplain	1-Early:Willow	1-Early:Willow	Weed-Inventory+Spot-Treat	0.0100				No	3
Moist Floodplain	1-Early:Willow	1-Early:Willow	Wild-Horse-Grazing	0.0670	0.9990		1	Yes	20
Moist Floodplain	1-Early:Willow	U:Exotic Forb&Tree	Exotic-Invasion	0.0010				No	5
Moist Floodplain	1-Early:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010	3		No	20
Moist Floodplain	1-Early:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010	3		No	20
Moist Floodplain	1-Early:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0670	0.0005	3		No	20
Moist Floodplain	1-Early:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0670	0.0005	3		No	20
Moist Floodplain	1-Early:Willow	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0670	0.0010			No	20
Moist Floodplain	2-Mid:Cottonwood	1-Early:Cottonwood	Flooding-20yr	0.0500				Yes	
Moist Floodplain	2-Mid:Cottonwood	2-Mid:Cottonwood	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990		1	No	20
Moist Floodplain	2-Mid:Cottonwood	2-Mid:Cottonwood	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990		1	No	20
Moist Floodplain	2-Mid:Cottonwood	2-Mid:Cottonwood	Fence	0.0100				No	19
Moist Floodplain	2-Mid:Cottonwood	2-Mid:Cottonwood	Late-Cattle-Grazing_0dd-Yr	0.0670	0.9995		0	No	20
Moist Floodplain	2-Mid:Cottonwood	2-Mid:Cottonwood	Late-Cattle-Grazing_Even-Yr	0.0670	0.9995		0	No	20
Moist Floodplain	2-Mid:Cottonwood	2-Mid:Cottonwood	Weed-Inventory+Spot-Treat	0.0100				No	3
Moist Floodplain	2-Mid:Cottonwood	2-Mid:Cottonwood	Wild-Horse-Grazing	0.0670	0.9990		1	No	20
Moist Floodplain	2-Mid:Cottonwood	U:Desertified	Wild-Horse-Grazing	0.0670	0.0010			No	20
Moist Floodplain	2-Mid:Cottonwood	U:Exotic Forb&Tree	Exotic-Invasion	0.0010				Yes	5
Moist Floodplain	2-Mid:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010			No	20
Moist Floodplain	2-Mid:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010			No	20
Moist Floodplain	2-Mid:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0670	0.0005			No	20
Moist Floodplain	2-Mid:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0670	0.0005			No	20
Moist Floodplain	2-Mid:Willow	1-Early:Willow	Flooding-20yr	0.0500				Yes	
Moist Floodplain	2-Mid:Willow	2-Mid:Willow	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990		1	No	20
Moist Floodplain	2-Mid:Willow	2-Mid:Willow	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990		1	No	20
Moist Floodplain	2-Mid:Willow	2-Mid:Willow	Fence	0.0100				No	19
Moist Floodplain	2-Mid:Willow	2-Mid:Willow	Late-Cattle-Grazing_0dd-Yr	0.0670	0.9995		0	No	20
Moist Floodplain	2-Mid:Willow	2-Mid:Willow	Late-Cattle-Grazing_Even-Yr	0.0670	0.9995		0	No	20
Moist Floodplain	2-Mid:Willow	2-Mid:Willow	Weed-Inventory+Spot-Treat	0.0100				No	3
Moist Floodplain	2-Mid:Willow	2-Mid:Willow	Wild-Horse-Grazing	0.0670	0.9990		1	No	20
Moist Floodplain	2-Mid:Willow	U:Desertified	Wild-Horse-Grazing	0.0670	0.0010			No	20
Moist Floodplain	2-Mid:Willow	U:Exotic Forb&Tree	Exotic-Invasion	0.0010				No	5

Moist Floodplain	2-Mid:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010		No	20
Moist Floodplain	2-Mid:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010		No	20
Moist Floodplain	2-Mid:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0670	0.0005		No	20
Moist Floodplain	2-Mid:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0670	0.0005		No	20
Moist Floodplain	3-Late:Cottonwood	1-Early:Cottonwood	Flooding-100yr	0.0100			Yes	
Moist Floodplain	3-Late:Cottonwood	3-Late:Cottonwood	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990	1	No	20
Moist Floodplain	3-Late:Cottonwood	3-Late:Cottonwood	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990	1	No	20
Moist Floodplain	3-Late:Cottonwood	3-Late:Cottonwood	Fence	0.0100			No	19
Moist Floodplain	3-Late:Cottonwood	3-Late:Cottonwood	Late-Cattle-Grazing_0dd-Yr	0.0670	0.9995	0	No	20
Moist Floodplain	3-Late:Cottonwood	3-Late:Cottonwood	Late-Cattle-Grazing_Even-Yr	0.0670	0.9995	0	No	20
Moist Floodplain	3-Late:Cottonwood	3-Late:Cottonwood	Weed-Inventory+Spot-Treat	0.0100			No	3
Moist Floodplain	3-Late:Cottonwood	3-Late:Cottonwood	Wild-Horse-Grazing	0.0670	0.9990	1	No	20
Moist Floodplain	3-Late:Cottonwood	U:Desertified	Wild-Horse-Grazing	0.0670	0.0010		No	20
Moist Floodplain	3-Late:Cottonwood	U:Exotic Forb&Tree	Exotic-Invasion	0.0010			No	5
Moist Floodplain	3-Late:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010		No	20
Moist Floodplain	3-Late:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010		No	20
Moist Floodplain	3-Late:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0670	0.0005		No	20
Moist Floodplain	3-Late:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0670	0.0005		No	20
Moist Floodplain	3-Late:Willow	1-Early:Willow	Flooding-100yr	0.0100			Yes	
Moist Floodplain	3-Late:Willow	3-Late:Willow	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990	1	No	20
Moist Floodplain	3-Late:Willow	3-Late:Willow	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990	1	No	20
Moist Floodplain	3-Late:Willow	3-Late:Willow	Fence	0.0100			No	19
Moist Floodplain	3-Late:Willow	3-Late:Willow	Late-Cattle-Grazing_0dd-Yr	0.0670	0.9995	0	No	20
Moist Floodplain	3-Late:Willow	3-Late:Willow	Late-Cattle-Grazing_Even-Yr	0.0670	0.9995	0	No	20
Moist Floodplain	3-Late:Willow	3-Late:Willow	Weed-Inventory+Spot-Treat	0.0100			No	3
Moist Floodplain	3-Late:Willow	3-Late:Willow	Wild-Horse-Grazing	0.0670	0.9990	1	No	20
Moist Floodplain	3-Late:Willow	U:Desertified	Wild-Horse-Grazing	0.0670	0.0010		No	20
Moist Floodplain	3-Late:Willow	U:Exotic Forb&Tree	Exotic-Invasion	0.0010			No	5
Moist Floodplain	3-Late:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010		Yes	20
Moist Floodplain	3-Late:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010		Yes	20
Moist Floodplain	3-Late:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0670	0.0005		Yes	20
Moist Floodplain	3-Late:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0670	0.0005		Yes	20
Moist Floodplain	PointBar:Bare Ground	PointBar:Bare Ground	Early-Cattle-Grazing_0dd-Yr	0.0590			Yes	20
Moist Floodplain	PointBar:Bare Ground	PointBar:Bare Ground	Early-Cattle-Grazing_Even-Yr	0.0590			Yes	20

Moist Floodplain	PointBar:Bare Ground	PointBar:Bare Ground	Fence	0.0100					No	19	
Moist Floodplain	PointBar:Bare Ground	PointBar:Bare Ground	Flooding-7yr	0.1400					Yes		
Moist Floodplain	PointBar:Bare Ground	PointBar:Bare Ground	Late-Cattle-Grazing_0dd-Yr	0.0670					Yes	20	
Moist Floodplain	PointBar:Bare Ground	PointBar:Bare Ground	Late-Cattle-Grazing_Even-Yr	0.0670					Yes	20	
Moist Floodplain	PointBar:Bare Ground	PointBar:Bare Ground	Wild-Horse-Grazing	0.0670					Yes	20	
Moist Floodplain	U:Annual Spp	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001				Yes		
Moist Floodplain	U:Annual Spp	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes		
Moist Floodplain	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0590		3		1	No	20	
Moist Floodplain	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0590		3		1	No	20	
Moist Floodplain	U:Annual Spp	U:Annual Spp	Fence	0.0100					No	19	
Moist Floodplain	U:Annual Spp	U:Annual Spp	Flooding-100yr	0.0100	0.9900				Yes		
Moist Floodplain	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0670		3		0	No	20	
Moist Floodplain	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0670		3		0	No	20	
Moist Floodplain	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes		
Moist Floodplain	U:Annual Spp	U:Annual Spp	Weed-Inventory+Spot-Treat	0.0100					No	3	
Moist Floodplain	U:Annual Spp	U:Annual Spp	Wild-Horse-Grazing	0.0670				1	No	20	
Moist Floodplain	U:Annual Spp	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Moist Floodplain	U:Desertified	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001				Yes		
Moist Floodplain	U:Desertified	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes		
Moist Floodplain	U:Desertified	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990			1	No	20	
Moist Floodplain	U:Desertified	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990			1	No	20	
Moist Floodplain	U:Desertified	U:Desertified	Fence	0.0100					No	19	
Moist Floodplain	U:Desertified	U:Desertified	Flooding-100yr	0.0100	0.9900				Yes		
Moist Floodplain	U:Desertified	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0670	0.9995			0	No	20	
Moist Floodplain	U:Desertified	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0670	0.9995			0	No	20	
Moist Floodplain	U:Desertified	U:Desertified	ReplacementFire	0.0100					Yes		
Moist Floodplain	U:Desertified	U:Desertified	Weed-Inventory+Spot-Treat	0.0100					No	3	
Moist Floodplain	U:Desertified	U:Desertified	Wild-Horse-Grazing	0.0670	0.9990			1	No	20	
Moist Floodplain	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010				No	20	
Moist Floodplain	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010				No	20	
Moist Floodplain	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_0dd-Yr	0.0670	0.0005				No	20	
Moist Floodplain	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_Even-Yr	0.0670	0.0005				No	20	
Moist Floodplain	U:Desertified	U:Early Shrub	Wild-Horse-Grazing	0.0670	0.0010				No	20	
Moist Floodplain	U:Desertified	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Moist Floodplain	U:Desertified	U:SAP	AS-Invasion	0.0050					No		
Moist Floodplain	U:Early Shrub	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001				Yes		
Moist Floodplain	U:Early Shrub	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes		
Moist Floodplain	U:Early Shrub	U:Early Shrub	Fence	0.0100					No	19	
Moist Floodplain	U:Early Shrub	U:Early Shrub	Flooding-100yr	0.0100	0.9900				Yes		
Moist Floodplain	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0100					Yes		
Moist Floodplain	U:Early Shrub	U:Early Shrub	Weed-Inventory+Spot-Treat	0.0050					No	3	
Moist Floodplain	U:Early Shrub	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Moist Floodplain	U:Exotic Forb&Tree	1-Early:Willow	Exotic-Control	0.0100	0.6000		4		Yes		20

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Moist Floodplain	U:Exotic Forb&Tree	2-Mid:Willow	Exotic-Control	0.0100	0.6000	5	19		No		20
Moist Floodplain	U:Exotic Forb&Tree	3-Late:Willow	Exotic-Control	0.0100	0.6000	20			No		20
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_Odd-Yr	0.0590		3		1	No	20	
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_Even-Yr	0.0590		3		1	No	20	
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Exotic-Control	0.0100	0.4000				Yes		20
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Fence	0.0100					No	19	
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Flooding-100yr	0.0100		20			Yes		
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Flooding-20yr	0.0500			19		Yes		
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_Odd-Yr	0.0670		3		0	No	20	
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_Even-Yr	0.0670		3		0	No	20	
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	ReplacementFire	0.0100					Yes		
Moist Floodplain	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Wild-Horse-Grazing	0.0670				1	No	20	
Moist Floodplain	U:Incised-EFT	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001				Yes		
Moist Floodplain	U:Incised-EFT	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes		
Moist Floodplain	U:Incised-EFT	U:Desertified	Exotic-Control	0.0100	0.6000				Yes		20
Moist Floodplain	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_Odd-Yr	0.0590		3		1	No		
Moist Floodplain	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_Even-Yr	0.0590		3		1	No		
Moist Floodplain	U:Incised-EFT	U:Incised-EFT	Exotic-Control	0.0100	0.4000				Yes		20
Moist Floodplain	U:Incised-EFT	U:Incised-EFT	Fence	0.0100					No	19	
Moist Floodplain	U:Incised-EFT	U:Incised-EFT	Flooding-100yr	0.0100	0.9900				Yes		
Moist Floodplain	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_Odd-Yr	0.0670		3		0	No		
Moist Floodplain	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_Even-Yr	0.0670		3		0	No		
Moist Floodplain	U:Incised-EFT	U:Incised-EFT	ReplacementFire	0.0100					Yes		
Moist Floodplain	U:Incised-EFT	U:Incised-EFT	Wild-Horse-Grazing	0.0670				1	No	20	
Moist Floodplain	U:Pasture	U:Pasture	Early-Cattle-Grazing_Odd-Yr	0.0590				1	No		
Moist Floodplain	U:Pasture	U:Pasture	Early-Cattle-Grazing_Even-Yr	0.0590				1	No		
Moist Floodplain	U:Pasture	U:Pasture	Late-Cattle-Grazing_Odd-Yr	0.0670				0	No		
Moist Floodplain	U:Pasture	U:Pasture	Late-Cattle-Grazing_Even-Yr	0.0670				0	No		
Moist Floodplain	U:SAP	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001				Yes		
Moist Floodplain	U:SAP	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes		
Moist Floodplain	U:SAP	U:Annual Spp	Early-Cattle-Grazing_Odd-Yr	0.0590	0.0010				Yes	20	
Moist Floodplain	U:SAP	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010				Yes	20	
Moist Floodplain	U:SAP	U:Annual Spp	Late-Cattle-Grazing_Odd-Yr	0.0670	0.0005				Yes	20	
Moist Floodplain	U:SAP	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0670	0.0005				Yes	20	
Moist Floodplain	U:SAP	U:Annual Spp	ReplacementFire	0.0100					Yes		
Moist Floodplain	U:SAP	U:Annual Spp	Wild-Horse-Grazing	0.0670	0.0010				Yes	20	
Moist Floodplain	U:SAP	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Moist Floodplain	U:SAP	U:SAP	Early-Cattle-Grazing_Odd-Yr	0.0590	0.9990			1	No	20	

Moist Floodplain	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990		1	No	20
Moist Floodplain	U:SAP	U:SAP	Fence	0.0100				No	19
Moist Floodplain	U:SAP	U:SAP	Flooding-100yr	0.0100	0.9900			Yes	
Moist Floodplain	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0670	0.9995		0	No	20
Moist Floodplain	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0670	0.9995		0	No	20
Moist Floodplain	U:SAP	U:SAP	Weed-Inventory+Spot-Treat	0.0100				No	3
Moist Floodplain	U:SAP	U:SAP	Wild-Horse-Grazing	0.0670	0.9990		1	No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010	3		No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010	3		No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0670	0.0005	3		No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0670	0.0005	3		No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Desertified	Wild-Horse-Grazing	0.0670	0.0010			No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Exotic Forb&Tree	Exotic-Invasion	0.0010		5		Yes	5
Moist Floodplain	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990	3	1	No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990	3	1	No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Fence	0.0100				No	19
Moist Floodplain	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Flooding-20yr	0.0500				Yes	
Moist Floodplain	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0670	0.9995	3	0	No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0670	0.9995	3	0	No	20
Moist Floodplain	U:Shrb-Frb Encr	U:Shrb-Frb Encr	ReplacementFire	0.0100				Yes	
Moist Floodplain	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Weed-Inventory+Spot-Treat	0.0100				No	3
Moist Floodplain	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0670	0.9990		1	No	20
Montane Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Flooding-7yr	0.1400				Yes	
Montane Riparian	1-Early:Cottonwood	1-Early:Cottonwood	LivestockGrazingControl	0.0100				No	30
Montane Riparian	1-Early:Cottonwood	1-Early:Cottonwood	NativeGrazing	0.0200				Yes	
Montane Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Wild-Horse-Grazing	0.0760	0.9990		1	No	31
Montane Riparian	1-Early:Cottonwood	1-Early:Willow	ReplacementFire	0.0200				Yes	
Montane Riparian	1-Early:Cottonwood	U:Desertified	Wild-Horse-Grazing	0.0760	0.0010			No	31
Montane Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990		1	No	31
Montane Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990		1	No	31
Montane Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995		0	No	31
Montane Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995		0	No	31
Montane Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Weed-Inventory+Spot-Treat	0.0100				No	3
Montane Riparian	1-Early:Cottonwood	U:Exotic Forb&Tree	Exotic-Invasion	0.0010				Yes	5
Montane Riparian	1-Early:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010			No	31
Montane Riparian	1-Early:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010			No	31

Montane Riparian	1-Early:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005			No	31
Montane Riparian	1-Early:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005			No	31
Montane Riparian	1-Early:Willow	1-Early:Willow	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3		Yes	31
Montane Riparian	1-Early:Willow	1-Early:Willow	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3		Yes	31
Montane Riparian	1-Early:Willow	1-Early:Willow	Flooding-7yr	0.1400				Yes	
Montane Riparian	1-Early:Willow	1-Early:Willow	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995	3		Yes	31
Montane Riparian	1-Early:Willow	1-Early:Willow	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	3		Yes	31
Montane Riparian	1-Early:Willow	1-Early:Willow	LivestockGrazingControl	0.0100				No	30
Montane Riparian	1-Early:Willow	1-Early:Willow	NativeGrazing	0.0200				Yes	
Montane Riparian	1-Early:Willow	1-Early:Willow	ReplacementFire	0.0200				Yes	
Montane Riparian	1-Early:Willow	1-Early:Willow	Weed-Inventory+Spot-Treat	0.0100				No	3
Montane Riparian	1-Early:Willow	1-Early:Willow	Wild-Horse-Grazing	0.0760				Yes	31
Montane Riparian	1-Early:Willow	U:Exotic Forb&Tree	Exotic-Invasion	0.0010				No	5
Montane Riparian	1-Early:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3		No	31
Montane Riparian	1-Early:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3		No	31
Montane Riparian	1-Early:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005	3		No	31
Montane Riparian	1-Early:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005	3		No	31
Montane Riparian	1-Early:Willow	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0760				No	31
Montane Riparian	2-Mid:Cottonwood	1-Early:Cottonwood	Flooding-20yr	0.0500				Yes	
Montane Riparian	2-Mid:Cottonwood	1-Early:Willow	ReplacementFire	0.0200				Yes	
Montane Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	LivestockGrazingControl	0.0100				No	30
Montane Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Wild-Horse-Grazing	0.0760	0.9990		1	No	31
Montane Riparian	2-Mid:Cottonwood	U:Desertified	Wild-Horse-Grazing	0.0760	0.0010			No	31
Montane Riparian	2-Mid:Cottonwood	U:Exotic Forb&Tree	Exotic-Invasion	0.0010				No	5
Montane Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990		1	No	31
Montane Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990		1	No	31
Montane Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995		0	No	31
Montane Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995		0	No	31
Montane Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Weed-Inventory+Spot-Treat	0.0100				No	3
Montane Riparian	2-Mid:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010			No	31
Montane Riparian	2-Mid:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010			No	31
Montane Riparian	2-Mid:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005			No	31
Montane Riparian	2-Mid:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005			No	31

Montane Riparian	3-Late:Cottonwood	1-Early:Cottonwood	Flooding-100yr	0.0100			Yes	
Montane Riparian	3-Late:Cottonwood	1-Early:Willow	ReplacementFire	0.0200			Yes	
Montane Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	1	No	31
Montane Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	1	No	31
Montane Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995	0	No	31
Montane Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	0	No	31
Montane Riparian	3-Late:Cottonwood	3-Late:Cottonwood	LivestockGrazingControl	0.0100			No	30
Montane Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Weed-Inventory+Spot-Treat	0.0100			No	3
Montane Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Wild-Horse-Grazing	0.0760	0.9990	1	No	31
Montane Riparian	3-Late:Cottonwood	U:Desertified	Wild-Horse-Grazing	0.0760	0.0010		No	31
Montane Riparian	3-Late:Cottonwood	U:Exotic Forb&Tree	Exotic-Invasion	0.0010			No	5
Montane Riparian	3-Late:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010		No	31
Montane Riparian	3-Late:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010		No	31
Montane Riparian	3-Late:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005		No	31
Montane Riparian	3-Late:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005		No	31
Montane Riparian	3-Late:Willow	1-Early:Willow	Flooding-20yr	0.0500			Yes	
Montane Riparian	3-Late:Willow	1-Early:Willow	ReplacementFire	0.0200			Yes	
Montane Riparian	3-Late:Willow	3-Late:Willow	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	1	No	31
Montane Riparian	3-Late:Willow	3-Late:Willow	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	1	No	31
Montane Riparian	3-Late:Willow	3-Late:Willow	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995	0	No	31
Montane Riparian	3-Late:Willow	3-Late:Willow	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	0	No	31
Montane Riparian	3-Late:Willow	3-Late:Willow	LivestockGrazingControl	0.0100			No	30
Montane Riparian	3-Late:Willow	3-Late:Willow	Weed-Inventory+Spot-Treat	0.0100			No	3
Montane Riparian	3-Late:Willow	3-Late:Willow	Wild-Horse-Grazing	0.0760	0.9990	1	No	31
Montane Riparian	3-Late:Willow	U:Desertified	Wild-Horse-Grazing	0.0760	0.0010		No	31
Montane Riparian	3-Late:Willow	U:Exotic Forb&Tree	Exotic-Invasion	0.0010			No	5
Montane Riparian	3-Late:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010		Yes	31
Montane Riparian	3-Late:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010		Yes	31
Montane Riparian	3-Late:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005		Yes	31
Montane Riparian	3-Late:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005		Yes	31
Montane Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Early-Cattle-Grazing_0dd-Yr	0.0670			Yes	31
Montane Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Early-Cattle-Grazing_Even-Yr	0.0670			Yes	31
Montane Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Flooding-7yr	0.1400			Yes	

Montane Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Late-Cattle-Grazing_Odd-Yr	0.0760				Yes	31
Montane Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Late-Cattle-Grazing_Even-Yr	0.0760				Yes	31
Montane Riparian	PointBar:Bare Ground	PointBar:Bare Ground	LivestockGrazingControl	0.0100				No	30
Montane Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Wild-Horse-Grazing	0.0760				Yes	31
Montane Riparian	U:Annual Spp	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001			Yes	
Montane Riparian	U:Annual Spp	1-Early:Willow	Flooding-100yr	0.0100	0.0099			Yes	
Montane Riparian	U:Annual Spp	1-Early:Willow	Inexpensive-Floodplain-Restoration	0.0100	0.9000			Yes	
Montane Riparian	U:Annual Spp	1-Early:Willow	Natural-Recovery	1.0000			2	Yes	15
Montane Riparian	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Odd-Yr	0.0670		3	1	No	31
Montane Riparian	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0670		3	1	No	31
Montane Riparian	U:Annual Spp	U:Annual Spp	Flooding-100yr	0.0100	0.9900			Yes	
Montane Riparian	U:Annual Spp	U:Annual Spp	Flooding-20yr	0.0500	0.9500	30		Yes	
Montane Riparian	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Native-Seed	0.0100	0.2000			Yes	
Montane Riparian	U:Annual Spp	U:Annual Spp	Inexpensive-Floodplain-Restoration	0.0100	0.1000			Yes	
Montane Riparian	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Odd-Yr	0.0760		3	0	No	31
Montane Riparian	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0760		3	0	No	31
Montane Riparian	U:Annual Spp	U:Annual Spp	LivestockGrazingControl	0.0100				No	30
Montane Riparian	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000				Yes	2
Montane Riparian	U:Annual Spp	U:Annual Spp	Wild-Horse-Grazing	0.0760				No	31
Montane Riparian	U:Annual Spp	U:Desertified	Herbicide-Plateau+Native-Seed	0.0100	0.8000			Yes	
Montane Riparian	U:Annual Spp	U:Incised-EFT	Exotic-Invasion	0.0010				No	5
Montane Riparian	U:Annual Spp	U:Inset-A	Flooding-20yr	0.0500	0.0500	30		Yes	
Montane Riparian	U:Desertified	1-Early:Willow	Flooding-100yr	0.0100	0.0100			Yes	
Montane Riparian	U:Desertified	1-Early:Willow	Inexpensive-Floodplain-Restoration	0.0100	0.9000			Yes	
Montane Riparian	U:Desertified	1-Early:Willow	Natural-Recovery	1.0000			2	Yes	15
Montane Riparian	U:Desertified	U:Desertified	Flooding-20yr	0.0500	0.9500	30		Yes	
Montane Riparian	U:Desertified	U:Desertified	LivestockGrazingControl	0.0100				No	30
Montane Riparian	U:Desertified	U:Desertified	Wild-Horse-Grazing	0.0760	0.9990		1	No	31
Montane Riparian	U:Desertified	U:Early Shrub	Wild-Horse-Grazing	0.0760	0.0010			No	31
Montane Riparian	U:Desertified	U:Incised-EFT	Exotic-Invasion	0.0010				No	5
Montane Riparian	U:Desertified	U:Inset-A	Flooding-20yr	0.0500	0.0500	30		Yes	
Montane Riparian	U:Desertified	U:Desertified	Early-Cattle-Grazing_Odd-Yr	0.0670	0.9990	3	1	No	31
Montane Riparian	U:Desertified	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3	1	No	31
Montane Riparian	U:Desertified	U:Desertified	Flooding-100yr	0.0100	0.9900			Yes	
Montane Riparian	U:Desertified	U:Desertified	Inexpensive-Floodplain-Restoration	0.0100	0.1000			Yes	
Montane Riparian	U:Desertified	U:Desertified	Late-Cattle-Grazing_Odd-Yr	0.0760	0.9995	3	0	No	31
Montane Riparian	U:Desertified	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	3	0	No	31
Montane Riparian	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_Odd-Yr	0.0670	0.0010	3		No	31
Montane Riparian	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3		No	31
Montane Riparian	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_Odd-Yr	0.0760	0.0005	3		No	31
Montane Riparian	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005	3		No	31
Montane Riparian	U:Desertified	U:Early Shrub	ReplacementFire	0.0200				Yes	
Montane Riparian	U:Desertified	U:SAP	AS-Invasion	0.0050				No	
Montane Riparian	U:Early Shrub	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0010			Yes	
Montane Riparian	U:Early Shrub	1-Early:Willow	Flooding-100yr	0.0100	0.0099			Yes	
Montane Riparian	U:Early Shrub	1-Early:Willow	Inexpensive-Floodplain-Restoration	0.0100	0.9000			Yes	

Montane Riparian	U:Early Shrub	1-Early:Willow	Natural-Recovery	1.0000				2	Yes	15	
Montane Riparian	U:Early Shrub	U:Early Shrub	Flooding-100yr	0.0100	0.9900				Yes		
Montane Riparian	U:Early Shrub	U:Early Shrub	Flooding-20yr	0.0500	0.9500	30			Yes		
Montane Riparian	U:Early Shrub	U:Early Shrub	Inexpensive-Floodplain-Restoration	0.0100	0.1000				Yes		
Montane Riparian	U:Early Shrub	U:Early Shrub	LivestockGrazingControl	0.0100					No	30	
Montane Riparian	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0200					Yes		
Montane Riparian	U:Early Shrub	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Montane Riparian	U:Early Shrub	U:Inset-A	Flooding-20yr	0.0500	0.0500	30			Yes		
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3			Yes	31	
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3		1	No	31	
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3			Yes	31	
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3		1	No	31	
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005	3			Yes	31	
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995	3		0	No	31	
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005	3			Yes	31	
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	3		0	No	31	
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	LivestockGrazingControl	0.0100					No	30	
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	NativeGrazing	0.0200			4		Yes		
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Wild-Horse-Grazing	0.0760				1	No	31	
Montane Riparian	U:Exotic Forb&Tree	1-Early:Willow	Exotic-Control	0.0100	0.6000		4		No		20
Montane Riparian	U:Exotic Forb&Tree	3-Late:Willow	Exotic-Control	0.0100	0.6000	5			No		20
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Exotic-Control	0.0100	0.4000				Yes		20
Montane Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	ReplacementFire	0.0200					Yes		
Montane Riparian	U:Incised-EFT	1-Early:Willow	Flooding-100yr	0.0100	0.0100				Yes		
Montane Riparian	U:Incised-EFT	1-Early:Willow	Inexpensive-Floodplain-Restoration	0.0100					Yes		
Montane Riparian	U:Incised-EFT	U:Desertified	Exotic-Control	0.0100	0.6000				Yes		20
Montane Riparian	U:Incised-EFT	U:Exotic Forb&Tree	Natural-Recovery	1.0000				2	Yes	15	
Montane Riparian	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_0dd-Yr	0.0670		3		1	No	31	
Montane Riparian	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_Even-Yr	0.0670		3		1	No	31	
Montane Riparian	U:Incised-EFT	U:Incised-EFT	Exotic-Control	0.0100	0.4000				Yes		20
Montane Riparian	U:Incised-EFT	U:Incised-EFT	Flooding-100yr	0.0100	0.9900				Yes		
Montane Riparian	U:Incised-EFT	U:Incised-EFT	Flooding-20yr	0.0500	0.9500	30			Yes		
Montane Riparian	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_0dd-Yr	0.0760		3		0	No	31	
Montane Riparian	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_Even-Yr	0.0760		3		0	No	31	
Montane Riparian	U:Incised-EFT	U:Incised-EFT	LivestockGrazingControl	0.0100					No	30	
Montane Riparian	U:Incised-EFT	U:Incised-EFT	ReplacementFire	0.0100					Yes		

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Montane Riparian	U:Incised-EFT	U:Incised-EFT	Wild-Horse-Grazing	0.0760				1	No	31	
Montane Riparian	U:Incised-EFT	U:Inset-EFT	Flooding-20yr	0.0500	0.0500	30			Yes		
Montane Riparian	U:Inset-A	U:Inset-A	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3			Yes	31	
Montane Riparian	U:Inset-A	U:Inset-A	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3			Yes	31	
Montane Riparian	U:Inset-A	U:Inset-A	Flooding-7yr	0.1400					Yes		
Montane Riparian	U:Inset-A	U:Inset-A	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995	3			Yes	31	
Montane Riparian	U:Inset-A	U:Inset-A	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	3			Yes	31	
Montane Riparian	U:Inset-A	U:Inset-A	LivestockGrazingControl	0.0100					No	30	
Montane Riparian	U:Inset-A	U:Inset-A	ReplacementFire	0.0010					Yes		
Montane Riparian	U:Inset-A	U:Inset-A	Weed-Inventory+Spot-Treat	0.0100					No	3	
Montane Riparian	U:Inset-A	U:Inset-A	Wild-Horse-Grazing	0.0760	0.9990				Yes	31	
Montane Riparian	U:Inset-A	U:Inset-EFT	Exotic-Invasion	0.0010					No	5	
Montane Riparian	U:Inset-A	U:Inset-HU	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3			No	31	
Montane Riparian	U:Inset-A	U:Inset-HU	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3			No	31	
Montane Riparian	U:Inset-A	U:Inset-HU	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005	3			No	31	
Montane Riparian	U:Inset-A	U:Inset-HU	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005	3			No	31	
Montane Riparian	U:Inset-A	U:Inset-HU	Wild-Horse-Grazing	0.0760	0.0010				Yes	31	
Montane Riparian	U:Inset-A	U:Inset-SFE	NativeGrazing	0.0200			4		Yes		
Montane Riparian	U:Inset-B	U:Inset-A	Flooding-20yr	0.0500					Yes		
Montane Riparian	U:Inset-B	U:Inset-A	ReplacementFire	0.0010					Yes		
Montane Riparian	U:Inset-B	U:Inset-B	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990			1	No	31	
Montane Riparian	U:Inset-B	U:Inset-B	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990			1	No	31	
Montane Riparian	U:Inset-B	U:Inset-B	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995			0	No	31	
Montane Riparian	U:Inset-B	U:Inset-B	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995			0	No	31	
Montane Riparian	U:Inset-B	U:Inset-B	LivestockGrazingControl	0.0100					No	30	
Montane Riparian	U:Inset-B	U:Inset-B	Weed-Inventory+Spot-Treat	0.0100					No	3	
Montane Riparian	U:Inset-B	U:Inset-B	Wild-Horse-Grazing	0.0760	0.9990			1	No	31	
Montane Riparian	U:Inset-B	U:Inset-EFT	Exotic-Invasion	0.0010					No	5	
Montane Riparian	U:Inset-B	U:Inset-HU	Wild-Horse-Grazing	0.0760	0.0010				No	31	
Montane Riparian	U:Inset-B	U:Inset-SFE	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010				Yes	31	
Montane Riparian	U:Inset-B	U:Inset-SFE	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010				Yes	31	
Montane Riparian	U:Inset-B	U:Inset-SFE	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005				Yes	31	
Montane Riparian	U:Inset-B	U:Inset-SFE	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005				Yes	31	
Montane Riparian	U:Inset-EFT	U:Inset-A	Exotic-Control	0.0100	0.6000		4		No		20
Montane Riparian	U:Inset-EFT	U:Inset-B	Exotic-Control	0.0100	0.4000	5			Yes		20
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3			Yes	31	
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3		1	No	31	
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3			Yes	31	
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3		1	No	31	
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Exotic-Control	0.0100	0.4000				Yes		20
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005	3			Yes	31	
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995	3		0	No		
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005	3			Yes	31	
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	3		0	No	31	
Montane Riparian	U:Inset-EFT	U:Inset-EFT	LivestockGrazingControl	0.0100					No	30	
Montane Riparian	U:Inset-EFT	U:Inset-EFT	NativeGrazing	0.0200			4		Yes		
Montane Riparian	U:Inset-EFT	U:Inset-EFT	ReplacementFire	0.0010					Yes		
Montane Riparian	U:Inset-EFT	U:Inset-EFT	Wild-Horse-Grazing	0.0760				1	No	31	
Montane Riparian	U:Inset-HU	U:Inset-A	Natural-Recovery	1.0000					Yes	5	

Montane Riparian	U:Inset-HU	U:Inset-HU	Early-Cattle-Grazing_0dd-Yr	0.0670					Yes	31
Montane Riparian	U:Inset-HU	U:Inset-HU	Early-Cattle-Grazing_Even-Yr	0.0670					Yes	31
Montane Riparian	U:Inset-HU	U:Inset-HU	Late-Cattle-Grazing_0dd-Yr	0.0760					Yes	31
Montane Riparian	U:Inset-HU	U:Inset-HU	Late-Cattle-Grazing_Even-Yr	0.0760					Yes	31
Montane Riparian	U:Inset-HU	U:Inset-HU	LivestockGrazingControl	0.0100					No	30
Montane Riparian	U:Inset-HU	U:Inset-HU	Wild-Horse-Grazing	0.0760					Yes	31
Montane Riparian	U:Inset-SFE	U:Inset-A	Natural-Recovery	1.0000				2	Yes	15
Montane Riparian	U:Inset-SFE	U:Inset-EFT	Exotic-Invasion	0.0010					Yes	5
Montane Riparian	U:Inset-SFE	U:Inset-HU	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3			No	31
Montane Riparian	U:Inset-SFE	U:Inset-HU	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3			No	31
Montane Riparian	U:Inset-SFE	U:Inset-HU	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005	3			No	31
Montane Riparian	U:Inset-SFE	U:Inset-HU	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005	3			No	31
Montane Riparian	U:Inset-SFE	U:Inset-HU	Wild-Horse-Grazing	0.0760	0.0010				No	31
Montane Riparian	U:Inset-SFE	U:Inset-SFE	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3		1	No	31
Montane Riparian	U:Inset-SFE	U:Inset-SFE	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3		1	No	31
Montane Riparian	U:Inset-SFE	U:Inset-SFE	Flooding-100yr	0.0100		20			Yes	
Montane Riparian	U:Inset-SFE	U:Inset-SFE	Flooding-20yr	0.0500			19		Yes	
Montane Riparian	U:Inset-SFE	U:Inset-SFE	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995	3		0	No	31
Montane Riparian	U:Inset-SFE	U:Inset-SFE	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	3		0	No	31
Montane Riparian	U:Inset-SFE	U:Inset-SFE	LivestockGrazingControl	0.0100					No	30
Montane Riparian	U:Inset-SFE	U:Inset-SFE	NativeGrazing	0.0200			4		Yes	
Montane Riparian	U:Inset-SFE	U:Inset-SFE	ReplacementFire	0.0010					Yes	
Montane Riparian	U:Inset-SFE	U:Inset-SFE	Weed-Inventory+Spot-Treat	0.0100					No	3
Montane Riparian	U:Inset-SFE	U:Inset-SFE	Wild-Horse-Grazing	0.0760	0.9990			1	No	31
Montane Riparian	U:Pasture	U:Pasture	Early-Cattle-Grazing_0dd-Yr	0.0670				1	No	
Montane Riparian	U:Pasture	U:Pasture	Early-Cattle-Grazing_Even-Yr	0.0670				1	No	
Montane Riparian	U:Pasture	U:Pasture	Late-Cattle-Grazing_0dd-Yr	0.0760				0	No	
Montane Riparian	U:Pasture	U:Pasture	Late-Cattle-Grazing_Even-Yr	0.0760				0	No	
Montane Riparian	U:SAP	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001				Yes	
Montane Riparian	U:SAP	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes	
Montane Riparian	U:SAP	1-Early:Willow	Inexpensive-Floodplain-Restoration	0.0100	0.9000				Yes	
Montane Riparian	U:SAP	1-Early:Willow	Natural-Recovery	1.0000				2	Yes	15
Montane Riparian	U:SAP	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3			Yes	31
Montane Riparian	U:SAP	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3			Yes	31
Montane Riparian	U:SAP	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005	3			Yes	31
Montane Riparian	U:SAP	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005	3			Yes	31
Montane Riparian	U:SAP	U:Annual Spp	Wild-Horse-Grazing	0.0760	0.0010				Yes	31
Montane Riparian	U:SAP	U:Incised-EFT	Exotic-Invasion	0.0010					No	5
Montane Riparian	U:SAP	U:Inset-A	Flooding-20yr	0.0500	0.0500	30			Yes	
Montane Riparian	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3		1	No	31
Montane Riparian	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3		1	No	31
Montane Riparian	U:SAP	U:SAP	Flooding-20yr	0.0500	0.9500	30			Yes	
Montane Riparian	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995	3		0	No	31
Montane Riparian	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	3		0	No	31
Montane Riparian	U:SAP	U:SAP	LivestockGrazingControl	0.0100					No	30
Montane Riparian	U:SAP	U:SAP	Wild-Horse-Grazing	0.0760	0.9990			1	No	31
Montane Riparian	U:SAP	U:SAP	Flooding-100yr	0.0100	0.9900				Yes	
Montane Riparian	U:SAP	U:SAP	Inexpensive-Floodplain-Restoration	0.0100	0.1000				Yes	
Montane Riparian	U:SAP	U:SAP	ReplacementFire	0.0200					Yes	2

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Montane Riparian	U:Shrb-Frb Encr	1-Early:Willow	Natural-Recovery	1.0000				2	Yes	15
Montane Riparian	U:Shrb-Frb Encr	U:Desertified	Wild-Horse-Grazing	0.0760	0.0010				No	31
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	LivestockGrazingControl	0.0100					No	30
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	NativeGrazing	0.0200			4		Yes	
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0760	0.9990			1	No	31
Montane Riparian	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3			No	31
Montane Riparian	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3			No	31
Montane Riparian	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0760	0.0005	3			No	31
Montane Riparian	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0760	0.0005	3			No	31
Montane Riparian	U:Shrb-Frb Encr	U:Exotic Forb&Tree	Exotic-Invasion	0.0010					Yes	5
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3		1	No	31
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3		1	No	31
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Flooding-100yr	0.0100		20			Yes	
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Flooding-20yr	0.0500			19		Yes	
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0760	0.9995	3		0	No	31
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0760	0.9995	3		0	No	31
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	ReplacementFire	0.0200					Yes	
Montane Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Weed-Inventory+Spot-Treat	0.0100					No	3
Montane Sagebrush Steppe	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0542	0.9990	3		1	No	
Montane Sagebrush Steppe	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990	3		1	No	
Montane Sagebrush Steppe	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0068		3		0	No	
Montane Sagebrush Steppe	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0068		3		0	No	
Montane Sagebrush Steppe	1-Early:All	1-Early:All	ReplacementFire	0.0125					Yes	
Montane Sagebrush Steppe	1-Early:All	U:ASPG	AS-Invasion	0.0025					No	
Montane Sagebrush Steppe	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0542	0.0010	3			No	
Montane Sagebrush Steppe	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0542	0.0010	3			No	
Montane Sagebrush Steppe	2-Mid:Open	1-Early:All	ReplacementFire	0.0250					Yes	
Montane Sagebrush Steppe	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_0dd-Yr	0.0542	0.9990			1	No	
Montane Sagebrush Steppe	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990			1	No	
Montane Sagebrush Steppe	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	2-Mid:Open	4-Late:Dense	Alternate-Succession	0.0056		28			Yes	
Montane Sagebrush Steppe	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0542	0.0010				No	
Montane Sagebrush Steppe	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0542	0.0010				No	
Montane Sagebrush Steppe	2-Mid:Open	U:SAP-Closed	AS-Invasion	0.0025					No	
Montane Sagebrush Steppe	3-Late:Closed	1-Early:All	Aroga-Outbreak	0.0670	0.2500			5	Yes	
Montane Sagebrush Steppe	3-Late:Closed	1-Early:All	ReplacementFire	0.0200					Yes	
Montane Sagebrush Steppe	3-Late:Closed	1-Early:All	Supplemental-Salt-Block	0.0100				5	Yes	
Montane Sagebrush Steppe	3-Late:Closed	2-Mid:Open	Aroga-Outbreak	0.0670	0.7500				Yes	
Montane Sagebrush Steppe	3-Late:Closed	2-Mid:Open	Severe-Drought	0.0070	0.1000				Yes	
Montane Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0542	0.9990			1	No	
Montane Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990			1	No	
Montane Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	3-Late:Closed	3-Late:Closed	Severe-Drought	0.0070	0.9000				Yes	
Montane Sagebrush Steppe	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0542	0.0010				No	
Montane Sagebrush Steppe	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0542	0.0010				No	
Montane Sagebrush Steppe	3-Late:Closed	U:SAP-Closed	AS-Invasion	0.0025		30			No	
Montane Sagebrush Steppe	4-Late:Dense	1-Early:All	Aroga-Outbreak	0.0670	0.2500			1	Yes	

Montane Sagebrush Steppe	4-Late:Dense	1-Early:All	ReplacementFire	0.0200				Yes	
Montane Sagebrush Steppe	4-Late:Dense	2-Mid:Open	Aroga-Outbreak	0.0670	0.7500			Yes	
Montane Sagebrush Steppe	4-Late:Dense	3-Late:Closed	Severe-Drought	0.0070	0.1000			Yes	
Montane Sagebrush Steppe	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_0dd-Yr	0.0542	0.9990		1	No	
Montane Sagebrush Steppe	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990		1	No	
Montane Sagebrush Steppe	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_0dd-Yr	0.0068			0	No	
Montane Sagebrush Steppe	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_Even-Yr	0.0068			0	No	
Montane Sagebrush Steppe	4-Late:Dense	4-Late:Dense	Severe-Drought	0.0070	0.9000			Yes	
Montane Sagebrush Steppe	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0542	0.0010			No	
Montane Sagebrush Steppe	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0542	0.0010			No	
Montane Sagebrush Steppe	4-Late:Dense	U:SAP-Dense	AS-Invasion	0.0025				No	
Montane Sagebrush Steppe	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0542			1	No	
Montane Sagebrush Steppe	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0542			1	No	
Montane Sagebrush Steppe	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Seed	0.0100	0.1000			Yes	
Montane Sagebrush Steppe	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0068			0	No	
Montane Sagebrush Steppe	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0068			0	No	
Montane Sagebrush Steppe	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000				Yes	2
Montane Sagebrush Steppe	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005				Yes	
Montane Sagebrush Steppe	U:Annual Spp	U:SDI-A	Herbicide-Plateau+Seed	0.0100	0.8000			Yes	
Montane Sagebrush Steppe	U:Annual Spp	U:SI-A+AS	Herbicide-Plateau+Seed	0.0100	0.1000			Yes	
Montane Sagebrush Steppe	U:ASPG	1-Early:All	Herbicide-Plateau+Native-Seed	0.0100	0.7000			No	
Montane Sagebrush Steppe	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0542	0.0010			No	
Montane Sagebrush Steppe	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0542	0.0010			No	
Montane Sagebrush Steppe	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0542	0.9990		1	No	
Montane Sagebrush Steppe	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990		1	No	
Montane Sagebrush Steppe	U:ASPG	U:ASPG	Herbicide-Plateau+Native-Seed	0.0100	0.1500			No	
Montane Sagebrush Steppe	U:ASPG	U:ASPG	Herbicide-Plateau+Native-Seed	0.0100	0.1500			Yes	
Montane Sagebrush Steppe	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0068			0	No	
Montane Sagebrush Steppe	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0068			0	No	
Montane Sagebrush Steppe	U:ASPG	U:ASPG	ReplacementFire	0.0250				Yes	2
Montane Sagebrush Steppe	U:ASPG	U:Exotic Forbs	Exotic-Invasion	0.0005				Yes	
Montane Sagebrush Steppe	U:Depleted	U:Depleted	Severe-Drought	0.0070	0.9000			Yes	
Montane Sagebrush Steppe	U:Depleted	U:Early Shrub	Masticate+Plateau+NativeSeed	0.0100	0.2000			Yes	
Montane Sagebrush Steppe	U:Depleted	U:Early Shrub	ReplacementFire	0.0200				Yes	
Montane Sagebrush Steppe	U:Depleted	U:Early Shrub	Severe-Drought	0.0070	0.1000			Yes	
Montane Sagebrush Steppe	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0005				Yes	
Montane Sagebrush Steppe	U:Depleted	U:SA-Closed	AS-Invasion	0.0050				No	
Montane Sagebrush Steppe	U:Depleted	U:Seeded Native	Masticate+Plateau+NativeSeed	0.0100	0.8000			Yes	
Montane Sagebrush Steppe	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0200				Yes	
Montane Sagebrush Steppe	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0005				Yes	
Montane Sagebrush Steppe	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0542			1	No	
Montane Sagebrush Steppe	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0542			1	No	
Montane Sagebrush Steppe	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.2000			Yes	
Montane Sagebrush Steppe	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0068			0	No	
Montane Sagebrush Steppe	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0068			0	No	
Montane Sagebrush Steppe	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0200				Yes	
Montane Sagebrush Steppe	U:Exotic Forbs	U:SDI-A	Exotic-Control	0.0100	0.8000			Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:Annual Spp	Aroga-Outbreak	0.0670	0.2500	40		Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:Annual Spp	Masticate+Plateau+NativeSeed	0.0100	0.1000			Yes	

Montane Sagebrush Steppe	U:SA-Closed	U:Annual Spp	ReplacementFire	0.0400			29		Yes	2
Montane Sagebrush Steppe	U:SA-Closed	U:Annual Spp	ReplacementFire	0.0400		30			Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:Annual Spp	Severe-Drought	0.0070	0.1000				Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:Annual Spp	Spike+Plateau+Seed	0.0100	0.1000				Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:ASPG	Masticate+Plateau+NativeSeed	0.0100	0.1000				Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:ASPG	Spike+Plateau+Seed	0.0100	0.1000				Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:SA-Closed	Aroga-Outbreak	0.0670	0.7500	40			Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:SA-Closed	Early-Cattle-Grazing_0dd-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SA-Closed	U:SA-Closed	Early-Cattle-Grazing_Even-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SA-Closed	U:SA-Closed	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SA-Closed	U:SA-Closed	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SA-Closed	U:SA-Closed	Severe-Drought	0.0070	0.9000				Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:SA-Dense	Alternate-Succession	0.0056		28	29		Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:SDI-A	Spike+Plateau+Seed	0.0100	0.8000				Yes	
Montane Sagebrush Steppe	U:SA-Closed	U:Seeded Native	Masticate+Plateau+NativeSeed	0.0100	0.8000				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:Annual Spp	Aroga-Outbreak	0.0670	0.2500				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:Annual Spp	Masticate+Plateau+NativeSeed	0.0100	0.1000				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:Annual Spp	ReplacementFire	0.0400					Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:Annual Spp	Severe-Drought	0.0070	0.1000				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:Annual Spp	Spike+Plateau+Seed	0.0100	0.1000				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:ASPG	Masticate+Plateau+NativeSeed	0.0100	0.1000				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:ASPG	Spike+Plateau+Seed	0.0100	0.1000				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:SA-Closed	Aroga-Outbreak	0.0670	0.7500				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:SA-Closed	Severe-Drought	0.0070	0.9000				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:SA-Dense	Early-Cattle-Grazing_0dd-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SA-Dense	U:SA-Dense	Early-Cattle-Grazing_Even-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SA-Dense	U:SA-Dense	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SA-Dense	U:SA-Dense	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SA-Dense	U:SDI-A	Spike+Plateau+Seed	0.0100	0.8000				Yes	
Montane Sagebrush Steppe	U:SA-Dense	U:Seeded Native	Masticate+Plateau+NativeSeed	0.0100	0.8000				Yes	
Montane Sagebrush Steppe	U:SAP-Closed	1-Early:All	Supplemental-Salt-Block	0.0100	0.8000			5	Yes	
Montane Sagebrush Steppe	U:SAP-Closed	U:Annual Spp	Aroga-Outbreak	0.0670	0.2500	40		5	Yes	
Montane Sagebrush Steppe	U:SAP-Closed	U:Annual Spp	ReplacementFire	0.0400	0.5000		29		Yes	2
Montane Sagebrush Steppe	U:SAP-Closed	U:Annual Spp	ReplacementFire	0.0400	0.5000	30			Yes	
Montane Sagebrush Steppe	U:SAP-Closed	U:ASPG	ReplacementFire	0.0400	0.5000		29		Yes	2
Montane Sagebrush Steppe	U:SAP-Closed	U:ASPG	ReplacementFire	0.0400	0.5000	30			Yes	
Montane Sagebrush Steppe	U:SAP-Closed	U:ASPG	Severe-Drought	0.0070	0.1000				Yes	
Montane Sagebrush Steppe	U:SAP-Closed	U:ASPG	Supplemental-Salt-Block	0.0100	0.2000			5	Yes	
Montane Sagebrush Steppe	U:SAP-Closed	U:Early Shrub	Exotic-Invasion	0.0005					Yes	
Montane Sagebrush Steppe	U:SAP-Closed	U:SA-Closed	Early-Cattle-Grazing_0dd-Yr	0.0542	0.0010				No	
Montane Sagebrush Steppe	U:SAP-Closed	U:SA-Closed	Early-Cattle-Grazing_Even-Yr	0.0542	0.0010				No	
Montane Sagebrush Steppe	U:SAP-Closed	U:SAP-Closed	Aroga-Outbreak	0.0670	0.7500	40			Yes	
Montane Sagebrush Steppe	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_0dd-Yr	0.0542	0.9990			1	No	
Montane Sagebrush Steppe	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990			1	No	
Montane Sagebrush Steppe	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SAP-Closed	U:SAP-Closed	Severe-Drought	0.0070	0.9000				Yes	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Montane Sagebrush Steppe	U:SAP-Closed	U:SAP-Dense	Alternate-Succession	0.0056		28	29		Yes	
Montane Sagebrush Steppe	U:SAP-Dense	1-Early:All	Supplemental-Salt-Block	0.0100	0.8000			5	Yes	
Montane Sagebrush Steppe	U:SAP-Dense	U:Annual Spp	ReplacementFire	0.0400	0.5000				Yes	
Montane Sagebrush Steppe	U:SAP-Dense	U:ASPG	Aroga-Outbreak	0.0670	0.2500			1	Yes	
Montane Sagebrush Steppe	U:SAP-Dense	U:ASPG	ReplacementFire	0.0400	0.5000				Yes	
Montane Sagebrush Steppe	U:SAP-Dense	U:ASPG	Supplemental-Salt-Block	0.0100	0.2000			5	Yes	
Montane Sagebrush Steppe	U:SAP-Dense	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes	
Montane Sagebrush Steppe	U:SAP-Dense	U:SA-Dense	Early-Cattle-Grazing_0dd-Yr	0.0542	0.0010				No	
Montane Sagebrush Steppe	U:SAP-Dense	U:SA-Dense	Early-Cattle-Grazing_Even-Yr	0.0542	0.0010				No	
Montane Sagebrush Steppe	U:SAP-Dense	U:SAP-Closed	Aroga-Outbreak	0.0670	0.7500				Yes	
Montane Sagebrush Steppe	U:SAP-Dense	U:SAP-Closed	Severe-Drought	0.0070	0.1000				Yes	
Montane Sagebrush Steppe	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_0dd-Yr	0.0542	0.9990			1	No	
Montane Sagebrush Steppe	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990			1	No	
Montane Sagebrush Steppe	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SAP-Dense	U:SAP-Dense	Severe-Drought	0.0070	0.9000				Yes	
Montane Sagebrush Steppe	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_0dd-Yr	0.0542	0.0010	3			Yes	
Montane Sagebrush Steppe	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_0dd-Yr	0.0542	0.0010	3			Yes	
Montane Sagebrush Steppe	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_0dd-Yr	0.0542	0.9990	3		1	No	
Montane Sagebrush Steppe	U:SDI-A	U:SDI-A	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990	3		1	No	
Montane Sagebrush Steppe	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_0dd-Yr	0.0068		3		0	No	
Montane Sagebrush Steppe	U:SDI-A	U:SDI-A	Late-Cattle-Grazing_Even-Yr	0.0068		3		0	No	
Montane Sagebrush Steppe	U:SDI-A	U:SDI-A	ReplacementFire	0.0050					Yes	
Montane Sagebrush Steppe	U:SDI-A	U:SI-A+AS	AS-Invasion	0.0010					No	
Montane Sagebrush Steppe	U:SDI-B	2-Mid:Open	Natural-Recovery	0.0010					No	10
Montane Sagebrush Steppe	U:SDI-B	U:SDI-B	Alternate-Succession	0.0056		28			Yes	
Montane Sagebrush Steppe	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_0dd-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SDI-B	U:SDI-B	Early-Cattle-Grazing_Even-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SDI-B	U:SDI-A	ReplacementFire	0.0050					Yes	
Montane Sagebrush Steppe	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SDI-B	U:SDI-B	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SDI-B	U:SI-B+AS	AS-Invasion	0.0010					No	
Montane Sagebrush Steppe	U:SDI-C	1-Early:All	Supplemental-Salt-Block	0.0100				5	Yes	
Montane Sagebrush Steppe	U:SDI-C	3-Late:Closed	Natural-Recovery	0.0100					No	10
Montane Sagebrush Steppe	U:SDI-C	U:SDI-A	Aroga-Outbreak	0.0670	0.2500	40		5	Yes	
Montane Sagebrush Steppe	U:SDI-C	U:SDI-B	Aroga-Outbreak	0.0670	0.7500	40			Yes	
Montane Sagebrush Steppe	U:SDI-C	U:SDI-B	Severe-Drought	0.0070	0.1000				Yes	
Montane Sagebrush Steppe	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_0dd-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SDI-C	U:SDI-C	Early-Cattle-Grazing_Even-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SDI-C	U:SDI-C	Severe-Drought	0.0070	0.9000				Yes	
Montane Sagebrush Steppe	U:SDI-C	U:SDI-A	ReplacementFire	0.0050					Yes	
Montane Sagebrush Steppe	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SDI-C	U:SDI-C	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SDI-C	U:SI-C+AS	AS-Invasion	0.0010					No	
Montane Sagebrush Steppe	U:SDI-D	4-Late:Dense	Natural-Recovery	0.1000					No	10
Montane Sagebrush Steppe	U:SDI-D	U:SDI-A	Aroga-Outbreak	0.0670	0.2500			1	Yes	
Montane Sagebrush Steppe	U:SDI-D	U:SDI-B	Aroga-Outbreak	0.0670	0.7500				Yes	
Montane Sagebrush Steppe	U:SDI-D	U:SDI-C	Severe-Drought	0.0070	0.1000				Yes	
Montane Sagebrush Steppe	U:SDI-D	U:SDI-D	Early-Cattle-Grazing_0dd-Yr	0.0542				1	No	

Montane Sagebrush Steppe	U:SDI-D	U:SDI-D	Early-Cattle-Grazing_Even-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SDI-D	U:SDI-D	Severe-Drought	0.0070	0.9000				Yes	
Montane Sagebrush Steppe	U:SDI-D	U:SDI-A	ReplacementFire	0.0050					Yes	
Montane Sagebrush Steppe	U:SDI-D	U:SDI-D	Late-Cattle-Grazing_Odd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SDI-D	U:SDI-D	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SDI-D	U:SI-D+AS	AS-Invasion	0.0010					No	
Montane Sagebrush Steppe	U:Seeded Native	1-Early:All	Natural-Recovery	0.3300			12		No	5
Montane Sagebrush Steppe	U:Seeded Native	2-Mid:Open	Natural-Recovery	0.3300		13	29		No	5
Montane Sagebrush Steppe	U:Seeded Native	3-Late:Closed	Natural-Recovery	0.3300		30	59		No	5
Montane Sagebrush Steppe	U:Seeded Native	4-Late:Dense	Natural-Recovery	0.3300		60			No	5
Montane Sagebrush Steppe	U:Seeded Native	U:Annual Spp	AS-Invasion	0.0050			12		No	
Montane Sagebrush Steppe	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_Odd-Yr	0.0542	0.0010	3			No	
Montane Sagebrush Steppe	U:Seeded Native	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0542	0.0010	3			No	
Montane Sagebrush Steppe	U:Seeded Native	U:SAP-Closed	AS-Invasion	0.0050		13	59		No	
Montane Sagebrush Steppe	U:Seeded Native	U:SAP-Dense	AS-Invasion	0.0050		60			No	
Montane Sagebrush Steppe	U:Seeded Native	U:Seeded Native	Aroga-Outbreak	0.0670	0.2500	40		5	Yes	
Montane Sagebrush Steppe	U:Seeded Native	U:Seeded Native	Aroga-Outbreak	0.0670	0.7500	40		12	Yes	
Montane Sagebrush Steppe	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Odd-Yr	0.0542	0.9990	3		1	No	
Montane Sagebrush Steppe	U:Seeded Native	U:Seeded Native	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990	3		1	No	
Montane Sagebrush Steppe	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Odd-Yr	0.0068		3		0	No	
Montane Sagebrush Steppe	U:Seeded Native	U:Seeded Native	Late-Cattle-Grazing_Even-Yr	0.0068		3		0	No	
Montane Sagebrush Steppe	U:Seeded Native	U:Seeded Native	ReplacementFire	0.0050					Yes	
Montane Sagebrush Steppe	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_Odd-Yr	0.0542	0.0010	3			Yes	
Montane Sagebrush Steppe	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_Odd-Yr	0.0542	0.9990	3		1	No	
Montane Sagebrush Steppe	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_Even-Yr	0.0542	0.0010	3			Yes	
Montane Sagebrush Steppe	U:SI-A+AS	U:SI-A+AS	Early-Cattle-Grazing_Even-Yr	0.0542	0.9990	3		1	No	
Montane Sagebrush Steppe	U:SI-A+AS	U:SI-A+AS	Wet-Year	0.0670					No	
Montane Sagebrush Steppe	U:SI-A+AS	U:SDI-A	Competition	0.3300					No	3
Montane Sagebrush Steppe	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_Odd-Yr	0.0068		3		0	No	
Montane Sagebrush Steppe	U:SI-A+AS	U:SI-A+AS	Late-Cattle-Grazing_Even-Yr	0.0068		3		0	No	
Montane Sagebrush Steppe	U:SI-A+AS	U:SI-A+AS	ReplacementFire	0.0100					Yes	2
Montane Sagebrush Steppe	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_Odd-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SI-B+AS	U:SI-B+AS	Early-Cattle-Grazing_Even-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SI-B+AS	U:SI-B+AS	Wet-Year	0.0670					No	
Montane Sagebrush Steppe	U:SI-B+AS	U:SI-D+AS	Alternate-Succession	0.0006		28			Yes	
Montane Sagebrush Steppe	U:SI-B+AS	U:SDI-B	Competition	0.3300					No	3
Montane Sagebrush Steppe	U:SI-B+AS	U:SDI-B	Herbicide-Plateau+Seed	0.0100	0.8000				No	
Montane Sagebrush Steppe	U:SI-B+AS	U:SI-A+AS	ReplacementFire	0.0100					Yes	2
Montane Sagebrush Steppe	U:SI-B+AS	U:SI-B+AS	Herbicide-Plateau+Seed	0.0100	0.2000				No	
Montane Sagebrush Steppe	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_Odd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SI-B+AS	U:SI-B+AS	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_Odd-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SI-C+AS	U:SI-C+AS	Early-Cattle-Grazing_Even-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SI-C+AS	U:SDI-C	Competition	0.3300					No	3
Montane Sagebrush Steppe	U:SI-C+AS	U:SDI-C	Herbicide-Plateau+Seed	0.0100	0.8000				No	
Montane Sagebrush Steppe	U:SI-C+AS	U:SI-A+AS	ReplacementFire	0.0100					Yes	
Montane Sagebrush Steppe	U:SI-C+AS	U:SI-C+AS	Herbicide-Plateau+Seed	0.0100	0.2000				No	
Montane Sagebrush Steppe	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_Odd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SI-C+AS	U:SI-C+AS	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	

Montane Sagebrush Steppe	U:SI-C+AS	U:SI-C+AS	Wet-Year	0.0670					Yes	
Montane Sagebrush Steppe	U:SI-D+AS	U:SI-D+AS	Early-Cattle-Grazing_0dd-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SI-D+AS	U:SI-D+AS	Early-Cattle-Grazing_Even-Yr	0.0542				1	No	
Montane Sagebrush Steppe	U:SI-D+AS	U:SI-D+AS	Wet-Year	0.0670					No	
Montane Sagebrush Steppe	U:SI-D+AS	U:SDI-D	Competition	0.3300					No	3
Montane Sagebrush Steppe	U:SI-D+AS	U:SI-A+AS	Aroga-Outbreak	0.0670	0.2500			1	Yes	
Montane Sagebrush Steppe	U:SI-D+AS	U:SI-A+AS	ReplacementFire	0.0100					Yes	
Montane Sagebrush Steppe	U:SI-D+AS	U:SI-B+AS	Aroga-Outbreak	0.0670	0.7500				Yes	
Montane Sagebrush Steppe	U:SI-D+AS	U:SI-D+AS	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:SI-D+AS	U:SI-D+AS	Late-Cattle-Grazing_Even-Yr	0.0068				0	No	
Montane Sagebrush Steppe	U:Unpalat. Forb	U:SDI-A	Thin+24D+Seed	0.0000	0.9000				Yes	
Montane Sagebrush Steppe	U:Unpalat. Forb	U:Unpalat. Forb	ReplacementFire	0.0200					Yes	
Montane Sagebrush Steppe	U:Unpalat. Forb	U:Unpalat. Forb	Thin+24D+Seed	0.0000	0.1000				Yes	
Montane Sagebrush Steppe-Subalpine	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0800	0.9990	3		1	No	
Montane Sagebrush Steppe-Subalpine	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0800	0.9990	3		1	No	
Montane Sagebrush Steppe-Subalpine	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0100		3		0	No	
Montane Sagebrush Steppe-Subalpine	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0100		3		0	No	
Montane Sagebrush Steppe-Subalpine	1-Early:All	1-Early:All	ReplacementFire	0.0125					Yes	
Montane Sagebrush Steppe-Subalpine	1-Early:All	U:ASPG	AS-Invasion	0.0010					No	
Montane Sagebrush Steppe-Subalpine	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0800	0.0010	3			No	
Montane Sagebrush Steppe-Subalpine	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0800	0.0010	3			No	
Montane Sagebrush Steppe-Subalpine	2-Mid:Open	1-Early:All	ReplacementFire	0.0250					Yes	
Montane Sagebrush Steppe-Subalpine	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_0dd-Yr	0.0800	0.9990			1	No	
Montane Sagebrush Steppe-Subalpine	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0800	0.9990			1	No	
Montane Sagebrush Steppe-Subalpine	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_0dd-Yr	0.0100				0	No	
Montane Sagebrush Steppe-Subalpine	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0100				0	No	
Montane Sagebrush Steppe-Subalpine	2-Mid:Open	4-Late:Dense	Alternate-Succession	0.0056		28	29		Yes	
Montane Sagebrush Steppe-Subalpine	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0800	0.0010				No	
Montane Sagebrush Steppe-Subalpine	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0800	0.0010				No	
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	1-Early:All	ReplacementFire	0.0200					Yes	
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	2-Mid:Open	Severe-Drought	0.0070	0.1000				Yes	
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0800	0.9990			1	No	

Montane Sagebrush Steppe-Subalpine	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0800	0.9990		1	No
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0100			0	No
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0100			0	No
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	3-Late:Closed	Severe-Drought	0.0070	0.9000			Yes
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	5-Late:Open	Tree-Invasion	0.0080		75		Yes
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0800	0.0010			No
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0800	0.0010			No
Montane Sagebrush Steppe-Subalpine	3-Late:Closed	U:SAP-Closed	AS-Invasion	0.0010		30		No
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	1-Early:All	ReplacementFire	0.0200				Yes
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	3-Late:Closed	Severe-Drought	0.0070	0.1000			Yes
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_0dd-Yr	0.0800	0.9990		1	No
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	4-Late:Dense	Early-Cattle-Grazing_Even-Yr	0.0800	0.9990		1	No
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_0dd-Yr	0.0100			0	No
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	4-Late:Dense	Late-Cattle-Grazing_Even-Yr	0.0100			0	No
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	4-Late:Dense	Severe-Drought	0.0070	0.9000			Yes
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	5-Late:Open	Tree-Invasion	0.0080		75		Yes
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0800	0.0010			No
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0800	0.0010			No
Montane Sagebrush Steppe-Subalpine	4-Late:Dense	U:SAP-Dense	AS-Invasion	0.0010				No
Montane Sagebrush Steppe-Subalpine	5-Late:Open	1-Early:All	ReplacementFire	0.0200				Yes
Montane Sagebrush Steppe-Subalpine	5-Late:Open	4-Late:Dense	Severe-Drought	0.0070	0.1000			Yes
Montane Sagebrush Steppe-Subalpine	5-Late:Open	4-Late:Dense	Small-Tree-Lopping	0.0100				Yes
Montane Sagebrush Steppe-Subalpine	5-Late:Open	5-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0800	0.9990		1	No
Montane Sagebrush Steppe-Subalpine	5-Late:Open	5-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0800	0.9990		1	No
Montane Sagebrush Steppe-Subalpine	5-Late:Open	5-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0100			0	No
Montane Sagebrush Steppe-Subalpine	5-Late:Open	5-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0100			0	No

Montane Sagebrush Steppe-Subalpine	5-Late:Open	5-Late:Open	Severe-Drought	0.0070	0.9000				Yes
Montane Sagebrush Steppe-Subalpine	5-Late:Open	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0800	0.0005		124		No
Montane Sagebrush Steppe-Subalpine	5-Late:Open	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0800	0.0005		124		No
Montane Sagebrush Steppe-Subalpine	5-Late:Open	U:SAP-Dense	AS-Invasion	0.0010		75	124		No
Montane Sagebrush Steppe-Subalpine	5-Late:Open	U:TEA	AS-Invasion	0.0010		125			No
Montane Sagebrush Steppe-Subalpine	5-Late:Open	U:TEA	Early-Cattle-Grazing_0dd-Yr	0.0800	0.0005	125			No
Montane Sagebrush Steppe-Subalpine	5-Late:Open	U:TEA	Early-Cattle-Grazing_Even-Yr	0.0800	0.0005	125			No
Montane Sagebrush Steppe-Subalpine	6-Late:Closed	1-Early:All	Masticate+Native-Seed	0.0100	0.9900				Yes
Montane Sagebrush Steppe-Subalpine	6-Late:Closed	1-Early:All	ReplacementFire	0.0100					Yes
Montane Sagebrush Steppe-Subalpine	6-Late:Closed	1-Early:All	RxFire	0.0100	0.7000				Yes
Montane Sagebrush Steppe-Subalpine	6-Late:Closed	2-Mid:Open	Insect/Disease	0.0056	0.1000				Yes
Montane Sagebrush Steppe-Subalpine	6-Late:Closed	6-Late:Closed	RxFire	0.0100	0.3000				No
Montane Sagebrush Steppe-Subalpine	6-Late:Closed	U:Early Shrub	Masticate+Native-Seed	0.0100	0.0100				Yes
Montane Sagebrush Steppe-Subalpine	6-Late:Closed	U:TEA	Tree-Encroachment	0.0200					No
Montane Sagebrush Steppe-Subalpine	U:Annual Spp	1-Early:All	Herbicide-Plateau+Native-Seed	0.0100	0.9000				Yes
Montane Sagebrush Steppe-Subalpine	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0800				1	No
Montane Sagebrush Steppe-Subalpine	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0800				1	No
Montane Sagebrush Steppe-Subalpine	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Native-Seed	0.0100	0.1000				Yes
Montane Sagebrush Steppe-Subalpine	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes
Montane Sagebrush Steppe-Subalpine	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes
Montane Sagebrush Steppe-Subalpine	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0800	0.0010				No
Montane Sagebrush Steppe-Subalpine	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0800	0.0010				No
Montane Sagebrush Steppe-Subalpine	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0800	0.9990			1	No
Montane Sagebrush Steppe-Subalpine	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0800	0.9990			1	No

Montane Sagebrush Steppe-Subalpine	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:ASPG	U:ASPG	ReplacementFire	0.0250					Yes
Montane Sagebrush Steppe-Subalpine	U:ASPG	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes
Montane Sagebrush Steppe-Subalpine	U:Depleted	U:Depleted	Severe-Drought	0.0070	0.9000				Yes
Montane Sagebrush Steppe-Subalpine	U:Depleted	U:Early Shrub	ReplacementFire	0.0200					Yes
Montane Sagebrush Steppe-Subalpine	U:Depleted	U:Early Shrub	Severe-Drought	0.0070	0.1000				Yes
Montane Sagebrush Steppe-Subalpine	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes
Montane Sagebrush Steppe-Subalpine	U:Depleted	U:SAP-Closed	AS-Invasion	0.0010			59		No
Montane Sagebrush Steppe-Subalpine	U:Depleted	U:SAP-Dense	AS-Invasion	0.0010		60			Yes
Montane Sagebrush Steppe-Subalpine	U:Depleted	U:TEA	Tree-Invasion	0.0080		125			Yes
Montane Sagebrush Steppe-Subalpine	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0200					Yes
Montane Sagebrush Steppe-Subalpine	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes
Montane Sagebrush Steppe-Subalpine	U:Exotic Forbs	1-Early:All	Exotic-Control	0.0100	0.8000				Yes
Montane Sagebrush Steppe-Subalpine	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0800				1	No
Montane Sagebrush Steppe-Subalpine	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0800				1	No
Montane Sagebrush Steppe-Subalpine	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.2000				Yes
Montane Sagebrush Steppe-Subalpine	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0200					Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0800	0.0010				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0800	0.0010				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:Annual Spp	ReplacementFire	0.0400	0.0500				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:ASPG	ReplacementFire	0.0400	0.9500				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:ASPG	Severe-Drought	0.0070	0.1000				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:Early Shrub	Exotic-Invasion	0.0005					Yes

Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_0dd-Yr	0.0800	0.9990			1	No
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:SAP-Closed	Early-Cattle-Grazing_Even-Yr	0.0800	0.9990			1	No
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_0dd-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:SAP-Closed	Late-Cattle-Grazing_Even-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:SAP-Closed	Severe-Drought	0.0070	0.9000				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:SAP-Dense	Alternate-Succession	0.0056		28	29		Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Closed	U:TEA	Tree-Invasion	0.0080		75			
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0800	0.0010				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0800	0.0010				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:Annual Spp	ReplacementFire	0.0400	0.9500				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:ASPG	ReplacementFire	0.0400	0.0500				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:SAP-Closed	Severe-Drought	0.0070	0.1000				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_0dd-Yr	0.0800	0.9990			1	No
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:SAP-Dense	Early-Cattle-Grazing_Even-Yr	0.0800	0.9990			1	No
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_0dd-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:SAP-Dense	Late-Cattle-Grazing_Even-Yr	0.0100				0	No
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:SAP-Dense	Severe-Drought	0.0070	0.9000				Yes
Montane Sagebrush Steppe-Subalpine	U:SAP-Dense	U:TEA	Tree-Invasion	0.0080		100			Yes
Montane Sagebrush Steppe-Subalpine	U:TEA	1-Early:All	Insect/Disease	0.0056	0.4000				Yes
Montane Sagebrush Steppe-Subalpine	U:TEA	1-Early:All	ReplacementFire	0.0100	0.4000				Yes
Montane Sagebrush Steppe-Subalpine	U:TEA	U:Annual Spp	ReplacementFire	0.0100	0.0100				Yes
Montane Sagebrush Steppe-Subalpine	U:TEA	U:Early Shrub	Insect/Disease	0.0056	0.5000				Yes
Montane Sagebrush Steppe-Subalpine	U:TEA	U:Early Shrub	ReplacementFire	0.0100	0.5000				Yes
Montane Sagebrush Steppe-Subalpine	U:TEA	1-Early:All	Masticate+Native-Seed	0.0100	0.9000				Yes
Montane Sagebrush Steppe-Subalpine	U:TEA	U:Annual Spp	Insect/Disease	0.0056	0.1000				Yes

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Montane Sagebrush Steppe-Subalpine	U:TEA	U:Annual Spp	Masticate+Native-Seed	0.0100	0.0100				Yes
Montane Sagebrush Steppe-Subalpine	U:TEA	U:Early Shrub	Masticate+Native-Seed	0.0100	0.0900				Yes
Montane Sagebrush Steppe-Subalpine	U:Unpalat. Forb	1-Early:All	Thin+24D+Seed	0.0000	0.9000				Yes
Montane Sagebrush Steppe-Subalpine	U:Unpalat. Forb	U:Unpalat. Forb	ReplacementFire	0.0200					Yes
Montane Sagebrush Steppe-Subalpine	U:Unpalat. Forb	U:Unpalat. Forb	Thin+24D+Seed	0.0000	0.1000				Yes
Mountain Shrub	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0540	0.9990	3		1	No
Mountain Shrub	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0540	0.9990	3		1	No
Mountain Shrub	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0068		3		0	No
Mountain Shrub	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0068		3		0	No
Mountain Shrub	1-Early:All	1-Early:All	NativeGrazing	0.0200					Yes
Mountain Shrub	1-Early:All	1-Early:All	ReplacementFire	0.0125					Yes
Mountain Shrub	1-Early:All	1-Early:All	Severe-Drought	0.0070					Yes
Mountain Shrub	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0540	0.0010	3			No
Mountain Shrub	1-Early:All	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0540	0.0010	3			No
Mountain Shrub	1-Early:All	U:SAP	AS-Invasion	0.0025					No
Mountain Shrub	2-Mid:Open	1-Early:All	ReplacementFire	0.0200					Yes
Mountain Shrub	2-Mid:Open	1-Early:All	Severe-Drought	0.0070	0.1000				Yes
Mountain Shrub	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_0dd-Yr	0.0540	0.9990			1	No
Mountain Shrub	2-Mid:Open	2-Mid:Open	Early-Cattle-Grazing_Even-Yr	0.0540	0.9990			1	No
Mountain Shrub	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No
Mountain Shrub	2-Mid:Open	2-Mid:Open	Late-Cattle-Grazing_Even-Yr	0.0068				0	No
Mountain Shrub	2-Mid:Open	2-Mid:Open	NativeGrazing	0.0200				-1	No
Mountain Shrub	2-Mid:Open	2-Mid:Open	Severe-Drought	0.0070	0.9000				Yes
Mountain Shrub	2-Mid:Open	3-Late:Closed	Tree-Invasion	0.0100		20			Yes
Mountain Shrub	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0540	0.0010				No
Mountain Shrub	2-Mid:Open	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0540	0.0010				No
Mountain Shrub	2-Mid:Open	U:SAP	AS-Invasion	0.0025					No
Mountain Shrub	3-Late:Closed	1-Early:All	ReplacementFire	0.0250					Yes
Mountain Shrub	3-Late:Closed	2-Mid:Open	Severe-Drought	0.0070	0.1000				Yes
Mountain Shrub	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_0dd-Yr	0.0540	0.9990			1	No
Mountain Shrub	3-Late:Closed	3-Late:Closed	Early-Cattle-Grazing_Even-Yr	0.0540	0.9990			1	No
Mountain Shrub	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No
Mountain Shrub	3-Late:Closed	3-Late:Closed	Late-Cattle-Grazing_Even-Yr	0.0068				0	No
Mountain Shrub	3-Late:Closed	3-Late:Closed	NativeGrazing	0.0200					No
Mountain Shrub	3-Late:Closed	3-Late:Closed	Severe-Drought	0.0070	0.9000				Yes
Mountain Shrub	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0540	0.0010				No
Mountain Shrub	3-Late:Closed	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0540	0.0010				No
Mountain Shrub	3-Late:Closed	U:SAP	AS-Invasion	0.0025			124		No
Mountain Shrub	3-Late:Closed	U:TEA	AS-Invasion	0.0025		125			No
Mountain Shrub	3-Late:Closed	U:TEA	Tree-Encroachment	0.0200		125			No
Mountain Shrub	U:Depleted	1-Early:All	Masticate+Native-Seed	0.0100	0.1000	125			Yes
Mountain Shrub	U:Depleted	2-Mid:Open	Masticate+Native-Seed	0.0100	0.7000	125			Yes
Mountain Shrub	U:Depleted	U:Depleted	NativeGrazing	0.0200			4		Yes
Mountain Shrub	U:Depleted	U:Depleted	NativeGrazing	0.0200		5	20	-1	No
Mountain Shrub	U:Depleted	U:Depleted	Severe-Drought	0.0070	0.9000				Yes

Mountain Shrub	U:Depleted	U:Depleted	Small-Tree-Lopping	0.0100		80	124	20	Yes	
Mountain Shrub	U:Depleted	U:Early Shrub	Masticate+Native-Seed	0.0100	0.2000	125			Yes	
Mountain Shrub	U:Depleted	U:Early Shrub	ReplacementFire	0.0200					Yes	
Mountain Shrub	U:Depleted	U:Early Shrub	Severe-Drought	0.0070	0.1000				Yes	
Mountain Shrub	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes	
Mountain Shrub	U:Depleted	U:SAP	AS-Invasion	0.0050					No	
Mountain Shrub	U:Depleted	U:TEA	Tree-Invasion	0.0100		125			Yes	
Mountain Shrub	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0200					Yes	
Mountain Shrub	U:Early Shrub	U:Exotic Forbs	Exotic-Invasion	0.0005					Yes	
Mountain Shrub	U:Exotic Forbs	1-Early:All	Exotic-Control	0.0100	0.8000				Yes	
Mountain Shrub	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0540				1	No	
Mountain Shrub	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0540				1	No	
Mountain Shrub	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.2000				Yes	
Mountain Shrub	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Mountain Shrub	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0068				0	No	
Mountain Shrub	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0200					Yes	
Mountain Shrub	U:SAP	1-Early:All	Masticate+Plateau+NativeSeed	0.0100	0.1000	125			Yes	
Mountain Shrub	U:SAP	2-Mid:Open	Masticate+Plateau+NativeSeed	0.0100	0.7000	125			Yes	
Mountain Shrub	U:SAP	U:Exotic Forbs	Exotic-Invasion	0.0005					No	
Mountain Shrub	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0540	0.0010	3			Yes	
Mountain Shrub	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0540	0.9990	3		1	No	
Mountain Shrub	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0540	0.0010	3			Yes	
Mountain Shrub	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0540	0.9990	3		1	No	
Mountain Shrub	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0068		3		0	No	
Mountain Shrub	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0068		3		0	No	
Mountain Shrub	U:SAP	U:SAP	Masticate+Plateau+NativeSeed	0.0100	0.2000	125			Yes	
Mountain Shrub	U:SAP	U:SAP	NativeGrazing	0.0200			4		Yes	
Mountain Shrub	U:SAP	U:SAP	NativeGrazing	0.0200		5	20	-1	No	
Mountain Shrub	U:SAP	U:SAP	ReplacementFire	0.0250			4		Yes	2
Mountain Shrub	U:SAP	U:SAP	ReplacementFire	0.1000		5			Yes	
Mountain Shrub	U:SAP	U:SAP	Severe-Drought	0.0070	0.1000				Yes	
Mountain Shrub	U:SAP	U:SAP	Severe-Drought	0.0070	0.9000		4		Yes	
Mountain Shrub	U:SAP	U:SAP	Severe-Drought	0.0070	0.9000	5		5	Yes	
Mountain Shrub	U:SAP	U:SAP	Small-Tree-Lopping	0.0100		80	124	20	Yes	
Mountain Shrub	U:SAP	U:TEA	Tree-Invasion	0.0100		125			Yes	
Mountain Shrub	U:TEA	1-Early:All	Insect/Disease	0.0056	0.4000				Yes	
Mountain Shrub	U:TEA	1-Early:All	Masticate+Plateau+NativeSeed	0.0100	0.8000				Yes	
Mountain Shrub	U:TEA	U:Early Shrub	Insect/Disease	0.0056	0.6000				Yes	
Mountain Shrub	U:TEA	U:Early Shrub	Masticate+Plateau+NativeSeed	0.0100	0.1000				Yes	
Mountain Shrub	U:TEA	U:Early Shrub	ReplacementFire	0.0100	0.5000				Yes	
Mountain Shrub	U:TEA	U:SAP	Masticate+Plateau+NativeSeed	0.0100	0.1000				Yes	
Mountain Shrub	U:TEA	U:SAP	ReplacementFire	0.0100	0.5000				Yes	
Mountain Shrub	U:Unpalat. Forb	U:Unpalat. Forb	ReplacementFire	0.0200					Yes	
Owyhee River Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990			1	No	31
Owyhee River Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990			1	No	31
Owyhee River Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Fence	0.0100					No	19

Owyhee River Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Flooding-7yr	0.1400				Yes	
Owyhee River Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995		0	No	31
Owyhee River Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995		0	No	31
Owyhee River Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Weed-Inventory+Spot-Treat	0.0100				No	3
Owyhee River Riparian	1-Early:Cottonwood	1-Early:Cottonwood	Wild-Horse-Grazing	0.0762	0.9990		1	No	31
Owyhee River Riparian	1-Early:Cottonwood	1-Early:Willow	ReplacementFire	0.0100				Yes	
Owyhee River Riparian	1-Early:Cottonwood	U:Desertified	Wild-Horse-Grazing	0.0762	0.0010			No	31
Owyhee River Riparian	1-Early:Cottonwood	U:Exotic Forb&Tree	Exotic-Invasion	0.0010				Yes	5
Owyhee River Riparian	1-Early:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010			No	31
Owyhee River Riparian	1-Early:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010			No	31
Owyhee River Riparian	1-Early:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005			No	31
Owyhee River Riparian	1-Early:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005			No	31
Owyhee River Riparian	1-Early:Willow	1-Early:Willow	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3		Yes	31
Owyhee River Riparian	1-Early:Willow	1-Early:Willow	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3		Yes	31
Owyhee River Riparian	1-Early:Willow	1-Early:Willow	Fence	0.0100				No	19
Owyhee River Riparian	1-Early:Willow	1-Early:Willow	Flooding-7yr	0.1400				Yes	
Owyhee River Riparian	1-Early:Willow	1-Early:Willow	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995	3		Yes	31
Owyhee River Riparian	1-Early:Willow	1-Early:Willow	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995	3		Yes	31
Owyhee River Riparian	1-Early:Willow	1-Early:Willow	ReplacementFire	0.0100				Yes	
Owyhee River Riparian	1-Early:Willow	1-Early:Willow	Weed-Inventory+Spot-Treat	0.0100				No	3
Owyhee River Riparian	1-Early:Willow	1-Early:Willow	Wild-Horse-Grazing	0.0762				Yes	31
Owyhee River Riparian	1-Early:Willow	U:Exotic Forb&Tree	Exotic-Invasion	0.0010				No	5
Owyhee River Riparian	1-Early:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3		No	31
Owyhee River Riparian	1-Early:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3		No	31
Owyhee River Riparian	1-Early:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005	3		No	31
Owyhee River Riparian	1-Early:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005	3		No	31
Owyhee River Riparian	1-Early:Willow	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0762				No	31
Owyhee River Riparian	2-Mid:Cottonwood	1-Early:Cottonwood	Flooding-20yr	0.0500				Yes	
Owyhee River Riparian	2-Mid:Cottonwood	1-Early:Willow	ReplacementFire	0.0100				Yes	
Owyhee River Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990		1	No	31
Owyhee River Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990		1	No	31
Owyhee River Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Fence	0.0100				No	19
Owyhee River Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995		0	No	31

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Owyhee River Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995	0	No	31
Owyhee River Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Weed-Inventory+Spot-Treat	0.0100			No	3
Owyhee River Riparian	2-Mid:Cottonwood	2-Mid:Cottonwood	Wild-Horse-Grazing	0.0762	0.9990	1	No	31
Owyhee River Riparian	2-Mid:Cottonwood	U:Desertified	Wild-Horse-Grazing	0.0762	0.0010		No	31
Owyhee River Riparian	2-Mid:Cottonwood	U:Exotic Forb&Tree	Exotic-Invasion	0.0010			Yes	5
Owyhee River Riparian	2-Mid:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010		No	31
Owyhee River Riparian	2-Mid:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010		No	31
Owyhee River Riparian	2-Mid:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005		No	31
Owyhee River Riparian	2-Mid:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005		No	31
Owyhee River Riparian	2-Mid:Willow	1-Early:Willow	Flooding-20yr	0.0500			Yes	
Owyhee River Riparian	2-Mid:Willow	1-Early:Willow	ReplacementFire	0.0100			Yes	
Owyhee River Riparian	2-Mid:Willow	2-Mid:Willow	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	1	No	31
Owyhee River Riparian	2-Mid:Willow	2-Mid:Willow	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	1	No	31
Owyhee River Riparian	2-Mid:Willow	2-Mid:Willow	Fence	0.0100			No	19
Owyhee River Riparian	2-Mid:Willow	2-Mid:Willow	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995	0	No	31
Owyhee River Riparian	2-Mid:Willow	2-Mid:Willow	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995	0	No	31
Owyhee River Riparian	2-Mid:Willow	2-Mid:Willow	Weed-Inventory+Spot-Treat	0.0100			No	3
Owyhee River Riparian	2-Mid:Willow	2-Mid:Willow	Wild-Horse-Grazing	0.0762	0.9990	1	No	31
Owyhee River Riparian	2-Mid:Willow	U:Desertified	Wild-Horse-Grazing	0.0762	0.0010		No	31
Owyhee River Riparian	2-Mid:Willow	U:Exotic Forb&Tree	Exotic-Invasion	0.0010			No	5
Owyhee River Riparian	2-Mid:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010		No	31
Owyhee River Riparian	2-Mid:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010		No	31
Owyhee River Riparian	2-Mid:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005		No	31
Owyhee River Riparian	2-Mid:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005		No	31
Owyhee River Riparian	3-Late:Cottonwood	1-Early:Cottonwood	Flooding-100yr	0.0100			Yes	
Owyhee River Riparian	3-Late:Cottonwood	1-Early:Willow	ReplacementFire	0.0100			Yes	
Owyhee River Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	1	No	31
Owyhee River Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	1	No	31
Owyhee River Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Exotic-Invasion	0.0010			No	5
Owyhee River Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Fence	0.0100			No	19
Owyhee River Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995	0	No	31
Owyhee River Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995	0	No	31
Owyhee River Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Weed-Inventory+Spot-Treat	0.0100			No	3

Owyhee River Riparian	3-Late:Cottonwood	3-Late:Cottonwood	Wild-Horse-Grazing	0.0762	0.9990		1	No	31
Owyhee River Riparian	3-Late:Cottonwood	U:Desertified	Wild-Horse-Grazing	0.0762	0.0010			No	31
Owyhee River Riparian	3-Late:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010			No	31
Owyhee River Riparian	3-Late:Cottonwood	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010			No	31
Owyhee River Riparian	3-Late:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005			No	31
Owyhee River Riparian	3-Late:Cottonwood	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005			No	31
Owyhee River Riparian	3-Late:Willow	1-Early:Willow	Flooding-100yr	0.0100				Yes	
Owyhee River Riparian	3-Late:Willow	1-Early:Willow	ReplacementFire	0.0100				Yes	
Owyhee River Riparian	3-Late:Willow	3-Late:Willow	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990		1	No	31
Owyhee River Riparian	3-Late:Willow	3-Late:Willow	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990		1	No	31
Owyhee River Riparian	3-Late:Willow	3-Late:Willow	Fence	0.0100				No	19
Owyhee River Riparian	3-Late:Willow	3-Late:Willow	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995		0	No	31
Owyhee River Riparian	3-Late:Willow	3-Late:Willow	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995		0	No	31
Owyhee River Riparian	3-Late:Willow	3-Late:Willow	Weed-Inventory+Spot-Treat	0.0100				No	3
Owyhee River Riparian	3-Late:Willow	3-Late:Willow	Wild-Horse-Grazing	0.0762	0.9990		1	No	31
Owyhee River Riparian	3-Late:Willow	U:Desertified	Wild-Horse-Grazing	0.0762	0.0010			No	31
Owyhee River Riparian	3-Late:Willow	U:Exotic Forb&Tree	Exotic-Invasion	0.0010				No	5
Owyhee River Riparian	3-Late:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010			Yes	31
Owyhee River Riparian	3-Late:Willow	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010			Yes	31
Owyhee River Riparian	3-Late:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005			Yes	31
Owyhee River Riparian	3-Late:Willow	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005			Yes	31
Owyhee River Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Early-Cattle-Grazing_0dd-Yr	0.0670				Yes	31
Owyhee River Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Early-Cattle-Grazing_Even-Yr	0.0670				Yes	31
Owyhee River Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Fence	0.0100				No	19
Owyhee River Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Flooding-7yr	0.1400				Yes	
Owyhee River Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Late-Cattle-Grazing_0dd-Yr	0.0762				Yes	31
Owyhee River Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Late-Cattle-Grazing_Even-Yr	0.0762				Yes	31
Owyhee River Riparian	PointBar:Bare Ground	PointBar:Bare Ground	Wild-Horse-Grazing	0.0762				Yes	31
Owyhee River Riparian	U:Annual Spp	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001			Yes	
Owyhee River Riparian	U:Annual Spp	1-Early:Willow	Flooding-100yr	0.0100	0.0099			Yes	
Owyhee River Riparian	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0670		3	1	No	31
Owyhee River Riparian	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0670		3	1	No	31
Owyhee River Riparian	U:Annual Spp	U:Annual Spp	Fence	0.0100				No	19
Owyhee River Riparian	U:Annual Spp	U:Annual Spp	Flooding-100yr	0.0100	0.9900			Yes	
Owyhee River Riparian	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0762		3	0	No	31
Owyhee River Riparian	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0762		3	0	No	31
Owyhee River Riparian	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000				Yes	

Owyhee River Riparian	U:Annual Spp	U:Annual Spp	Wild-Horse-Grazing	0.0762					No	31	
Owyhee River Riparian	U:Annual Spp	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Owyhee River Riparian	U:Desertified	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001				Yes		
Owyhee River Riparian	U:Desertified	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes		
Owyhee River Riparian	U:Desertified	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990			1	No	31	
Owyhee River Riparian	U:Desertified	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990			1	No	31	
Owyhee River Riparian	U:Desertified	U:Desertified	Fence	0.0100					No	19	
Owyhee River Riparian	U:Desertified	U:Desertified	Flooding-100yr	0.0100	0.9900				Yes		
Owyhee River Riparian	U:Desertified	U:Desertified	Flooding-20yr	0.0500	0.9500	30			Yes		
Owyhee River Riparian	U:Desertified	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995			0	No	31	
Owyhee River Riparian	U:Desertified	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995			0	No	31	
Owyhee River Riparian	U:Desertified	U:Desertified	ReplacementFire	0.0100					Yes		
Owyhee River Riparian	U:Desertified	U:Desertified	Wild-Horse-Grazing	0.0762					No	31	
Owyhee River Riparian	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010				No	31	
Owyhee River Riparian	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010				No	31	
Owyhee River Riparian	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005				No	31	
Owyhee River Riparian	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005				No	31	
Owyhee River Riparian	U:Desertified	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Owyhee River Riparian	U:Desertified	U:Inset-A	Flooding-20yr	0.0500	0.0500	30			Yes		
Owyhee River Riparian	U:Desertified	U:SAP	AS-Invasion	0.0050					No		
Owyhee River Riparian	U:Early Shrub	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001				Yes		
Owyhee River Riparian	U:Early Shrub	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes		
Owyhee River Riparian	U:Early Shrub	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0670				1	No	31	
Owyhee River Riparian	U:Early Shrub	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0670				1	No	31	
Owyhee River Riparian	U:Early Shrub	U:Early Shrub	Fence	0.0100					No	19	
Owyhee River Riparian	U:Early Shrub	U:Early Shrub	Flooding-100yr	0.0100	0.9900				Yes		
Owyhee River Riparian	U:Early Shrub	U:Early Shrub	Late-Cattle-Grazing_0dd-Yr	0.0762				0	No	31	
Owyhee River Riparian	U:Early Shrub	U:Early Shrub	Late-Cattle-Grazing_Even-Yr	0.0762				0	No	31	
Owyhee River Riparian	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0100					Yes		
Owyhee River Riparian	U:Early Shrub	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Owyhee River Riparian	U:Exotic Forb&Tree	1-Early:Willow	Exotic-Control	0.0100	0.6000		4		Yes		20
Owyhee River Riparian	U:Exotic Forb&Tree	2-Mid:Willow	Exotic-Control	0.0100	0.6000	5	19		No		20
Owyhee River Riparian	U:Exotic Forb&Tree	3-Late:Willow	Exotic-Control	0.0100	0.6000	20			No		20
Owyhee River Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_0dd-Yr	0.0670		3		1	No	31	
Owyhee River Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_Even-Yr	0.0670		3		1	No	31	
Owyhee River Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Exotic-Control	0.0100	0.4000				Yes		20
Owyhee River Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Fence	0.0100					No	19	
Owyhee River Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Flooding-20yr	0.0500					Yes		
Owyhee River Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_0dd-Yr	0.0762		3		0	No	31	
Owyhee River Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_Even-Yr	0.0762		3		0	No	31	

Owyhee River Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	ReplacementFire	0.0100					Yes		
Owyhee River Riparian	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Wild-Horse-Grazing	0.0762				1	No	31	
Owyhee River Riparian	U:Incised-EFT	1-Early:Cottonwood	Flooding-100yr	0.0100	0.0001				Yes		
Owyhee River Riparian	U:Incised-EFT	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes		
Owyhee River Riparian	U:Incised-EFT	U:Desertified	Exotic-Control	0.0100	0.6000				Yes		20
Owyhee River Riparian	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_0dd-Yr	0.0670		3		1	No	31	
Owyhee River Riparian	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_Even-Yr	0.0670		3		1	No	31	
Owyhee River Riparian	U:Incised-EFT	U:Incised-EFT	Exotic-Control	0.0100	0.4000				Yes		20
Owyhee River Riparian	U:Incised-EFT	U:Incised-EFT	Fence	0.0100					No	19	
Owyhee River Riparian	U:Incised-EFT	U:Incised-EFT	Flooding-100yr	0.0100	0.9900				Yes		
Owyhee River Riparian	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_0dd-Yr	0.0762		3		0	No	31	
Owyhee River Riparian	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_Even-Yr	0.0762		3		0	No	31	
Owyhee River Riparian	U:Incised-EFT	U:Incised-EFT	ReplacementFire	0.0100					Yes		
Owyhee River Riparian	U:Incised-EFT	U:Incised-EFT	Wild-Horse-Grazing	0.0762				1	No	31	
Owyhee River Riparian	U:Inset-A	U:Inset-A	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3			Yes	31	
Owyhee River Riparian	U:Inset-A	U:Inset-A	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3			Yes	31	
Owyhee River Riparian	U:Inset-A	U:Inset-A	Fence	0.0100					No	19	
Owyhee River Riparian	U:Inset-A	U:Inset-A	Flooding-7yr	0.1400					Yes		
Owyhee River Riparian	U:Inset-A	U:Inset-A	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995	3			Yes	31	
Owyhee River Riparian	U:Inset-A	U:Inset-A	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995	3			Yes	31	
Owyhee River Riparian	U:Inset-A	U:Inset-A	ReplacementFire	0.0010					Yes		
Owyhee River Riparian	U:Inset-A	U:Inset-A	Weed-Inventory+Spot-Treat	0.0100					No	3	
Owyhee River Riparian	U:Inset-A	U:Inset-A	Wild-Horse-Grazing	0.0762					Yes	31	
Owyhee River Riparian	U:Inset-A	U:Inset-EFT	Exotic-Invasion	0.0010					No	5	
Owyhee River Riparian	U:Inset-A	U:Inset-SFE	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3			No	31	
Owyhee River Riparian	U:Inset-A	U:Inset-SFE	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3			No	31	
Owyhee River Riparian	U:Inset-A	U:Inset-SFE	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005	3			No	31	
Owyhee River Riparian	U:Inset-A	U:Inset-SFE	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005	3			No	31	
Owyhee River Riparian	U:Inset-A	U:Inset-SFE	NativeGrazing	0.0200			4		Yes		
Owyhee River Riparian	U:Inset-A	U:Inset-SFE	Wild-Horse-Grazing	0.0762					No	31	
Owyhee River Riparian	U:Inset-B	U:Inset-A	Flooding-20yr	0.0500					Yes		
Owyhee River Riparian	U:Inset-B	U:Inset-A	ReplacementFire	0.0010					Yes		
Owyhee River Riparian	U:Inset-B	U:Inset-B	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990			1	No	31	
Owyhee River Riparian	U:Inset-B	U:Inset-B	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990			1	No	31	
Owyhee River Riparian	U:Inset-B	U:Inset-B	Fence	0.0100					No	19	
Owyhee River Riparian	U:Inset-B	U:Inset-B	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995			0	No	31	
Owyhee River Riparian	U:Inset-B	U:Inset-B	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995			0	No	31	
Owyhee River Riparian	U:Inset-B	U:Inset-B	Weed-Inventory+Spot-Treat	0.0100					No	3	
Owyhee River Riparian	U:Inset-B	U:Inset-B	Wild-Horse-Grazing	0.0762	0.9990			1	No	31	
Owyhee River Riparian	U:Inset-B	U:Inset-EFT	Exotic-Invasion	0.0010					No	5	
Owyhee River Riparian	U:Inset-B	U:Inset-HU	Wild-Horse-Grazing	0.0762	0.0100				No	31	
Owyhee River Riparian	U:Inset-B	U:Inset-SFE	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010				Yes	31	
Owyhee River Riparian	U:Inset-B	U:Inset-SFE	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010				Yes	31	
Owyhee River Riparian	U:Inset-B	U:Inset-SFE	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005				Yes	31	
Owyhee River Riparian	U:Inset-B	U:Inset-SFE	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005				Yes	31	
Owyhee River Riparian	U:Inset-EFT	U:Inset-A	Exotic-Control	0.0100	0.6000		4		No		20
Owyhee River Riparian	U:Inset-EFT	U:Inset-B	Exotic-Control	0.0100	0.4000				Yes		20
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3			Yes	31	

Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3		1	No	31	
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3			Yes	31	
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3		1	No	31	
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Exotic-Control	0.0100	0.4000				Yes		20
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Fence	0.0100					No	19	
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005	3			Yes	31	
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995	3		0	No	31	
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005	3			Yes	31	
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995	3		0	No	31	
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	NativeGrazing	0.0200			4		Yes		
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	ReplacementFire	0.0010					Yes		
Owyhee River Riparian	U:Inset-EFT	U:Inset-EFT	Wild-Horse-Grazing	0.0762				1	No	31	
Owyhee River Riparian	U:Inset-HU	U:Inset-HU	Early-Cattle-Grazing_0dd-Yr	0.0670					Yes	31	
Owyhee River Riparian	U:Inset-HU	U:Inset-HU	Early-Cattle-Grazing_Even-Yr	0.0670					Yes	31	
Owyhee River Riparian	U:Inset-HU	U:Inset-HU	Fence	0.0100					No	19	
Owyhee River Riparian	U:Inset-HU	U:Inset-HU	Late-Cattle-Grazing_0dd-Yr	0.0762					Yes	31	
Owyhee River Riparian	U:Inset-HU	U:Inset-HU	Late-Cattle-Grazing_Even-Yr	0.0762					Yes	31	
Owyhee River Riparian	U:Inset-HU	U:Inset-HU	Wild-Horse-Grazing	0.0762					Yes	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-EFT	Exotic-Invasion	0.0010					Yes	5	
Owyhee River Riparian	U:Inset-SFE	U:Inset-HU	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3			No	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-HU	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3			No	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-HU	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005	3			No	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-HU	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005	3			No	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-HU	Wild-Horse-Grazing	0.0762	0.0010				No	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3		1	No	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3		1	No	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	Fence	0.0100					No	19	
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	Flooding-100yr	0.0100		20			Yes		
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	Flooding-20yr	0.0500			19		Yes		
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995	3		0	No	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995	3		0	No	31	
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	NativeGrazing	0.0200			4		Yes		
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	ReplacementFire	0.0010					Yes		
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	Weed-Inventory+Spot-Treat	0.0100					No	3	
Owyhee River Riparian	U:Inset-SFE	U:Inset-SFE	Wild-Horse-Grazing	0.0762	0.9990			1	No	31	
Owyhee River Riparian	U:Pasture	U:Pasture	Early-Cattle-Grazing_0dd-Yr	0.0670				1	No		
Owyhee River Riparian	U:Pasture	U:Pasture	Early-Cattle-Grazing_Even-Yr	0.0670				1	No		
Owyhee River Riparian	U:Pasture	U:Pasture	Late-Cattle-Grazing_0dd-Yr	0.0762				0	No		
Owyhee River Riparian	U:Pasture	U:Pasture	Late-Cattle-Grazing_Even-Yr	0.0762				0	No		
Owyhee River Riparian	U:SAP	1-Early:Willow	Flooding-100yr	0.0100	0.0099				Yes		
Owyhee River Riparian	U:SAP	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010				Yes	31	
Owyhee River Riparian	U:SAP	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010				Yes	31	
Owyhee River Riparian	U:SAP	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005				Yes	31	
Owyhee River Riparian	U:SAP	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005				Yes	31	
Owyhee River Riparian	U:SAP	U:Annual Spp	ReplacementFire	0.0100					Yes		
Owyhee River Riparian	U:SAP	U:Annual Spp	Wild-Horse-Grazing	0.0762	0.0010				Yes	31	
Owyhee River Riparian	U:SAP	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Owyhee River Riparian	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990			1	No	31	
Owyhee River Riparian	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990			1	No	31	

Owyhee River Riparian	U:SAP	U:SAP	Fence	0.0100				No	19
Owyhee River Riparian	U:SAP	U:SAP	Flooding-100yr	0.0100	0.0001			Yes	
Owyhee River Riparian	U:SAP	U:SAP	Flooding-100yr	0.0100	0.9900			Yes	
Owyhee River Riparian	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995		0	No	31
Owyhee River Riparian	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995		0	No	31
Owyhee River Riparian	U:SAP	U:SAP	Wild-Horse-Grazing	0.0762	0.9990		1	No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0670	0.0010	3		No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0670	0.0010	3		No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0762	0.0005	3		No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0762	0.0005	3		No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Desertified	Wild-Horse-Grazing	0.0762	0.0010			No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Exotic Forb&Tree	Exotic-Invasion	0.0010		5		Yes	5
Owyhee River Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0670	0.9990	3	1	No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0670	0.9990	3	1	No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Fence	0.0100				No	19
Owyhee River Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Flooding-20yr	0.0500				Yes	
Owyhee River Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0762	0.9995	3	0	No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0762	0.9995	3	0	No	31
Owyhee River Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	ReplacementFire	0.0100				Yes	
Owyhee River Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Weed-Inventory+Spot-Treat	0.0100				No	3
Owyhee River Riparian	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0762	0.9900		1	No	31
Saline Meadow	1-Early:Open	1-Early:Open	Severe-Drought	0.0070				Yes	
Saline Meadow	1-Early:Open	1-Early:Open	Weed-Inventory+Spot-Treat	0.0100				No	3
Saline Meadow	1-Early:Open	1-Early:Open	Wet-Year	0.0670			1	Yes	
Saline Meadow	1-Early:Open	U:ASPG	AS-Invasion	0.0025				No	
Saline Meadow	1-Early:Open	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes	5
Saline Meadow	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990		1	No	
Saline Meadow	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990		1	No	
Saline Meadow	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.0240			0	No	
Saline Meadow	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0240			0	No	
Saline Meadow	2-Mid:Closed	2-Mid:Closed	Severe-Drought	0.0070			2	No	
Saline Meadow	2-Mid:Closed	2-Mid:Closed	Weed-Inventory+Spot-Treat	0.0100				No	3
Saline Meadow	2-Mid:Closed	2-Mid:Closed	Wet-Year	0.0670				Yes	
Saline Meadow	2-Mid:Closed	U:ASPG	AS-Invasion	0.0025				No	
Saline Meadow	2-Mid:Closed	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010			No	
Saline Meadow	2-Mid:Closed	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010			No	
Saline Meadow	2-Mid:Closed	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes	5
Saline Meadow	3-Late:Open	1-Early:Open	Wet-Year	0.0670	0.1000			Yes	
Saline Meadow	3-Late:Open	2-Mid:Closed	Wet-Year	0.0670	0.9000			Yes	
Saline Meadow	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990		1	No	
Saline Meadow	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990		1	No	
Saline Meadow	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0240			0	No	
Saline Meadow	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0240			0	No	
Saline Meadow	3-Late:Open	3-Late:Open	Severe-Drought	0.0070			2	No	
Saline Meadow	3-Late:Open	3-Late:Open	Weed-Inventory+Spot-Treat	0.0100				No	3
Saline Meadow	3-Late:Open	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010			No	
Saline Meadow	3-Late:Open	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010			No	
Saline Meadow	3-Late:Open	U:Exotic Forbs	Exotic-Invasion	0.0010				Yes	5
Saline Meadow	3-Late:Open	U:SAP	AS-Invasion	0.0025				No	

Saline Meadow	U:Annual Spp	1-Early:Open	Herbicide-Plateau+Native-Seed	0.0100	0.8000				Yes		
Saline Meadow	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0210		3		1	No		
Saline Meadow	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0210		3		1	No		
Saline Meadow	U:Annual Spp	U:Annual Spp	Herbicide-Plateau+Native-Seed	0.0100	0.2000			5	Yes		
Saline Meadow	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0240		3		0	No		
Saline Meadow	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0240		3		0	No		
Saline Meadow	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes	2	
Saline Meadow	U:Annual Spp	U:Annual Spp	Weed-Inventory+Spot-Treat	0.0100					No	3	
Saline Meadow	U:Annual Spp	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5	
Saline Meadow	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010	3			No		
Saline Meadow	U:ASPG	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010	3			No		
Saline Meadow	U:ASPG	U:ASPG	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990	3		1	No		
Saline Meadow	U:ASPG	U:ASPG	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990	3		1	No		
Saline Meadow	U:ASPG	U:ASPG	Late-Cattle-Grazing_0dd-Yr	0.0240		3		0	No		
Saline Meadow	U:ASPG	U:ASPG	Late-Cattle-Grazing_Even-Yr	0.0240		3		0	No		
Saline Meadow	U:ASPG	U:ASPG	ReplacementFire	0.0100					Yes	2	
Saline Meadow	U:ASPG	U:ASPG	Severe-Drought	0.0070			2		Yes		
Saline Meadow	U:ASPG	U:ASPG	Severe-Drought	0.0070		3		2	No		
Saline Meadow	U:ASPG	U:ASPG	Weed-Inventory+Spot-Treat	0.0100					No	3	
Saline Meadow	U:ASPG	U:ASPG	Wet-Year	0.0670					Yes		
Saline Meadow	U:ASPG	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5	
Saline Meadow	U:Depleted	1-Early:Open	Thin+Native-Seed	0.0100	0.7000				Yes		
Saline Meadow	U:Depleted	3-Late:Open	Thin+Native-Seed	0.0100	0.3000				Yes		
Saline Meadow	U:Depleted	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010	3		1	No		
Saline Meadow	U:Depleted	U:Depleted	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990	3		1	No		
Saline Meadow	U:Depleted	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010	3		1	No		
Saline Meadow	U:Depleted	U:Depleted	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990	3		1	No		
Saline Meadow	U:Depleted	U:Depleted	Late-Cattle-Grazing_0dd-Yr	0.0240		3		0	No		
Saline Meadow	U:Depleted	U:Depleted	Late-Cattle-Grazing_Even-Yr	0.0240		3		0	No		
Saline Meadow	U:Depleted	U:Depleted	Severe-Drought	0.0070	1.0000			2	No		
Saline Meadow	U:Depleted	U:Depleted	Weed-Inventory+Spot-Treat	0.0100					No	3	
Saline Meadow	U:Depleted	U:Depleted	Wet-Year	0.0670	1.0000				Yes		
Saline Meadow	U:Depleted	U:Exotic Forbs	Exotic-Invasion	0.0010	1.0000				Yes	5	
Saline Meadow	U:Depleted	U:SAP	AS-Invasion	0.0050	1.0000				No		
Saline Meadow	U:Exotic Forbs	1-Early:Open	Exotic-Control	0.0100	0.6000		2		No		20
Saline Meadow	U:Exotic Forbs	2-Mid:Closed	Exotic-Control	0.0100	0.6000	3	22		No		20
Saline Meadow	U:Exotic Forbs	3-Late:Open	Exotic-Control	0.0100	0.6000	23			No		20
Saline Meadow	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0210		3		1	No		
Saline Meadow	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0210		3		1	No		
Saline Meadow	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.4000				Yes		20
Saline Meadow	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0240		3		0	No		
Saline Meadow	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0240		3		0	No		
Saline Meadow	U:SAP	1-Early:Open	Spike+Plateau+Native-Seed	0.0100	0.9000				Yes		
Saline Meadow	U:SAP	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0210	0.0010				Yes		
Saline Meadow	U:SAP	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0210	0.0010				Yes		
Saline Meadow	U:SAP	U:Annual Spp	ReplacementFire	0.0100	0.1000				Yes	2	
Saline Meadow	U:SAP	U:Annual Spp	Severe-Drought	0.0070	0.1000				Yes		
Saline Meadow	U:SAP	U:ASPG	ReplacementFire	0.0100	0.9000				Yes		
Saline Meadow	U:SAP	U:ASPG	Spike+Plateau+Native-Seed	0.0100	0.1000				Yes		

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Saline Meadow	U:SAP	U:Exotic Forbs	Exotic-Invasion	0.0010	1.0000				Yes	5
Saline Meadow	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0210	0.9990			1	No	
Saline Meadow	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0210	0.9990			1	No	
Saline Meadow	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0240				0	No	
Saline Meadow	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0240				0	No	
Saline Meadow	U:SAP	U:SAP	Severe-Drought	0.0070	0.9000			1	No	
Saline Meadow	U:SAP	U:SAP	Weed-Inventory+Spot-Treat	0.0100	1.0000				No	3
Subalpine Fir-Spruce	1-Early:All	1-Early:All	Competition	0.0020				-10	No	
Subalpine Fir-Spruce	1-Early:All	1-Early:All	ReplacementFire	0.0050		11			Yes	
Subalpine Fir-Spruce	1-Early:All	1-Early:All	ReplacementFire	0.0133			10		Yes	
Subalpine Fir-Spruce	2-Mid:Closed	1-Early:All	ReplacementFire	0.0025		70			Yes	
Subalpine Fir-Spruce	2-Mid:Closed	1-Early:All	ReplacementFire	0.0050			69		Yes	
Subalpine Fir-Spruce	2-Mid:Closed	2-Mid:Closed	Competition	0.0010				-10	No	
Subalpine Fir-Spruce	2-Mid:Closed	2-Mid:Closed	SurfaceFire	0.0025					No	
Subalpine Fir-Spruce	2-Mid:Closed	3-Late:Open	Insect/Disease	0.0020		70			Yes	
Subalpine Fir-Spruce	3-Late:Open	1-Early:All	Insect/Disease	0.0020					Yes	
Subalpine Fir-Spruce	3-Late:Open	1-Early:All	ReplacementFire	0.0072		70			Yes	
Subalpine Fir-Spruce	3-Late:Open	1-Early:All	ReplacementFire	0.0080			69		Yes	
Subalpine Fir-Spruce	3-Late:Open	2-Mid:Closed	Fuel-Buildup	1.0000					No	60
Subalpine Fir-Spruce	3-Late:Open	3-Late:Open	SurfaceFire	0.0080		69			No	
Subalpine Fir-Spruce	4-Late:Closed	1-Early:All	Insect/Disease	0.0040					Yes	
Subalpine Fir-Spruce	4-Late:Closed	1-Early:All	ReplacementFire	0.0036					Yes	
Subalpine Fir-Spruce	4-Late:Closed	3-Late:Open	Senescence	0.0100		400			Yes	
Subalpine Fir-Spruce	4-Late:Closed	4-Late:Closed	Severe-Drought	0.0070					Yes	
Subalpine Fir-Spruce	4-Late:Closed	4-Late:Closed	SurfaceFire	0.0014					No	
Subalpine-Upper Montane Grassland	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.1000	0.9990	3		1	No	
Subalpine-Upper Montane Grassland	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.1000	0.9990	3		1	No	
Subalpine-Upper Montane Grassland	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0130	0.9995	3		0	No	
Subalpine-Upper Montane Grassland	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0130	0.9995	3		0	No	
Subalpine-Upper Montane Grassland	1-Early:All	1-Early:All	NativeGrazing	0.0200				1	No	
Subalpine-Upper Montane Grassland	1-Early:All	1-Early:All	ReplacementFire	0.0125					Yes	
Subalpine-Upper Montane Grassland	1-Early:All	1-Early:All	Snow-Deposition	0.0670					Yes	
Subalpine-Upper Montane Grassland	1-Early:All	U:Unpalat. Shrub	Early-Cattle-Grazing_0dd-Yr	0.1000	0.0010	3			No	
Subalpine-Upper Montane Grassland	1-Early:All	U:Unpalat. Shrub	Early-Cattle-Grazing_Even-Yr	0.1000	0.0010	3			No	
Subalpine-Upper Montane Grassland	1-Early:All	U:Unpalat. Shrub	Late-Cattle-Grazing_0dd-Yr	0.0130	0.0005	3			No	
Subalpine-Upper Montane Grassland	1-Early:All	U:Unpalat. Shrub	Late-Cattle-Grazing_Even-Yr	0.0130	0.0005	3			No	
Subalpine-Upper Montane Grassland	2-Mid:Closed	1-Early:All	ReplacementFire	0.0250					Yes	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Subalpine-Upper Montane Grassland	2-Mid:Closed	1-Early:All	Snow-Deposition	0.0670	0.9000		Yes
Subalpine-Upper Montane Grassland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.1000	0.9990	1	No
Subalpine-Upper Montane Grassland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.1000	0.9990	1	No
Subalpine-Upper Montane Grassland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.0130	0.9995	0	No
Subalpine-Upper Montane Grassland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0130	0.9995	0	No
Subalpine-Upper Montane Grassland	2-Mid:Closed	2-Mid:Closed	NativeGrazing	0.0200			No
Subalpine-Upper Montane Grassland	2-Mid:Closed	U:Unpalat. Shrub	Early-Cattle-Grazing_0dd-Yr	0.1000	0.0010		No
Subalpine-Upper Montane Grassland	2-Mid:Closed	U:Unpalat. Shrub	Early-Cattle-Grazing_Even-Yr	0.1000	0.0010		No
Subalpine-Upper Montane Grassland	2-Mid:Closed	U:Unpalat. Shrub	Late-Cattle-Grazing_0dd-Yr	0.0130	0.0005		No
Subalpine-Upper Montane Grassland	2-Mid:Closed	U:Unpalat. Shrub	Late-Cattle-Grazing_Even-Yr	0.0130	0.0005		No
Subalpine-Upper Montane Grassland	3-Late:Open	1-Early:All	ReplacementFire	0.0250			Yes
Subalpine-Upper Montane Grassland	3-Late:Open	1-Early:All	Snow-Deposition	0.0670	0.9000		Yes
Subalpine-Upper Montane Grassland	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.1000	0.9990	1	No
Subalpine-Upper Montane Grassland	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_Even-Yr	0.1000	0.9990	1	No
Subalpine-Upper Montane Grassland	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0130	0.9995	0	No
Subalpine-Upper Montane Grassland	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0130	0.9995	0	No
Subalpine-Upper Montane Grassland	3-Late:Open	3-Late:Open	NativeGrazing	0.0200		-1	No
Subalpine-Upper Montane Grassland	3-Late:Open	U:Unpalat. Shrub	Early-Cattle-Grazing_0dd-Yr	0.1000	0.0010		No
Subalpine-Upper Montane Grassland	3-Late:Open	U:Unpalat. Shrub	Early-Cattle-Grazing_Even-Yr	0.1000	0.0010		No
Subalpine-Upper Montane Grassland	3-Late:Open	U:Unpalat. Shrub	Late-Cattle-Grazing_0dd-Yr	0.0130	0.0005		No
Subalpine-Upper Montane Grassland	3-Late:Open	U:Unpalat. Shrub	Late-Cattle-Grazing_Even-Yr	0.0130	0.0005		No
Subalpine-Upper Montane Grassland	U:Unpalat. Forb	U:Unpalat. Forb	Early-Cattle-Grazing_0dd-Yr	0.1000		1	No
Subalpine-Upper Montane Grassland	U:Unpalat. Forb	U:Unpalat. Forb	Early-Cattle-Grazing_Even-Yr	0.1000		1	No
Subalpine-Upper Montane Grassland	U:Unpalat. Forb	U:Unpalat. Forb	Late-Cattle-Grazing_0dd-Yr	0.0130		0	No
Subalpine-Upper Montane Grassland	U:Unpalat. Forb	U:Unpalat. Forb	Late-Cattle-Grazing_Even-Yr	0.0130		0	No
Subalpine-Upper Montane Grassland	U:Unpalat. Forb	U:Unpalat. Forb	ReplacementFire	0.0200			Yes

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Subalpine-Upper Montane Grassland	U:Unpalat. Forb	U:Unpalat. Forb	Snow-Deposition	0.0670					Yes	
Subalpine-Upper Montane Grassland	U:Unpalat. Shrub	U:Unpalat. Shrub	Early-Cattle-Grazing_0dd-Yr	0.1000				1	No	
Subalpine-Upper Montane Grassland	U:Unpalat. Shrub	U:Unpalat. Shrub	Early-Cattle-Grazing_Even-Yr	0.1000				1	No	
Subalpine-Upper Montane Grassland	U:Unpalat. Shrub	U:Unpalat. Shrub	Late-Cattle-Grazing_0dd-Yr	0.0130				0	No	
Subalpine-Upper Montane Grassland	U:Unpalat. Shrub	U:Unpalat. Shrub	Late-Cattle-Grazing_Even-Yr	0.0130				0	No	
Subalpine-Upper Montane Grassland	U:Unpalat. Shrub	U:Unpalat. Shrub	NativeGrazing	0.0200			4		Yes	
Subalpine-Upper Montane Grassland	U:Unpalat. Shrub	U:Unpalat. Shrub	NativeGrazing	0.0200		5	19	-1	No	
Subalpine-Upper Montane Grassland	U:Unpalat. Shrub	U:Unpalat. Shrub	ReplacementFire	0.0200					Yes	
Subalpine-Upper Montane Grassland	U:Unpalat. Shrub	U:Unpalat. Shrub	Snow-Deposition	0.0670					Yes	
Wet Meadow-bottomland	1-Early:Open	1-Early:Open	Early-Cattle-Grazing_0dd-Yr	0.0556	0.9990			1	No	
Wet Meadow-bottomland	1-Early:Open	1-Early:Open	Early-Cattle-Grazing_Even-Yr	0.0556	0.9990			1	No	
Wet Meadow-bottomland	1-Early:Open	1-Early:Open	Flooding-100yr	0.0100					Yes	
Wet Meadow-bottomland	1-Early:Open	1-Early:Open	Late-Cattle-Grazing_0dd-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	1-Early:Open	1-Early:Open	Late-Cattle-Grazing_Even-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	1-Early:Open	1-Early:Open	Severe-Drought	0.0070					Yes	
Wet Meadow-bottomland	1-Early:Open	1-Early:Open	Weed-Inventory+Spot-Treat	0.0100					No	3
Wet Meadow-bottomland	1-Early:Open	1-Early:Open	Wild-Horse-Grazing	0.0635	0.9990				Yes	
Wet Meadow-bottomland	1-Early:Open	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5
Wet Meadow-bottomland	1-Early:Open	U:Hummocked	Wild-Horse-Grazing	0.0635	0.0010				Yes	
Wet Meadow-bottomland	1-Early:Open	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0556	0.0010					
Wet Meadow-bottomland	1-Early:Open	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0556	0.0010					
Wet Meadow-bottomland	1-Early:Open	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0635	0.0005					
Wet Meadow-bottomland	1-Early:Open	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0635	0.0005					
Wet Meadow-bottomland	2-Mid:Closed	1-Early:Open	Flooding-100yr	0.0100					Yes	
Wet Meadow-bottomland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.0556	0.9990			1	No	
Wet Meadow-bottomland	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0556	0.9990			1	No	
Wet Meadow-bottomland	2-Mid:Closed	2-Mid:Closed	Flooding-20yr	0.0500					Yes	
Wet Meadow-bottomland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	2-Mid:Closed	2-Mid:Closed	Severe-Drought	0.0070				2	No	
Wet Meadow-bottomland	2-Mid:Closed	2-Mid:Closed	Weed-Inventory+Spot-Treat	0.0100					No	3
Wet Meadow-bottomland	2-Mid:Closed	2-Mid:Closed	Wild-Horse-Grazing	0.0635	0.9990				Yes	
Wet Meadow-bottomland	2-Mid:Closed	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5
Wet Meadow-bottomland	2-Mid:Closed	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0556	0.0010				Yes	
Wet Meadow-bottomland	2-Mid:Closed	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0556	0.0010				Yes	
Wet Meadow-bottomland	2-Mid:Closed	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0635	0.0005				Yes	
Wet Meadow-bottomland	2-Mid:Closed	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0635	0.0005				Yes	
Wet Meadow-bottomland	2-Mid:Closed	U:Hummocked	Wild-Horse-Grazing	0.0635	0.0010				Yes	
Wet Meadow-bottomland	3-Late:Open	1-Early:Open	Flooding-100yr	0.0100					Yes	
Wet Meadow-bottomland	3-Late:Open	2-Mid:Closed	Flooding-20yr	0.0500					Yes	
Wet Meadow-bottomland	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0556	0.9990			1	No	

Wet Meadow-bottomland	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0556	0.9990			1	No	
Wet Meadow-bottomland	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	3-Late:Open	3-Late:Open	Severe-Drought	0.0070				2	No	
Wet Meadow-bottomland	3-Late:Open	3-Late:Open	Weed-Inventory+Spot-Treat	0.0100					No	3
Wet Meadow-bottomland	3-Late:Open	3-Late:Open	Wild-Horse-Grazing	0.0635	0.9990				Yes	
Wet Meadow-bottomland	3-Late:Open	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5
Wet Meadow-bottomland	3-Late:Open	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0556	0.0001				Yes	
Wet Meadow-bottomland	3-Late:Open	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0556	0.0001				Yes	
Wet Meadow-bottomland	3-Late:Open	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0635	0.0005				Yes	
Wet Meadow-bottomland	3-Late:Open	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0635	0.0005				Yes	
Wet Meadow-bottomland	3-Late:Open	U:Hummocked	Wild-Horse-Grazing	0.0635	0.0001				Yes	
Wet Meadow-bottomland	3-Late:Open	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0556	0.0009				No	
Wet Meadow-bottomland	3-Late:Open	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0556	0.0009				No	
Wet Meadow-bottomland	3-Late:Open	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0635	0.0001				No	
Wet Meadow-bottomland	3-Late:Open	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0635	0.0001				No	
Wet Meadow-bottomland	3-Late:Open	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0635	0.0009				No	
Wet Meadow-bottomland	U:Annual Spp	1-Early:Open	Flooding-100yr	0.0100	0.0010				Yes	
Wet Meadow-bottomland	U:Annual Spp	1-Early:Open	Inexpensive-Floodplain-Restoration	0.0100					Yes	
Wet Meadow-bottomland	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0556				1	No	
Wet Meadow-bottomland	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0556				1	No	
Wet Meadow-bottomland	U:Annual Spp	U:Annual Spp	Flooding-100yr	0.0100	0.9990				Yes	
Wet Meadow-bottomland	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0635				0	No	
Wet Meadow-bottomland	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0635				0	No	
Wet Meadow-bottomland	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes	
Wet Meadow-bottomland	U:Annual Spp	U:Annual Spp	Weed-Inventory+Spot-Treat	0.0100					No	3
Wet Meadow-bottomland	U:Annual Spp	U:Annual Spp	Wild-Horse-Grazing	0.0635				1	No	
Wet Meadow-bottomland	U:Annual Spp	U:Incised-EFT	Exotic-Invasion	0.0010					No	5
Wet Meadow-bottomland	U:Desertified	1-Early:Open	Flooding-100yr	0.0100	0.0100				Yes	
Wet Meadow-bottomland	U:Desertified	1-Early:Open	Inexpensive-Floodplain-Restoration	0.0100					Yes	
Wet Meadow-bottomland	U:Desertified	U:Annual Spp	AS-Invasion	0.0050			74		No	
Wet Meadow-bottomland	U:Desertified	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0556	0.9990	3		1	No	
Wet Meadow-bottomland	U:Desertified	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0556	0.9990	3		1	No	
Wet Meadow-bottomland	U:Desertified	U:Desertified	Flooding-100yr	0.0100	0.9900				Yes	
Wet Meadow-bottomland	U:Desertified	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0635	0.9995	3		0	No	
Wet Meadow-bottomland	U:Desertified	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0635	0.9995	3		0	No	
Wet Meadow-bottomland	U:Desertified	U:Desertified	ReplacementFire	0.0010					Yes	
Wet Meadow-bottomland	U:Desertified	U:Desertified	Severe-Drought	0.0070	0.9000			75	Yes	
Wet Meadow-bottomland	U:Desertified	U:Desertified	Weed-Inventory+Spot-Treat	0.0100					No	3
Wet Meadow-bottomland	U:Desertified	U:Desertified	Wild-Horse-Grazing	0.0635	0.9990			1	No	
Wet Meadow-bottomland	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0556	0.0010	3			No	
Wet Meadow-bottomland	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0556	0.0010	3			No	
Wet Meadow-bottomland	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_0dd-Yr	0.0635	0.0005	3			No	
Wet Meadow-bottomland	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_Even-Yr	0.0635	0.0005	3			No	
Wet Meadow-bottomland	U:Desertified	U:Early Shrub	Severe-Drought	0.0070	0.1000				Yes	
Wet Meadow-bottomland	U:Desertified	U:Early Shrub	Wild-Horse-Grazing	0.0635	0.0010				No	
Wet Meadow-bottomland	U:Desertified	U:Incised-EFT	Exotic-Invasion	0.0010					No	5
Wet Meadow-bottomland	U:Desertified	U:SA	AS-Invasion	0.0050		75			No	
Wet Meadow-bottomland	U:Early Shrub	1-Early:Open	Flooding-100yr	0.0100	0.0010				Yes	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Wet Meadow-bottomland	U:Early Shrub	U:Early Shrub	Flooding-100yr	0.0100	0.9990				Yes		
Wet Meadow-bottomland	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0010					Yes		
Wet Meadow-bottomland	U:Early Shrub	U:Early Shrub	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wet Meadow-bottomland	U:Early Shrub	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Wet Meadow-bottomland	U:Exotic Forbs	1-Early:Open	Exotic-Control	0.0100	0.6000		2		Yes		20
Wet Meadow-bottomland	U:Exotic Forbs	2-Mid:Closed	Exotic-Control	0.0100	0.6000	3	74		Yes		20
Wet Meadow-bottomland	U:Exotic Forbs	3-Late:Open	Exotic-Control	0.0100	0.6000	75			Yes		20
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0556		3		1	No		
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0556		3		1	No		
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.4000				Yes		20
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Flooding-100yr	0.0100					Yes		
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Flooding-20yr	0.0500				3	Yes		
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0635		3		0	No		
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0635		3		0	No		
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Severe-Drought	0.0070			2		Yes		
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Severe-Drought	0.0070		3		2	No		
Wet Meadow-bottomland	U:Exotic Forbs	U:Exotic Forbs	Wild-Horse-Grazing	0.0635					Yes		
Wet Meadow-bottomland	U:Hummocked	1-Early:Open	Natural-Recovery	1.0000			5		Yes	5	
Wet Meadow-bottomland	U:Hummocked	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0556	0.0010				No		
Wet Meadow-bottomland	U:Hummocked	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0556	0.0010				No		
Wet Meadow-bottomland	U:Hummocked	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0635	0.0005				No		
Wet Meadow-bottomland	U:Hummocked	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0635	0.0005				No		
Wet Meadow-bottomland	U:Hummocked	U:Desertified	Wild-Horse-Grazing	0.0635	0.0010				Yes		
Wet Meadow-bottomland	U:Hummocked	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5	
Wet Meadow-bottomland	U:Hummocked	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0556	0.9990	3			Yes		
Wet Meadow-bottomland	U:Hummocked	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0556	0.9990	3			Yes		
Wet Meadow-bottomland	U:Hummocked	U:Hummocked	Flooding-100yr	0.0100					Yes		
Wet Meadow-bottomland	U:Hummocked	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0635	0.9995	3			Yes		
Wet Meadow-bottomland	U:Hummocked	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0635	0.9995	3			Yes		
Wet Meadow-bottomland	U:Hummocked	U:Hummocked	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wet Meadow-bottomland	U:Hummocked	U:Hummocked	Wild-Horse-Grazing	0.0635	0.9990				Yes		
Wet Meadow-bottomland	U:Incised-EFT	1-Early:Open	Inexpensive-Floodplain-Restoration	0.0100					Yes		
Wet Meadow-bottomland	U:Incised-EFT	U:Desertified	Exotic-Control	0.0100	0.6000				Yes		20
Wet Meadow-bottomland	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_0dd-Yr	0.0556		3		1	No		
Wet Meadow-bottomland	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_Even-Yr	0.0556		3		1	No		
Wet Meadow-bottomland	U:Incised-EFT	U:Incised-EFT	Exotic-Control	0.0100	0.4000				Yes		20
Wet Meadow-bottomland	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_0dd-Yr	0.0635		3		0	No		
Wet Meadow-bottomland	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_Even-Yr	0.0635		3		0	No		
Wet Meadow-bottomland	U:Incised-EFT	U:Incised-EFT	ReplacementFire	0.0100					Yes		
Wet Meadow-bottomland	U:Incised-EFT	U:Incised-EFT	Wild-Horse-Grazing	0.0635				1	No	20	
Wet Meadow-bottomland	U:SA	1-Early:Open	Flooding-100yr	0.0100	0.0010				Yes		
Wet Meadow-bottomland	U:SA	1-Early:Open	Inexpensive-Floodplain-Restoration	0.0100					Yes		
Wet Meadow-bottomland	U:SA	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0556	0.0010				Yes		
Wet Meadow-bottomland	U:SA	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0556	0.0010				Yes		
Wet Meadow-bottomland	U:SA	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0635	0.0005				Yes		
Wet Meadow-bottomland	U:SA	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0635	0.0005				Yes		
Wet Meadow-bottomland	U:SA	U:Annual Spp	ReplacementFire	0.0250					Yes		
Wet Meadow-bottomland	U:SA	U:Annual Spp	Severe-Drought	0.0070	0.1000				Yes		
Wet Meadow-bottomland	U:SA	U:Annual Spp	Wild-Horse-Grazing	0.0635	0.0010				Yes		

Wet Meadow-bottomland	U:SA	U:Incised-EFT	Exotic-Invasion	0.0010					No	5
Wet Meadow-bottomland	U:SA	U:SA	Early-Cattle-Grazing_0dd-Yr	0.0556	0.9990			1	No	
Wet Meadow-bottomland	U:SA	U:SA	Early-Cattle-Grazing_Even-Yr	0.0556	0.9990			1	No	
Wet Meadow-bottomland	U:SA	U:SA	Flooding-100yr	0.0100	0.9990				Yes	
Wet Meadow-bottomland	U:SA	U:SA	Late-Cattle-Grazing_0dd-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	U:SA	U:SA	Late-Cattle-Grazing_Even-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	U:SA	U:SA	Severe-Drought	0.0070	0.9000				Yes	
Wet Meadow-bottomland	U:SA	U:SA	Weed-Inventory+Spot-Treat	0.0100					No	3
Wet Meadow-bottomland	U:SA	U:SA	Wild-Horse-Grazing	0.0635	0.9990			1	Yes	
Wet Meadow-bottomland	U:Shrb-Frb Encr	1-Early:Open	Natural-Recovery	1.0000		1	5		No	10
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0556	0.0010				Yes	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0556	0.0010				Yes	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0635	0.0005				Yes	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0635	0.0005				Yes	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Desertified	Wild-Horse-Grazing	0.0635	0.0010				Yes	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0556	0.9990			1	No	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0556	0.9990			1	No	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Flooding-100yr	0.0100					Yes	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Flooding-20yr	0.0500				3	Yes	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0635	0.9995			0	No	
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Weed-Inventory+Spot-Treat	0.0100					No	3
Wet Meadow-bottomland	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0635	0.9990			1	No	
Wet Meadow-Montane	1-Early:Open	1-Early:Open	LivestockGrazingControl	0.0100					No	30
Wet Meadow-Montane	1-Early:Open	1-Early:Open	NativeGrazing	0.0200	0.9500				Yes	
Wet Meadow-Montane	1-Early:Open	1-Early:Open	Severe-Drought	0.0070					Yes	
Wet Meadow-Montane	1-Early:Open	1-Early:Open	Very-Wet-Year	0.0181				1	Yes	
Wet Meadow-Montane	1-Early:Open	1-Early:Open	Weed-Inventory+Spot-Treat	0.0100					No	3
Wet Meadow-Montane	1-Early:Open	1-Early:Open	Wild-Horse-Grazing	0.0540	0.9990				Yes	31
Wet Meadow-Montane	1-Early:Open	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5
Wet Meadow-Montane	1-Early:Open	U:Hummocked	Wild-Horse-Grazing	0.0540	0.0010				Yes	31
Wet Meadow-Montane	1-Early:Open	Wallow:Bare Ground	NativeGrazing	0.0200	0.0500				Yes	
Wet Meadow-Montane	2-Mid:Closed	1-Early:Open	ReplacementFire	0.0250					Yes	5
Wet Meadow-Montane	2-Mid:Closed	1-Early:Open	Very-Wet-Year	0.0181					Yes	
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_0dd-Yr	0.0472	0.9990			1	No	31
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	Early-Cattle-Grazing_Even-Yr	0.0472	0.9990			1	No	31
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_0dd-Yr	0.0540	0.9995			0	No	31
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	Late-Cattle-Grazing_Even-Yr	0.0540	0.9995			0	No	31
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	LivestockGrazingControl	0.0100					No	30
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	NativeGrazing	0.0200	0.9500			1	No	
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	Severe-Drought	0.0070				2	No	
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	Weed-Inventory+Spot-Treat	0.0100					No	3
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	Wet-Year	0.0670					Yes	
Wet Meadow-Montane	2-Mid:Closed	2-Mid:Closed	Wild-Horse-Grazing	0.0540	0.9990			1	No	31
Wet Meadow-Montane	2-Mid:Closed	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5
Wet Meadow-Montane	2-Mid:Closed	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0472	0.0010				Yes	31
Wet Meadow-Montane	2-Mid:Closed	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0472	0.0010				Yes	31
Wet Meadow-Montane	2-Mid:Closed	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0540	0.0005				Yes	31

Wet Meadow-Montane	2-Mid:Closed	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0540	0.0005				Yes	31	
Wet Meadow-Montane	2-Mid:Closed	U:Hummocked	Wild-Horse-Grazing	0.0540	0.0010				Yes	31	
Wet Meadow-Montane	2-Mid:Closed	Wallow:Bare Ground	NativeGrazing	0.0200	0.0500				Yes		
Wet Meadow-Montane	3-Late:Open	1-Early:Open	ReplacementFire	0.0250					No	5	
Wet Meadow-Montane	3-Late:Open	1-Early:Open	Very-Wet-Year	0.0181					Yes		
Wet Meadow-Montane	3-Late:Open	2-Mid:Closed	Wet-Year	0.0670					Yes		
Wet Meadow-Montane	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_0dd-Yr	0.0472	0.9990			1	No	31	
Wet Meadow-Montane	3-Late:Open	3-Late:Open	Early-Cattle-Grazing_Even-Yr	0.0472	0.9990			1	No	31	
Wet Meadow-Montane	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_0dd-Yr	0.0540	0.9995			0	No	31	
Wet Meadow-Montane	3-Late:Open	3-Late:Open	Late-Cattle-Grazing_Even-Yr	0.0540	0.9995			0	No	31	
Wet Meadow-Montane	3-Late:Open	3-Late:Open	LivestockGrazingControl	0.0100					No	30	
Wet Meadow-Montane	3-Late:Open	3-Late:Open	NativeGrazing	0.0200	0.9500			1	No		
Wet Meadow-Montane	3-Late:Open	3-Late:Open	Severe-Drought	0.0070				2	No		
Wet Meadow-Montane	3-Late:Open	3-Late:Open	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wet Meadow-Montane	3-Late:Open	3-Late:Open	Wild-Horse-Grazing	0.0540	0.9990			1	No	31	
Wet Meadow-Montane	3-Late:Open	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5	
Wet Meadow-Montane	3-Late:Open	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0472	0.0001				Yes	31	
Wet Meadow-Montane	3-Late:Open	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0472	0.0001				Yes	31	
Wet Meadow-Montane	3-Late:Open	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0540	0.0001				Yes	31	
Wet Meadow-Montane	3-Late:Open	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0540	0.0001				Yes	31	
Wet Meadow-Montane	3-Late:Open	U:Hummocked	Wild-Horse-Grazing	0.0540	0.0005				Yes	31	
Wet Meadow-Montane	3-Late:Open	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0472	0.0009				No	31	
Wet Meadow-Montane	3-Late:Open	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0472	0.0009				No	31	
Wet Meadow-Montane	3-Late:Open	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0540	0.0005				No	31	
Wet Meadow-Montane	3-Late:Open	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0540	0.0005				No	31	
Wet Meadow-Montane	3-Late:Open	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0540	0.0005				No	31	
Wet Meadow-Montane	3-Late:Open	Wallow:Bare Ground	NativeGrazing	0.0200	0.0500				Yes		
Wet Meadow-Montane	U:Annual Spp	1-Early:Open	Alternate-Succession	1.0000					Yes	5	7
Wet Meadow-Montane	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0472				1	No	31	
Wet Meadow-Montane	U:Annual Spp	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0472				1	No	31	
Wet Meadow-Montane	U:Annual Spp	U:Annual Spp	Inexpensive-Floodplain-Restoration	0.0100					Yes	31	
Wet Meadow-Montane	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0540				0	No	31	
Wet Meadow-Montane	U:Annual Spp	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0540				0	No	31	
Wet Meadow-Montane	U:Annual Spp	U:Annual Spp	LivestockGrazingControl	0.0100					No	30	
Wet Meadow-Montane	U:Annual Spp	U:Annual Spp	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wet Meadow-Montane	U:Annual Spp	U:Annual Spp	Wild-Horse-Grazing	0.0540				1	No	31	
Wet Meadow-Montane	U:Annual Spp	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Wet Meadow-Montane	U:Annual Spp	U:Annual Spp	ReplacementFire	0.1000					Yes		
Wet Meadow-Montane	U:Desertified	1-Early:Open	Alternate-Succession	1.0000					Yes	5	7
Wet Meadow-Montane	U:Desertified	U:Desertified	Inexpensive-Floodplain-Restoration	0.0100					Yes	31	
Wet Meadow-Montane	U:Desertified	U:Desertified	LivestockGrazingControl	0.0100					No	30	
Wet Meadow-Montane	U:Desertified	U:Desertified	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wet Meadow-Montane	U:Desertified	U:Desertified	Wild-Horse-Grazing	0.0540	0.9990			1	No	31	
Wet Meadow-Montane	U:Desertified	U:Early Shrub	Severe-Drought	0.0070	0.0010	3			No		
Wet Meadow-Montane	U:Desertified	U:Early Shrub	Wild-Horse-Grazing	0.0540	0.0010				Yes	31	
Wet Meadow-Montane	U:Desertified	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Wet Meadow-Montane	U:Desertified	U:Annual Spp	AS-Invasion	0.0050			74		No		
Wet Meadow-Montane	U:Desertified	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0472	0.9990	3		1	No	31	
Wet Meadow-Montane	U:Desertified	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0472	0.9990	3		1	No	31	

Wet Meadow-Montane	U:Desertified	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0540	0.9995	3		0	No	31	
Wet Meadow-Montane	U:Desertified	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0540	0.9995	3		0	No	31	
Wet Meadow-Montane	U:Desertified	U:Desertified	ReplacementFire	0.0250					Yes		
Wet Meadow-Montane	U:Desertified	U:Desertified	Severe-Drought	0.0070	0.9000			75	Yes		
Wet Meadow-Montane	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_0dd-Yr	0.0472	0.0010	3			No	31	
Wet Meadow-Montane	U:Desertified	U:Early Shrub	Early-Cattle-Grazing_Even-Yr	0.0472	0.0010	3			No	31	
Wet Meadow-Montane	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_0dd-Yr	0.0540	0.0005	3			No	31	
Wet Meadow-Montane	U:Desertified	U:Early Shrub	Late-Cattle-Grazing_Even-Yr	0.0540	0.0005	3			No	31	
Wet Meadow-Montane	U:Desertified	U:SAP	AS-Invasion	0.0050		74			No		
Wet Meadow-Montane	U:Early Shrub	1-Early:Open	Alternate-Succession	1.0000					Yes	5	7
Wet Meadow-Montane	U:Early Shrub	U:Early Shrub	Inexpensive-Floodplain-Restoration	0.0100					Yes	31	
Wet Meadow-Montane	U:Early Shrub	U:Early Shrub	LivestockGrazingControl	0.0100					No	30	
Wet Meadow-Montane	U:Early Shrub	U:Early Shrub	ReplacementFire	0.0250					Yes		
Wet Meadow-Montane	U:Early Shrub	U:Early Shrub	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wet Meadow-Montane	U:Early Shrub	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Wet Meadow-Montane	U:Exotic Forbs	1-Early:Open	Exotic-Control	0.0100	0.6000		2		Yes		20
Wet Meadow-Montane	U:Exotic Forbs	2-Mid:Closed	Exotic-Control	0.0100	0.6000	3	74		Yes		20
Wet Meadow-Montane	U:Exotic Forbs	3-Late:Open	Exotic-Control	0.0100	0.6000	75			Yes		20
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	LivestockGrazingControl	0.0100					No	30	
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Severe-Drought	0.0070			2		Yes		
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Severe-Drought	0.0070		3		2	No		
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Wet-Year	0.0670	0.1000				No		
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Wild-Horse-Grazing	0.0540					Yes	31	
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_0dd-Yr	0.0472		3		1	No	31	
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Early-Cattle-Grazing_Even-Yr	0.0472		3		1	No	31	
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Exotic-Control	0.0100	0.4000				Yes		20
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_0dd-Yr	0.0540		3		0	No	31	
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Late-Cattle-Grazing_Even-Yr	0.0540		3		0	No	31	
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	ReplacementFire	0.0250					Yes	5	
Wet Meadow-Montane	U:Exotic Forbs	U:Exotic Forbs	Wet-Year	0.0670	0.9000				Yes		
Wet Meadow-Montane	U:Hummocked	1-Early:Open	Natural-Recovery	1.0000					Yes	5	
Wet Meadow-Montane	U:Hummocked	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0472	0.0010				No	31	
Wet Meadow-Montane	U:Hummocked	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0472	0.0010				No	31	
Wet Meadow-Montane	U:Hummocked	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0540	0.0005				No	31	
Wet Meadow-Montane	U:Hummocked	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0540	0.0005				No	31	
Wet Meadow-Montane	U:Hummocked	U:Desertified	Wild-Horse-Grazing	0.0540	0.0010				Yes	31	
Wet Meadow-Montane	U:Hummocked	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5	
Wet Meadow-Montane	U:Hummocked	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0472	0.9990				Yes	31	
Wet Meadow-Montane	U:Hummocked	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0472	0.9990				Yes	31	
Wet Meadow-Montane	U:Hummocked	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0540	0.9995				Yes	31	
Wet Meadow-Montane	U:Hummocked	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0540	0.9995				Yes	31	
Wet Meadow-Montane	U:Hummocked	U:Hummocked	LivestockGrazingControl	0.0100					No	30	
Wet Meadow-Montane	U:Hummocked	U:Hummocked	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wet Meadow-Montane	U:Hummocked	U:Hummocked	Wet-Year	0.0670				3	Yes		
Wet Meadow-Montane	U:Hummocked	U:Hummocked	Wild-Horse-Grazing	0.0540	0.9990				Yes	31	
Wet Meadow-Montane	U:Incised-EFT	U:Desertified	Exotic-Control	0.0100	0.6000				Yes		20
Wet Meadow-Montane	U:Incised-EFT	U:Exotic Forbs	Alternate-Succession	1.0000					No	5	7
Wet Meadow-Montane	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_0dd-Yr	0.0472		3		1	No	31	
Wet Meadow-Montane	U:Incised-EFT	U:Incised-EFT	Early-Cattle-Grazing_Even-Yr	0.0472		3		1	No	31	

Appendix 4. Probabilistic Transitions for Ecological Systems. Output Obtained from ST-Sim 2.4.8 Database.

Wet Meadow-Montane	U:Incised-EFT	U:Incised-EFT	Exotic-Control	0.0100	0.4000				Yes		20
Wet Meadow-Montane	U:Incised-EFT	U:Incised-EFT	Inexpensive-Floodplain-Restoration	0.0100					Yes	31	
Wet Meadow-Montane	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_0dd-Yr	0.0540		3		0	No	31	
Wet Meadow-Montane	U:Incised-EFT	U:Incised-EFT	Late-Cattle-Grazing_Even-Yr	0.0540		3		0	No	31	
Wet Meadow-Montane	U:Incised-EFT	U:Incised-EFT	LivestockGrazingControl	0.0100					No	30	
Wet Meadow-Montane	U:Incised-EFT	U:Incised-EFT	ReplacementFire	0.0100					Yes		
Wet Meadow-Montane	U:Incised-EFT	U:Incised-EFT	Wild-Horse-Grazing	0.0540				1	No	31	
Wet Meadow-Montane	U:SAP	1-Early:Open	Alternate-Succession	1.0000					Yes	5	7
Wet Meadow-Montane	U:SAP	U:Annual Spp	Wild-Horse-Grazing	0.0540	0.0010				Yes	31	
Wet Meadow-Montane	U:SAP	U:Incised-EFT	Exotic-Invasion	0.0010					No	5	
Wet Meadow-Montane	U:SAP	U:SAP	Inexpensive-Floodplain-Restoration	0.0100					Yes	31	
Wet Meadow-Montane	U:SAP	U:SAP	LivestockGrazingControl	0.0100					No	30	
Wet Meadow-Montane	U:SAP	U:SAP	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wet Meadow-Montane	U:SAP	U:SAP	Wild-Horse-Grazing	0.0540	0.9990			1	No	31	
Wet Meadow-Montane	U:SAP	U:Annual Spp	Early-Cattle-Grazing_0dd-Yr	0.0472	0.0010				Yes	31	
Wet Meadow-Montane	U:SAP	U:Annual Spp	Early-Cattle-Grazing_Even-Yr	0.0472	0.0010				Yes	31	
Wet Meadow-Montane	U:SAP	U:Annual Spp	Late-Cattle-Grazing_0dd-Yr	0.0540	0.0005				Yes	31	
Wet Meadow-Montane	U:SAP	U:Annual Spp	Late-Cattle-Grazing_Even-Yr	0.0540	0.0005				Yes	31	
Wet Meadow-Montane	U:SAP	U:Annual Spp	ReplacementFire	0.0250					Yes		
Wet Meadow-Montane	U:SAP	U:Annual Spp	Severe-Drought	0.0070	0.1000				Yes		
Wet Meadow-Montane	U:SAP	U:SAP	Early-Cattle-Grazing_0dd-Yr	0.0472	0.9990			1	No	31	
Wet Meadow-Montane	U:SAP	U:SAP	Early-Cattle-Grazing_Even-Yr	0.0472	0.9990			1	No	31	
Wet Meadow-Montane	U:SAP	U:SAP	Late-Cattle-Grazing_0dd-Yr	0.0540	0.9995			0	No	31	
Wet Meadow-Montane	U:SAP	U:SAP	Late-Cattle-Grazing_Even-Yr	0.0540	0.9995			0	No	31	
Wet Meadow-Montane	U:SAP	U:SAP	Severe-Drought	0.0070	0.9000				Yes		
Wet Meadow-Montane	U:Shrb-Frb Encr	1-Early:Open	Herbicide-Shrubs	0.0100	0.8000				Yes		
Wet Meadow-Montane	U:Shrb-Frb Encr	1-Early:Open	Natural-Recovery	1.0000			2		Yes	10	
Wet Meadow-Montane	U:Shrb-Frb Encr	3-Late:Open	Herbicide-Shrubs	0.0100	0.1000				Yes		
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_0dd-Yr	0.0472	0.0010				Yes	31	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Desertified	Early-Cattle-Grazing_Even-Yr	0.0472	0.0010				Yes	31	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_0dd-Yr	0.0540	0.0005				Yes	31	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Desertified	Late-Cattle-Grazing_Even-Yr	0.0540	0.0005				Yes	31	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Desertified	Wild-Horse-Grazing	0.0540	0.0010				Yes	31	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Exotic Forbs	Exotic-Invasion	0.0010					No	5	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_0dd-Yr	0.0472	0.9990			1	Yes	31	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Early-Cattle-Grazing_Even-Yr	0.0472	0.9990			1	Yes	31	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Herbicide-Shrubs	0.0100	0.1000				Yes		
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_0dd-Yr	0.0540	0.9995			0	Yes	31	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Late-Cattle-Grazing_Even-Yr	0.0540	0.9995			0	Yes	31	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	LivestockGrazingControl	0.0100					No	30	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	ReplacementFire	0.0250					Yes		
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Wet-Year	0.0670					Yes		
Wet Meadow-Montane	U:Shrb-Frb Encr	U:Shrb-Frb Encr	Wild-Horse-Grazing	0.0540	0.9990			1	No	31	
Wet Meadow-Montane	Wallow:Bare Ground	1-Early:Open	Natural-Recovery	1.0000					Yes	5	
Wet Meadow-Montane	Wallow:Bare Ground	U:Exotic Forbs	Exotic-Invasion	0.0010					Yes	5	
Wet Meadow-Montane	Wallow:Bare Ground	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0472	0.0010				Yes	31	

Wet Meadow-Montane	Wallow:Bare Ground	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0472	0.0010		Yes	31
Wet Meadow-Montane	Wallow:Bare Ground	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0540	0.0010		Yes	31
Wet Meadow-Montane	Wallow:Bare Ground	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0540	0.0010		Yes	31
Wet Meadow-Montane	Wallow:Bare Ground	U:Hummocked	Wild-Horse-Grazing	0.0540	0.0010		Yes	31
Wet Meadow-Montane	Wallow:Bare Ground	Wallow:Bare Ground	Early-Cattle-Grazing_0dd-Yr	0.0472	0.9990		Yes	31
Wet Meadow-Montane	Wallow:Bare Ground	Wallow:Bare Ground	Early-Cattle-Grazing_Even-Yr	0.0472	0.9990		Yes	31
Wet Meadow-Montane	Wallow:Bare Ground	Wallow:Bare Ground	Late-Cattle-Grazing_0dd-Yr	0.0540	0.9990		Yes	31
Wet Meadow-Montane	Wallow:Bare Ground	Wallow:Bare Ground	Late-Cattle-Grazing_Even-Yr	0.0540	0.9990		Yes	31
Wet Meadow-Montane	Wallow:Bare Ground	Wallow:Bare Ground	LivestockGrazingControl	0.0100			No	30
Wet Meadow-Montane	Wallow:Bare Ground	Wallow:Bare Ground	NativeGrazing	0.0200			Yes	
Wet Meadow-Montane	Wallow:Bare Ground	Wallow:Bare Ground	Weed-Inventory+Spot-Treat	0.0100			No	3
Wet Meadow-Montane	Wallow:Bare Ground	Wallow:Bare Ground	Wet-Year	0.0670		3	Yes	
Wet Meadow-Montane	Wallow:Bare Ground	Wallow:Bare Ground	Wild-Horse-Grazing	0.0540	0.9990		Yes	31
Wetland	1-Early:All	1-Early:All	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990	1	No	
Wetland	1-Early:All	1-Early:All	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990	1	No	
Wetland	1-Early:All	1-Early:All	Flooding-20yr	0.0500		5	No	
Wetland	1-Early:All	1-Early:All	Late-Cattle-Grazing_0dd-Yr	0.0675	0.9995	0	No	
Wetland	1-Early:All	1-Early:All	Late-Cattle-Grazing_Even-Yr	0.0675	0.9995	0	No	
Wetland	1-Early:All	1-Early:All	Weed-Inventory+Spot-Treat	0.0100			No	3
Wetland	1-Early:All	1-Early:All	Wild-Horse-Grazing	0.0675	0.9990	1	No	
Wetland	1-Early:All	U:Exotic Forb&Tree	Exotic-Invasion	0.0010			No	5
Wetland	1-Early:All	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010		Yes	
Wetland	1-Early:All	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010		Yes	
Wetland	1-Early:All	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0675	0.0005		Yes	
Wetland	1-Early:All	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0675	0.0005		Yes	
Wetland	1-Early:All	U:Hummocked	Wild-Horse-Grazing	0.0675	0.0010		Yes	
Wetland	3-Late:All	3-Late:All	Early-Cattle-Grazing_0dd-Yr	0.0590	0.9990	1	No	
Wetland	3-Late:All	3-Late:All	Early-Cattle-Grazing_Even-Yr	0.0590	0.9990	1	No	
Wetland	3-Late:All	3-Late:All	Flooding-20yr	0.0500		5	No	
Wetland	3-Late:All	3-Late:All	Late-Cattle-Grazing_0dd-Yr	0.0675	0.9995	0	No	
Wetland	3-Late:All	3-Late:All	Late-Cattle-Grazing_Even-Yr	0.0675	0.9995	0	No	
Wetland	3-Late:All	3-Late:All	Weed-Inventory+Spot-Treat	0.0100			No	3
Wetland	3-Late:All	3-Late:All	Wild-Horse-Grazing	0.0675	0.9990	1	No	
Wetland	3-Late:All	U:Exotic Forb&Tree	Exotic-Invasion	0.0010			No	5
Wetland	3-Late:All	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0590	0.0010		Yes	
Wetland	3-Late:All	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0590	0.0010		Yes	
Wetland	3-Late:All	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0675	0.0005		Yes	

Wetland	3-Late:All	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0675	0.0005				Yes		
Wetland	3-Late:All	U:Hummocked	Wild-Horse-Grazing	0.0675	0.0010				Yes		
Wetland	U:Exotic Forb&Tree	1-Early:All	Exotic-Control	0.0100	0.6000	10	74		Yes		20
Wetland	U:Exotic Forb&Tree	3-Late:All	Exotic-Control	0.0100	0.6000	75			Yes		20
Wetland	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_0dd-Yr	0.0590				1	No		
Wetland	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Early-Cattle-Grazing_Even-Yr	0.0590				1	No		
Wetland	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Exotic-Control	0.0100	0.4000				Yes		20
Wetland	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Flooding-20yr	0.0500				5	No		20
Wetland	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_0dd-Yr	0.0675				0	No		
Wetland	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Late-Cattle-Grazing_Even-Yr	0.0675				0	No		
Wetland	U:Exotic Forb&Tree	U:Exotic Forb&Tree	Wild-Horse-Grazing	0.0675	0.0010			1	No		
Wetland	U:Exotic Forb&Tree	WATER:Water	Exotic-Control	0.0100	0.6000		9		Yes		20
Wetland	U:Hummocked	U:Exotic Forb&Tree	Exotic-Invasion	0.0010					Yes	5	
Wetland	U:Hummocked	U:Hummocked	Early-Cattle-Grazing_0dd-Yr	0.0590					Yes		
Wetland	U:Hummocked	U:Hummocked	Early-Cattle-Grazing_Even-Yr	0.0590					Yes		
Wetland	U:Hummocked	U:Hummocked	Flooding-20yr	0.0500				5	No		
Wetland	U:Hummocked	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0675					Yes		
Wetland	U:Hummocked	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0675					Yes		
Wetland	U:Hummocked	U:Hummocked	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wetland	U:Hummocked	U:Hummocked	Wild-Horse-Grazing	0.0675					Yes		
Wetland	WATER:Water	U:Exotic Forb&Tree	Exotic-Invasion	0.0010					No	5	
Wetland	WATER:Water	U:Hummocked	Late-Cattle-Grazing_0dd-Yr	0.0675	0.0005				Yes		
Wetland	WATER:Water	U:Hummocked	Late-Cattle-Grazing_Even-Yr	0.0675	0.0005				Yes		
Wetland	WATER:Water	U:Hummocked	Wild-Horse-Grazing	0.0675	0.0010				Yes		
Wetland	WATER:Water	WATER:Water	Flooding-20yr	0.0500				5	No		
Wetland	WATER:Water	WATER:Water	Late-Cattle-Grazing_0dd-Yr	0.0675	0.9995			0	No		
Wetland	WATER:Water	WATER:Water	Late-Cattle-Grazing_Even-Yr	0.0675	0.9995			0	No		
Wetland	WATER:Water	WATER:Water	Weed-Inventory+Spot-Treat	0.0100					No	3	
Wetland	WATER:Water	WATER:Water	Wild-Horse-Grazing	0.0675	0.9990			1	No		

Appendix 5
Temporal Multipliers

Fire Activity Variability

Federal data were available for fire activity from 1984 to 2012 for the IL Ranch and from 1980 to 2012 for the TS-Horseshoe Ranch. Data from the federal Monitoring Trends in Burn Severity (MTBS) were downloaded for the whole western U.S.A. and time series of fire size from 1980 to 2012 were extracted by “clipping” to each project areas (all ownerships) with ARC GIS 10 (Figure A5-1).

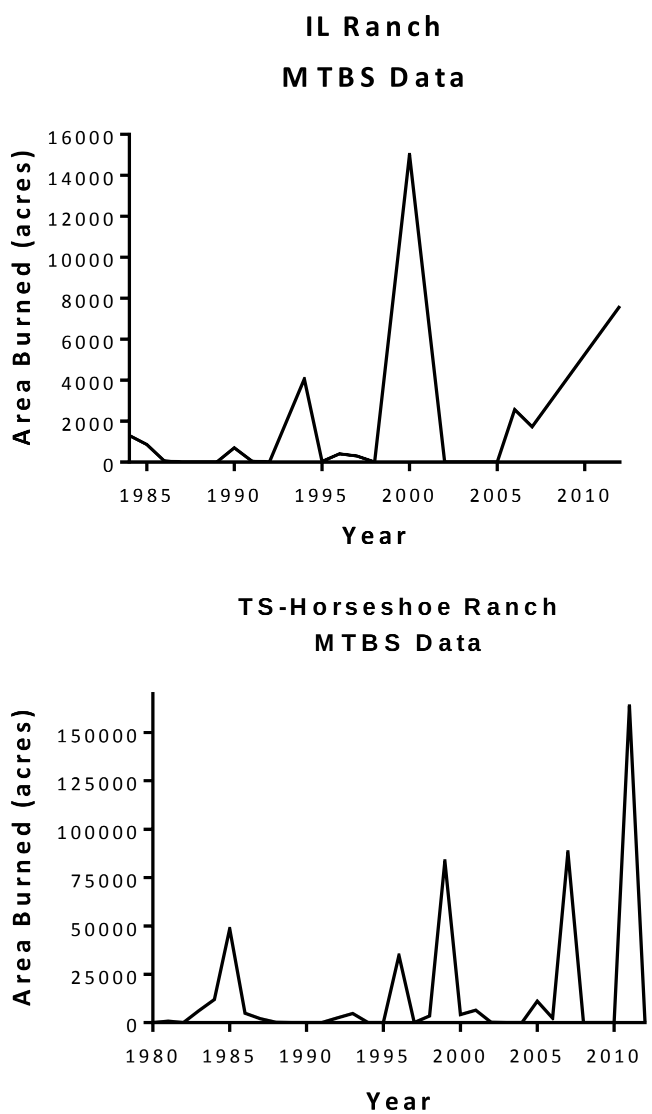


Figure A5-1. Area burned (acres) from 1984 to 2012 for the IL Ranch and from 1980 to 2012 for the TS-Horseshoe Ranch based on downloaded geodata from MTBS.

To introduce future fire variability into simulations, we used properties of previous fires and past precipitation time series to calculate time series of future burn area. Ten time series of fire activity were used as replicates for all scenarios. First, maximum fire size was obtained from past fire data in each project area. The maximum fire sizes were 15,000 acres for the IL Ranch and 110,827 acres for the TS-Horseshoe Ranch. Maximum fire size determined the upper limit of future fires because the rest of the calculation of area burned was a non-dimensional function of fire variability between zero and one based on current and past drought levels. To capture drought variability we used the Standard Precipitation Index (SPI), which was first published in 1993 as a drought index based only on precipitation (McKee, et al. 1993). SPI is based on the probability of precipitation for any time scale. Different time scales reflect the fact that some ecological and physical processes operate at different time scales.

Second, using monthly data records from 1895-2013, ten 30-year time series of SPI (1895-2013) were created using 10 randomly selected start years: 1935 for replicate #1, 1917 for replicate #2, 1919 for replicate #3, 1897 for replicate #4, 1952 for replicate #5, 1945 for replicate #6, 1956 for replicate #7, 1960 for replicate #8, 1922 for replicate #9, and 1954 for replicate #10. Note that these start dates were used for other temporal variables described later. Two SPI metrics were derived: cumulative 8-month (ending in August) and cumulative 24-month periods. The 8-month SPI measured fuels dryness/wetness during the current year, whereas the 24-month SPI measured the same characteristic cumulatively from the last two years. We assumed that fire activity in the current year was more likely if the 8-month SPI indicated a current dry year; however, if the 24-month SPI up to the previous year indicated wetter than average condition fine fuel was assumed to have built up in shrublands. Taylor and Beaty (2005) showed that drought is highly negatively correlated to fire frequency and total area burned for forest types during pre-settlement in the northern Sierra Nevada: more fire was observed during increasingly drier years. The same relationship holds for average temperature (Westerling et al. 2008). This, however, does not apply to shrublands that must first experience consecutive wetter than average years to accumulate fine fuels that will more likely burn in a dry year immediately following the wet year sequence (Westerling and Bryant 2008; Westerling 2009). We used two versatile Gompertz equations to represent this differential effect of years:

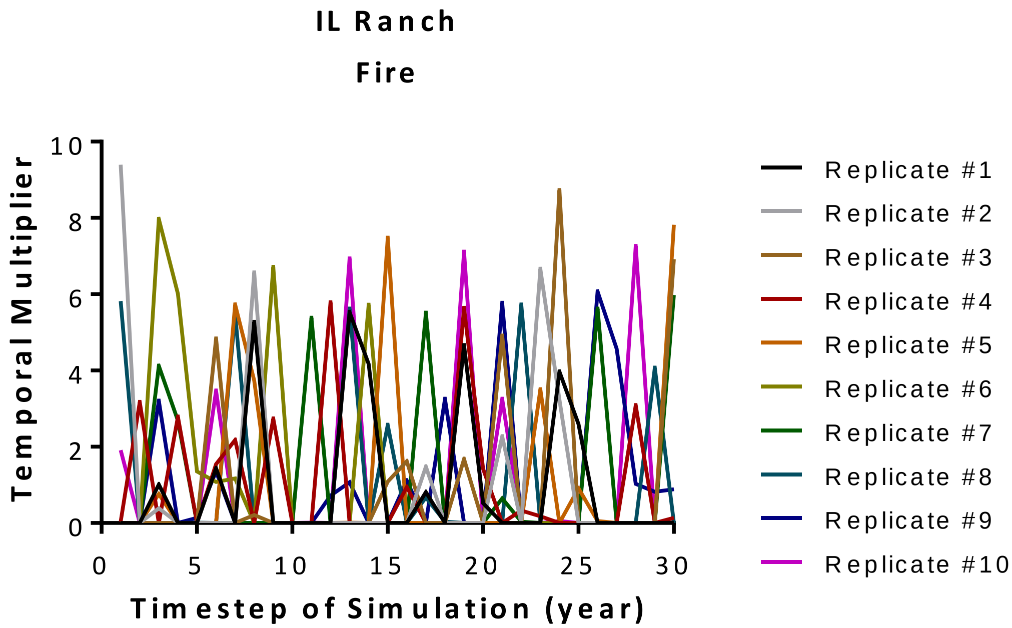
$$\text{Yearly shrubland-woodland area burned variability} = \text{MaxFire} \times e^{-1.1 \times \exp[-2 \times 0.01 \times \text{SPI}\{\mathit{24\text{-}mo,\ t\text{-}1}\}]} \times \left(1 - e^{-2.5 \times \exp[-50 \times 0.01 \times \text{SPI}\{\mathit{8\text{-}mo,t}\}]}\right)$$

(Eq. A5-1)

where MaxFire = maximum fire area. Equation A5-1 combines two Gompertz functions to accommodate negative and positive values of SPI (tables of SPI are always multiplied by 100 that we converted back to a probability by multiplying by 0.01). The first part of equation A5-1 after MaxFire, representing fine fuels production over two year ending in the previous year *t-1*, is a classic Gompertz function. Wetter years (SPI > 0) increase the value of this function (fine fuels accumulation) to a maximum of one. The first part of the equation is multiplied by the second function representing the current year, which is one minus another Gompertz function bound between zero and one. Increasingly drier soil moisture (SPI < 0) causes the second part of equation A5-1 to increase to a maximum of one (maximum ignition probability). Two “cleaning up” processes were used after the time series was created to compensate for the fact that equation A5-1 is a continuous function creating even tiny improbable fires evey year. First, we wanted to preserve on average the number of fire years seen in the historic record by using a random number generator to retain about 22 fire years out of the 1984 to 2012 sequence; therefore, years not retained had zero fire. Second, the time series was “cleaned up” by removing all fire ocurrences <1 acre.

Newmont workshop participants were concerned that the variability expressed by equation A5-1 would not capture the important future threat of rare, but very large fires (it did not based on the historic records). To incorporation this concern, we randomly determined if any one fire year could become a very high fire year if a random number had a frequency less than 0.1 (3 out of 30 years) and multiplied the expected fire size by five. Fire size derived from equation A5-1 and modifications is not the final temporal multiplier, however, because it is not divided by its average area burned over 30 years. Yearly values of Eq. A5-1 where divided by their temporal average over 30 years (Figure A5-2).

Although Eq. A5-1 attempted to capture fire variability, the amount of fire depends on fire management actions, which consists of fire suppression. However, reference classes in the models are assigned reference fire return intervals, which do not reflect the current era of fire exclusion. It was assumed that the uncharacteristic classes’ fire return intervals do reflect the current period, by definition. Therefore, the effect of fire suppression was obtained by multiplying each yearly value of reference classes only by 0.1 to represent 90% fire suppression. We determined that fire suppression was about 90% successful because that is about the ratio of MTBS area burn or number of fires, respectively, and the predicted area burned or number of fires under reference conditions as simulated with the models. The 10 time-series (i.e., 10 replicates) were uploaded into ST-Sim such that each yearly value in a replicate temporal multiplier multiplied the average wildfire rate in the models for a specific time step.



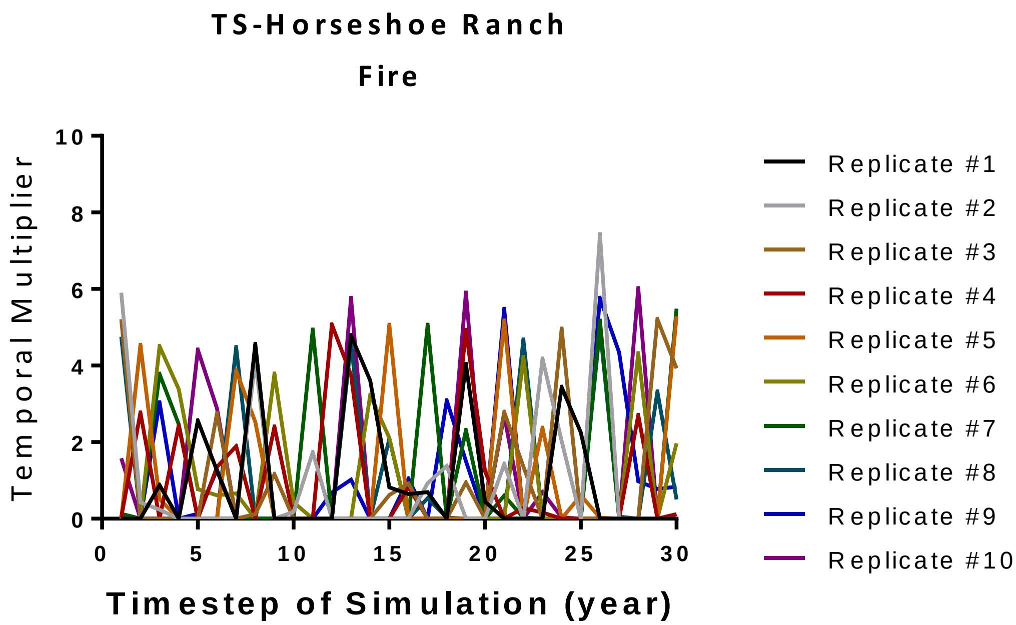


Figure A5-2. Ten replicates of temporal multipliers for fire variability on the IL Ranch and TS-Horseshoe Ranch. Each replicate is color-coded and represented by a 30-year period. A temporal multiplier of "1" means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance's modeled rate.

Upland Variability

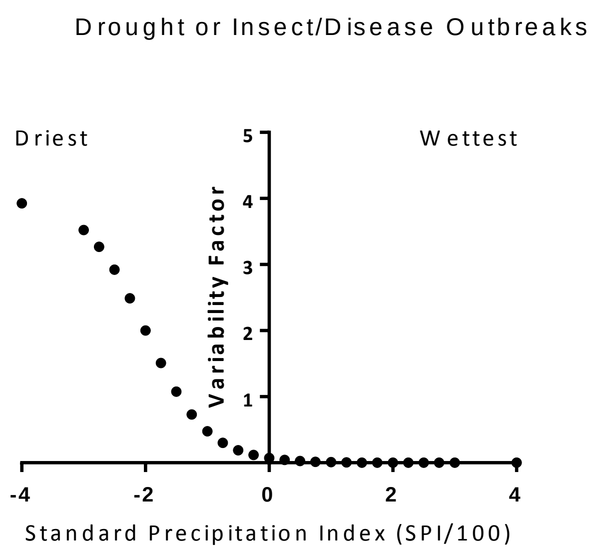
Remaining upland temporal multipliers were climate related: annual grass invasion rate, Aroga moth outbreak, drought-induced mortality, insect and disease mortality, tree invasion rate, tree encroachment, very-wet-year mortality, wet year, snow deposition, and avalanches. The SPI was used for many temporal multipliers, except wet year, snow deposition, and avalanches.

We assumed that more severe droughts cause increased plant mortality, whereas wetter conditions suppress mortality. We also assumed that insect/disease mortality variability and tree encroachment were also caused by severe drought. Tree encroachment is the process by which mature juniper, pinyon, or white fir trees suppress and ultimately eliminate through soil moisture competition the shrub and herbaceous understory in shrublands invaded by trees for decades. On Newmont ranches, this disturbance is a minor contributor to vegetation dynamics.

We used the 12 month SPI of the current year to evaluate if the project area had experience a drought. Because SPI can be negative, therefore incompatible with ST-Sim as a temporal multiplier, we chose a sigmoid function (SPI = -200 is the inflection point) with negative exponentials to create positive values that increased exponentially with smaller (more negative) SPI values:

$$\text{Drought, insect-disease mortality, or tree encroachment} = 4 \times e^{2 \times (0.01 \times SPI - 2)} / (1 + e^{2 \times (0.01 \times SPI - 2)})$$

(Eq. A5-2)



Function parameters were chosen such that the time series were close to zero for SPI ≥ 0 (i.e., wet), between zero and one for values of the time series ≥ -150 (i.e., a weak to moderate drought), and an enhanced drought (function >1) for SPI values < -150 (moderate to severe drought). The parameter “4” allowed the function to reach a maximum value of four. The wettest observed SPI was 308 and the driest one was -197. To obtain the temporal multiplier time series, each value of equation A5-2 was divided by the time series' average over 30 years. Figure A5-3 shows the temporal multipliers.

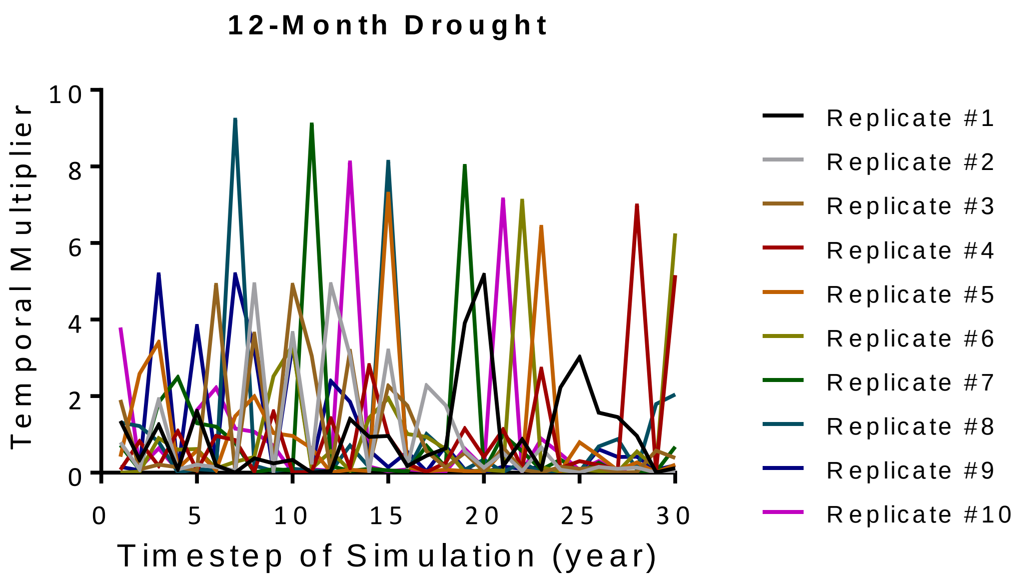
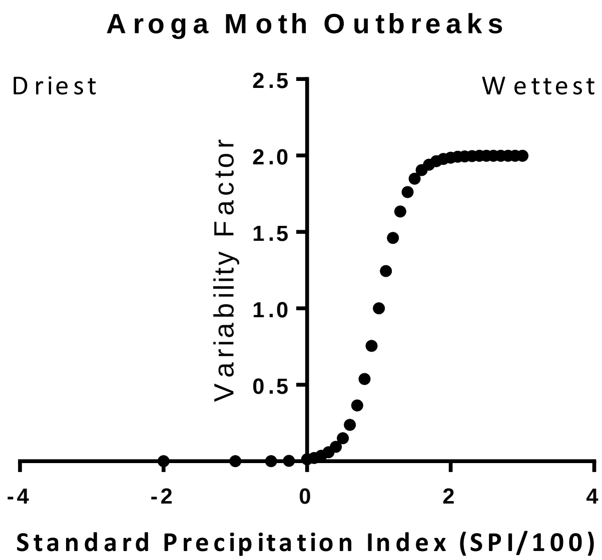


Figure A5-3. Ten replicates of temporal probability multipliers for drought variability. Each replicate is color-coded and represented by a 30-year period. A temporal multiplier of "1" means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance's modeled rate.

The variability of Aroga moth outbreaks was determined by above average precipitation in May and June causing a higher likelihood of outbreaks; therefore, we used the June SPI lagged for the two prior months. We again used a sigmoid function with an inflection point of 1 where the variability factor was greater,

$$\text{Aroga moth outbreak variability factor} = 2 \times e^{5 \times (0.01 \times \text{SPI} - 1)} / (1 + e^{5 \times (0.01 \times \text{SPI} - 1)})$$

(Eq. A5-3)



Function parameters were chosen such that the time series were close to zero for SPI ≤ 0 (i.e., dry), between zero and one for values of the time series ≥ 100 (i.e., a weak to moderate wet period), and an enhanced outbreak (function >1) for SPI values >100 (moderate to strong wet period). The parameter "2" allowed the function to reach a maximum value of two. To obtain the temporal multiplier time series, each value of equation A5-3 was divided by the time series' average over 30 years. Figure A5-4 shows the temporal multipliers.

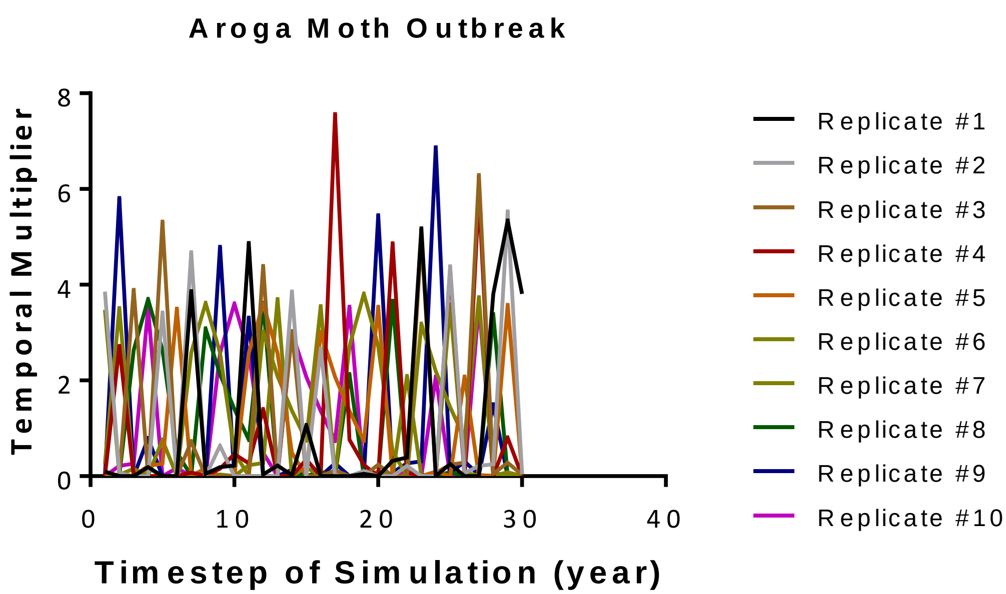
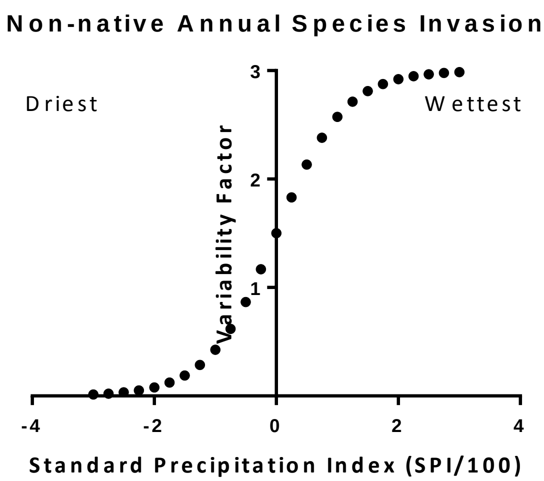


Figure A5-4. Ten replicates of temporal probability multipliers for Aroga moth outbreak variability. Each replicate is color-coded and represented by a 30-year period. A temporal multiplier of "1"

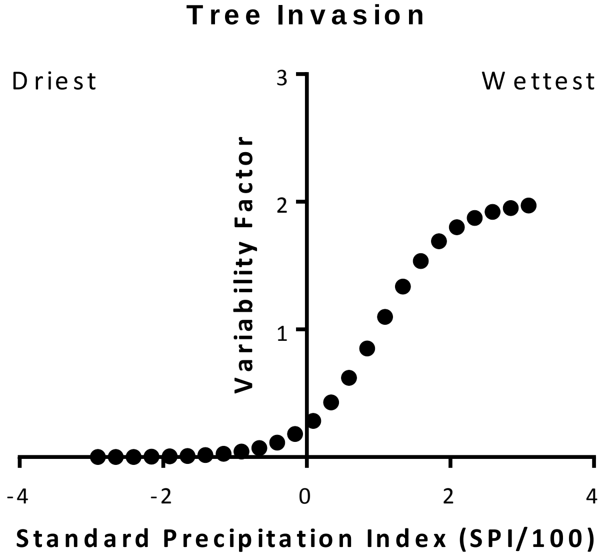
means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance's modeled rate.

Temporal variability for non-native annual grass and forb invasion and tree (mostly pinyon and juniper) invasion rates were dependent on drought levels: greater drought severity, therefore lower soil moisture, was detrimental to recruitment and growth and, conversely, greater soil moisture favored the spread of annual grasses and trees (Bradley 2009; Brown et al. 2004; Smith et al. 2000). We assumed that tree invasion was a much slower process than annual grass invasion. SPI values from the 4-month period finishing in June (end of annual grass germination) were chosen for annual grass invasion, whereas SPI time series of 6-month period finishing in September (end of primary period of tree growth) were used for tree (white fir for higher elevations as pinyon and juniper are nearly absent from both landscapes) invasion. We used a sigmoid function with for each of annual grasses and tree invasion to represent the contribution of negative and positive SPI values expressed as positive values of invasion variability. We assumed that non-native annual species invasion can occur during droughts, but at a suppressed rate (variability factor < 1). Tree invasion variability mostly occurred during wet years. This implies that SPI was directly related to the variability of these invasion rates:

$$\text{Annual grass variability factor (below)} = 3 \times e^{1.8 \times \exp(0.01 \times \text{SPI})}/(1+e^{1.8 \times \exp(0.01 \times \text{SPI})}) \quad \textit{(Eq. A5-4)}$$



$$\text{Tree invasion variability factor (below)} = 2 \times e^{2 \times \exp(0.01 \times [\text{SPI} + 291] - 3.9)}/(1+e^{2 \times \exp(0.01 \times [\text{SPI} + 291] - 3.9)}) \quad \textit{(Eq. A5-5)}$$



Parameters values were chosen to reflect that both annual grass invasion and tree invasion happens even during moderately dry conditions and the rate is one (i.e., not different from neutral). The yearly invasion values calculated with these sigmoid functions were transformed into temporal multipliers by dividing each year's value by the temporal average of the time series (Figs. A5-4 and A5-5).

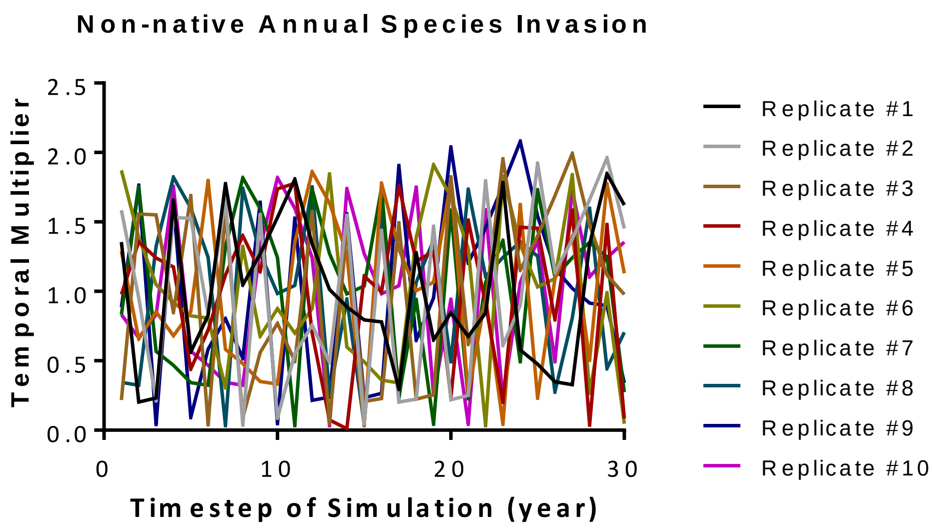


Figure A5-5. Ten replicates of temporal multipliers for non-native annual species invasion variability. Each replicate is color-coded and represented by a 30-year period. A temporal multiplier of "1" means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance's modeled rate.

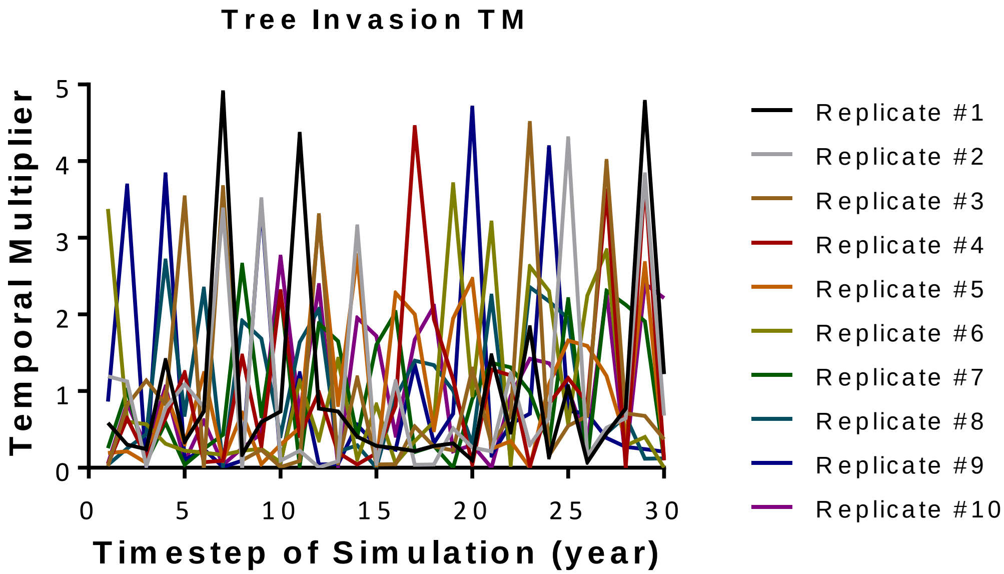
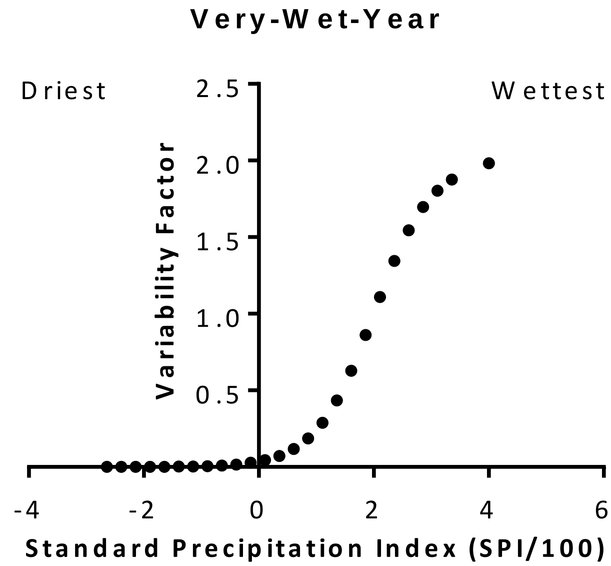


Figure A5-6. Ten replicates of temporal multipliers for tree invasion variability. Each replicate is color-coded and represented by a 30-year period. A temporal multiplier of "1" means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance's modeled rate.

The very-wet year temporal multiplier calculation used the same time series of SPI for 12-month ending in October (end of the hydrologic year), however the wet side of the SPI spectrum caused larger values. The very-wet year temporal multiplier introduced variability to mortality caused by shrub root rot or attack of roots by rootworms in salt desert communities. The calculation of these temporal multipliers was very similar to that of tree encroachment, except that the relation to SPI was flipped and that this factor was enhanced for SPI >200 (very wet):

$$\text{Very-wet year} = 2 \times e^{2 \times (0.01 \times [\text{SPI} + 264] - 4.64)} / (1 + e^{2 \times (0.01 \times [\text{SPI} - 264] - 4.64)})$$

(Eq. A5-6)



The temporal multipliers were obtained by dividing each yearly value by the temporal average over 30 years (Fig. A5-7).

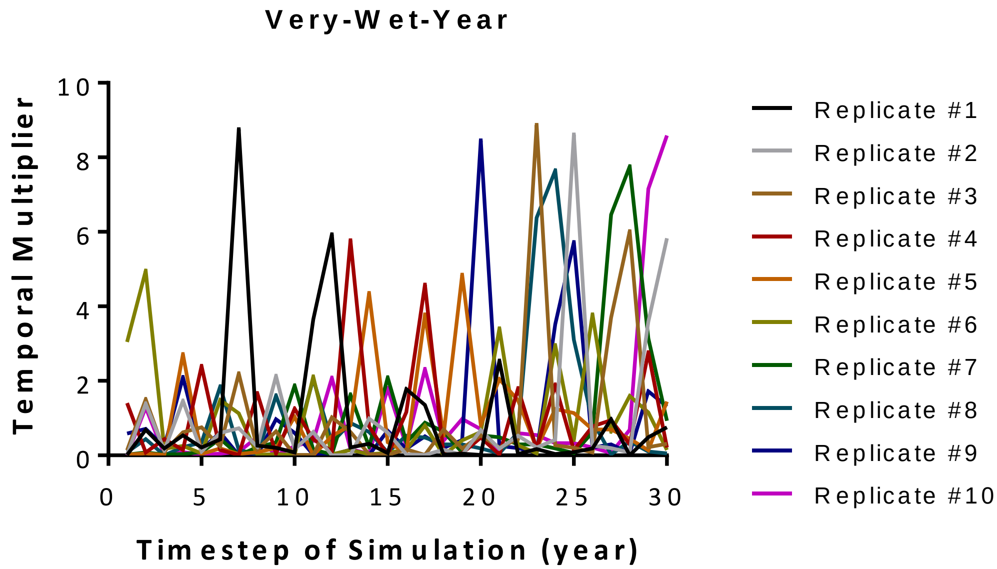


Figure A5-7. Ten temporal multipliers for very-wet years. Each replicate is color-coded and represented by a 30-year period. A temporal multiplier of "1" means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance's modeled rate.

Two snow related variability factors were used for snow deposition affecting shrub mortality in subalpine-montane grassland and for avalanches acting as a stand replacing disturbance in aspen-mixed conifer. Data came from the Upper Jack Creek Snowtel Station (IL Ranch area), which had a record from 1978 to 2012. Ten new random start dates were selected as the Snotel time series was of different length than that of SPI and USGS gage stations (in increasing order of replicate number): 1992, 1951, 1996, 2002, 1989, 2005, 2003, 1990, 1979, 2009. The variability in snow deposition was simply Snotel's maximum of precipitation accumulation (inches) divided by the 30-year temporal average (Figure A5-8):

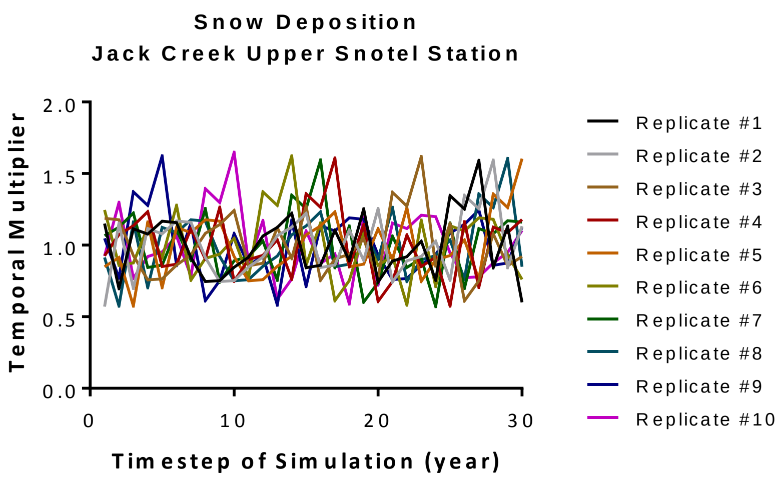


Figure A5-8. Temporal multipliers for snow deposition calculated from the Jack Creek Upper Snotel Station. The ten replicates are color-coded and shown each per 30-year period. A temporal multiplier of "1" means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance's modeled rate.

Avalanche variability was derived from an index developed by TNC staff as we couild not find an index in the literature. Avalanches are considered more likely with more snow falls in the shortest number of days possible. Therefore, Snotel's maximum of precipitation accumulation (inches) was divided by the number of snow days. The yearly variation was obtained by dividing the avalanche index by the 30-year temporal average of each replicate (Figure A5-9).

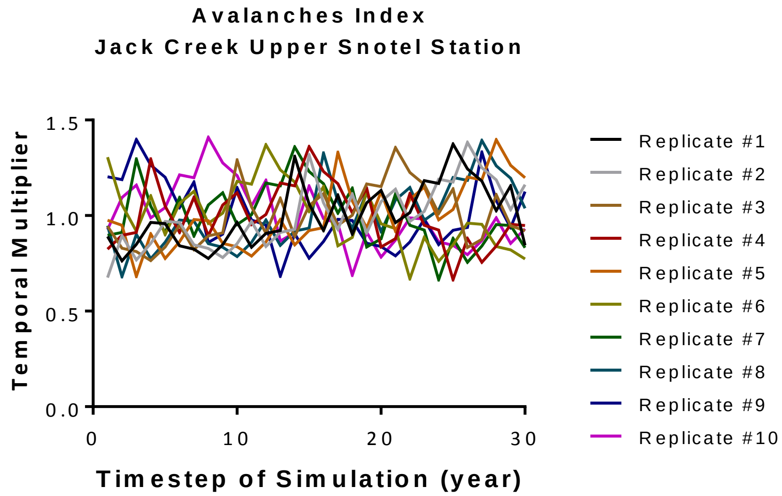


Figure A5-9. Temporal multipliers for avalanches calculated from the Jack Creek Upper Snotel Station. The ten replicates are color-coded and shown each per 30-year period. A temporal multiplier of "1" means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance's modeled rate.

Riparian Variability

Montane riparian and desert washes systems were strongly dependent on flood events and their discharge variation (Rood et al. 2003; McBride and Strahan 1984). We matched streams with the longest USGS guage time series closest to each Newmont ranch for the different riparian systems. We used flow data from Martin Creek in the Santa Rosa Range (1922 to 2013) for the IL Ranch and from Lamoille Canyon in the Ruby Mountains (1944 to 2012) for the TS-Horseshoe Ranch, and the Humboldt River at Palissade (1922 to 2012) for the Moist Floodplain system of the TS-Horseshoe Ranch and the Owyhee River Riprian system of the IL Ranch. We created ten replicates of 30 years each by resampling the original time series using random start years before 1988 (= 2013 – 30 years) to start the time series (1952, 1956, 1958, 1945, 1954, 1946, 1944, 1955, 1962, and 1951).

Peak yearly flow data were used to calculate temporal variability for the 7-year, 20-year, and 100-year flood events, whereas annual flow data were used to derived exotic species invasion rates. Seven-year, 20-year, and 100-year flood events were all based on filtering for increasingly higher values of annual peak flow**.** The three levels of flooding corresponded to 7-year events that killed or removed only herbaceous vegetation; 20-year events that killed or removed shrubs and young trees; and 100-year events that top-killed larger trees (i.e., these are three distinct disturbances in the riparian models). We used a crude recurrence analysis to obtain flow thresholds for 7-, 20-, and 100-year flood events (Fig. A5-10).

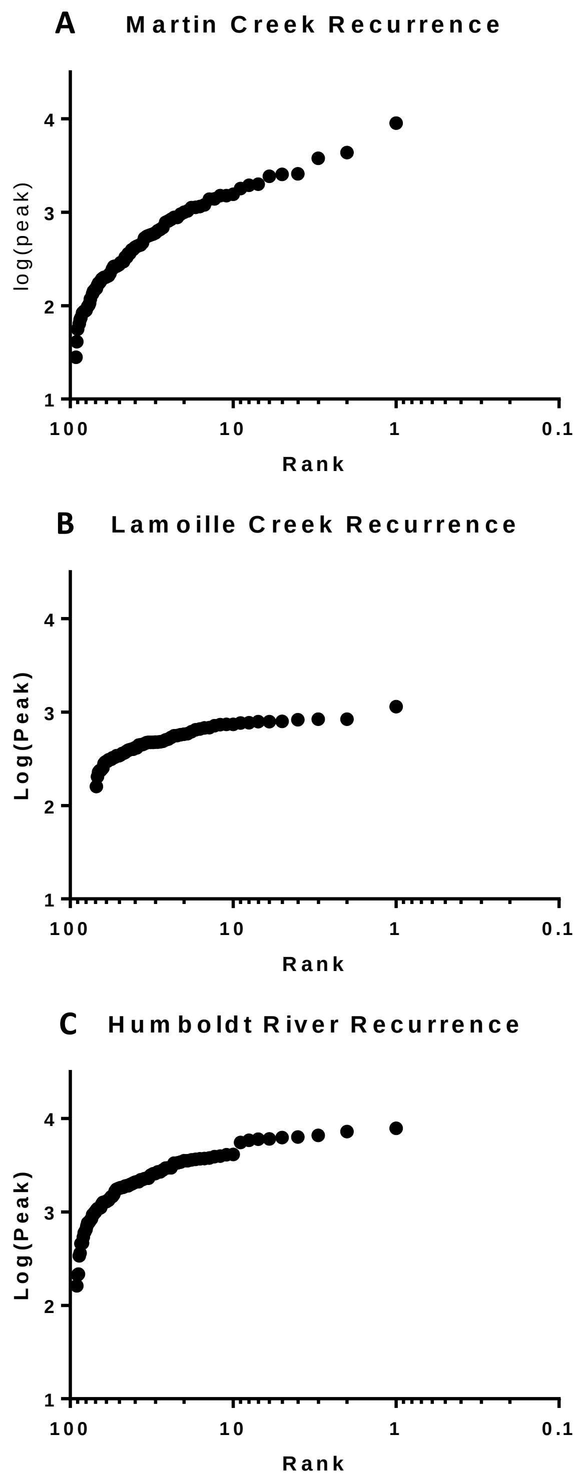
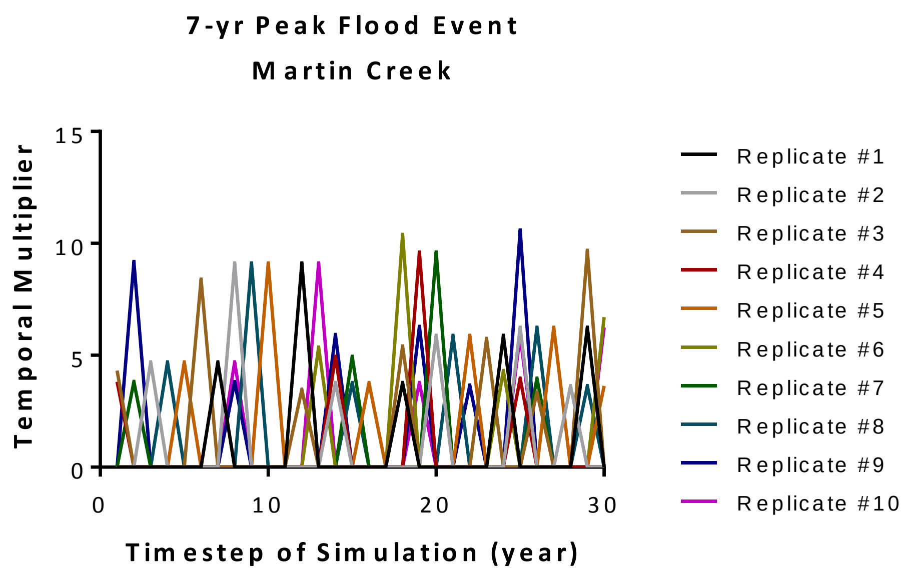


Figure A5-10. Recurrence analysis to obtain flow thresholds for 7-, 20-, and 100-year flood events for Martin Creek (A), Lamoille Creek (B), and (C) the Humboldt River. A temporal multiplier of "1" means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance's modeled rate.

The 7-, 20-, and 100-year flood time series, respectively, encompassed yearly flood events greater than 1,413, 2,511, and 9,000 cfs of peak flow for Martin Creek, 311, 831, and 1,140 cfs for Lamoille Creek, and 3,899, 6,309, and 7,840 for the Humboldt River in certain years; otherwise, flood events were zero. Each yearly value of each time series was divided by the temporal average to obtain the temporal multipliers (Figure A5-11 for Martin Creek, Figure A5-12 for Lamoille Creek, and Figure A5-13 for the Humboldt River).



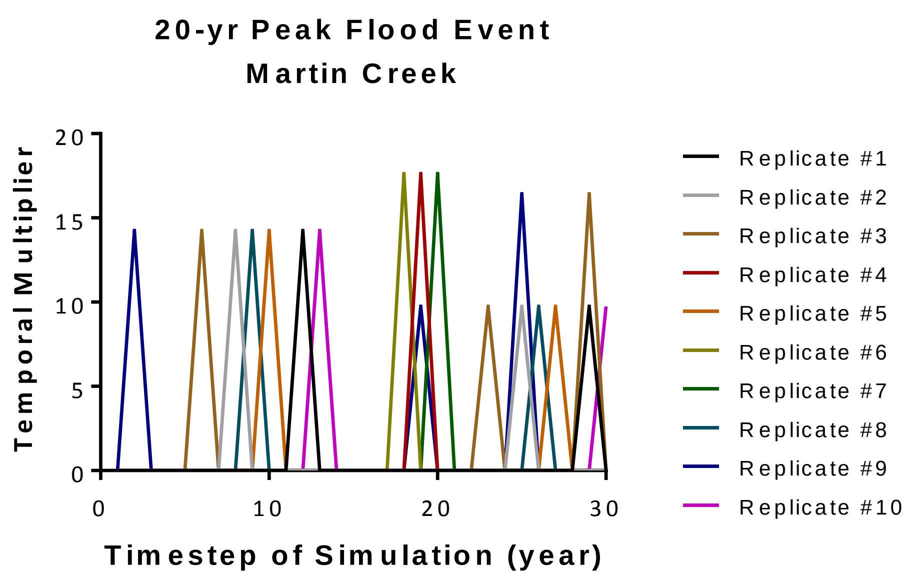
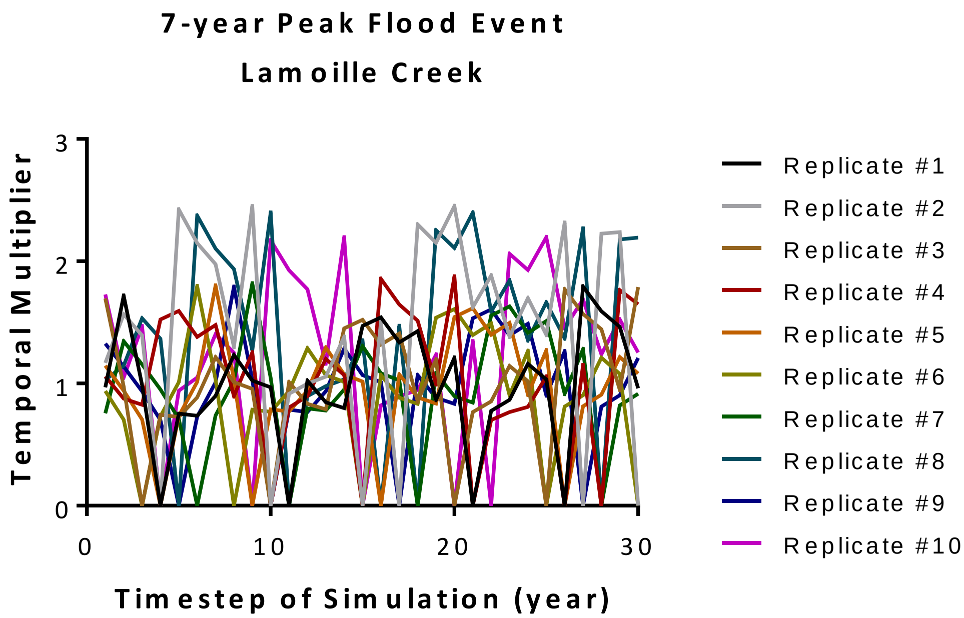


Figure A5-11. Temporal multipliers for 7- and 20-year flood events based on peak flows from the Martin Creek in Nevada's Santa Rose Range. The temporal multipliers for the 100-year flood event were all zero. The 10 replicates are color-coded and shown each per 30-year period. A temporal

multiplier of “1” means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance’s modeled rate.



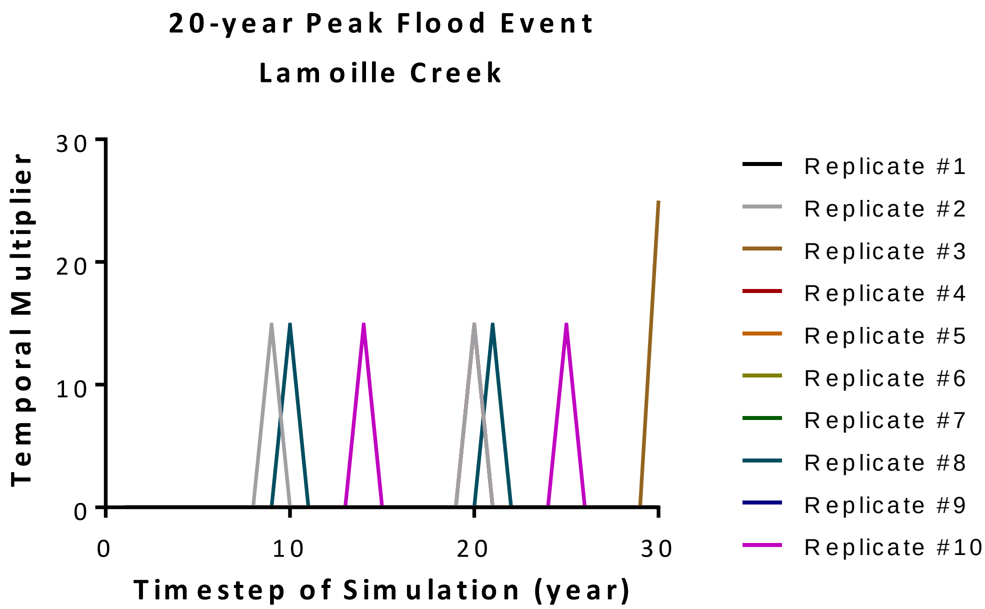


Figure A5-12. Temporal multipliers for 7- and 20-year flood events based on peak flows from the Lamoille Creek in Nevada’s Ruby Mountains. The temporal multipliers for the 100-year flood event were all zero. The 10 replicates are color-coded and shown each per 30-year period. A temporal multiplier of “1” means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance’s modeled rate.

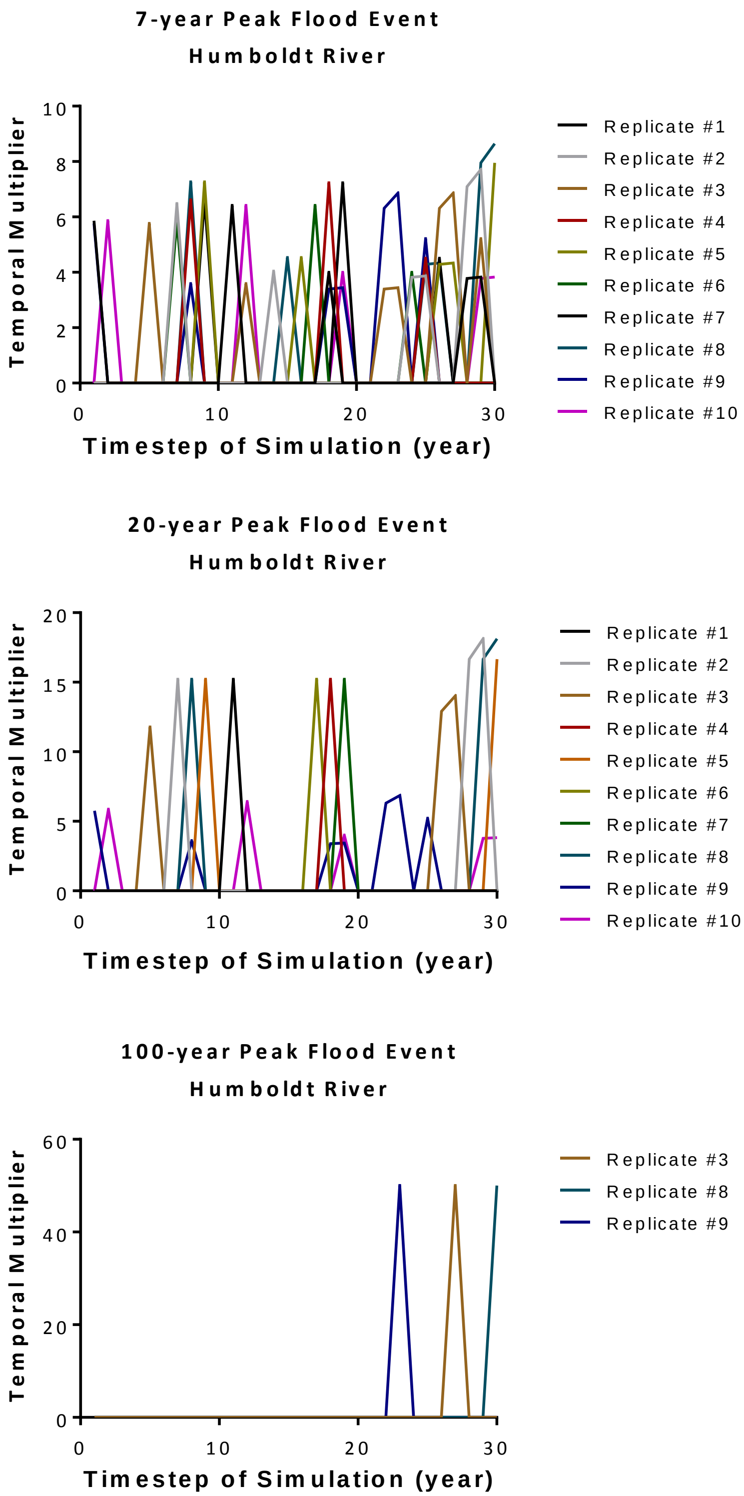
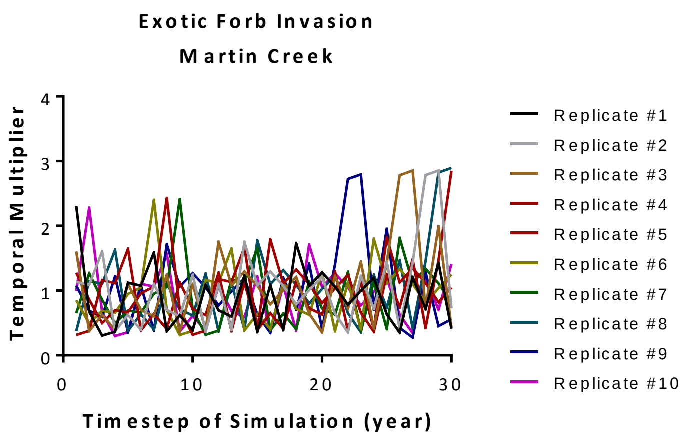
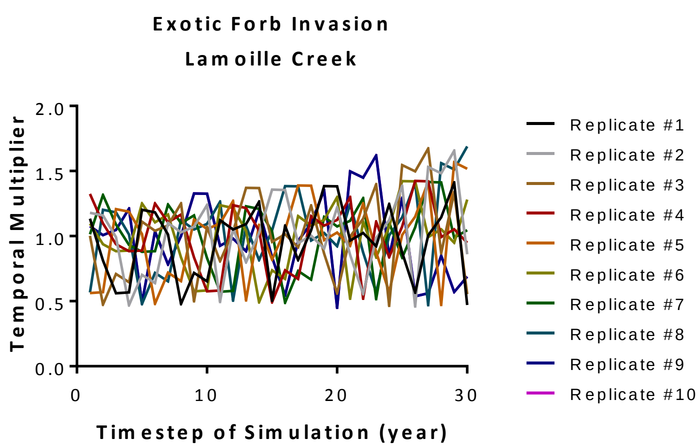


Figure A5-13. Temporal multipliers for 7-, 20, and 100-year flood events based on peak flows from the Humboldt River. Except for three replicates, the temporal multipliers for the 100-year flood event were all zero. The 10 replicates are color-coded and shown each per 30-year period. A temporal

multiplier of “1” means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance’s modeled rate.

Annual discharge from Martin Creek, Lamoille Creek, and the Humboldt River were used to determine exotic forb and exotic tree invasion rates in the riparian systems of the appropriate landscapes. 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 variability of exotic forb invasion also affects upland systems (mostly invasion by thistles) and it was noticed in the field that patches of thistles were frequently in shallow dry washes or along wet systems. Therefore, we used the same annual flow data from Martin Creek (randomly picked among the three drainages; see figure below for correlated variability among drainages) to represent the variability of exotic forb invasion rate in upland systems as an average surrogate for wet years, which a riparian system would integrate. The number of upland acres affected by the variability factor was very small. The rate of exotic forb invasion in ST-Sim models was, therefore, multiplied by the annual flow temporal multiplier. The temporal multipliers were obtained by using the annual flow time series without filtering and divided by the time series temporal average. Data are shown in Figure A5-14.





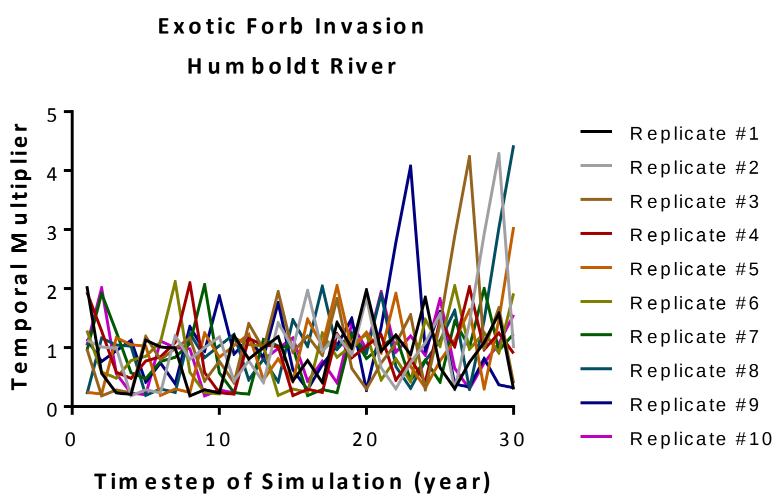


Figure A5-14. Riparian temporal multipliers for exotic species invasion calculated from annual discharge data from annual yearly flows recorded from Martin Creek, Lamoille Creek, and Humboldt River. The ten replicates are color-coded and shown each per 30-year period. A temporal multiplier

of “1” means no change to the rate in the ST-Sim models, whereas temporal multipliers <0 and >0, respectively, represent suppression and enhancement of a disturbance’s modeled rate.

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Appendix 6. Management actions and costs by ecological systems on Newmont ranches.

Vegetation Type	Transition Group	Cost ($/acre)
All Systems	Chainsaw-Thinning	800
Aspen-Mixed Conifer	Chainsaw-Thinning	800
Montane Sagebrush Steppe	Chainsaw-Thinning	300
Montane Sagebrush Steppe-Subalpine	Chainsaw-Thinning	300
All Systems	Exotic-Control	80
Aspen Woodland	Fence	400
Aspen-Mixed Conifer	Fence	400
Montane Riparian	Fence	350
Owyhee River Riparian	Fence	350
Wet Meadow-Montane	Fence	400
All Systems	Fuel-Break	110
Basin Wildrye-bottomland	Herbicide-Plateau+Native-Seed	295
Basin Wildrye-montane	Herbicide-Plateau+Native-Seed	295
Four-Wing Saltbush	Herbicide-Plateau+Native-Seed	295
Lower Montane-Valley Grassland	Herbicide-Plateau+Native-Seed	295
Montane Sagebrush Steppe-Subalpine	Herbicide-Plateau+Native-Seed	295
Saline Meadow	Herbicide-Plateau+Native-Seed	295
All Systems	Herbicide-Plateau+Seed	170
All Systems	Herbicide-Shrubs	125
Lower Montane-Valley Grassland	Inexpensive Floodplain-Restoration	500
Moist Floodplain	Inexpensive Floodplain-Restoration	2,000
Montane Riparian	Inexpensive Floodplain-Restoration	2,000
Wet Meadow-bottomland	Inexpensive Floodplain-Restoration	2,000
Wet Meadow-Montane	Inexpensive Floodplain-Restoration	100
All Systems	Masticate+24D+Plateau+NativeSeed	650
All Systems	Masticate+Native-Seed	450
Basin Wildrye-montane	Masticate+Plateau+NativeSeed	600
Montane Sagebrush Steppe	Masticate+Plateau+NativeSeed	600
Mountain Shrub	Masticate+Plateau+NativeSeed	600
Basin Wildrye-bottomland	Masticate+Plateau+Seed	550
All Systems	Mastication	300
Aspen Woodland	RxFire	150
Aspen-Mixed Conifer	RxFire	150
Basin Wildrye-bottomland	RxFire	150
Basin Wildrye-montane	RxFire	150
Montane Sagebrush Steppe	RxFire	150
Montane Sagebrush Steppe-Subalpine	RxFire	150
Subalpine Fir-Spruce	RxFire	150
All Systems	Shrub+Grass-Seeding	110
Montane Riparian	Small-Rock-Dam	100
Wet Meadow-Montane	Small-Rock-Dam	100
Big Sagebrush-upland+trees	Small-Tree-Lopping	200

Low Sagebrush Steppe	Small-Tree-Lopping	300
Montane Sagebrush Steppe-Subalpine	Small-Tree-Lopping	300
Mountain Shrub	Small-Tree-Lopping	200
Lower Montane-Valley Grassland	Spike+Plateau+Native-Seed	225
Saline Meadow	Spike+Plateau+Native-Seed	225
Montane Sagebrush Steppe	Spike+Plateau+Seed	125
All Systems	Supplemental-Salt-Block	20
All Systems	Thin+24D+Plateau+NativeSeed	475
All Systems	Thin+24D+Seed	285
Basin Wildrye-montane	Thin+Native-Seed	300
Big Sagebrush-upland no trees	Thin+Native-Seed	300
Big Sagebrush-upland+trees	Thin+Native-Seed	300
Four-Wing Saltbush	Thin+Native-Seed	300
Lower Montane-Valley Grassland	Thin+Native-Seed	300
Saline Meadow	Thin+Native-Seed	300
All Systems	Thin+Plateau+Native-Seed	300
Basin Wildrye-bottomland	Thin+Seed	175
Basin Wildrye-montane	Thin+Seed	175
Big Sagebrush-semidesert	Thin+Seed	175
Big Sagebrush-upland no trees	Thin+Seed	175
Big Sagebrush-upland+trees	Thin+Seed	175
Montane Sagebrush Steppe-Subalpine	Thin+Seed	175
All Systems	Thin-Plateau-Seed	210
All Systems	Weed-Inventory+Spot-Treat	50

Appendix 7
Overview of Ecological Departure and Unified Ecological Departure

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

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

Example calculations of both ecological departure and unified ecological departure, for a simplified shrubland ecological system, are shown in the following table (equations are presented in footnotes). In the table, there are two reference classes ("younger" and "older") and two uncharacteristic classes ("exotic species" and "introduced species seeding") expressed by their current percentages in the landscape. Their respective NRVs are also shown. The first uncharacteristic class is undesirable and is expected to be expensive to restore. Therefore, the class has been assigned an undesirability level of 1, which converts to a high-risk function value of -0.5, thereby multiplying the observed percentage of the class to yield the effective observed percentage (see footnotes for formula). The other uncharacteristic vegetation class is an introduced species seeding that managers consider acceptable for wildlife management and for keeping cheatgrass to low levels. Managers in this hypothetical example decided that no penalty will be incurred for an introduced species seeding (undesirability = 0) if it does not exceed a 25% management threshold in the landscape. In this example, ecological departure and unified ecological departure are calculated, respectively, in the observed percentage and effective observed percentage columns. In the table, the presence of the introduced species seeding lowers unified ecological departure (i.e., better condition) compared to the traditional ecological departure. The undesirable uncharacteristic class increases unified ecological departure (i.e., worse condition, closer to 100% departure) beyond what is observed for ecological departure.

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

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

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

[@] Unified Ecological Departure (UED) =

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

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

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

$HRF_j = -e^{c(B-1)}/(1 + e^{c(B-1)})$

where *c* is an arbitrary fitted coefficient (here 10) and B is the undesirability level from the table. HRF = 0, -0.5, and -1 for, respectively, values of B = 0, 1, and 2.

Appendix 8. Description of habitat suitability calculation for greater sage-grouse, mule deer, and golden eagle

1. Greater Sage-Grouse Habitat Suitability

Data were collected on habitats and Greater sage-grouse (hereafter, sage-grouse) demography as part of a long-term research program on sage-grouse ecology from 2003-2012, in Eureka County, Nevada (Falcon-to-Gondor study area; see Gibson et al. 2013). We used covariates that were identified as important from that field project to build spatial models of four demographic parameters (i.e. life history stages): nest site selection (NSS), nest success (NS), and chick survival (CS), and female (Appendix 8 Tables 1 and 2; Kane et al, *in prep*). These parameters were used to model the per capita population growth rate (λ) as a function of the spatial variation in sage-grouse demographic parameters to predict contributions of specific habitat characteristics to regional population dynamics. This process, coupled with the ST-Sim results, allows for spatially explicit interpretation of how management actions impact sage-grouse demography on the current landscape and into the future.

In order to build the spatial models, rasters for environmental variables were gathered and analyzed in the software R (R Core Team, 2014). All rasters were at a 60 x 60 m resolution. Rasters from ST-Sim that included both ecological system and vegetation class were imported. Elevation and slope were obtained from the USGS National Elevation Dataset Digital Elevation Model (i.e. DEM). Lek locations were made available by the Nevada Department of Wildlife (NDOW). Additionally, eight new geo-referenced and filmed leks discovered in 2015 by the IL Ranch manager and BLM staff were added to the analysis. All rasters were standardized to obtain a “standard normal” raster with mean 0 and a standard deviation 1, unless otherwise noted. Rasters were standardized as a way of transforming the data to comparable scales and also to equalize the range and data variability. For calculation of the four demographic parameters the following general form of logistic regression equation was used (Hosmer and Lemeshow 1989):

$$S= e^{((\beta0+ \beta1X1+\beta2X2+\ldots+\beta nXn)/ (1+\exp (\beta0+ \beta1X1+\beta2X2+\ldots+\beta nXn))}$$

where β_0 is the model intercept, β_i are the logistic regression coefficients (Appendix 8 Table 4), and X_i are the measured covariates.

1.1 Nest Site Selection (NSS)

Nest locations were not available for either the IL or TS-Horseshoe ranches. So every pixel in the study region was considered as a potential nest point. Since nesting locations and associated vegetation do not occur at roads, roads were excluded as nesting habitat. Distance to lek was previously found to have a negative influence on NSS (Gibson et al. 2015). It is calculated as the distance from every pixel in the study region to the nearest lek. Sage-grouse are dependent on sagebrush and other native shrubs for nesting (Braun et al. 1977, Connelly et al. 2004); the amount of sagebrush present around a nest within a 1000m radius circle was calculated. This variable was the proportion of pixels within the moving window designated as nesting habitat. Appendix 8 Table 1 shows the ecological systems and vegetation class codes classified as nesting habitat. Additionally, elevation and slope were included in the NSS calculation. It has been previously shown that sage-grouse prefer to use habitats at moderate slopes and elevations (Gibson et al 2015):

$$NSS = (1-(1/ (1+e^{(\beta0+ (\beta NSS1*elev.)+ (\beta NSS2*slope) + (\beta NSS3* \text{dist. to lek}) + (\beta NSS4* \text{amount of sagebrush} + (\beta NSS5*slope*elev.)+ (\beta NSS6 *\text{dist. to lek}* \text{amount of sagebrush})}))$$

Appendix 8 Table 1. State and associated classes within those states that were categorized as nesting habitat. Italics indicate ecological systems and classes that were only considered available habitat above 6,890 ft. (2,100m).

Ecological System	Vegetation Class
Big Sagebrush-semidesert	2-Mid:Open
	3-Late:Closed
	4-Late:Dense
	U:Depleted
	U:SA-Closed
	U:SA-Dense
	U:SAP-Closed
	U:SAP-Dense
	U:SDI-B
	U:SDI-C
	U:SDI-D
	U:SI-B+AS
	U:SI-C+AS
	U:SI-D+AS
Big Sagebrush-upland no trees	2-Mid:Open
	3-Late:Closed
	4-Late:Dense
	U:Depleted
	U:SA-Closed
	U:SA-Dense
	U:SAP-Closed
	U:SAP-Dense
	U:SDI-B
	U:SDI-C
	U:SDI-D
	U:SI-B+AS
	U:SI-C+AS
	U:SI-D+AS
Big Sagebrush-upland+trees	2-Mid:Open
	3-Late:Closed
	4-Late:Dense
	5-Late:Open
	U:Depleted
	U:SA-Closed
	U:SA-Dense
	U:SAP-Closed
	U:SAP-Dense
	U:SDI-B
	U:SDI-C
	U:SDI-D
	U:SDI-E
	U:SI-B+AS
	U:SI-C+AS
	U:SI-D+AS
	U:SI-E+AS

Ecological System	Vegetation Class
Black Sagebrush	Mid-open
	Late-closed
	U:Depleted
	U:SA
	U:SAP
	U:SDI-B
	U:SDI-C
	U:SI-B+AS
	U:SI-C+AS
Juniper Woodland	U:SAP
Low Sagebrush	3-Late:Closed
	U:Depleted
	U:SA
	U:SAP
	U:SDI-B
	U:SDI-C
	U:SI-B+AS
	U:SI-C+AS
Low Sagebrush Steppe	3-Late:Closed
	U:Depleted
Moist Floodplain	U:Desertified
	U:SAP
Montane Riparian	U:Desertified
	U:SAP
Montane Sagebrush Steppe	2-Mid:Open
	3-Late:Closed
	4-Late:Dense
	U:Depleted
	U:SA-Closed
	U:SA-Dense
	U:SAP-Closed
	U:SAP-Dense
	U:SDI-B
	U:SDI-C
	U:SDI-D
	U:SI-B+AS
	U:SI-C+AS
	U:SI-D+AS
Montane Sagebrush Steppe-Subalpine	2-Mid:Open
	3-Late:Closed
	4-Late:Dense
	U:Depleted
	U:SAP-Closed
	U:SAP-Dense
Mountain Shrub	*2-Mid:Open*

	U:Depleted
	U:SAP
Owyhee River Riparian	U:SAP

1.2 Nest success (NS)

Nest success is derived from daily nest survival and the exposure time of the nest to predation. To calculate the probability of daily nest survival, the proportion of grass-dominated vegetation or grasslands classes around each pixel within a 2000m radius was measured. Grass-dominated classes include those dominated by non-native annuals, non-native seeded species (e.g. crested wheatgrass (A*gropyron cristatum*)), and native grass species, excluding Basin Wildrye systems (*Leymus cinereus*). Fire was previously identified as having a negative association with NS as burned sites tend to convert to non-native annual grasslands (e.g. cheatgrass (*Bromus tectorum*)) following wildfire (Blomberg et al. 2012). Additionally, non-native species seedings, forage kochia (*Kochia prostrata*), and/or early seral native grasses appear to have negative impacts on NS (J. Sedinger, pers. comm.). Daily nest survival is also influenced by the cover of non-sagebrush shrub species at a nest site. Greater shrub cover is associated with enhanced predation protection for pre-nesting females and supply a relatively high protein food for chicks immediately after hatching. Estimates of non-sagebrush shrub cover for the IL and TS-Horseshoe ranches were extrapolated from field data from Eureka Co. A statistical relationship was found between sagebrush cover and total non-sagebrush cover. To calculate the non-sagebrush shrub cover, the low range of sagebrush for nesting habitat was multiplied by a constant, approximately 0.1976. These variables, proportion of grasslands and non-sagebrush shrub cover, were used in a logistic regression to estimate daily nest survival. Nest success was then estimated by using the exposure period for sage- grouse (9 egg laying days + 28 incubation days = 37 days exposed) as an exponent of daily nest survival. Finally, NS is influenced by factors such as visitation and overall nest quality. Gibson et al. 2015 found that observer-related abandonment introduced a negative bias (0.068) into estimates of overall NS by reducing the average timing of nest fate and thereby lowering daily nest survival. This bias was added to daily nest survival model:

$$\text{Daily nest survival} = (1-(1/\ (1+e^{((\beta NS0)\ +(\beta NS1*\text{amount of grasslands})\ +\ (\beta NS2*\ \text{non-sagebrush shrub cover}))})))$$

$$NS_1 = \text{daily nest survival}^{37}+0.068$$

In many instances females whose nest fails (likely due to predation) will initial a second nest attempt. Data from the Eureka Co. dataset suggest the re-nesting propensity is 85%. In order to account for re-nesting the following equation is used to correct daily nest survival:

$$NS = NS_1 + (1\ NS_1) * (\text{renesting probability}) * NS_1$$

1.3 Infrastructure Impacts (I)

The TS-Horseshoe Ranch includes infrastructure such as mines, high use roads, and power lines. Such infrastructure is not present on the IL Ranch. The effect of infrastructure of sage-grouse habitat suitability was handled as post-hoc modifications of NSS and NS by decreasing their values with decreasing distance to infrastructure. We followed Gibson et al. 2013, which documents the impacts of the Falcon-to-Gondor Transmission line on sage-grouse population dynamics. Distance from infrastructure was incorporated into our models after NSS and NS were estimated. Distance from each pixel to all infrastructure was measured within the TS-Horseshoe Ranch and then standardized the distance using the mean and standard deviation from the Eureka Co. dataset. The same general equation was used for both Nest-Site Selection and Nest Success, though intercepts and beta coefficients varied (Appendix 8 Table 2):

$$I = (1-(1/ (1+e^{(\beta 0 + (\beta I1*\text{dist. to infrastructure}) + (\beta I2*\text{dist. to infrastructure2}))})))$$

Appendix 8 Table 2. Variables and beta coefficients used calculate the infrastructure effect at the TS-Horseshoe Ranch. The infrastructure buffer was added to the unadjusted Nest-Site Selection and Nest Success.

Model	Variable	Beta coefficient
Nest Site Selection	Intercept	-2.01765
	Dist. to infrastructure	0.3453
	Dist. to infrastructure^2	-0.18176
Nest Success	Intercept	3.0928324
	Dist. to infrastructure	0.1405036
	Dist. to infrastructure^2	-0.1195951

1.4 Chick Survival (CS)

Daily chick survival was calculated as a function of daily distance moved between nests and late- brood habitat (LBH). All pixels were reclassified based on their availability as LBH (Appendix 8 Table 3). In wet meadows, the presence of exotic forb classes may impede the ability of sage-grouse to locate and use otherwise good LBH. A 180m moving window was applied to the wet meadows. If more than two of the surrounding pixels was an exotic forb or annual grass class, then the pixel was designated as non-LBH regardless of the pixel vegetation. The distance was measured between each pixel to the closest pixel of LBH. From the Eureka Co. data, it takes roughly 6 weeks (42 days) for chicks to travel from a nest to LBH. Chick survival varied among weeks so the probabilities of chicks surviving was estimated for each week based on daily survival for that week and distance moved. This variable was then divided by 35 (representing 35 days of exposure). Finally, distance moved was standardized using the average and standard deviation of distance moved from the Eureka Co. data. The final chick survival was the sum of the weekly survival rates:

$$\text{Weekly survival (WS)} = (1-(1/\ (1+e^{(\beta CS0\ +\ (\beta CS1 * \text{daily dist.})\ +\ \beta CS2)})))$$

where β_0 is the intercept, β_{CS1} is the coefficient for average daily distances moved by a brood,

and β_{CS2} is the coefficient for each week

$$CS = WS_1 * WS_2 * WS_3 * WS_4 * WS_5 * WS_6$$

Appendix 8 Table 3. State and associated classes within those states that were categorized as nesting habitat. Italics indicate ecological systems and classes that were only considered available habitat above 6,000 ft. (1,829m).

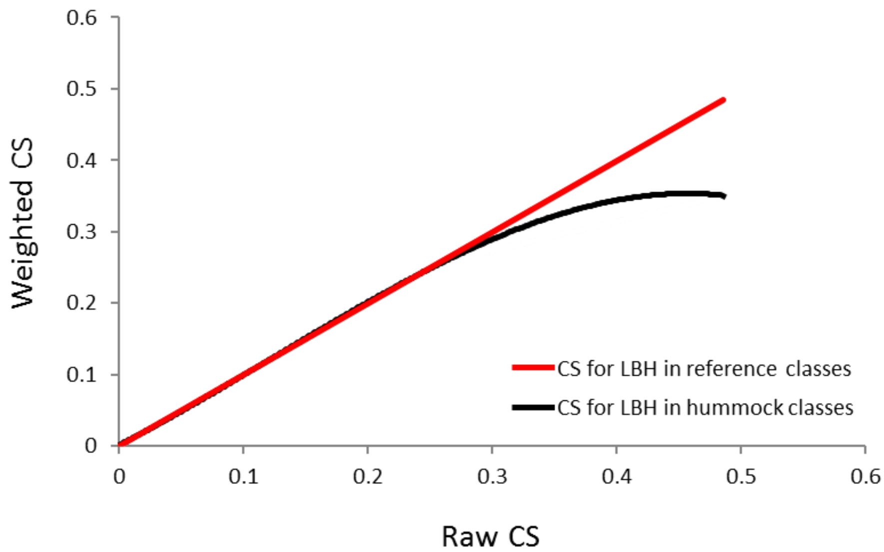
Ecological System	Vegetation Class
Basin Wildrye-bottomland	U:Pasture
Basin Wildrye-montane	U:Pasture
Low Sagebrush	*1-Early:All*
	2-Mid:Open
	3-Late:Closed
	U:ASPG
	U:SDI-A
	U:SDI-B
	U:SDI-C
	U:Seeded Native
	U:SI-A+AS
	U:SI-B+AS
	U:SI-C+AS
Low Sagebrush Steppe	*1-Early:All*
	2-Mid:Open
	3-Late:Closed
Lower Montane-Valley Grassland	1-Early:All
	2-Mid:Open
	4-Late:Closed
	U:ASPG
	U:Increaser Grass
Moist Floodplain	1-Early:Cottonwood
	1-Early:Willow
	2-Mid:Willow
	3-Late:Willow
	U:Pasture
Montane Riparian	1-Early:Cottonwood
	1-Early:Willow
	U:Pasture
	U:SDI
Montane Riparian	U:SDI+AS

Ecological System	Vegetation Class
Montane Sagebrush Steppe	1-Early:All
	2-Mid:Open
	U:ASPG
	U:SDI-A
	U:SDI-B
	U:Seeded Native
	U:SI-A+AS
	U:SI-B+AS
Montane Sagebrush Steppe-Subalpine	1-Early:All
	2-Mid:Open
	U:ASPG
Mountain Shrub	*1-Early:All*
	2-Mid:Open
Owyhee River Riparian	1-Early:Willow
	U:Early Shrub
	U:Pasture
	U:SDI
	U:SDI+AS
Subalpine-Upper Montane Grassland	1-Early:All
	2-Mid:Closed
	3-Late:Open
	U:Unpalat. Shrub
Wet Meadow-Montane	1-Early:Open
	2-Mid:Closed
	3-Late:Open
	U:Hummocked
	U:Pasture
	Wallow

In the current CS equation, only distance from a pixel to the nearest LBH pixel is measured. However, not all LBH may equally contribute to CS. This is most apparent when comparing hummocked classes with reference classes in wet meadow systems. In order to account for the difference between hummocked and other LBH, two separate distance were measured: distance to the nearest hummocked class and distance to the nearest reference LBH classes. For pixels nearer to hummocked classes, CS was recalculated using the previously described methods. Then a weight was applied to the new CS, which represents a 30% reduction of CS for pixels with the highest unweighted CS (Appendix 8 Fig. 1). The equation for the weight is:

$$CS_W = -3.3761 * CS_{hum}^3 + 1.2479 * CS_{hum}^2 + 0.887 * CS_{hum} + 0.0011$$

Where CS_W is weighted CS and CS_{hum} is the unweighted CS for areas closest to hummocked classes. Once the original CS raster and weighted CS raster were then merged so that weighted CS values were retained in areas closest to hummocked classes.



Appendix 8 Fig. 1. The relationship between the raw chick survival (CS) and weighted CS. Weighted CS was applied to pixels that were nearest to hummocked classes compared to other late brood habitat.

1.5 Female Survival (FS)

There is a trade-off between the reproductive success of an individual female and that female's survival (i.e. females who successfully raise a brood have a lower annual survival rate; Blomberg et al. 2013). In order to calculate female survival, first the probability that a female will successfully hatch a nest and that nest will survive is calculated (termed nest survival (N_S) here. N_S is a function of nest site selection and nest success:

$$N_S = NSS * \text{renesting propensity} * NS + (1 - NS) + NSS * 0.385 * NS$$

We then calculated the probability that at least one chick hatches and survives through late brood-rearing (BS). BS is a function of NS, CS, mean clutch size (females only) across all age classes (3.6), and mean hatchability of the clutch (0.92). Estimates of hatchability of clutch comes from Taylor et al. (2012). BS is calculated as:

$$BS = NS * (1 - (1 - CS)^{(\text{mean clutch size * mean hatchability of the clutch})})$$

Both BS and N_S are standardized along with spring, summer, and fall survival, and then used to calculate female survival:

$$FS = \text{Spring Survival} * (1-(1/(1+e^{3.009277+\beta\text{Summer Survival} + \beta NS*NS})))^2 * (1-(1/(1+e^{3.009277+\beta\text{Fall Survival}+\beta BS*BS})))^3 * 0.99$$

Spring survival represented monthly nesting survival rates in April and May (0.93), and winter survival represented monthly winter survival during November-March (0.99) (Blomberg et al. 2013b). β Summer Survival and β Fall Survival are season-specific effects for summer and fall, respectively. βNS was the negative effect of successfully hatching a nest on summer survival, and βBS was the negative effect of successfully raising a brood on fall survival.

1.6 Per-Capita Population Growth Rate (λ)

We used the life table response experiment (LTRE) (Caswell 1989, Cooch et al. 2001) as a tool to understand the contribution of specific seasonal habitats to regional population dynamics of the sage-grouse. LTRE is a retrospective analysis which expresses λ as a function of observed variation in the demographic parameters. We use this approach to understand how much of the change in population growth rate can be attributed to the changes in four demographic parameters. Additionally, this allows us to estimate λ at each pixel so that spatial and temporal patterns of change can be identified.

First, fecundity was calculated for adults (F_1) and juveniles (F_2). Due to a lack of data, fecundity was assumed to be the same for adults and juveniles. F_i is the value of nest site selection, nest success, chick survival, and female survival at a given pixel multiplied by the half of the mean clutch size (3.6) and the mean post-fledging survival (0.528):

$$F_i = NSS*NS*CS*(\text{mean clutch size}/2) * \text{post-fledging survival}$$

Once fecundity is calculated, a matrix is created with mean female survival, S_1 and S_2, respectively (though as with fecundity a single survival rate is used for juveniles and adults). The most positive eigenvalue from these matrix products is the per-capita growth. This matrix is then used to calculate the λ at each pixel. Finally, the difference between lambda at current conditions and the average λ from the Eureka Co. data; this is done to normalize the results to the Eureka Co. dataset.

Appendix 8 Table 5. Variables and beta coefficients used for the three life history stages used to estimate lambda. Note that Nest Success is estimated from the Daily Nest Survival. See Gibson et al. 2015 for description of how equations were derived.

Model	Variable	Beta coefficient
Nest Site Selection	Intercept	-2.34506
	Elevation	0.59617
	Slope	0.50795
	Dist. to Lek	-0.64372
	Amount of Sagebrush	1.43117
	Slope*Elevation	-0.331
	Dist. to Lek*Amount of Sagebrush	-0.62407
Daily Nest Survival	Intercept	2.9816303
	Non-sagebrush shrub cover	0.2958471
	Amount of grasslands	-0.1170051
Chick Survival	Intercept	1.6472797
	Dist. moved	-1.3712585
	Week 1	-1.3781732
	Week 2	-0.6970342

	Week 3	0.0549484
	Week 4	-0.0973284
	Week 5	0.1817422
	Week 6	1.647279

2. Mule deer habitat suitability

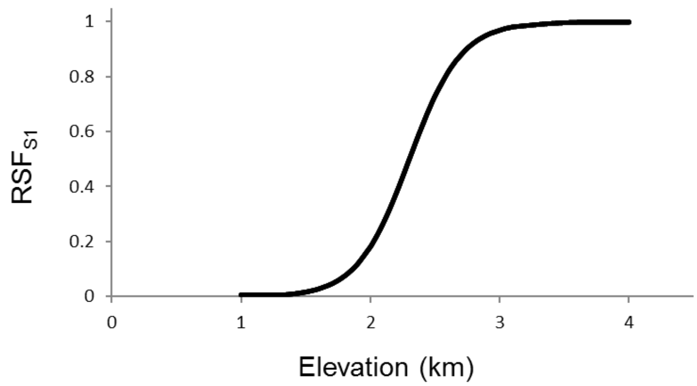
Heuristic resource selection functions (RSFs) for mule deer were developed with help from researchers at UNR and biologists at NDOW, since movement data were not available across the two Newmont properties. In addition to consultation with these experts, all equations were vetted at a workshop in Elko, NV September 29th – October 1st, 2015. RSFs were categorized into 4 categories: summer, winter, topography, and migration. When a moving window analysis was performed, window was 2000m, a window used previously for mule deer landscape metrics (Kie et al 2002). All analyses were conducted using software R (R Core Team 2014) and package 'raster' (Hijman 2015).

2.1 Summer

Five RSFs were selected to model summer habitat suitability, ($RSF_{S,i}$, i = 1,2,..,5).

2.1.1 Summer elevation (RSF_{S1}) - During summer, mule deer tend to migrate to higher elevation to follow moisture and cooler temperatures (Cox et al. 2009). Elevations were constrained between 1000m and 3200m to encompass regional elevation ranges. A sigmodal relationship was modelled between summer elevation and habitat suitability:

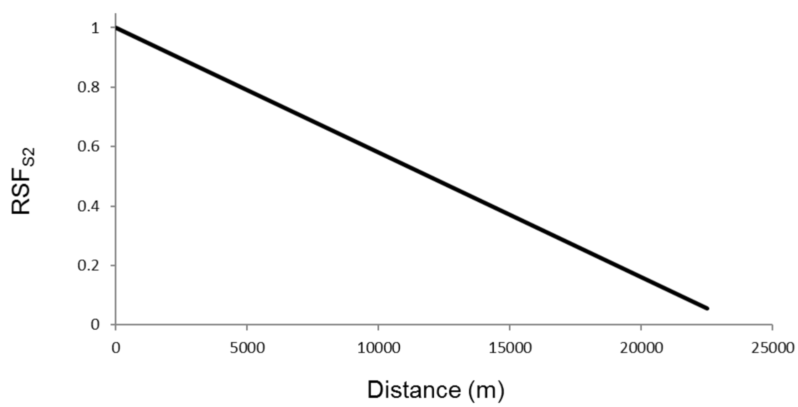
$$RSF_{S1}= e^{5*(\text{summer elevation} -2.3)} / (1+e^{5*(\text{summer elevation} -2.3)})$$



Appendix 8 Fig. 2. Resource selection function for summer elevation on mule deer habitat suitability.

2.1.1 Distance to moist habitats (RSF_{S2}) – Calculated as the distance from any given pixel to the nearest pixels categorized as moist habitats (i.e. remain green through the summer) (Appendix 8 Table 6). A negative linear relationship was used:

$$RSF_{S2} = 1 + (-0.000042 * \text{dist. to moist habitats})$$



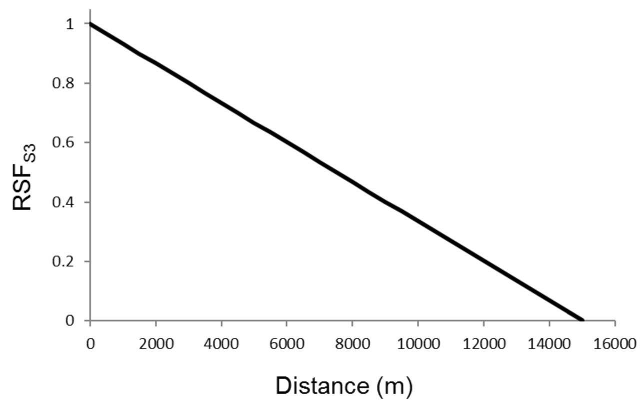
Appendix 8 Fig. 3. Resource selection function for distance to moist habitats on mule deer habitat suitability.

Appendix 8 Table 6. Vegetation classes and associated systems categorized as moist habitat for mule deer.

Ecological System	Vegetation Class	Ecological System	Vegetation Class
Aspen Woodland	1-Early:Closed	Montane Riparian	1-Early:Cottonwood
	2-Mid:Closed		1-Early:Willow
	3-Late:Closed		2-Mid:Cottonwood
	4-Late:Open		3-Late:Cottonwood
	U:Depleted		3-Late:Willow
Aspen-Mixed Conifer	1-Early:All		U:Inset-A
	2-Mid:Closed		U:Inset-B
	3-Late:Closed	Moist Floodplain	1-Early:Cottonwood
	4-Late:Open		1-Early:Willow
	5-Late:Closed		2-Mid:Cottonwood
Wet Meadow-Montane	1-Early:Open		2-Mid:Willow
	2-Mid:Closed		3-Late:Cottonwood
	3-Late:Open		3-Late:Willow
Saline Meadow	1-Early:Open	Owyhee River Riparian	1-Early:Cottonwood
	2-Mid:Closed		1-Early:Willow
	3-Late:Open		2-Mid:Cottonwood
Wet Meadow-bottomland	1-Early:Open		2-Mid:Willow
	2-Mid:Closed		3-Late:Cottonwood
	3-Late:Open		3-Late:Willow
Wetland	1-Early:All		U:Inset-A
	3-Late:All		U:Inset-B

2.1.3 Distance to water source (RSF_{S3}) – Distance from a given pixel to the nearest mapped water source was recorded. Water sources included both natural (e.g. perennial streams) and anthropogenic (e.g. cattle troughs). A negative linear relationship was used to model the relationship between distance to water and habitat suitability:

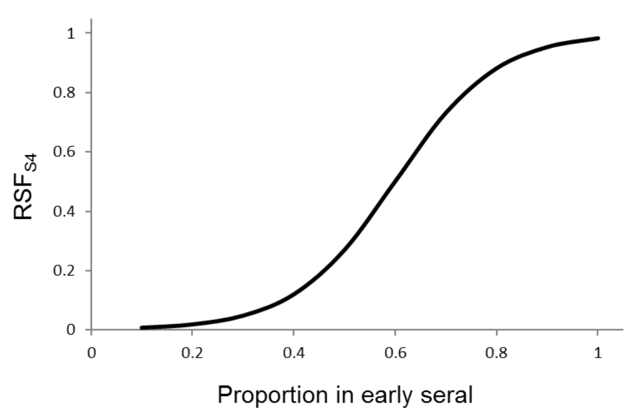
$$RSF_{S3} = 1 + (-0.0000665 * \text{dist. to water})$$



Appendix 8 Fig. 4. Resource selection function for distance to water sources on mule deer habitat suitability.

2.1.4 Proportion of early seral classes – Calculated as the proportion of classes designated as early seral forage within 2000m of a given pixel (Appendix 8 Table 7). Only classes that had useable early forage for mule deer were included. Mule deer prefer younger vegetation due lower concentration of secondary metabolites and higher nutrient content (pers. comm. C. Schroeder). A sigmodal relationship was used:

$$RSF_{S4} = e^{10*(\text{prop. early seral } -0.6)} / (1 + e^{10*(\text{prop. early seral } -0.6)})$$



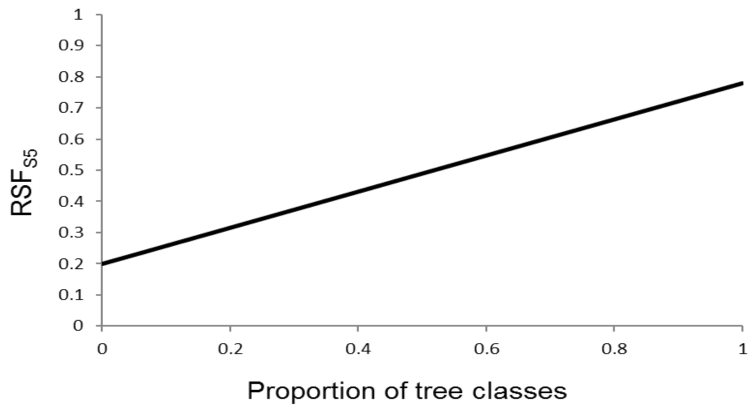
Appendix 8 Fig. 5. Resource selection function for proportion of early seral forage classes within a 2000m radius.

Appendix 8 Table 7. Vegetation classes and associated systems categorized as early seral forage for mule deer.

Ecological System	Vegetation Class
Aspen Woodland	1-Early:Closed
Basin Wildrye-bottomland	1-Early:Open
	U:SDI+AS
Basin Wildrye-montane	1-Early:Open
	U:SDI+AS
Big Sagebrush-semidesert	1-Early:All
	U:SDI-A
	U:SI-A+AS
Big Sagebrush-upland no trees	1-Early:All
	U:SDI-A
	U:SI-A+AS
Big Sagebrush-upland+trees	1-Early:All
	U:SDI-A
	U:SI-A+AS
Black Sagebrush	U:SDI-A
	U:SI-A+AS
Curl-leaf Mountain Mahogany	1-Early:All
Four-Wing Saltbush	1-Early:Open
Greasewood	1-Early:All
Juniper Woodland	1-Early:Open
Limber Pine Woodland	1-Early:All
Low Sagebrush	1-Early:All
	U:SI-A+AS
Low Sagebrush Steppe	1-Early:All
Lower Montane-Valley Grassland	1-Early:All
Mixed Salt Desert	1-Early:All
	U:SDI+AS
Moist Floodplain	1-Early:Cottonwood
	1-Early:Willow
Montane Riparian	1-Early:Cottonwood
	1-Early:Willow
	U:Inset-A
Montane Sagebrush Steppe	1-Early:All
	U:SDI-A
	U:SI-A+AS
Montane Sagebrush Steppe-Subalpine	1-Early:All
Mountain Shrub	1-Early:All
Owyhee River Riparian	1-Early:Cottonwood
	1-Early:Willow
	U:Inset-A
Saline Meadow	1-Early:Open
Subalpine Fir-Spruce	1-Early:All
Subalpine-Upper Montane Grassland	1-Early:All
Wet Meadow-Bottomland	1-Early:Open
Wet Meadow-Montane	1-Early:Open
Wetland	1-Early:All
Winterfat	1-Early:All

2.1.5 Proportion of tree classes (RSF_{S5}) - Calculated as the proportion of classes with sufficient tree cover within a 2,000m radius (Appendix 8 Table 8). Trees provide shading for mule deer. The RSF was constrained between 0.2 and 0.8, as mule deer are known to readily shade under other vegetation if tree cover is unavailable (C. Schroeder, pers. comm.). A negative linear relationship was used:

$$RSF_{S5} = 0.2 + (0.58 * \text{prop. tree class})$$



Appendix 8 Fig. 6. Resource selection function for proportion of tree classes within a 2000m radius.

Appendix 8 Table 8. Vegetation classes and associated systems categorized as tree classes for mule deer.

Ecological System	Vegetation Class
Aspen Woodland	1-Early:Closed
	2-Mid:Closed
	3-Late:Closed
	4-Late:Open
	U:Depleted
Aspen-Mixed Conifer	1-Early:All
	2-Mid:Closed
	3-Late:Closed
	4-Late:Open
	5-Late:Closed
Big Sagebrush-upland+trees	5-Late:Open
	U:TEA
Curl-leaf Mountain Mahogany	1-Early:All
	3-Mid:Closed
	2-Mid:Open
	4-Late:Open
	5-Late:Closed
	U:Tree Ann Spp.
Juniper Woodland	3-Mid:Open
	4-Late:Open
	4-Late:Open
	U:SAP
Limber Pine Woodland	1-Early:All
	2-Mid:Open
	3-Late:Open
Low Sagebrush	U:Tree Ann Spp.
	U:TE
Low Sagebrush Steppe	U:TE
Moist Floodplain	2-Mid:Cottonwood
	3-Late:Cottonwood
Montane Riparian	2-Mid:Cottonwood
	3-Late:Cottonwood
Montane Sagebrush Steppe-Subalpine	U:TEA
Owyhee River Riparian	2-Mid:Cottonwood
	3-Late:Cottonwood
Subalpine Fir-Spruce	1-Early:All
	2-Mid:Closed
	3-Late:Open
	4-Late:Closed

Once the individual summer RSFs were calculated, these were weighted and then summed (Appendix 8 Table 8):

$$RSF_S = RSF_{S1}*w_{S1}+RSF_{S2}*w_{S2}+RSF_{S3}*w_{S3}+RSF_{S4}*w_{S4}+ RSF_{S5}*w_{S5}$$

Appendix 8 Table 9. The individual RSF and their weights used to calculate the summer RSF.

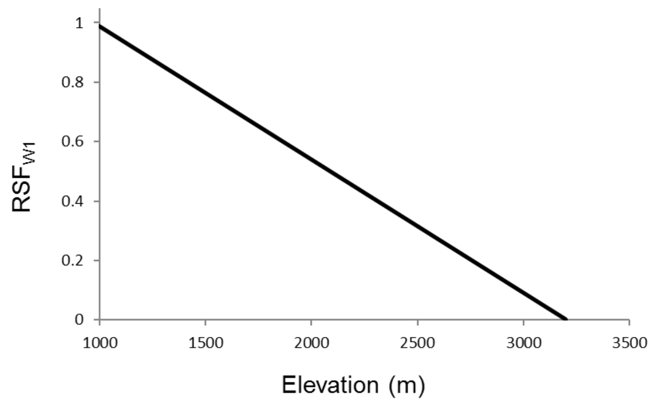
Resource Selection Function	Weight
Summer elevation	0.3
Dist. to moist habitat	0.25
Dist. to water	0.2
Prop. early seral	0.15
Prop. tree class	0.1

2.2 Winter

Four RSFs were used to model winter habitat suitability, ($RSF_{w,i}$, i = 1,2,..,4).

2.2.1 Winter elevation (RSF_{W1}) – During winter, mule deer tend to migrate to lower elevations to avoid colder temperatures and higher snow depths (Cox et al. 2009). Elevations were constrained between 1000m and 3200m to encompass regional elevation ranges. A negative linear relationship was used to model winter elevation RSF:

$$RSF_{W1}= 1.439 + (-0.000449* \text{winter elevation})$$

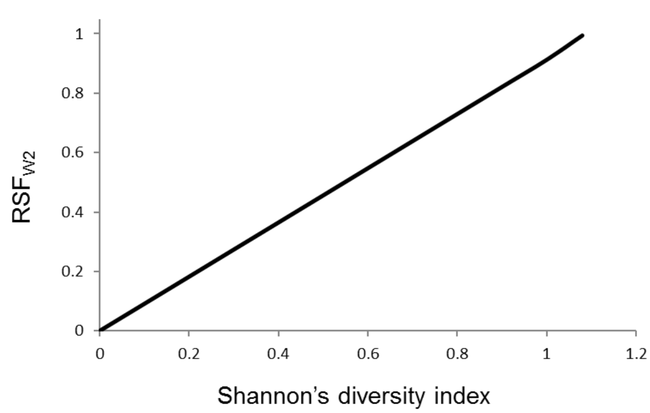


Appendix 8 Fig. 6. Resource selection function for winter elevation.

2.2.2 Shrub diversity (RSF$_{W2}$) – As snow depths increase during winter, forbs and grasses become less available; mule deer diet shifts toward shrubs, including sagebrush (Carpenter et al. 1979). Due to shrub chemistry, mule deer are unable to subsist on a single type of shrub during the winter, instead requiring a diversity of shrubs to forage on (Cox et al. 2009). In order to model the effect of shrub diversity on habitat suitability, the Shannon's diversity index of shrub classes within a 2000m radius is calculated. Then the result is divided by the log of number of shrub classes to constrain the RSF between 0 and 1:

$$RSF_{W2} = \text{shrub diversity}/\log(N)$$

where N = number of shrub classes within the study area

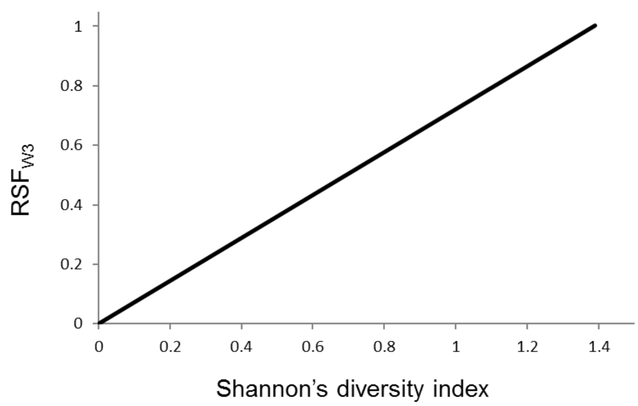


Appendix 8 Fig. 7. Resource selection function for shrub diversity for mule deer.

2.2.3 Age diversity (RSF_{W3}) – As with shrub forage, mule deer prefer a diversity of age classes among forage, due to higher concentrations of metabolites in older plants (Cox et al. 2009). As with shrub diversity, age diversity was calculated using the Shannon's diversity index (see Shrub diversity for calculation:

$$RSF_{W3} = \text{age diversity}/\log(N)$$

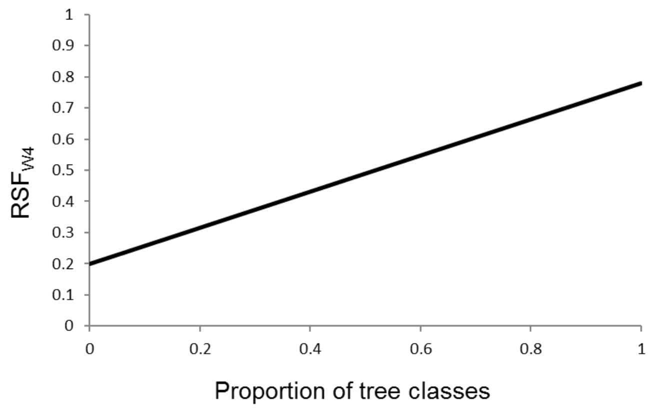
where N = number of age classes within the study area



Appendix 8 Fig. 8. Resource selection function for age diversity among forage classes for mule deer.

2.2.4 Proportion of tree classes (RSF_{W4}) - Calculated as the proportion of classes with sufficient tree cover within a 2,000m radius. Tree cover provides protection from winter weather (C. Schroeder, pers. comm.). The same classes and linear equation used for summer proportion of tree classes were used for winter (See Appendix 8 Table 8):

$$RSF_{S5} = 0.2 + (0.58 * \text{prop. tree class})$$



Appendix 8 Fig. 9. Resource selection function for proportion of tree classes within a 2000m radius.

Once the individual winter RSFs were calculated, these were weighted and then summed (Appendix 8 Table 9):

$$RSF_S = RSF_{S1}*w_{S1}+RSF_{S2}*w_{S2}+RSF_{S3}*w_{S3}+RSF_{S4}*w_{S4}$$

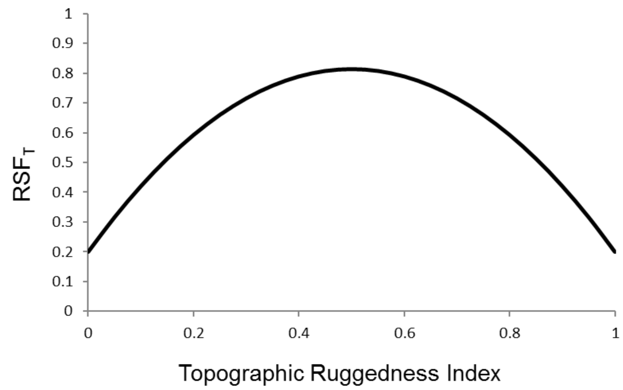
Appendix 8 Table 10. The individual RSF and their weights used to calculate the winter RSF.

Resource Selection Function	Weight
Elevation	0.35
Shrub diversity	0.25
Age diversity	0.25
Prop. tree class	0.15

2.3 Topography

2.3.1 Topography (RSF_T) – Calculated as the Topographic Ruggedness Index (TRI). TRI is defined as the mean of differences in elevation between a pixel and surrounding pixels. TRI was calculated using the “terrain” function in the ‘Raster package’ in software R (R CITATION). Mule deer prefer intermediate levels of TRI (C.Schroeder, pers. comm.). The TRI RSF was limited between 0.2 and 0.8 and used a parabolic function:

$$RSF_T = .2 + (-2.45*TRI^2) + (2.45*TRI^2)$$

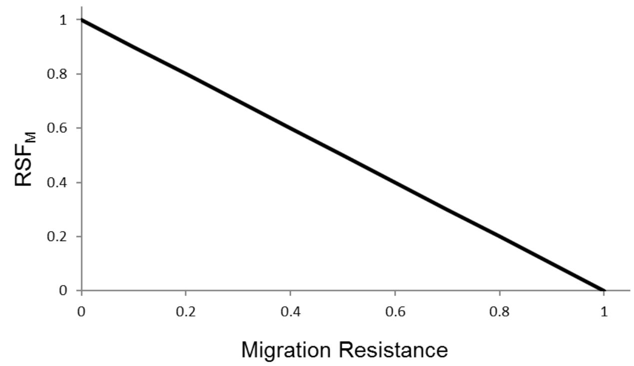


Appendix 8 Fig. 10. Resource selection function for topography. Topographic ruggedness index was used to model mule deer respond to topography.

4. Migration

2.4.1 Migratory resistance (RSF_M) – Many mule deer populations migrate between summer and winter ranges. These migratory paths and associated stopover sites tend to be consistent across generations. As such, any diversion from their traditional migratory corridor may increase stress among affected individuals. In order model migration corridor fidelity and negative consequences associated with diversion or infrastructure, migration path data were obtained from NDOW for the two study areas. These data were based on collared individuals. In GIS, a raster was created using the distance from the migration corridors. A resistance value was given to distances within three intervals from the mapped corridors (Appendix 8 Table 11). Resistance ranged from 0 (i.e. no resistance) to 1.0 (i.e. highly resistant). Additionally, since some infrastructure may impede migration or act as a mortality source (e.g. roads), infrastructure was merged with the distance calculation and given a resistance level (Appendix 8 Table 12). The final RSF was a negative linear relationship between resistance values and habitat suitability:

$$RSF_M = 1+ (\text{resistance}^{*}- 1)$$



Appendix 8 Fig. 11. Resource selection function for migration resistance for mule deer. Low resistance indicates mule deer are within traditional migration corridors and not impeded by infrastructure.

Appendix 8 Table 11. Resistance values assigned to distance from migration corridor for mule deer.

Distance from Corridor (m)	Resistance
0-500	0.1
500-2500	0.3
2500-5000	0.6
>5000	1

Appendix 8 Table 12. Resistance values assigned to infrastructure for mule deer.

Infrastructure	Resistance
Local road	0.2
Paved Road	0.5
Mine-active	1
Mine-Inactive	1
Developed-town	1

2.5. Mule Deer RSF

Overall mule deer habitat suitability (HS_{MD}) was the product of multiplying the average of the four RSF (i.e. RSF_S, RSF_W, RSF_T, and RSF_M) and the Simpson's evenness index. Simpson's evenness was used as it shifts the final value toward the lowest value among the RSFs:

$$HS_{MD} = \text{average}\ \{RSF_S, RSF_W, RSF_T, RSF_M\} \times \text{Simpson's Index of Evenness}$$

$$HS_{MD} = \left(\sum_{i=S,W,T,M} RSF_i/N\right) \times \left(1-\sum_{i=S,W,T,M} p_i^2\right)/(1-1/N)$$

where p_i is the relative value of the RSF_i: $p_i = RSF_i / \sum_{j=S,W,T,M} RSF_j$ and N = 4 RSFs.

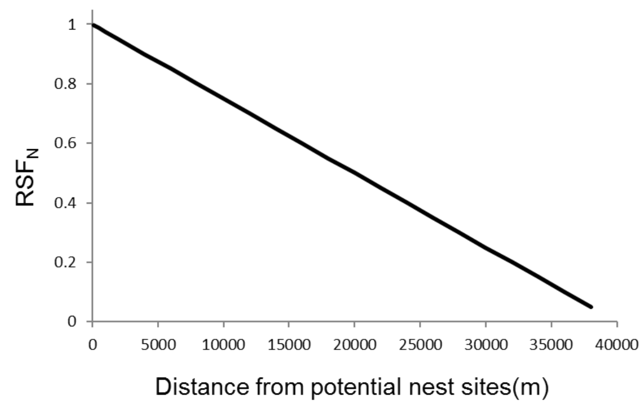
3. Golden Eagle Habitat Suitability

Heuristic resource selection functions (RSFs) for golden eagle were developed with help from biologists at USFW, NDOW, and Great Basin Ecology, Inc. In addition to consultation with these experts, all equations were vetted at a workshop in Elko, NV September 29th – October 1st, 2015. RSFs were categorized into 3 categories: potential nest sites, amount of deep soil, and alternative prey. For moving window analyses, a window of 3750m was used. This distance corresponds with the mean travel distance for golden eagle kills in the Snake River Birds of Prey National Conservation Area (Marzluff et al. 1997).

3.1 Potential nest sites

3.1.1 Distance to potential nest sites (RSF_N) - Calculated as the distance to potential nest sites from a given pixel. Golden eagles generally nest in cliff faces or rock outcrops (citation). Additionally recent field observations have found golden eagle nests in old growth pinyon and juniper (C. Nicolai, pers. comm.). In order to model potential nest sites, two rasters were generated. First, location of cliffs was mapped. Slope was derived from a 60 m resolution DEM. Slopes greater than 30° were used to delineate potential cliff faces. Given the course resolution of the DEM, 30° was used as this was lowest slope which encompassed the majority of known golden eagle nests in the NDOW database. The second raster was created by mapping old growth juniper classes. This included the Late:Open class in the Juniper Woodland ecological system; this system was absent from the IL. Once the rasters were merged together and distance to potential nests was calculated, a negative linear relationship was used to model the RSF:

$$RSF_N = 1 + (\text{dist. from nest}*-0.000025)$$

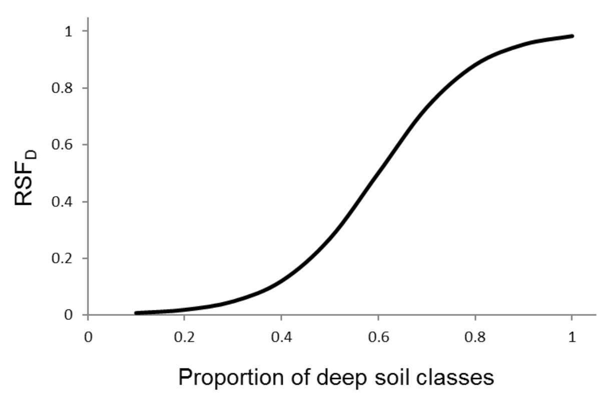


Appendix 8 Fig. 12. Resource selection function for potential nest sites for golden eagles.

3.2 Amount of deep soil

3.2.1 Proportion of deep soil (RSF_D) - calculated as the proportion of deep soil surrounding a pixel within the moving window. This variable is used as a proxy for black-tailed jackrabbit abundances, a primary food source for golden eagles in the Intermountain West (Collopy 1983). All vegetation classes within each ecological system were given a value of 0, 0.5, or 1.0 (Appendix 8 Table 13). A value of "1.0" represented deep soils, while "0.5" represented moderately deep soils. A sigmoidal relationship was used to describe the RSF:

$$RSF_D = e^{10*(\text{prop. deep soil} -0.6)} / (1+ e^{10*(\text{prop. deep soil} -0.6)})$$



Appendix 8 Fig. 13. Resource selection function for amount of deep soils. Deep soils were used as a proxy for black-tailed jackrabbit abundance within a 3750m radius

Appendix 8 Table 13. Ecological systems that were assigned a value for deep soils. Systems not shown were given a value of "0". "1" indicates a deep soil; "0.5" indicated moderately deep soils. Note all classes within these systems were given the values shown.

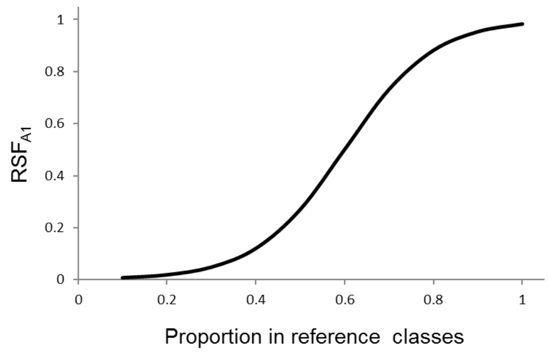
Ecological systems	Deep soil value
Agriculture	1
Basin Wildrye-bottomland	1
Basin Wildrye-montane	1
Big Sagebrush-semidesert	1
Big Sagebrush-upland no trees	0.5
Big Sagebrush-upland+trees	0.5
Black Sagebrush	1
Four-Wing Saltbush	1
Greasewood	1
Mixed Salt Desert	1
Moist Floodplain	1
Montane Riparian	1
Saline Meadow	1
Subalpine-Upper Montane Grassland	1
Wet Meadow-bottomland	1
Wet Meadow-Montane	1
Winterfat	1

3.3 Alternative Prey

To model the presence of prey other than black-tailed jackrabbits, 3 variables were used at IL and 4 variables were used at TSHS, ($RSF_{A,\,i}$, i = 1, 2... 4).

3.3.1 Proportion of alternative mammal habitat (RSF_{A1}) – calculated as the proportion of pixels in reference classes and other acceptable classes within the moving window. This was calculated to estimate non-jackrabbit mammalian prey, such as ground squirrels. In years when jackrabbit populations decrease, golden eagle often supplement their diet with the other mammalian prey. In addition to reference classes for all ecological systems, included classes were both introduced and native seeded classes and pastures in Basin Wildrye systems. The same equation was used for proportion in reference class as proportion of deep soils:

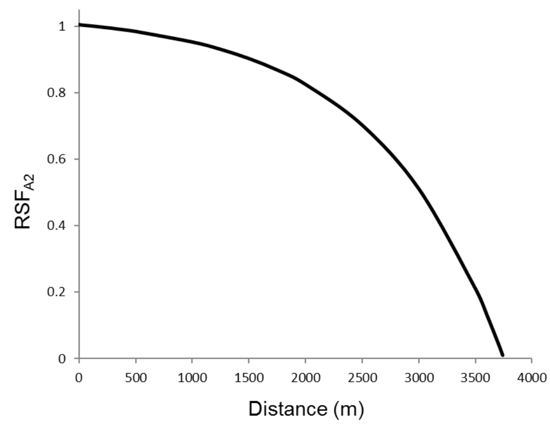
$$RSF_{A1} = e^{10*(\text{prop. alt. mammal -0.6})} / (1+ e^{10*(\text{prop. alt. mammal -0.6})})$$



Appendix 8 Fig. 14. Resource selection function for proportion in reference class. This included reference, seeded, and Basin Wildrye pasture classes. This variable was used as a proxy for non-black-tailed jackrabbit mammal abundance within a 3750m radius

3.3.2 Distance to chukar habitat (RSF_{A2}) – calculated as the distance from a pixel to the nearest chukar habitat pixel. The ecological system Montane Riparian was used to designate chukar habitat. Recent field observations have indicated that in golden eagles may hunt chukar opportunistically in central Nevada (C. Nicolai, pers. comm.). A decreasing curvilinear function was used (note all distances greater than 3750 were given a value of 0):

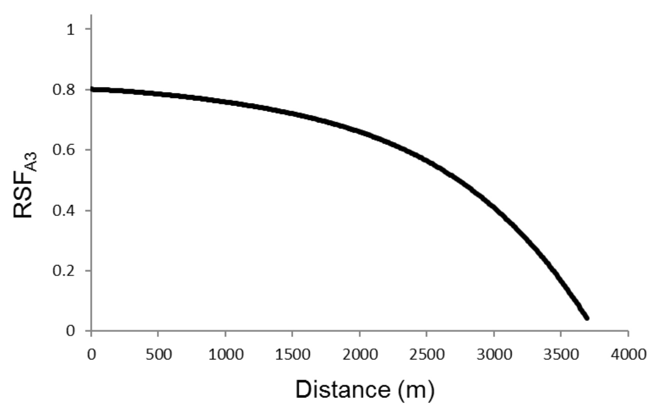
$$RSF_{A2} =1.04-(1.04*e^{(0.0009*(\text{dist. chukar-3750})}) /(1+e^{40*(\text{dist. chukar -3750})})$$



Appendix 8 Fig. 15. Resource selection function for distance to chukar habitat.

3.3.3 Distance to road (RSF$_{A3}$) – calculated as the distance from a pixel to the nearest road pixel. This variable was used to incorporate roadkill as a potential food source. The RSF was limited to a maximum of 0.8 to model the increased mortality risk from vehicle collision. A decreasing curvilinear relationship used:

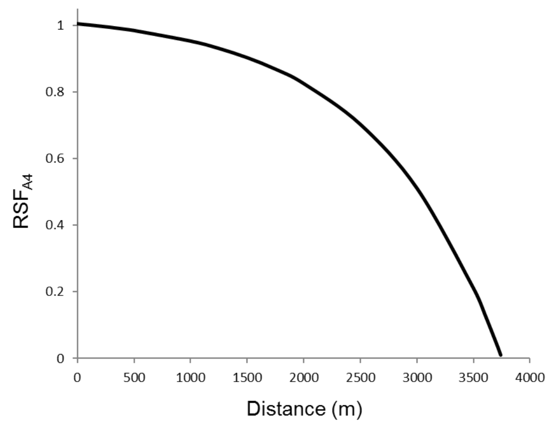
$$RSF_{A3}=0.83(-0.83*e^{0.0009*(\text{dist. to road}-3750)})/\,(1+e^{40*(\text{dist. to road }-3750)})$$



Appendix 8 Fig. 16. Resource selection function for distance to the nearest road. Roads were considered sources for roadkill.

3.3.4 Distance to calving grounds (RSF$_{A4}$) – calculated as the distance of a pixel to the nearest early season grazing pixel. This variable was only used at IL, where calving and early season grazing alternate between two pastures. Golden eagles are known to feed on cattle afterbirth and will often congregate in areas where calving commonly occurs. The same RSF equation used for chukar habitat was applied to distance to calving grounds:

$$RSF_{A4} = 1.04-(1.04*e^{(0.0009*(\text{dist. calving}-3750)}) /(1+e^{40*(\text{dist. calving }-3750)})$$



Appendix 8 Fig. 17. Resource selection function for distance calving grounds.

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