Market Based Approach for Restoring Rangelands and Critical Wildlife Habitat in the Sagebrush Biome

Conservation Innovation Grant

Cooperative Sagebrush Initiative and Ecosystem Management Research Institute

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Descriptions of Demonstration Projects

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Introduction

The Cooperative Sagebrush Initiative (CSI) is a collaborative effort of landowners, government agencies, industry, academia, and conservation groups whose purpose is to provide leadership, coordination, and funding for sagebrush conservation and recovery. CSI has a primary objective of maintaining and improving sagebrush ecosystems and, in so doing, providing for sagebrush associated species such as sage-grouse. CSI has recognized that mitigation, especially associated with energy production activities will be important for maintaining sagebrush ecosystems. Mitigation of energy developments can occur both on-site and off-site. A challenge in the use of off-site mitigation is assuring that ecosystem services, including wildlife habitat for sagebrush-associated species, produced by off-site mitigation are commensurate with on-site impacts. If benefits produced by off-site mitigation can be quantified and shown to be equivalent to impacts from developments or other activities, then it may be possible to develop a credit trading system where landowners or agencies may produce benefits that industry or other developers would be willing to purchase to replace resources lost on-site through their development activities. CSI members were interested in such a credit trading system, but required a reproducible and defensible tracking system based on appropriate ecosystem service metrics in order for it to be potentially implemented. This project was initiated to develop and evaluate a metric system for mitigation in sagebrush ecosystems and to further evaluate the potential for development of a mitigation credit trading system based on the metrics. The proposed metric system relied on the use of ecological sites as classified and described by the Natural Resource Conservation Service as a basis for assuring equivalency of sagebrush ecosystems and ecosystem services. The system also used an evaluation of wildlife habitats to evaluate equivalency of benefits and impacts at landscape scales.

In this report, scientific names of all species are included in Appendix C. The report summarizes findings in the main body, and includes more detailed data and maps in Appendices.

Objectives

The objectives of this project were to:

- Report on the effectiveness of NRCS ecological sites as a basis for mitigation metrics of ecosystem services,
- Test a market-based offset system within working landscapes across western states,
- Develop opportunities for producers to realize economic benefits from habitat management practices on private and grazing permit lands by accruing merchantable credits while maintaining and enhancing forage productivity,
- Engage western industry, agriculture, conservation groups, and state and federal agencies in a new economic relationship,
- Create demonstrations of habitat and species credit trading arrangements with broad applicability to other regions and resource sectors, and
- Test and evaluate the capacity of market based incentives to recover populations of declining species.

Metric System

The metric system used in this project requires that impact and mitigation sites be compared at both the site and landscape scales to assure that sagebrush ecosystem services and sagebrush-associated wildlife species are commensurately mitigated. The initial conceptual framework for the metric system was described by Haufler and Suring (2008) as follows:

"The basic framework for quantifying services lost at impact sites and gained at mitigation sites requires assessments of the following:

1. The *existing level* of services provided at the impact and mitigation sites prior to the initiation of development and mitigation activities. These services are considered to be influenced by both the characteristics of the specific impact and mitigation sites as well as the surrounding landscape;

2. The *resulting level* of services expected at the impact and mitigation sites after the impact development and mitigation activities are carried out, considering both site and landscape effects;

3. The *duration* of the change (or period of time over which a change in services occurs) at the impact and mitigation sites; and

4. The *length of time* before the mitigation is expected to be fully successful at the mitigation site.

By assessing the above factors, it should be possible to design a metric system that allows consistent quantification of mitigation required to offset expected impacts from a broad range of development activities. The basic units proposed to quantify benefits associated with mitigation activities or detriments associated with development impacts are really a variety of ecosystem services lost or gained over time. They are calculated in the same manner, so that a "credit unit" has an equal, but opposite, value as a "debit unit." Thus, the benefits of credit units produced are intended to fully and specifically offset the detrimental debit units from a development."

"In the case of the sagebrush biome, the number of credit units or debit units associated with any activity should be a function of the following factors:

1. The area affected by the activity;

2. The ecological sites occurring in the affected areas;

3. The existing conditions within the area (essentially a measure of quality evaluated relative to a baseline);

4. The extent of change (positive or negative) caused by the activity relative to the existing conditions;

5. The spatial or landscape context in which the area is located (related primarily to habitat quality for selected species); and

6. The timing and duration of the expected change."

This metric system relies on NRCS ecological sites as an underlying framework to ensure that ecosystem benefits produced by off-site mitigation are similar to those being impacted by energy or other developments. The metric system measures impacts and mitigation benefits based on comparisons to native sagebrush ecosystems for each ecological site, and incorporating changes to conditions for wildlife species assessed at landscape scales. Haufler and Suring (2008) described the use of ecological sites for this purpose.

"The area affected must be characterized in terms of its existing and inherent (potential) conditions. Natural Resources Conservation Service (NRCS) ecological sites (http://esis.sc.egov.usda.gov/) provide a classification system that can facilitate identification of biotic and underlying abiotic drivers of ecosystem diversity that could provide consistency for measuring ecosystem services and thus mitigation benefits. Ecological sites classify areas that have similar soils and other abiotic and biotic conditions within defined precipitation zones within a Major Land Resource Area (MLRA). MLRAs are geo-climatically defined areas delineated by NRCS that have been mapped for the entire U.S. (NRCS 2006, http://soils.usda.gov/survey/geography/mlra/). Ecological site classifications have been developed for most MLRAs, with ecological site descriptions developed for each specific ecological site within these MLRAs. These sites are linked to soils, and are therefore mapped wherever NRCS soils mapping has occurred.

For each ecological site, various plant communities described as specific "states" *(may be termed either states or plant communities*) as influenced by natural or anthropogenic disturbances have been identified. The dynamics of these plant communities or states are incorporated into a state and transition model for each site. Changes among states are defined as "transitions," with some changes crossing "thresholds" that may make transition back to a prior state difficult (Friedel 1991, Laycock 1991). Various states that might occur on each ecological site have been described in ecological site descriptions (ESDs) for most MLRAs in the Rocky Mountain West, with work proceeding on those areas not yet completed. Descriptions of states for a specific ecological site should include all of the states that occurred historically under historical disturbance regimes (historical states), and other states produced as a result of recent (post-European settlement) anthropogenic influences including introduction of exotic species (anthropogenic states). Past influences of Native Americans are incorporated as part of the historical states. Some ecological site descriptions have not included descriptions of the full range of historical states and transitions, so these may need further development for some MLRAs. A full state and transition model for an ecological site should include descriptions of all

of the states that occurred historically as well as any currently common states produced by anthropogenic influences.

Use of ecological sites as defined by NRCS assures that ecosystem services are being considered in equivalent locations having similar abiotic environments. For example, two loamy ecological sites within the same MLRA and precipitation zone should have the potential of supporting similar states with similar potential productivity and thus have the potential to contribute similar ecosystem services. The services they are producing at any time will be determined by the existing plant community occurring at that time, but the potential of loamy sites should basically be the same. A saline upland ecological site in the same MLRA and precipitation zone would have different plant communities or states associated with it than the loamy ecological site, as the different soil properties favor the occurrence of different plant species and support different productivity, growth rates, and other factors. While both may contribute some similar ecosystem services, such as contributing to the habitat of a certain species, they are

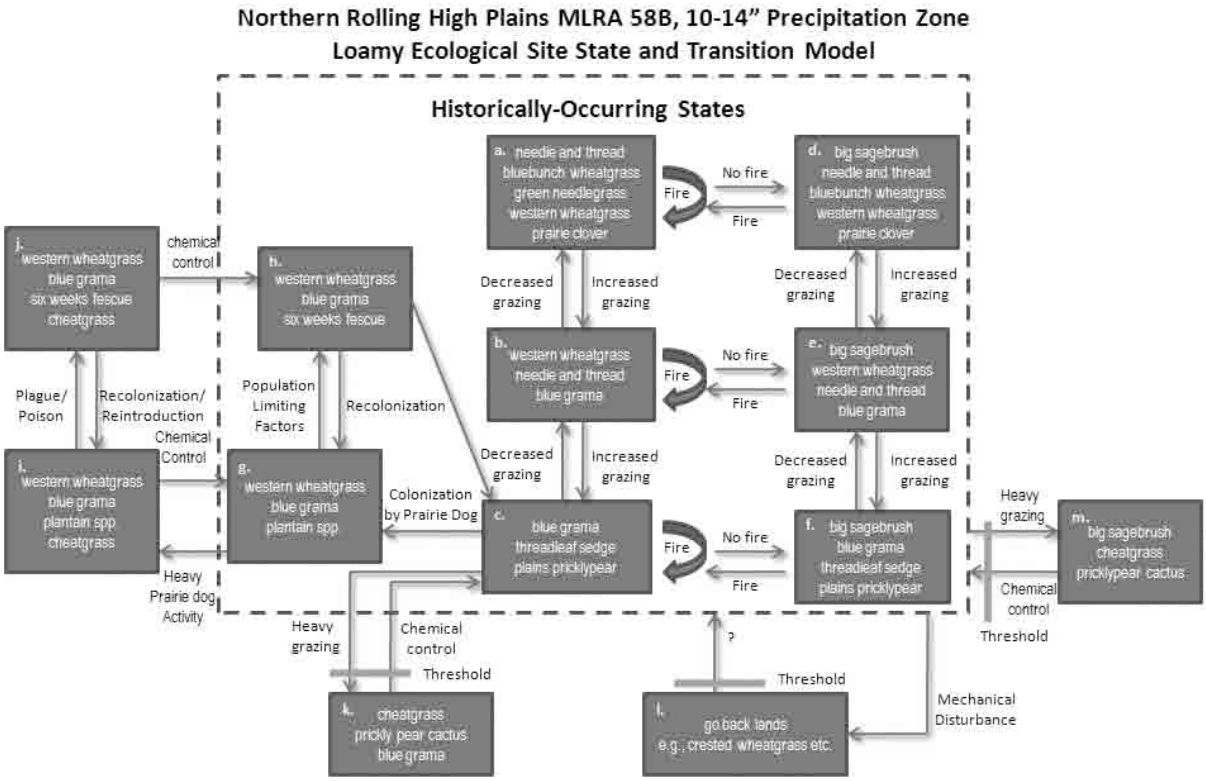

Figure 1–State and transition model for loamy ecological sites within the 10-14" precipitation zone of MLRA 58B, the Northern Rolling High Plains. States identified outside of the dashed box did not occur historically but rather are the result of recent anthropogenic changes.

inherently different in their compositions, productivity, and other factors. For any one ecosystem service, such as habitat for one species of interest, it may be possible to measure the contribution of existing conditions for that one ecosystem service. However, other ecosystem services provided by the site, for example grazing productivity, will be inherently different, so

that if the goal is to produce a system that tracks equivalent credit or debit units for a suite of ecosystem services, then use of ecological sites can help assure that equivalent services are capable of being provided. Other ecological classifications could serve a similar function. However, other systems are not currently available within the sagebrush biome that consider underlying site potential with the same level of development, mapping, and acceptance by potential users as the NRCS ecological site classification system.

Ecological sites within an MLRA and precipitation zone have been described by NRCS in its ESD process (http://esis.sc.egov.usda.gov/). While ESDs have been prepared for many MLRAs within the sagebrush biome, others are still being prepared. NRCS has indicated that completing the ESDs is a high priority, and these should be available in the near future. Where ESDs are lacking, developers can produce their own descriptions of ecological sites if they have the appropriate knowledge of the ecology of the area. Each ESD provides descriptions of the site, its plant compositions and productivity, soils, and an array of other characteristics. In areas where soils have been mapped, the specific ecological sites occurring on an impact or mitigation area will also be available on a map. In areas where soils have not been mapped, on-site sampling will be needed to determine the specific ecological sites of the impact and mitigation areas based on the soils present in these areas."

While ecological sites form the underlying framework for quantifying credits and debits at mitigation and development sites, actual characteristics of existing or resulting vegetation provide the actual data driving the metric system. Sites must be stratified not only by ecological sites, but also by differences in existing and resulting vegetation. By characterizing these conditions in comparison to reference communities developed for each ecological site, the metric system determines the gains or losses associated with impacts or mitigation at the site level.

Landscape level comparisons assess the overall value of impact and mitigation areas to selected species of concern, and include consideration of total available habitat and cumulative human impacts. Development impacts and mitigation benefits to wildlife species on two sites that have the same ecological site and similar existing plant communities may differ from each other because of landscape influences. Surrounding plant communities, terrain, human developments, or other land characteristics may influence the value of each site to a particular wildlife species and result in different effects. Wildlife population responses may also differ due to different range distributions , presence of competing species, or other factors. For these reasons, landscape level analyses are important to use as potential modifiers to site level metrics. Various methods are potentially available for modeling habitat responses at the landscape level (Beck and Suring 2008). In this metric system, we used an approach to habitat modeling termed habitat based- species viability (Roloff and Haufler 1997, 2002) to compare species responses to habitat changes resulting from impact or mitigation.

Methods

Project locations

The metric system was tested at 7 different sites where mitigation treatments were applied. A map of these locations is shown in Figure 2. At each location, monitoring was conducted pretreatment and then repeated for 1-3 years post-treatment, depending on when during the project the treatments occurred.

Figure 2. Locations of 7 project locations where mitigation treatments were conducted and monitored using the mitigation metric system.

Site level methods

At the site level, the metric system required the following data, information, and analytical tools for determination of changes to ecosystem services as a result of project impact or mitigation practices:

- A map of ecological site(s) for impact and/or mitigation areas,
- Description of existing plant communities (pretreatment and post-treatment) occurring on each ecological site in impact and mitigation areas including the cover of all plant species present, and
- Description of reference plant communities for each ecological site in each project area.

For each project area, soils maps were obtained from NRCS data sources. In addition, Ecological Site Descriptions (ESDs) were obtained, where available. Existing vegetation on each project area was mapped using NAIP imagery (air photos) coupled with selected on-the-ground mapping using GPS units.

Vegetation sampling was conducted at each project site. Vegetation was sampled at replicated plots that were placed using stratified random sampling. GPS points were randomly generated in a GIS for each ecological site/vegetation class to be sampled. Plots were located and sampled from the generated GPS points unless the plot was determined to not be in the designated conditions (i.e. ecological site was not what was mapped, or site was recently disturbed). At each point, a 30 transect was delineated, as was a 15m X 25m macroplot (Figure 3).

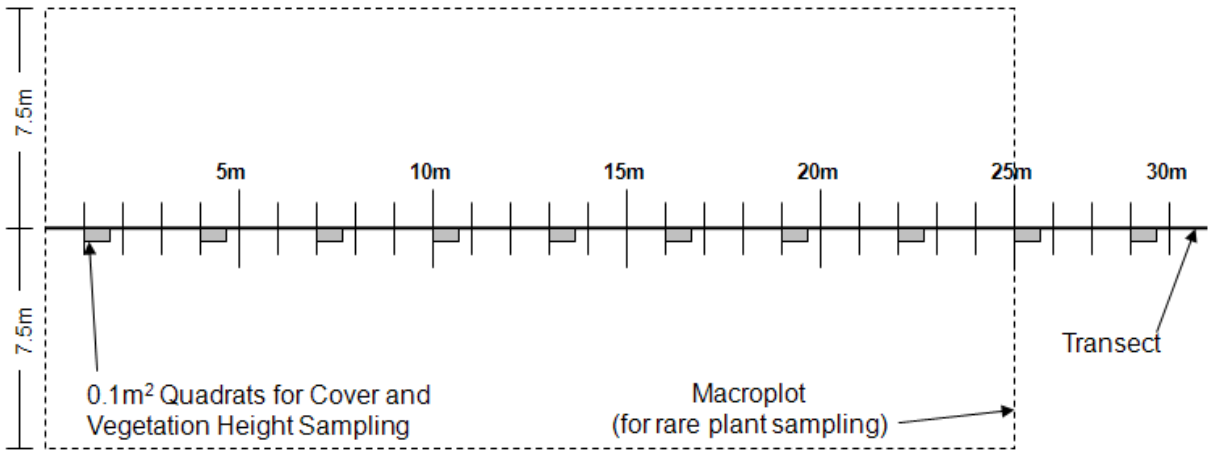

Figure 3. Diagram of plot layout used for vegetation sampling including the 30m transect for line intercept of wood vegetation, the 15m X 25M macroplot for rare plants, and the placement of small quadrats (Daubenmire frames) for vegetation cover and height measurements.

At each plot the following information was recorded: date, GPS location, county, MUSYM (NRCS soil name), soil texture, ecological site, elevation, slope gradient, and slope complexity. A 30m transect was staked out and sampling was conducted along this transect. A series of $0.1m^2$ quadrats (Daubenmire frames) located 3 m apart were sampled using ocular estimates for cover of each species of vegetation for a total of 10 quadrats per transect. A minimum of two photographs were taken of each plot, one looking out along the transect, and one looking down at the first Daubenmire plot. A macroplot (15mX25m) was delineated and sampled for the

occurrence of rarer species as well as the density of woody vegetation >1" DBH recorded in 1" diameter classes. Cover of woody vegetation less than and greater than 1m in height was recorded by species along the 30m transect using the line intercept method. Height of each type of vegetation (grasses, forbs, woody vegetation) was recorded at each of the quadrat locations. Some of the vegetation sampling was conducted by EMRI, while some was conducted by partners involved in a specific project site.

Plant communities were sampled in treatment areas prior to treatment, and then from 1-3 years post-treatment, depending on the timing of treatment during the three years of the project. Changes to plant compositions were calculated for each treatment area stratified by ecological sites. In addition, statistical analyses of changes to specific plant species were conducted using the pre and post-treatment data compared using the repeated multi-year sampling of each plot compiled for each ecological site in each treatment area.

For each ecological site occurring on each treatment area, a state and transition model of historically-occurring states or plant communities was developed (see Figure 1 as an example). This model identified the different plant communities that could have been present in response to fire, grazing, and the interaction of these two disturbances. A detailed description of each plant community was then developed. The description included the dominant plant species, other plant species expected to be found in that plant community, and estimates of productivity of herbaceous vegetation. Using this information, a specific disturbance response state was selected for use as a reference community. The description of the plant composition of this community was used to develop a similarity index. The similarity index was used to evaluate the compositions of existing vegetation, both prior to mitigation and post-mitigation, for each project area. NRCS (2006) has used similarity indices for comparisons of plant communities in relation to what they term the historical climax plant community (HCPC). Our state and transition models identified and described multiple plant communities or states that occurred historically. We selected the long fire return interval/light grazing historical plant community for use as a reference plant community. This plant community was selected as the reference community because it:

- included sagebrush as a post fire condition which was a desirable feature by most sagebrush-associated species,
- included a diversity of grasses and forbs not found on sites with heavier grazing utilization, and
- is typically the least well represented plant community in comparison to estimated historical amounts of the different plant communities present in the landscape.

Other plant communities could be selected in place of the selected plant community with sufficient justification as to why they should be used as the reference plant community.

We compared existing plant communities to the composition of the selected reference plant community using a similarity index. We modified the calculation of the similarity index used by NRCS (2006) in several ways. First, we allowed a range of values of selected groupings of plant species to contribute to the similarity score, rather than only 1 maximum value to allow for a greater range of possible plant compositions that could be considered desirable. For example,

for a particular ecological site and reference historical plant community, we might allow sagebrush to contribute up to 30% of the relative cover, site specific grass species that occur under light grazing conditions up to 50%, generalist grass species that occur across moderate grazing conditions up to 40%, increaser grass species under greater grazing intensities up to 10%, native forbs up to 20%, selected increaser forb species maximized at 5%, and other woody species allowed up to 5%. This then adds up to 160%, where the maximum plant composition in a similarity index can be no more than 100%. We put the maximum score of a plot at 100%, adjusting the plot down to this level if its score exceeded 100%. Further, we defined desired conditions that must have been met for a plot to reach the highest scores. For example, at least 15% of the score must be sagebrush (if the plot only had 5% sagebrush, then its maximum score would be 90%, regardless of the other vegetation present). Grass species indicative of light grazing must have at least 10% relative cover for the site to receive a similarity score of 100%, and similarly desirable forbs were assigned a minimum value of 10%. Thus, while various combinations of plant species could contribute to the similarity score, certain characteristics must be present for any plot to achieve high similarity values. An example of the calculation of a similarity index is shown in Table 1.

In addition to quantifying the contributions of native species in similarity indices, we also rated each plot for amounts of exotic species. Exotic species exhibited an effect in two ways. First, they contributed to the relative cover of a plot, but would not contribute to the similarity index, as only native species could count in the calculation in similarity scores. Second, we applied an exotic species deduction based on a curve we developed to show the relationship between level of exotic species and potential site integrity (Figure 4). We could not find suitable data to empirically derive a curve that measured ecological integrity of a plant community in relation to the total level of exotic species, so we developed a curve that we thought was a good initial hypothesis of this relationship. More research on the relationship of level of exotic species to both ecological integrity and ecosystem services of a site is needed.

Table 1. Example of the calculation of a similarity index for a loamy ecological site in the Fidelity project area in northeastern Wyoming. Ref % refers to the maximum amount that a grouping of species can contribute to the similarity index. Min and Max refer to the minimum amount that each species group must contribute for a plot to have a value approaching 100%, and the maximum total that the combination of groups can contribute towards the similarity score. Actual percentage is the relative cover of each species for the plot, actual % sum is the summation of the species in that grouping, cutoff% lists the contribution of that species group up to the allowable Ref % and applies this maximum value for that group if a higher percentage occurred in the plot, and Similarity index % is the percentage of the appropriate plant grouping towards the similarity value of that plot. Exotic species are totaled, and the exotic species correction is calculated from the exotic species modifier shown in Figure 4.

Fidelity Loamy

Reference plants						**Site F-1**		
Common name	PLANTS Code	Ref %	Min	Max	Actual %	Actual % sum	Cutoff%	Similarity index %
silver sagebrush	ARCA13	30	**15**		0	52.3	30	30
big sagebrush	ARTR2				52.3			
Idaho fescue	FEID	50		**75**	0	6.6	6.6	15.4
green needlegrass	NAVI4				6.6			
spike fescue	LEKI2				0			
bluebunch wheatgrass	PSSP6				0			
rhizomatous wheatgrass	PASM, ELTR7, ELLAL	40			4.7	4.7	4.7	
needle and thread	HECO26				0			
blue grama	BOGR2	10			2.3	4.1	4.1	
sedges	CADU6,CAFI				0			
prairie junegrass	KOMA				1.8			
Sandberg bluegrass	POSE				0			
yarrow	ACHIL, ACMI2	20	**10**		1.9	20.84	20	20
rosy pussytoes	ANRO2				0			
ballhead sandwort	ARCO5				1.5			
milkvetches	ASTRA				0			
asters	ASTER				0			
sego lily	CANU3				0			
tiny trumpet	COLI2				0			
bastard toadflax	COUM				0.9			
hawksbeard	CRAC2,CRRU3				0.04			
prairie clover	DALEA				0			
fleabane	ERIGE2				0			
scarlet beeblossom	GACO5				0			
prairie smoke	GETR				0.5			
hairy false goldenaster	HEVIV				0.1			
prairie flax	LILEL2				0			
desert biscuitroot	LOFO				0.4			
Silverleaf Indian breadroot	PEAR6				0			
beardtongue	PENST,PEAL2				0.6			
phlox	PHLOX,PHHO				7.9			
plantain	PLANT				0.2			
scurfpea	PSORA2				0.9			
prairie coneflower	RACO3				0			
scarlet globemallow	SPCO				2			
American vetch	VIAM				3.9			
prairie sagewort	ARFR4	5			0.5	1.5	1.5	1.5
spinystar	ESVIV				0.5			
plains pricklypear	OPPO				0.5			
beaked skeletonweed	SHRO2				0			
broom snakeweed	GUSA2				0			
Wood's rose	ROWOW	5			0	0	0	0
Gardner's saltbush	ATGA				0			
								66.9
EXOTICS							Exotic Correction	
ragweed	AMBRO				0	9.5	9.5	9.5	0.936
field brome	BRAR5				6.4			
cheatgrass	BRTE				0.1			
clasping pepperweed	LEPE2				3			
field cottonrose	LOARS5				0			
tall tumblemustard	SIAL2				0			
common dandelion	TAOF				0			
yellow salsify	TRDU				0			
						SIMILARITY INDEX		**62.64**

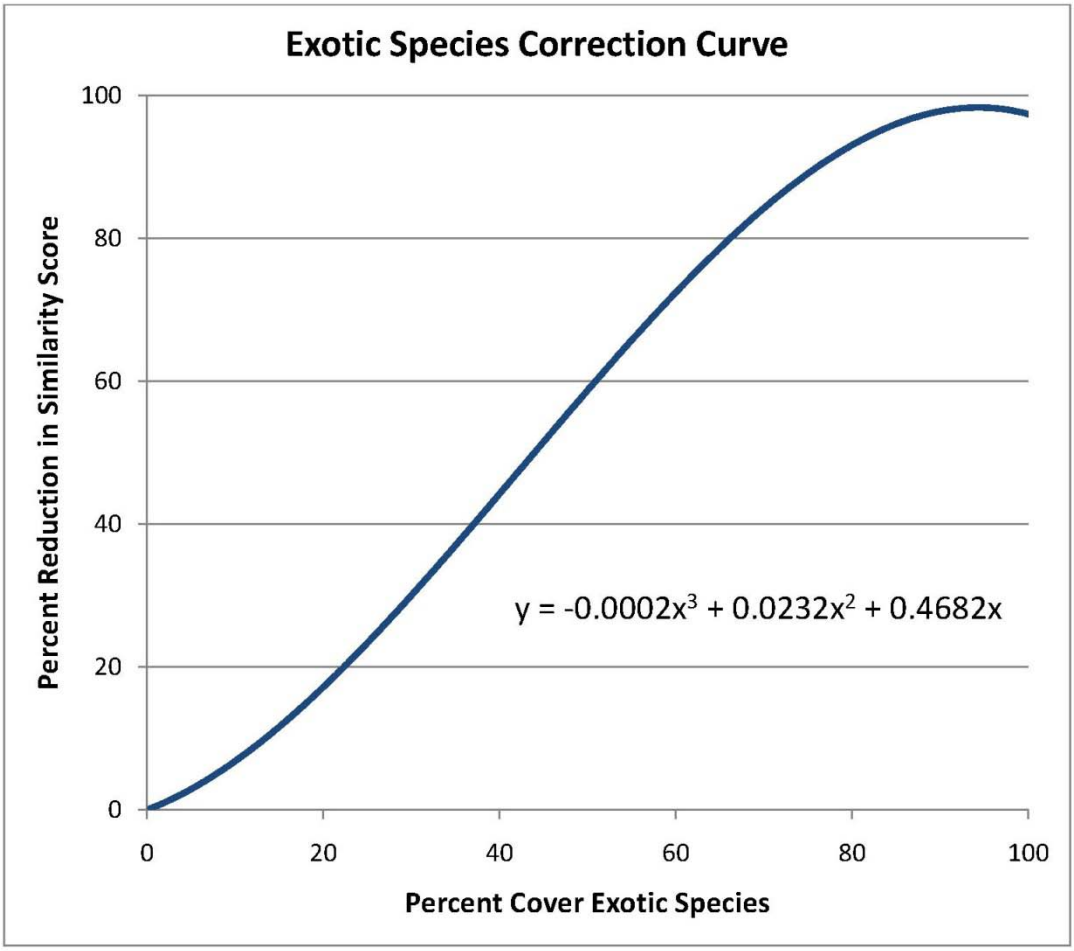

Figure 4. Curve of the estimated relationship (percent reduction in similarity index value) between the level of exotic species in a plot to the ecological integrity of the plant community represented by that plot.

Statistical analyses were run on vegetation data to compare changes between years. With each plot having repeated sampling from pre-treatment to post-treatment years, we compared values of each species with at least 1% relative cover in any year between the pre-treatment amounts and post-treatment amounts. We used both paired t-tests and the Wilcoxin non-parametric test to compare years. Significance levels were set at $P<0.05$ for reporting of results.

Landscape level methods

At the landscape level, the metric system required the following data, information, and analytical tools for determination of changes to wildlife habitat as a result of project impact or mitigation practices:

- List of wildlife species of concern to be included in the landscape analysis,

- Habitat models, including variables relating to impacts from development, for each species of concern, and
- Maps and data files that quantify the variables included in the wildlife models.

This information was collected on each of 7 project areas, and based on these data, mitigation benefits being produced by various treatments were evaluated and quantified. A total of 7 species were selected for modeling purposes. Table 2 lists which of the 7 species have current ranges that overlap with the project areas.

Table 2. Selected sagebrush associated wildlife species with current ranges encompassing project boundaries.

	Sage-Grouse	**Pronghorn Antelope**	**Pygmy Rabbit**	**Sage Sparrow**	**Sage Thrasher**	**Sagebrush Lizard**	**Sagebrush Vole**
California							
Ash Valley	X	X	X	X	X	X	X
Idaho							
Laidlaw Butte	X	X	X	X	X	X	X
Utah							
Deadman Bench	X	X		X	X	X	X
Anthro Mtn	X			X	X		
Rock Springs	X			X	X	X	X
Wyoming							
Fidelity	X	X		X	X	X	X
TBGPEA	X	X		X	X	X	X

Two landscape sizes were used for analysis. For pronghorn and sage-grouse the landscape was created by buffering the site treatment area by 5 miles. For pygmy rabbit, sage sparrow, sage thrasher, sagebrush lizard, and sagebrush vole the landscape was created by buffering the site treatment area by 1 mile.

We developed habitat suitability models for each of the 7 species based on information in the literature and applied these models to each treatment site used in this project. These models have not been peer-reviewed, but they do serve to demonstrate how habitat quality can be modeled in a consistent manner across mitigation sites, and how results from these models can be used in development of debit and credit units. We also applied a habitat-based species viability approach as an additional tool for evaluating habitat quality for the species, but recognize that various other habitat assessment approaches could be used in conducting

landscape level analyses (Beck and Suring 2008). The models and species viability approach used here demonstrate how landscape level analyses can produce reproducible and scientifically defensible results for developing a reliable metrics framework.

Our approach to habitat assessment first determines habitat quality for each species by developing a habitat potential map based on habitat suitability methods. A variety of data layers were used as inputs to create the species specific habitat potential maps. For portions of the landscape in which field data were not collected as discussed in the previous section, layers characterizing existing vegetation type, vegetation height, and vegetation cover where obtained from the LANDFIRE project (www.landfire.gov). These layers are derived from classified Landsat imagery and provide a fairly coarse map of habitat for species. The accuracy of the mapped vegetation from these layers was not evaluated in this project, although we expect that some accuracy issues exist. However, these layers do serve as a consistent vegetation map for purposes of calculating landscape metrics at each project location, and demonstrate how habitat models can be used. Accurate maps of existing vegetation are consistently one of the most limiting types of data for evaluation of species habitat. Where new or better maps of existing vegetation can be obtained, they should be substituted for the LANDFIRE maps used here.

The Soil Survey Geographic Database (SSURGO) available from the Natural Resources Conservation Service (NRCS) was used to map ecological sites for the project areas. Ecological site names were interpreted and modified by EMRI for consistency and clarity. When applicable, ecological sites were used as the basis for applying vegetation characteristics measured for the site analysis to determine habitat variables at the landscape scale.

These four input layers (vegetation type, vegetation height, vegetation cover, and ecological sites) were combined (intersected) to create layers with a large number of unique combinations. This meant that any given point (or cell) in the modeling area would have a call from each of the four layers. Secondarily, a list was generated of the unique variables for each of the four layers. For the vegetation height and vegetation cover layers, these were interpreted from the measured values collected in the field for height and percent cover classes, while for the vegetation type and ecological site layers were derived directly from the mapping layers.

For each unique variable combination, a habitat suitability index (HSI) score was assigned or calculated for each species of interest. For measured values such as canopy cover and height the appropriate HSI curve for each species was applied to calculate an HSI score for that value. Scores for non-measurable variables such as vegetation type and ecological site were assigned based on general information derived from sampled plot data. The scores for each species were combined using a geometric mean to calculate the final HSI score for each intersection of conditions. For areas within the scope of the site level analysis, HSI scores were calculated based on habitat variables measured in the field and stratified across ecological sites.

Based on the species' HSI values for each cell, a habitat quality grid was developed in ESRI® ArcInfo 9.3.1 for each species. This grid displayed general habitat quality of the landscape for each species. Due to the scale of input data the grid cell size was 30 m. The resulting grid depicted habitat suitability for the species of interest under existing habitat conditions.

Based on the habitat potential map, the number and quality of potential home ranges for each species were then mapped using the habitat based species viability approach. Each potential home range of a species was "grown" in a GIS analysis by randomly selecting a starting point of a single cell with the highest habitat quality that had not already been incorporated into a home range, and building a new home range that was grown in the GIS until it acquired an adequate amount of resources for a territory of the species to exist. Each identified home range was then evaluated for its resulting habitat quality based on how far each territory was spread out to obtain the required resources to survive and/or reproduce. Each identified home range was given a resulting value, and placed in a high, medium, low, or very low category. Home ranges for each species were modeled using the final HSI grids and the program HOMEGROWER. HOMEGROWER aggregates required elements into appropriate sized home ranges for each species within the planning landscape. Each species has minimum and maximum home range sizes that it will utilize. The quality of the habitat elements required by a species contained within a delineated home range determines the quality of that home range for the species. The quality of each potential home range delineated by HOMEGROWER is evaluated based on the amounts and distribution of the required habitat elements for the species occurring within each home range. This process has been described by Roloff and Haufler (1997, 2002).

HOMEGROWER works by placing starting points, or seeds, throughout the landscape. The starting number of seeds varies by species and landscape size, but enough are needed to insure that all high and medium quality habitat areas are occupied. This is because the species viability component assigns high viability associated with higher quality home ranges, and lower viability with lower quality home ranges. If enough high quality home ranges followed by medium quality home ranges occur, it doesn't matter if additional low quality home ranges also occur- the species should do well in the landscape. If only low quality home ranges exist for the species, then the viability of the species will have a much lower probability in the landscape. While exact probability estimates for each species in the landscape are not computed, comparisons of amounts of high, medium, and low quality home ranges can be done between pre-treatment and post-treatment landscapes and a determination of the likely response in terms of general viability potential of the species to management actions can be predicted. This comparative approach to viability assessments, as opposed to efforts to directly estimate probabilities, has been recommended as the most supportable way of using viability assessments (Beissinger and Westphal 1998, Ralls et al. 2002, Samson 2002, Beissinger et al. 2009).

From each seed, HOMEGROWER builds home ranges by evaluating the cells around the seed and growing the home range into the cells of highest quality. Cells are accumulated until the growth target, expressed as total HSI scores for that species has been met. HSI scores are

tallied based on area multiplied by the habitat quality for each pixel that is added to the home range. The target for each species is based on a multiplier of its allometric home range. Allometric home ranges are the estimated minimum area that a species could occur in based on its estimated metabolic requirements. For large mammals and reptiles, due to low metabolic rates, we assigned target values as 2x the allometric home range. For small mammals, with increasing metabolic rates, we assigned target values as 5x the allometric home range. For birds, with their high metabolic rates and greater movement capabilities, we assigned target values as 10x the allometric home range.

For example, if a bird had an allometric home range of 10 acres, its targeted home range requirements would be 100 acres or 100 HSI units. This could be met with a home range of 100 acres if all units in that home range contributed 1.0 in HSI value, and would receive an overall home range quality of 1.0, and then be designated a high quality home range. However, this rarely occurs in the real world. Home ranges are typically comprised of patches of habitat for the species of varying quality. HOMEGROWER builds home ranges for a species by starting with a single cell of the highest quality in the landscape that has not already been included in another home range. It then grows by aggregating cells of the next highest quality until it has acquired the HSI units desired for the species, in this case, 100 units. An upper threshold of size is set, beyond which HOMEGROWER ceases attempting to build a home range if the distances become too great to be utilized by the species. If in this example, HOMEGROWER identified a potential home range that took 190 acres to reach its target, it would be mapped as a home range, assigned an average HSI value of 0.53, and would be designated a medium quality home range. This process is repeated for the number of starting seeds identified for the species. If the number of seeds has quantified all of the high, medium, and low quality home ranges, then the number of initial seeds is deemed sufficient to assess the landscape quality for that species.

This analysis produces a map of home ranges of varying quality distributed across the landscape for each species. High quality home ranges are assumed to have high rates of occupancy, support high reproductive rates, and have high survival rates, thus providing good demographic support of the population of the species (Roloff and Haufler 2002). Kroll and Haufler (2006) documented this to occur for occupancy rates and reproductive rates using empirical analysis of dusky flycatcher habitat in Idaho.

Because HOMEGROWER uses a random selection of the highest quality pixels available, it has a stochastic component. Therefore, we ran 3 separate iterations of HOMEGROWER for each species, and averaged the values generated for numbers of home ranges. There was very little difference among the 3 runs for any species, so we determined that additional runs were not warranted. Runs were conducted for the entire landscape based on pre-treatment and post-treatment conditions.

The specific habitat suitability models developed for each species are included as Appendix A.

Reports on Each Project Area

The 7 different project areas and the results of treatments at both the site and landscape levels are summarized. Detailed results including maps of habitat assessments at the landscape level are included in Appendix B.

Fidelity Project, Northeastern WY (Seven Brothers East Ranch Sagebrush Improvement Project)

The Seven Brothers East Ranch is a 3105 acre property owned by Fidelity Exploration & Production Company (Fidelity) in Sheridan County, Wyoming. The current use of the property is grazing through a lease to David Kane, a neighboring rancher. The property supports an active sage-grouse lek that in 2008 supported 14 males, and also supported an active sharp-tailed grouse lek. The property consists of a mosaic of grasslands and sagebrush, with scattered patches of shrubs in some of the draws. Much of the area has been invaded by cheatgrass, field brome, and clasping pepperweed. The property also has a substantial invasion of leafy spurge, primarily in some of the draws. Thus, the property supports a sagebrush ecosystem, but is in reduced condition and at considerable risk because of the level of invasive species. A good diversity of native grasses and forbs is present, but these are suppressed in many areas by the invasive species. Greater amounts of sagebrush cover could be encouraged, as the current density of sagebrush is low relative to the needs of sage-grouse and other sagebrush-obligate species. However, the presence of the active lek is an indicator that sagebrush densities are at least adequate to support various sagebrush-affiliated species. Figure 5 displays NAIP imagery of the treatment portion of this property and the location of the active sage-grouse lek.

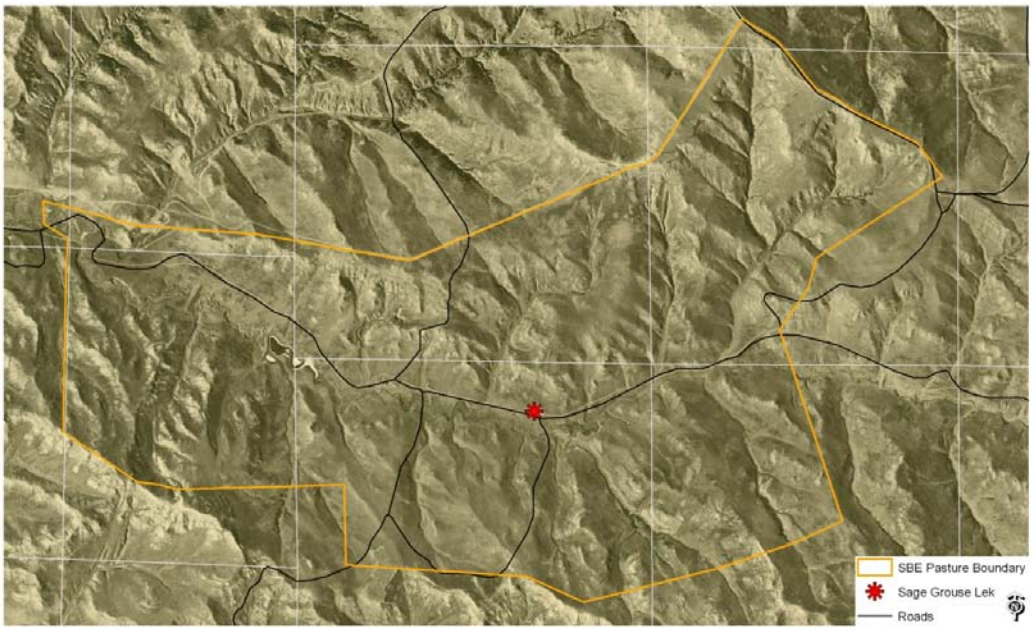

Figure 5. NAIP imagery of the Seven Brothers East Ranch treatment pasture showing the location of the active sage-grouse lek.

In 2009, 12 vegetation plots were sampled in the 2 predominant ecological sites in this project area, loamy sites and shallow loamy sites. The location of these plots is shown in Figure 6. Repeat sampling of these plots occurred in 2010 and will be repeated in 2011.

The Fidelity property occurs in Major Land Resource Area (MLRA) 43B, the Central Rockies, and in the 15-19" precipitation zone for this MLRA. Ecological sites in the treatment area of the property are shown in Figure 6. The primary drainage through the pasture includes the lowland ecological site, but this was not targeted for treatments. In addition, a small amount of the very shallow site occurs in the pasture, but this didn't include enough area to be addressed as a separate ecological site.

The climate and other characteristics for this area has been described in the NRCS ecological site descriptions for MLRA 43B. "Annual precipitation ranges from 15" to 19" per year. May is generally the wettest month. July, August and September are somewhat drier with daily amounts rarely exceeding one inch. Snowfall is quite heavy in the mountainous area. Annual snowfall averages close to 70 inches." "The growing season for the cool season plants will generally start about April 15 to May 1 and continue to about October 10."

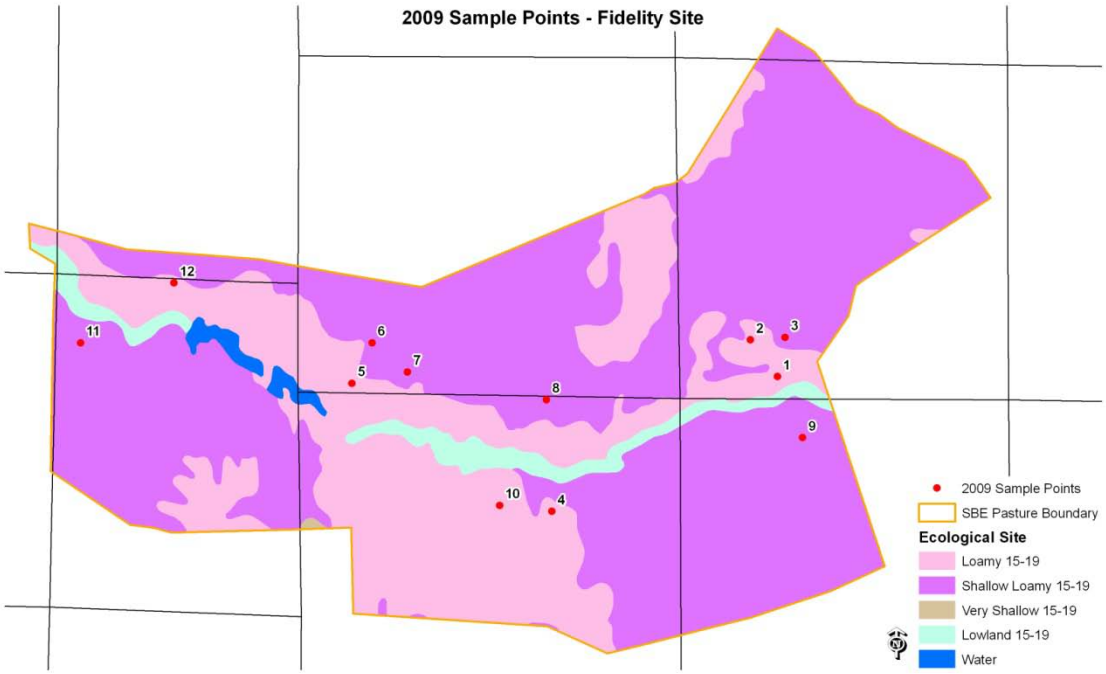

Figure 6. Ecological sites and vegetation sampling point locations for the treatment pasture of the Fidelity Seven Brothers East Ranch project area in northeastern Wyoming. Treatments were targeted at the Loamy and Shallow Loamy 15-19" precipitation zone ecological sites.

Reference Community Development

Reference conditions for the 2 primary upland ecological sites being treated (loamy and shallow loamy) were developed. A state and transition model for the loamy ecological site is displayed in Figure 7 and for shallow loamy ecological site in Figure 8. Descriptions of the historical plant communities occurring in this area are included after each state and transition model, and a reference community is quantified for use in similarity index comparisons for existing or future plant communities on treatment areas.

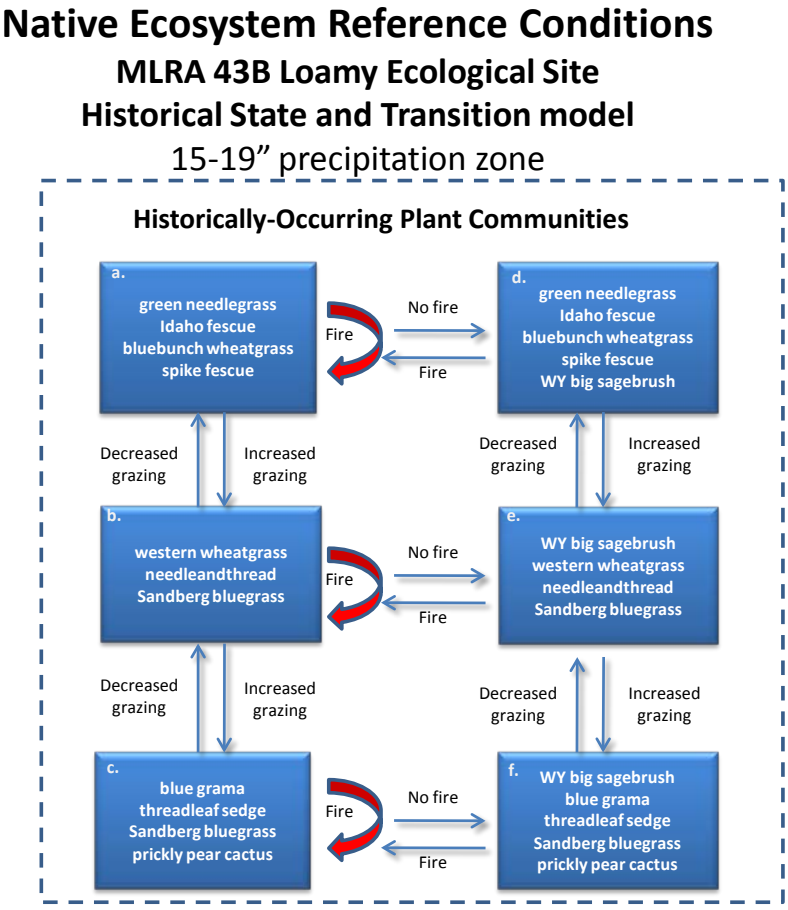

Figure 7. State and transition model displaying historically-occurring plant communities for loamy ecological sites in the 15-19" precipitation zone in MLRA 43B, Central Rockies.

A. Light herbivory, short fire return interval plant community:

Dominant species: Idaho fescue, green needlegrass, spike fescue, rhizomatous wheatgrass, needle and thread.

Other species: bluebunch wheatgrass, Indian ricegrass, nodding brome, mountain brome, plains reedgrass, onespike danthonia, basin wildrye, prairie junegrass, yarrow, rosy pussytoes, tarragon, prairie sagewort, prairie clover, fleabane, buckwheat, aster, hairy false goldenaster, desert parsley, lupine, bluebells, silverleaf Indian breadroot, beardtongue, phlox, prairie coneflower, American vetch, death camas.

Herbaceous productivity: 1500-3000 lbs/ac.

B. Moderate herbivory, short fire return interval plant community:
Dominant species: rhizomatous wheatgrass, needle and thread, prairie junegrass, Sandburg bluegrass,
Other species: bluebunch wheatgrass, blue grama, needleleaf sedge, theadleaf sedge, basin wildrye, yarrow, rosy pussytoes, fringed sagewort, fleabane, aster, lupine, phlox, American vetch, death camas, scarlet globemallow, rubber rabbitbrush.
Herbaceous productivity estimate: 1200-2500 lbs/ac.

C. Heavy herbivory, short fire return interval plant community:
Dominant species: blue grama, Sandberg bluegrass, threadleaf sedge, needleleaf sedge, rhizomatous wheatgrass
Other species: rubber rabbitbrush, prickly pear cactus, phlox, yarrow, scarlet globemallow, fringed sagewort, fleabane.
Herbaceous productivity estimate: 700-900 lbs/ac.

D. Light herbivory, long fire return interval plant community:
Dominant species: big sagebrush, Idaho fescue, green needlegrass, spike fescue, rhizomatous wheatgrass, needle and thread.
Other species: prairie junegrass, bluebunch wheatgrass, yarrow, rosy pussytoes, tarragon, prairie clover, fleabane, buckwheat, aster, hairy false goldenaster, desert parsley, lupine, bluebells, silverleaf Indian breadroot, beardtongue, phlox, prairie coneflower, American vetch, death camas, wood's rose, silver sagebrush.
Herbaceous productivity estimate: 1400-2800 lbs/ac.

E. Moderate herbivory, long fire return interval plant community:
Dominant species: big sagebrush, rhizomatous wheatgrass, needle and thread, prairie junegrass, Sandburg bluegrass
Other species: bluebunch wheatgrass, blue grama, needleleaf sedge, theadleaf sedge, yarrow, rosy pussytoes, fringed sagewort, fleabane, aster, lupine, phlox, American vetch, death camas, scarlet globemallow, prickly pear cactus, wood's rose, silver sagebrush
Herbaceous productivity estimate: 1000-2000 lbs/ac.

F. Heavy herbivory, long fire return interval plant community:
Dominant species: big sagebrush, blue grama, prickly pear cactus, Sandberg bluegrass, threadleaf sedge, rhizomatous wheatgrass
Other species: Needleleaf sedge, phlox, yarrow, scarlet globemallow, fringed sagewort, fleabane
Herbaceous productivity estimate: 500-700 lbs/ac.

Native Ecosystem Reference Conditions
MLRA 43B Shallow Loamy Ecological Site
Historical State and Transition model
15-19" precipitation zone

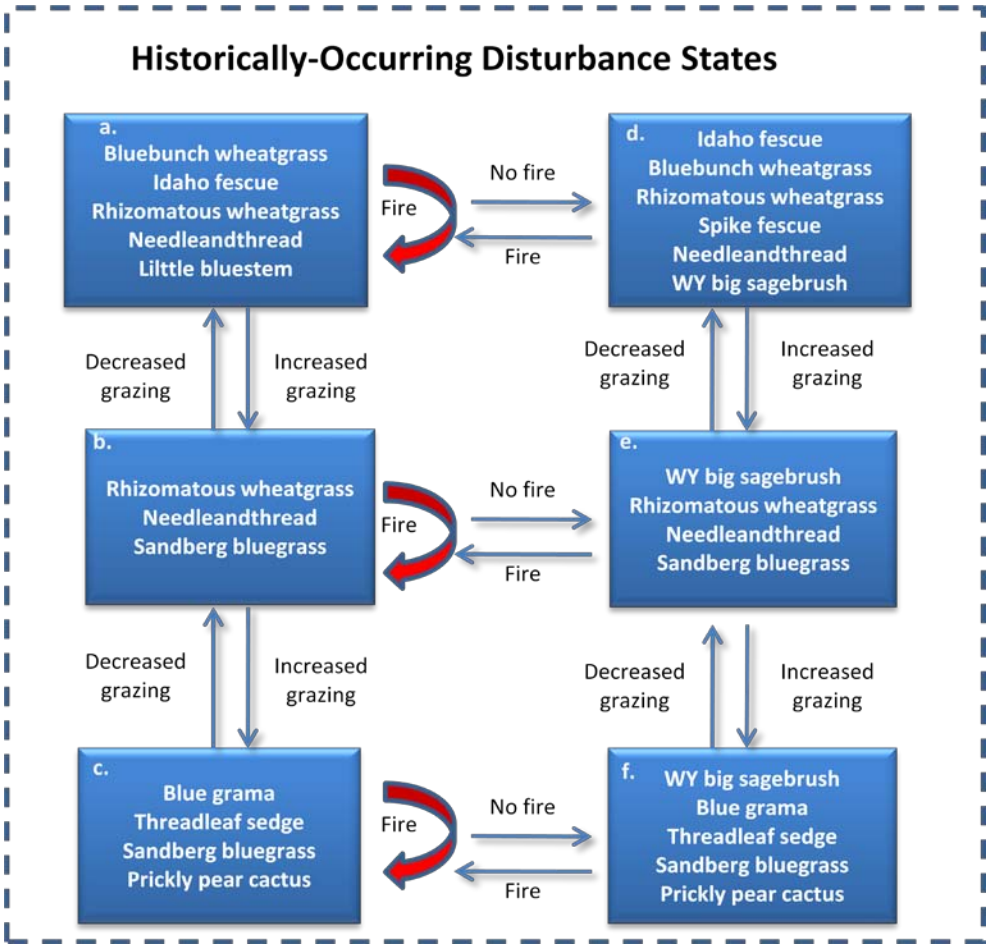

Figure 8. State and transition model for historical plant communities that occurred on the shallow loamy 15-19" precipitation zone ecological site in MLRA 43B.

A. Light herbivory, short fire return interval plant community:
Dominant species: Idaho fescue, bluebunch wheatgrass, green needlegrass, needle and thread, spike fescue, little bluestem, rhizomatous wheatgrass
Other species: Indian ricegrass, nodding brome, mountain brome, prairie junegrass, plains muhly, prairie clover, fleabane, aster, desert parsley, lupine, bluebells, silverleaf Indian breadroot, beardtongue, phlox, prairie coneflower, stonecrop, mountain goldenbanner, American vetch, sanddune wallflower, larkspur, rosy pussytoes, yarrow.
Herbaceous productivity estimate: 900-1800 lbs/ac.

B. Moderate herbivory, short fire return interval plant community:

Dominant species: Needle and thread, rhizomatous wheatgrass, prairie junegrass, Sandburg bluegrass.
Other species: plains muhly, sideoats grama, blue grama, little bluestem, bluebunch wheatgrass, Idaho fescue, threadleaf sedge, plains wallflower, hairy goldaster, scarlet globemallow, fleabane, phlox, prairie coneflower, American vetch, rosy pussytoes, yarrow.
Herbaceous productivity estimate: 800-1400 lbs/ac.

C. Heavy herbivory, short fire return interval plant community:
Dominant species: blue grama, sideoats grama, Sandburg bluegrass, threadleaf sedge, prairie junegrass, rhizomatous wheatgrass
Other species: needle and thread, phlox, common yarrow, rosy pussytoes, larkspur, bastard toadflax, fleabane, American vetch, prickly pear cactus.
Herbaceous productivity estimate: 450-900 lbs/ac.

D. Light herbivory, long fire return interval plant community:
Dominant species: Big sagebrush, Idaho fescue, bluebunch wheatgrass, green needlegrass, needle and thread, rhizomatous wheatgrass.
Other species: skunkbush sumac, winterfat, Indian ricegrass, nodding brome, mountain brome, prairie junegrass, plains muhly, blue wildrye, prairie clover, fleabane, aster, desert parsley, lupine, bluebells, Silverleaf Indian breadroot, beardtongue, phlox, prairie coneflower, stonecrop, mountain goldenbanner, American vetch, sanddune wallflower, larkspur, rosy pussytoes, yarrow.
Herbaceous productivity estimate: 800-1400 lbs/ac.

E. Moderate herbivory, long fire return interval plant community:
Dominant species: Big sagebrush, needle and thread, rhizomatous wheatgrass, prairie junegrass, Sandburg bluegrass.
Other species: skunkbush sumac, plains muhly, blue wildrye, sideoats grama, blue grama, little bluestem, bluebunch wheatgrass, Idaho fescue, threadleaf sedge, plains wallflower, hairy goldaster, scarlet globemallow, fleabane, phlox, prairie coneflower, American vetch, rosy pussytoes, yarrow, prickly pear cactus.
Herbaceous productivity estimate: 700-1200 lbs/ac.

F. Heavy herbivory, long fire return interval plant community:
Dominant species: big sagebrush, blue grama, Sandburg bluegrass, threadleaf sedge, prairie junegrass, prickly pear cactus,rhizomatous wheatgrass
Other species: needle and thread, phlox, yarrow, rosy pussytoes, larkspur, bastard toadflax, fleabane, American vetch.
Herbaceous productivity estimate: 400-700 lbs/ac.

Reference Community for Loamy and Shallow loamy ecological sites in the 15-19" precipitation zone in MLRA 43B.

A recommended reference community for both the loamy and shallow loamy ecological sites for the Fidelity project site is the long fire return interval light herbivory plant community.

While the plant diversity of the loamy sites is generally richer than the shallow loamy sites, the same list of potential species can serve as the reference community for use in comparisons of compositions using similarity indices. The suggested reference plant community would have the following composition:
big sagebrush and silver sagebrush: 0-30%, with a minimum of 15% to achieve a score of 100%, Idaho fescue, green needlegrass, spike fescue, and bluebunch wheatgrass: 0-50% with a minimum of 10% to achieve a score of 100%, rhizomatous wheatgrass, little bluestem, and needle and thread: 0-40%, blue grama, threadleaf and needleleaf sedges, prairie junegrass, prairie sandreed, plains reedgrass, and Sandberg bluegrass: 0-10%, with the total for all three groupings of grasses not to exceed 75%, native forbs (common yarrow, agoseric, textile onion, rosy pussytoes, ballhead sandwort, twogrooved milkvetch, groundplum milkvetch, Drummond's milkvetch, plains milkvetch, sego lily, downy paintedcup, tiny trumpet, hawksbeards, miner's candle, tarragon, prairie clover, fleabane, buckwheat, aster, hairy false goldenaster, desert parsley, lupine, bluebells, buckwheat, scarlet beeblossom, bedstraw, gentian, old man's whiskers, prairie flax, desert biscuitroot, wild mint, silverleaf Indian breadroot, Townsend daisy, tufted evening-primrose, purple locoweed, woolly groundsel, ragwort, white penstemon, threadleaf phaceia, plantain, scurfpea, globemallow, beardtongue, phlox, prairie coneflower, American vetch, death camas), excluding Forb B species: 0-20%, with a minimum of 10% to achieve a score of 100%, prairie sagewort, spinystar, plains pricklypear, beaked skeletonweed, broom snakeweed, wavy thistle, curlycup gumweed, and bastard toadflax: 0-5%, and Wood's rose, gardner's saltbrush, chokecherry, skunkbush sumac, common snowberry, winterfat, and rabbitbrush: 0-5%,

Treatments

The site was treated with the herbicide Plateau in Fall 2009. Patches of shrubs were to be avoided. Plateau was applied at a rate of 5 oz/acre mixed with 10 gallons of water/acre and using a surfactant. Most of the site was treated using aerial application, with an overlapping application of transects. Shrub patches were avoided leaving a 100' buffer left untreated by the aerial application. Ground crews on ATV's treated the areas closer to the shrub patches, taking care to avoid spraying the shrubs.

Control of leafy spurge occurred in summer, 2010. Ground crews using ATV's and backpack sprayers applied herbicide to each patch of leafy spurge.

It should be noted that this area was also included in a grasshopper control treatment applied to a large part of Sheridan County by the local Weed District due to the grasshopper plague conditions during the summer of 2010.

Sampling Results

Site level results
Sampling results for 2009 (pre-treatment) and 2010 (1st year post-treatment) for the shallow loamy and loamy ecological sites are listed in Table 3.

Table 3. Dominant species of plants at the Fidelity, Wyoming site prior to treatments, listed for each ecological site; presented as relative cover and standard errors. Bolded numbers were significantly different (P<0.05) between years.

	Ecological Site			
	2009		2010	
Plant Species	Loamy	Shallow Loamy	Loamy	Shallow Loamy
	% Relative Cover (standard error)			
Common yarrow	2.42 (1.47)	0.71 (0.46)	6.65 (5.27)	1.94 (1.25)
Silver sagebrush	1.53 (0.84)	0.36 (0.27)	5.46 (3.18)	3.55 (3.21)
Prairie sagewort	0.85 (0.35)	6.39 (2.58)	0.29 (0.14)	4.49 (1.72)
Big sagebrush	**32.51** (7.97)	25.42 (2.70)	**41.96** (8.11)	28.68 (3.55)
Field milkvetch	-	-	-	3.37 (2.18)
Twogrooved milkvetch	-	1.81 (1.20)	-	1.83 (1.72)
Blue grama	1.17 (0.34)	0.91 (0.34)	10.08 (3.79)	1.92 (0.72)
Field brome	**9.12** (4.29)	**8.01** (4.42)	**0.50** (0.33)	**0.91** (0.58)
Threadleaf sedge	0.79 (0.50)	5.71 (3.16)	1.19 (0.61)	8.32 (4.44)
Prairie sandreed	-	1.25 (1.13)	0.64 (0.64)	7.09 (4.77)
Yellow rabbitbrush	-	-	-	2.16 (2.16)
Bastard toadflax	0.17 (0.15)	1.87 (1.01)	1.23 (1.23)	2.89 (1.49)
Idaho fescue	**0.95 (0.65)**	2.48 (1.57)	1.13 (0.79)	0.44 (0.44)
Scarlet beeblossum	0.38 (0.24)	2.14 (0.72)	-	-
Broom snakeweed	1.90 (1.09)	1.26 (.46)	0.21 (0.13)	1.93 (0.73)
Needleandthread	1.56 (0.99)	1.54 (0.98)	3.31 (2.11)	1.98 (1.14)
Prairie junegrass	2.89 (1.21)	3.63 (0.77)	0.68 (0.35)	2.06 (0.59)
Clasping pepperweed	**3.82** (1.10)	**2.40** (0.60)	**-**	**-**
Green needlegrass	4.26 (0.86)	1.59 (1.23)	5.22 (1.37)	1.16 (0.54)
Rhizamatous wheatgrass	**7.21** (0.85)	2.15 (1.07)	4.48 (1.01)	2.02 (1.08)
Spiny phlox	3.73 (1.49)	**4.31** (1.23)	1.60 (0.60)	**2.42** (0.68)
Sandberg bluegrass	0.15 (0.10)	0.19 (0.12)	1.20 (0.60)	1.07 (0.48)
Bluebunch wheatgrass	6.75 (3.20)	15.88 (3.22)	3.83 (0.91)	8.42 (1.28)
Scarlet globemallow	2.45 (0.70)	0.36 (0.24)	1.99 (0.61)	0.38 (0.28)
White prairie aster	-	-	0.85 (0.45)	1.59 (1.17)
Common dandelion	7.08 (5.44)	-	0.84 (0.43)	0.17 (0.11)
American vetch	1.80 (0.65)	0.40 (0.19)	2.57 (1.04)	0.75 (0.47)

The results demonstrate that a good diversity of native plants occurs on the Fidelity project area. However, the results also demonstrate the level of invasive species that were also present prior to treatment, specifically field brome and clasping pepperweed. Mapping of invasive species was conducted on the site to aid in determining desired treatments. Control of cheatgrass, field brome, and clasping pepperweed was desired throughout the pasture. However, control of these species will be harmful to various desired species of shrubs. Therefore, shrub patches were also mapped, so that treatments can be planned to avoid negative effects on these desired species. Figures 9 and 10 display the results of this mapping in 2009.

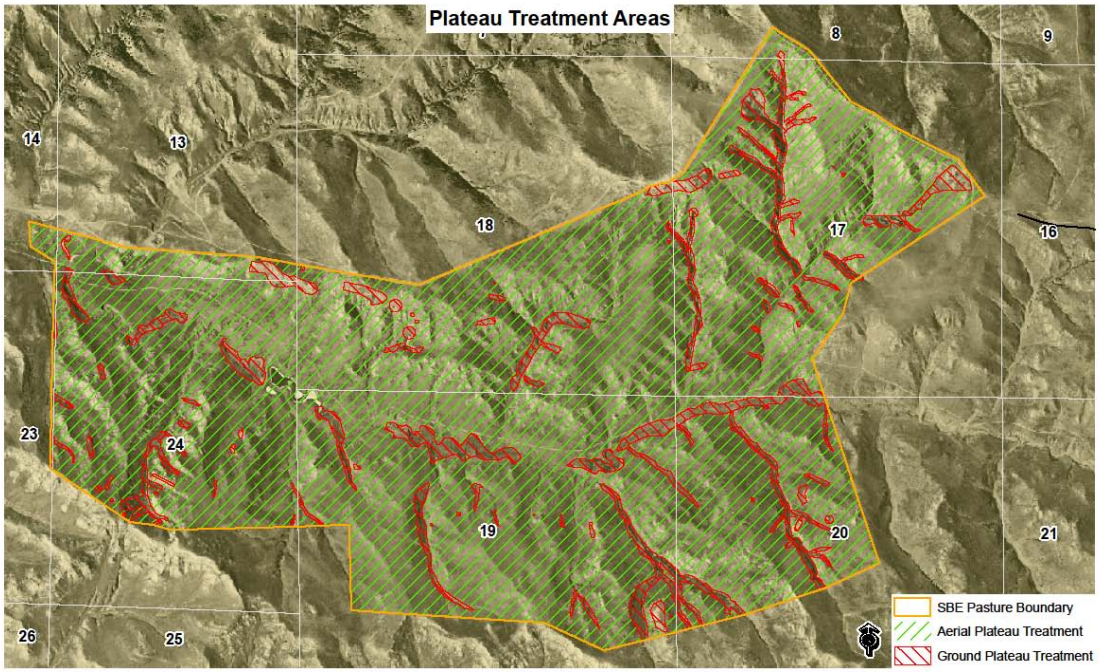

Figure 9. Map of shrub patches (labeled ground Plateau treatment areas) and areas designated for aerial herbicide application to control cheatgrass, field brome, and clasping pepperweed on the Fidelity project area in northeastern, Wyoming.

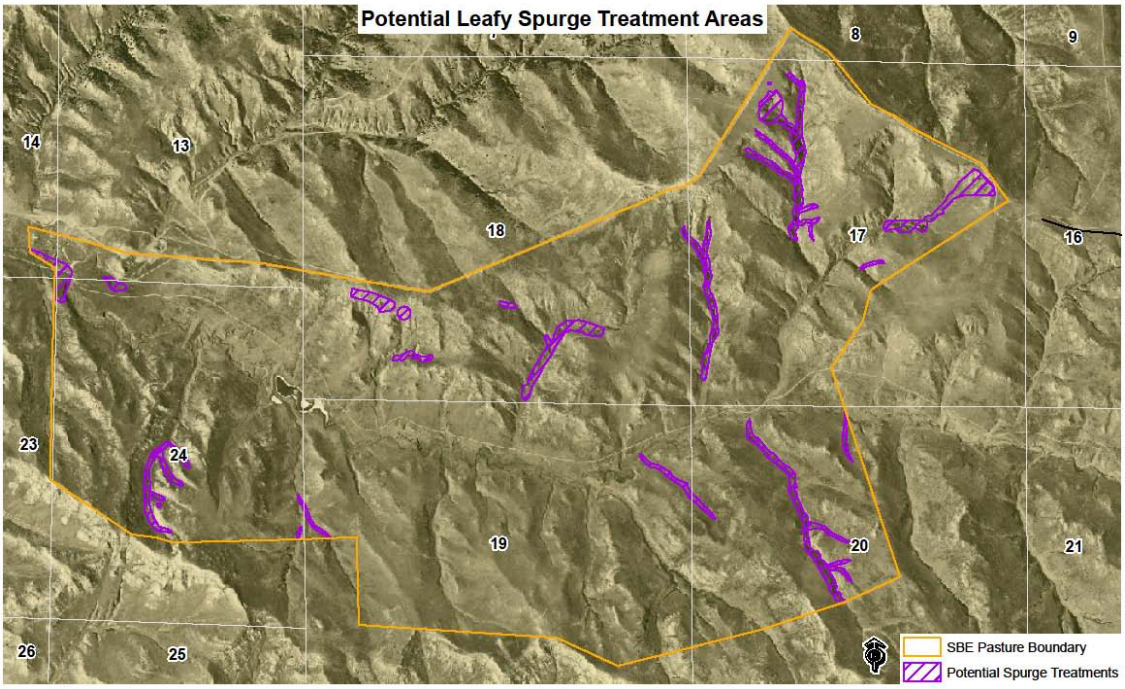

Figure 10. Map of drainages with leafy spurge invasion on Seven Brothers East Ranch. Ground application of herbicide occurred in summer 2010 for control of spurge in these areas.

Vegetation sampling in 2010 showed the significant decrease in field brome and clasping pepperweed produced by the herbicide treatment on both loamy and shallow loamy ecological sites. Rhizamatous wheatgrass displayed a significant decrease on plots of the loamy ecological site in 2010, and spiny phlox decreased on shallow loamy sites. Big sagebrush increased significantly on loamy sampling plots in 2010. It will be interesting to see how these species respond in 2011. The similarity indices calculated for the Fidelity site were:

loamy ecological sites: 55.61 in 2009, and 69.42 in 2010, and

shallow loamy ecological sites: 68,10 in 2009, and 64.29 in 2010.

While these values were not significantly different pre versus post-treatment, they do reveal the relatively good quality of native vegetation in the project area. It should also be noted that several of the loamy plots that had the lowest similarity values in 2009 due to the presence of exotic species increased dramatically in value in 2010, but other plots which lacked high levels of exotic species showed little change between the years, keeping the overall index from differing significantly. A comparison of levels of exotic species compared across all plots in the project area showed a highly significant ($P<0.01$) reduction between pre and post treatment.

Landscape level results

For the Fidelity Project there were six wildlife species modeled for the landscape analysis: pronghorn antelope, sagebrush lizard, sage sparrow, sage thrasher, sagebrush vole, and sage-grouse. Summary of the modeling results for each species are presented in Table 4. For maps of the modeling results for each species, see Appendix B.

Table 4. Results of habitat modeling for the Fidelity site. Numbers represent potential home ranges of species rated as high quality, medium quality, and low quality. Post-treatment analyses are still pending.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Pronghorn antelope	**0**	**1**	**29**	**P****	**P**	**P**
Sage thrasher	**1**	**114**	**47**	**P**	**P**	**P**
Sagebrush lizard	**0**	**0**	**2449**	**P**	**P**	**P**
Sage sparrow	**1**	**37**	**164**	**P**	**P**	**P**
Sagebrush vole	**30**	**3789**	**958**	**P**	**P**	**P**
Sage-grouse- nesting	**91**	**1015**	**958**	**P**	**P**	**P**
Sage-grouse brood-rearing	**151**	**650**	**69**	**P**	**P**	**P**
Sage-grouse- wintering	**0**	**6**	**106**	**P**	**P**	**P**

*Pre-high refers to pretreatment, high quality home ranges, Pre-medium refers to pretreatment medium quality home ranges, Pre-low refers to pretreatment low quality home ranges, Post-high refers to post-treatment high quality home ranges, Post-medium refers to post-treatment medium quality home ranges, and Post-low refers to post-treatment low quality home ranges.

**P refers to analyses that will be run with 2011 data.

Thunder Basin, Wyoming Project Area

The Thunder Basin project area includes planned sagebrush improvements on the property of the Seeley family located in Weston County, Wyoming. The site has a mix of sagebrush and grasses. The pasture is approximately 3200 acres in size, and has water developments at both the north and south ends. The project area is displayed in Figure 11. The cooperator on this project is the Thunder Basin Grasslands Prairie Ecosystem Association.

Figure 11. Overview of the "Seeley pasture" in the Thunder Basin project area in Weston, County, Wyoming.

This area is in MLRA 58B, the Northern Rolling High Plains and is in the 10-14" precipitation zone. As described in the ecological site descriptions for this MLRA, "wide fluctuations may occur in yearly precipitation and result in more drought years than those with more than normal precipitation. Temperatures show a wide range between summer and winter and between daily maximums and minimums." "Growth of native cool season plants begins about April 1 and continues to about July 1. Native warm season plants begin growth about May 15 and continue to about August 15. Green up of cool season plants may occur in September and October of most years." Ecological sites of the project area are shown in Figure 12. Included in this Figure are the sampling points that were established prior to treatment in 2008. The predominant ecological site on the area is loamy. This site was the target for improvements, although the smaller areas of sandy and shallow sandy also received treatment.

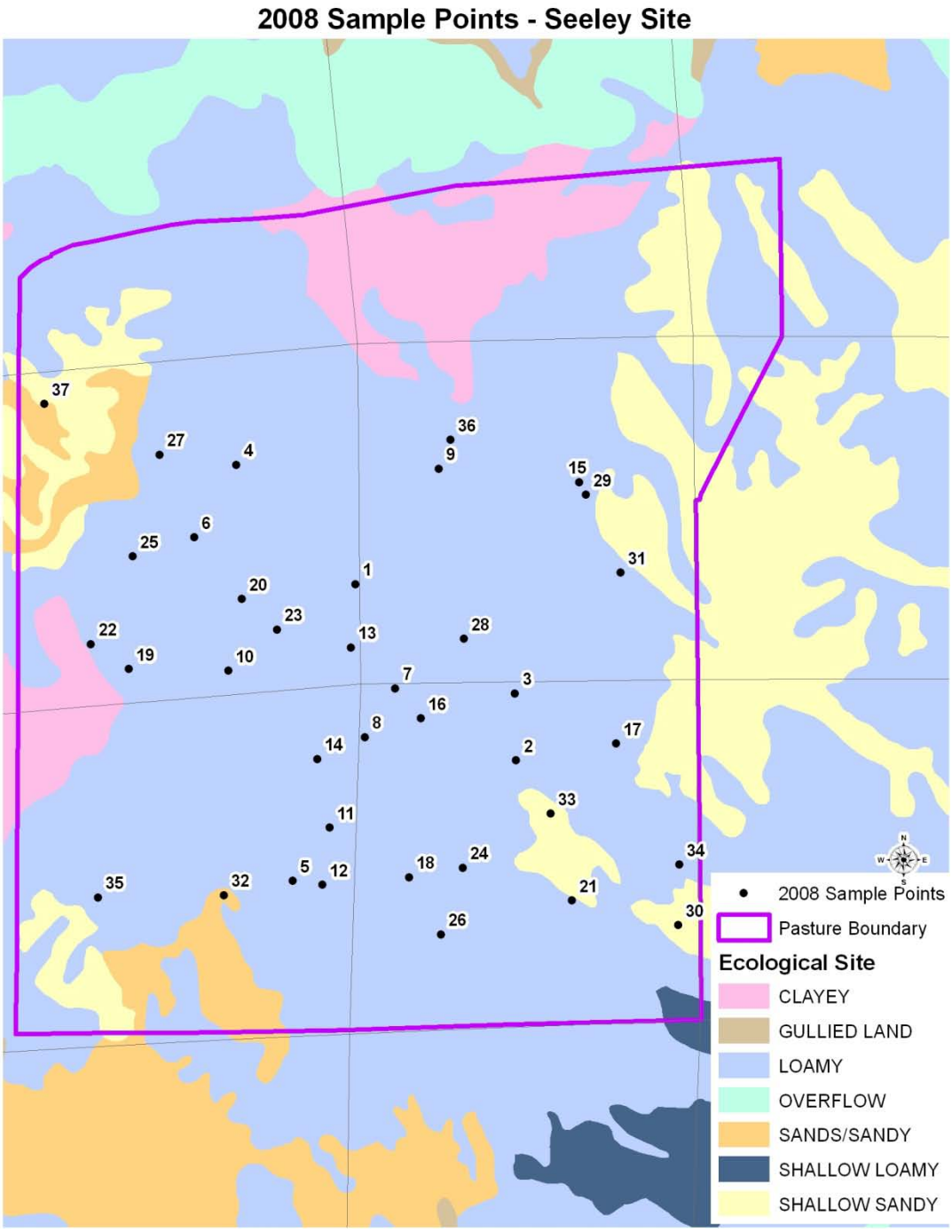

Figure 12. Ecological sites on the Seeley pasture in the Thunder Basin project area, and sample points included in the 2008 sampling of existing vegetation.

Development of Reference Community Descriptions

As mentioned, the treatment area in Thunder Basin is primarily a loamy ecological site, but inclusions of other ecological sites also occur on the treatment pasture. State and transition models for loamy, sandy, and shallow sandy sites in this area are shown in Figures 13-15.

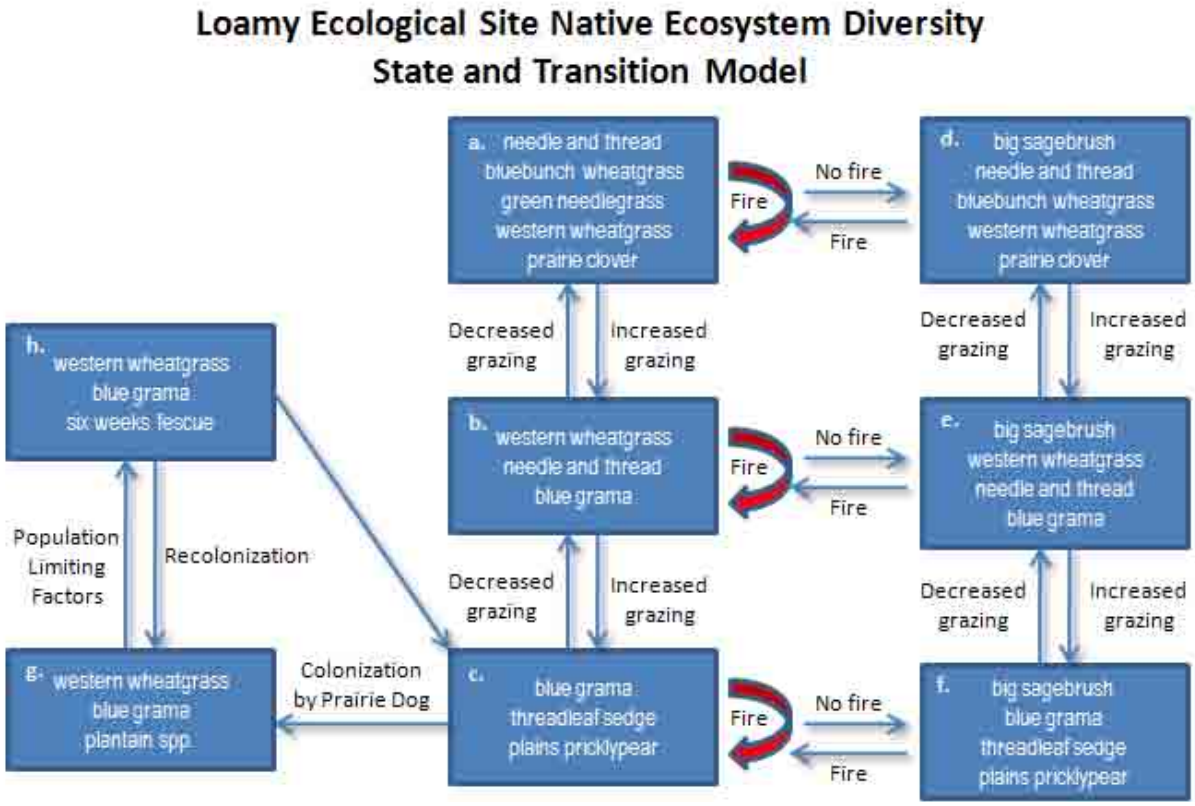

Figure 13. State and transition model for loamy sites in MLRA 58B, the Northern Rolling High Plains, for the 10-14" precipitation zone. Each box is a potentially occurring historical plant community.

Descriptions of historical communities for the Thunder Basin area were developed in a previous project (Haufler et al. 2008). The historical communities for loamy sites were described by Haufler et al. (2008) as: "Native ecosystem diversity on loamy ecological sites was influenced by natural disturbance regimes of fire, grazing, and prairie dogs. Grazing played an important role in influencing the species composition of ecosystems on this ecological site. Plant species that respond as decreasers with increasing grazing pressure on loamy sites include green needlegrass and Indian ricegrass. Species like western wheatgrass, thickspike wheatgrass, needleandthread, and little bluestem initially respond as increasers, however, they decrease as grazing pressure becomes more intense. Species that commonly increase as grazing becomes heavy include blue grama, hairy grama, threadleaf sedge, prairie junegrass, and Sandberg bluegrass. The frequent fire return interval played an important role in shaping the structure and species composition of native ecosystems on loamy ecological sites. In general, grass species were the dominant component and shrubs were a relatively minor component on these sites due to frequent fire. Areas that were protected from fire likely experienced an increase in

Wyoming big sagebrush and silver sagebrush. Loamy ecological sites were considered highly suitable habitat for prairie dog colonies, with preference given to those sites exhibiting relatively level conditions and with water sources nearby."

Historical plant communities described for the loamy ecological site are included here.

A. Short Fire Return Interval x Light Herbivory Regime
Dominant Species: needle and thread, green needlegrass, western wheatgrass, thickspike wheatgrass, bluebunch wheatgrass, prairie clover, and prairie coneflower
Other Characteristic Species: Indian ricegrass, Cusick's bluegrass, needleleaf sedge, American vetch, hawksbeard, biscuitroot, dotted blazing star, and evening primrose
Historical Grass and Forb Productivity Estimate: 1,100 lbs/acre

B. Short Fire Return Interval x Moderate Herbivory Regime
Dominant Species: western wheatgrass, needle and thread, Sandberg bluegrass, thickspike wheatgrass, blue grama, threadleaf sedge, and western yarrow
Other Characteristic Species: Indian ricegrass, bluebunch wheatgrass, Cusick's bluegrass, needleleaf sedge, prairie junegrass, prairie coneflower, prairie clover, biscuitroot, scurfpea, rosy pussytoes, milkvetch, stemless goldenweed, hawksbeard, textile onion, bluebells, scarlet globemallow, scarlet gaura, penstemon, and common pepperweed
Historical Grass and Forb Productivity Estimate: 900 lbs/acre

C. Short Fire Return Interval x Heavy Herbivory Regime
Dominant Species: blue grama, threadleaf sedge, plains pricklypear, prairie junegrass, western yarrow, rosy pussytoes, and common pepperweed
Other Characteristic Species: Western wheatgrass, thickspike wheatgrass, Sandberg bluegrass, scurfpea, milkvetch, penstemon, scarlet globemallow, scarlet gaura, stemless goldenweed, textile onion, bluebells, and Hood's phlox
Historical Grass and Forb Productivity Estimate: 550 lbs/acre

D. Long Fire Return Interval x Light Herbivory Regime
Dominant Species: big sagebrush, needle and thread, green needlegrass, western wheatgrass, thickspike wheatgrass, bluebunch wheatgrass, prairie clover, prairie coneflower, dotted blazing star, and winterfat
Other Characteristic Species: Indian ricegrass, Cusick's bluegrass, needleleaf sedge, American vetch, hawksbeard, biscuitroot, and evening primrose
Historical Grass and Forb Productivity Estimate: 925 lbs/acre

E. Long Fire Return Interval x Moderate Herbivory Regime
Dominant Species: big sagebrush, western wheatgrass, needle and thread, Sandberg bluegrass, thickspike wheatgrass, blue grama, threadleaf sedge, western yarrow, and winterfat
Other Characteristic Species: Indian ricegrass, bluebunch wheatgrass, Cusick's bluegrass, needleleaf sedge, prairie junegrass, prairie coneflower, prairie clover, biscuitroot, scurfpea,

rosy pussytoes, milkvetch, stemless goldenweed, hawksbeard, textile onion, bluebells, scarlet globemallow, scarlet gaura, penstemon, and common pepperweed

Historical Grass and Forb Productivity Estimate: 750 lbs/acre

F. Long Fire Return Interval x Heavy Herbivory Regime

Dominant Species: big sagebrush, blue grama, threadleaf sedge, plains pricklypear, and prairie junegrass, western yarrow, rosy pussytoes, and common pepperweed

Other Species: Western wheatgrass, thickspike wheatgrass, Sandberg bluegrass, scurfpea, milkvetch, penstemon, scarlet globemallow, scarlet gaura, stemless goldenweed, textile onion, bluebells, and Hood's phlox

Historical Grass and Forb Productivity Estimate: 475 lbs/acre

G. Prairie Dog Colony, Active Regime

Vegetation on active prairie dog colonies and to lesser extent in-active colonies exhibited a dwarfed or stunted growth pattern, due to repeated clipping. Characteristic species that occur on prairie dog colonies include western wheatgrass, blue grama, purple threeawn, six weeks fescue, threadleaf sedge, plantain spp., common yarrow, and aster species. Plant community composition on active prairie dog colonies was driven by factors that included colony density and age.

H. Prairie Dog Colony, In-active Regime

Prairie dog colonies are considered inactive as long as they are not currently used by prairie dogs, and they still provide the burrow structure characteristic of prairie dog communities, that other wildlife species are dependent upon. Field observations in the Thunder Basin planning area indicate that after approximately 7 years of non-use, most prairie dog burrows have collapsed and no longer serve the role as an inactive prairie dog colony. Plant community composition on inactive prairie dog colonies was driven by previous levels of disturbance by prairie dogs and length of time since abandonment. Colonies that previously had higher levels of disturbance were in early successional stages and took considerable time to recover to pre-disturbance conditions.

Shallow sandy ecological sites

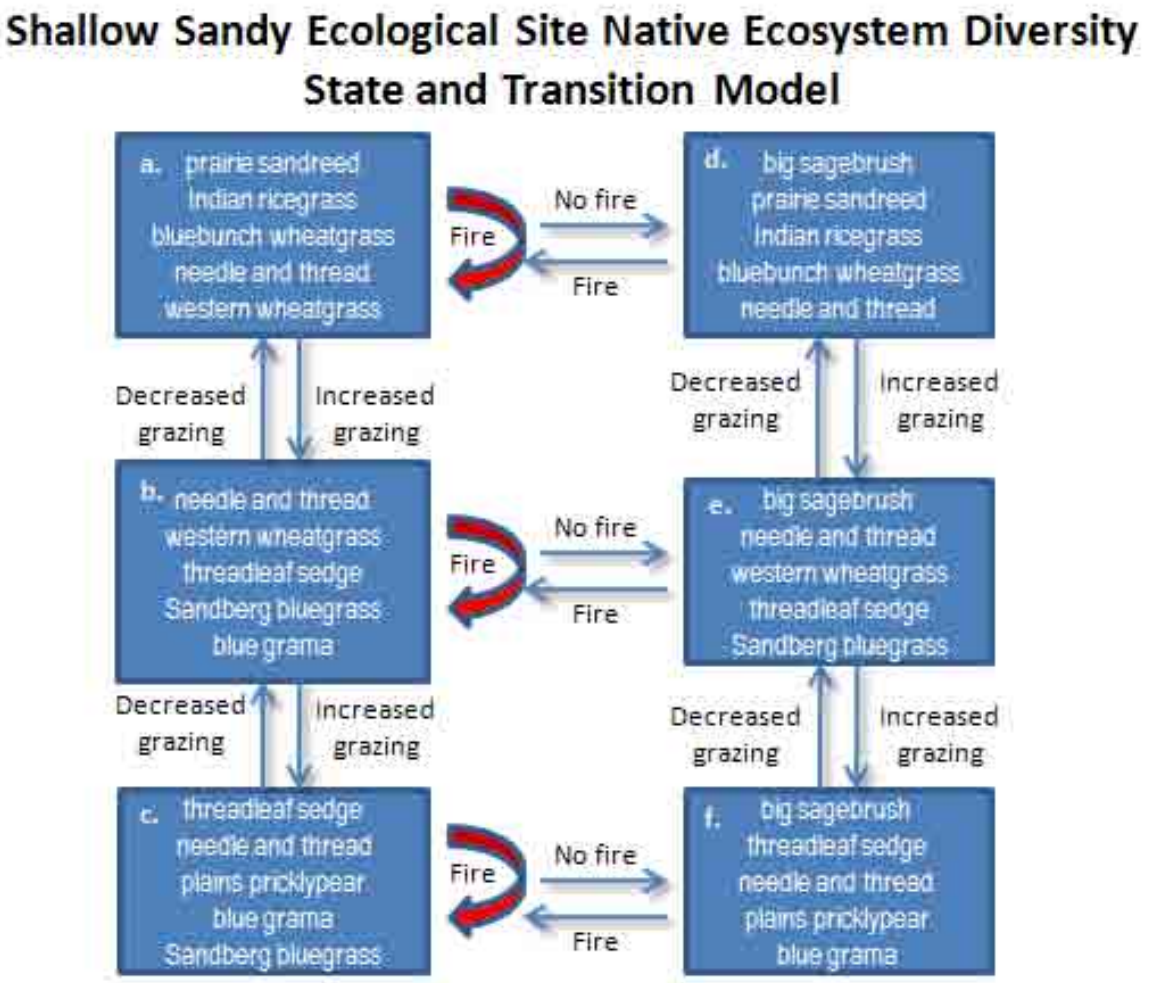

Figure 14. State and transition model for historical plant communities occurring on shallow sandy sites in the 10-14" precipitation zone of MLRA 58B, Northern Rolling High Plains.

A. Short Fire Return Interval x Light Grazing Regime

Dominant Species: prairie sandreed, Indian ricegrass, needle and thread, bluebunch wheatgrass, western wheatgrass, thickspike wheatgrass, prairie coneflower, American vetch, and prairie clover

Other Characteristic Species: little bluestem, threadleaf sedge, Sandberg bluegrass, and hawskbeard

Historical Grass and Forb Productivity Estimate: 850 lbs/acre

Structure: mixed grasses, herbaceous vegetation 5-7" in height.

B. Short Fire Return Interval x Moderate Grazing Regime

Dominant Species: needle and thread, western wheatgrass, threadleaf sedge, Sandberg bluegrass, and blue grama

Other Characteristic Species: little bluestem, prairie sandreed, Indian ricegrass, bluebunch wheatgrass, sideoats grama, plains muhly, prairie junegrass, plains pricklypear, prairie coneflower, American vetch, and yucca
Historical Grass and Forb Productivity Estimate: 700 lbs/acre
Structure: mixed grasses, herbaceous vegetation 3-5" in height.

C. Short Fire Return Interval x Heavy Grazing Regime

Dominant Species: needle and thread, threadleaf sedge, plain pricklypear, prairie junegrass, Sandberg bluegrass, and western yarrow
Other Characteristic Species: western wheatgrass, side oats grama, plains muhly, pussytoes, textile onion, fringed sagewort, scurfpea, and yucca
Historical Grass and Forb Productivity Estimate: 500 lbs/acre
Structure: mixed grasses, herbaceous vegetation 2-5" in height.

D. Long Fire Return Interval x Light Grazing Regime

Dominant Species: big sagebrush, prairie sandreed, Indian ricegrass, needle and thread, bluebunch wheatgrass, western wheatgrass, thickspike wheatgrass, prairie coneflower, American vetch, and prairie clover
Other Characteristic Species: little bluestem, threadleaf sedge, Sandberg bluegrass, hawskbeard, and winterfat
Historical Grass and Forb Productivity Estimate: 700 lbs/acre
Structure: mixed grasses and shrubs, herbaceous vegetation 3-5" in height, shrubs up to 2.5' in height.

E. Long Fire Return Interval x Moderate Grazing Regime

Dominant Species: big sagebrush, needle and thread, western wheatgrass, threadleaf sedge, Sandberg bluegrass, and blue grama
Other Characteristic Species: little bluestem, prairie sandreed, Indian ricegrass, bluebunch wheatgrass, sideoats grama, plains muhly, prairie junegrass, plains pricklypear, prairie coneflower, American vetch, and yucca
Historical Grass and Forb Productivity Estimate: 550 lbs/acre
Structure: mixed grasses and shrubs, herbaceous vegetation 3-5" in height, shrubs up to 2.5' in height.

F. Long Fire Return Interval x Heavy Grazing Regime

Dominant Species: big sagebrush, needle and thread, threadleaf sedge, plain pricklypear, prairie junegrass, Sandberg bluegrass, and western yarrow
Other Characteristic Species: western wheatgrass, side oats grama, plains muhly, pussytoes, textile onion, fringed sagewort, scurfpea, and yucca
Historical Grass and Forb Productivity Estimate: 400 lbs/acre
Structure: mixed grasses and shrubs, herbaceous vegetation 3-5" in height, shrubs up to 2.5' in height.

Sands/Sandy Ecological Sites

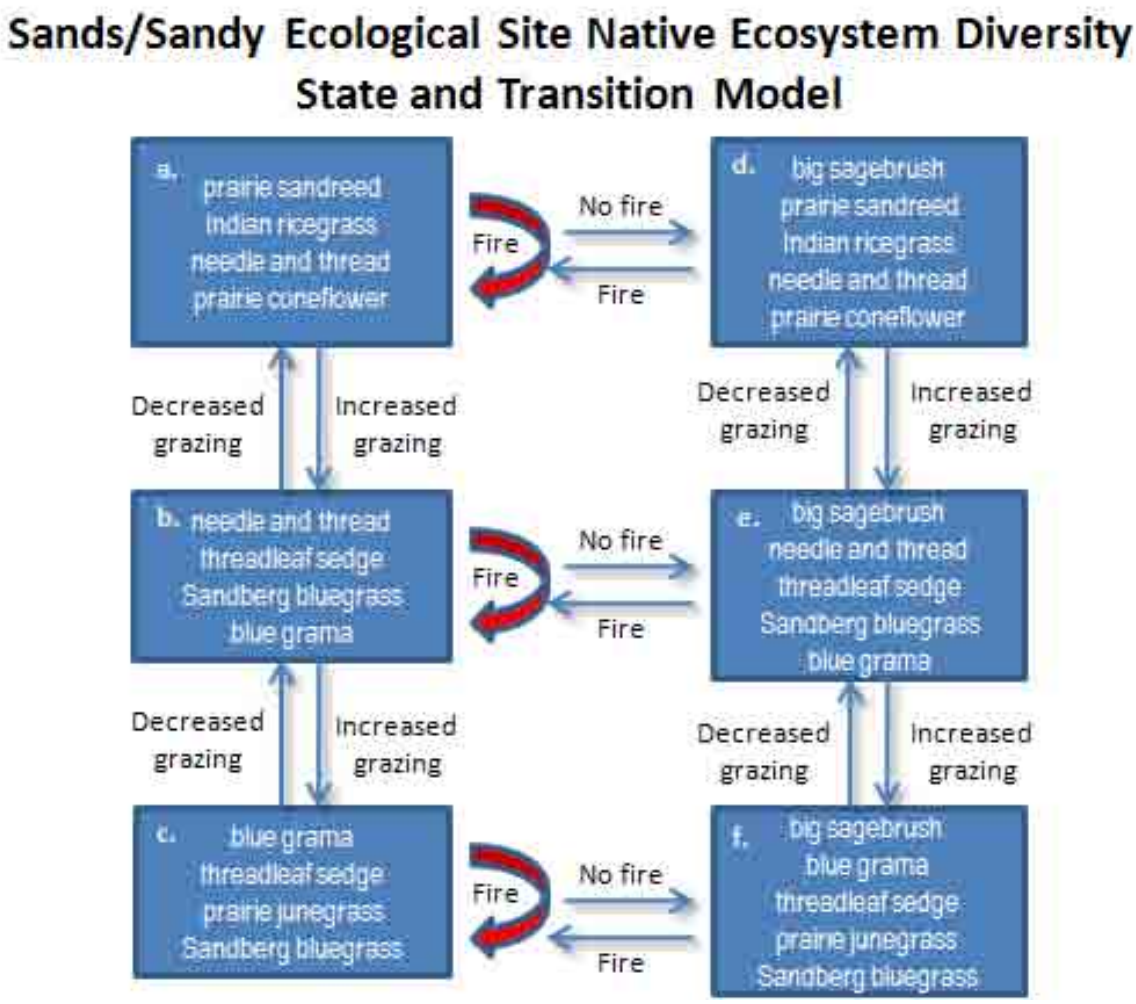

Figure 15. State and transition model showing historically occurring plant communities for sands/sandy ecological sites in the 10-14" precipitation zone of MLRA 58B, Northern Rolling High Plains.

A. Short Fire Return Interval x Light Grazing Regime

Dominant Species: prairie sandreed, Indian ricegrass, needle and thread, western wheatgrass, thickspike wheatgrass, prairie coneflower, American vetch, and prairie clover

Other Characteristic Species: little bluestem, threadleaf sedge, Sandberg bluegrass, and hawskbeard

Historical Grass and Forb Productivity Estimate: 1,100 lbs/acre

Structure: mixed grasses, 5-8" in height.

B. Short Fire Return Interval x Moderate Grazing Regime

Dominant Species: needle and thread, western wheatgrass, threadleaf sedge, Sandberg bluegrass, and blue grama

Other Characteristic Species: little bluestem, prairie sandreed, Indian ricegrass, prairie junegrass, plains pricklypear, prairie coneflower, American vetch, yucca

Historical Grass and Forb Productivity Estimate: 900 lbs/acre
Structure: mixed grasses, 4-7" in height.

C. Short Fire Return Interval x Heavy Grazing Regime

Dominant Species: needle and thread, threadleaf sedge, plain pricklypear, prairie junegrass, Sandberg bluegrass, blue grama, western yarrow
Other Characteristic Species: western wheatgrass, pussytoes, textile onion, fringed sagewort, scurfpea, and yucca
Historical Grass and Forb Productivity Estimate**:** 550 lbs/acre
Structure: mixed grasses, 3-5 inches in height.

D. Long Fire Return Interval x Light Grazing Regime

Dominant Species: big sagebrush, prairie sandreed, Indian ricegrass, needle and thread, western wheatgrass, thickspike wheatgrass, prairie coneflower, American vetch, and prairie clover
Other Characteristic Species: little bluestem, threadleaf sedge, Sandberg bluegrass, hawskbeard, and winterfat
Historical Grass and Forb Productivity Estimate: 925 lbs/acre
Structure: mixed grasses and shrubs, herbaceous vegetation 5-8" in height, shrubs up to 3' in height.

E. Long Fire Return Interval x Moderate Grazing Regime

Dominant Species: big sagebrush, needle and thread, western wheatgrass, threadleaf sedge, Sandberg bluegrass, and blue grama
Other Characteristic Species: little bluestem, prairie sandreed, Indian ricegrass, prairie junegrass, plains pricklypear, prairie coneflower, American vetch, yucca
Historical Grass and Forb Productivity Estimate: 750 lbs/acre
Structure: mixed grasses and shrubs, herbaceous vegetation 4-6 " in height, shrubs up to 3' in height.

F. Long Fire Return Interval x Heavy Grazing Regime

Dominant Species: big sagebrush, needle and thread, threadleaf sedge, plain pricklypear, prairie junegrass, Sandberg bluegrass, western yarrow
Other Characteristic Species: western wheatgrass, pussytoes, textile onion, fringed sagewort, scurfpea, and yucca
Historical Grass and Forb Productivity Estimate: 475 lbs/acre
Structure: mixed grasses and shrubs, herbaceous vegetation 3-5" in height, shrubs up to 2.5' in height.

Reference Community for Loamy, Sands/Sandy, and Shallow sandy ecological sites in the 10-14" precipitation zone in MLRA 58B.

The following reported and observed plant diversity of loamy sites was used as the reference community for use in comparisons of compositions using similarity indices:

big sagebrush: 0-25%, with a minimum of 15% to achieve a score of 100%, Indian ricegrass and green needlegrass: 0-15% with a minimum of 10% to achieve a score of 100%, rhizomatous wheatgrass: 0-30%, needle and thread: 0-30%, prairie junegrass, Sandberg bluegrass, and sixweeks fescue: 0-10%, blue grama, threadleaf and needleleaf sedges, and purple threeawn: 0-5%, with the total for all groupings of grasses not to exceed 75%, native forbs (Missouri milkvetch, narrowleaf stoneseed, fleabane, aster, Indian breadroot, plantain, scurfpea, globemallow, penstemon, Nuttal's violet, beardtongue, prairie phlox, prairie coneflower, American vetch, death camas), excluding Forb B species: 0-20%, with a minimum of 10% to achieve a score of 100%, Forb B species- prairie sagewort, plains pricklypear, spiny phlox, broom snakeweed, wavy thistle: 0-5%, and primrose, gardner's saltbrush, skunkbush sumac, common snowberry, winterfat, and rabbitbrush: 0-5%,

Results

Sampling points for the treatment area in Thunder Basin were established in 2008, at locations shown in Figure 12. These sampling points were sampled in 2008 by the Thunder Basin Grasslands Prairie Ecosystem Association. In 2009 and 2010, these same plots were sampled, but the Daubenmire frames were photographed and cover estimates determined from the vertical photographs after the end of the field season for the 2009 samples.

Site level results

Results of the 2008 and 2009 sampling of plots in the Thunder Basin treatment area are listed in Table 5.

Mean (standard error) similarity index values, adjusted for exotic species, for the three ecological sites were:

- Loamy 48.74 (3.13) in 2008 and 59.45 (2.39) in 2009,
- Shallow sandy 48.1 (10.2) in 2008 and 58.25 (6.45) in 2009, and
- Sands/sandy 54.25 (12.45) in 2008 and 68.95 (26.05) in 2009.

The similarity index for the loamy site was significantly greater ($P<0.05$) in 2009 than in 2008. Using mean values for the loamy ecological site, if all 3200 acres were assumed to be this ecological site, this would equate to the generation of approximately 342 credit units. This value still needs to be evaluated for landscape effects to wildlife species, but it demonstrates how mitigation credits could be generated at the site level.

Table 5. Dominant species of plants sampled in the Thunder Basin, Wyoming treatment area in 2008, 2009, and 2010 for each ecological site; presented as relative cover (standard error). Bolded numbers differ between 2008 and either 2009 or 2010.

Plant Species	Ecological Site								
	Loamy			Sands/Sandy			Shallow Sandy		
	2008	2009	2010	2008	2009	2010	2008	2009	2010
Crested wheatgrass	1.70 (1.66)	1.42 (1.42)	2.80 (1.91)	-	0.31 (0.31)	-	-	5.86 (5.86)	-
Prairie sagewort	**1.08** (0.39)	**1.93** (0.48)	3.18 (0.72)	0.22 (0.22)	-	-	2.21 (0.08)	3.34 (2.74)	0.17 (0.01)
Purple threeawn	**3.04** (1.32)	**1.31** (0.91)	4.09 (1.84)	0.81 (0.81)	0.78 (0.78)	-	-	-	-
Big sagebrush	10.15 (1.88)	12.10 (2.30)	14.91 (3.07)	3.13 (0.42)	6.93 (4.33)	10.32 (10.32)	2.28 (2.28)	3.28 (3.28)	-
Blue grama	**16.09** (2.19)	**13.51** (1.95)	16.14 (2.51)	15.01 (5.83)	14.60 (10.53)	12.14 (10.27)	8.58 (3.78)	10.50 (0.49)	8.35 (8.35)
Cheatgrass	**5.18** (1.64)	**3.02** (1.23)	1.36 (0.75)	0.51 (0.51)	-	0.66 (0.66)	2.07 (1.97)	-	-
Threadleaf sedge	**13.24** (2.89)	**11.23** (2.62)	9.85 (2.40)	20.10 (20.10)	17.73 (17.73)	25.08 (25.08)	10.71 (10.71)	14.53 (11.04)	8.35 (8.35)
Needleandthread	**21.21** (2.16)	**30.58** (2.27)	17.90 (2.10)	19.01 (11.48)	25.52 (2.63)	16.02 (3.26)	51.60 (32.19)	46.83 (21.81)	33.25 (20.65)
Pricklypear cactus	7.56 (1.42)	6.15 (1.07)	11.85 (1.52)	5.98 (4.30)	7.10 (2.87)	8.28 (4.35)	7.90 (7.90)	6.55 (6.55)	11.70 (11.70)
Rhizom. wheatgrass	14.26 (2.38)	15.71 (2.53)	10.89 (1.70)	19.69 (17.36)	26.97 (24.73)	17.10 (12.93)	10.21 (10.21)	8.78 (8.78)	13.01 (10.72)
Russian thistle	**3.30** (1.64)	**-**	-	5.60 (5.60)	-	-	1.72 (1.72)	-	-
Sand dropseed	0.02 (0.02)	-	-	9.85 (9.85)	-	-	-	-	-
Prairie sandreed	-	-	0.05 (0.05)	-	-	-	-	-	11.81 (11.81)
Sixweeks fescue	0.36 (0.16)	0.15 (0.06)	1.17 (0.28)	0.02 (0.02)	0.03 (0.03)	4.50 (3.18)	0.03 (0.03)	-	-

Landscape level results

For the TBGPEA Project there were six wildlife species modeled for the landscape analysis: pronghorn antelope, sagebrush lizard, sage sparrow, sage thrasher, sagebrush vole, and sage-

grouse. Summary of the modeling results for each species are presented in Table 6. For maps of the modeling results for each species, see Appendix B.

Table 6. Results of habitat modeling for the Seeley site for the TBGPEA project. Numbers represent potential home ranges of species rated as high quality, medium quality, and low quality. Post-treatment analyses are still pending.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Pronghorn antelope	-	-	-	P**	P	P
Sage thrasher	16	65	42	P	P	P
Sagebrush lizard	0	62	782	P	P	P
Sage sparrow	14	62	59	P	P	P
Sagebrush vole	596	2914	1711	P	P	P
Sage-grouse- nesting	381	1135	1286	P	P	P
Sage-grouse brood-rearing	179	469	273	P	P	P
Sage-grouse- wintering	0	44	131	P	P	P

*Pre-high refers to pretreatment, high quality home ranges, Pre-medium refers to pretreatment medium quality home ranges, Pre-low refers to pretreatment low quality home ranges, Post-high refers to post-treatment high quality home ranges, Post-medium refers to post-treatment medium quality home ranges, and Post-low refers to post-treatment low quality home ranges.

**P refers to analyses that will be run with 2011 data when it is available.

Laidlaw Park, Idaho

Idaho Department of Fish and Game is the primary cooperator on this project area. The treatment area is located on a recent burn in Laidlaw Park in Minidoka County, Idaho. Nearly 30,000 acres of a core habitat for sage-grouse and other sagebrush steppe wildlife in South-Central Idaho burned in August 2007. The area is part of the expanded Craters of the Moon National Monument and Preserve. Within the burn BLM manages approximately 28,000 acres and the Idaho Department of Lands nearly 2,000 acres. Pre-burn conditions of much of this area included a sagebrush overstory and depleted understory heavily invaded by cheatgrass. Without an aggressive rehabilitation effort to restore a vigorous perennial grass/forb understory and a sagebrush canopy, the area will become an exotic annual grassland and lose its value to native sagebrush/grass dependent wildlife species. The BLM is conducting seeding on 19,000 acres and the Idaho Department of Fish & Game and the Idaho Department of Lands proposes to rehabilitate 1,600 acres of state land. Ecological sites in the treatment area were predominantly loams and sandy loams in the 12-16" precipitation zone. A map of the project area showing ecological sites and sampling points established in 2009 is shown in Figure 16.

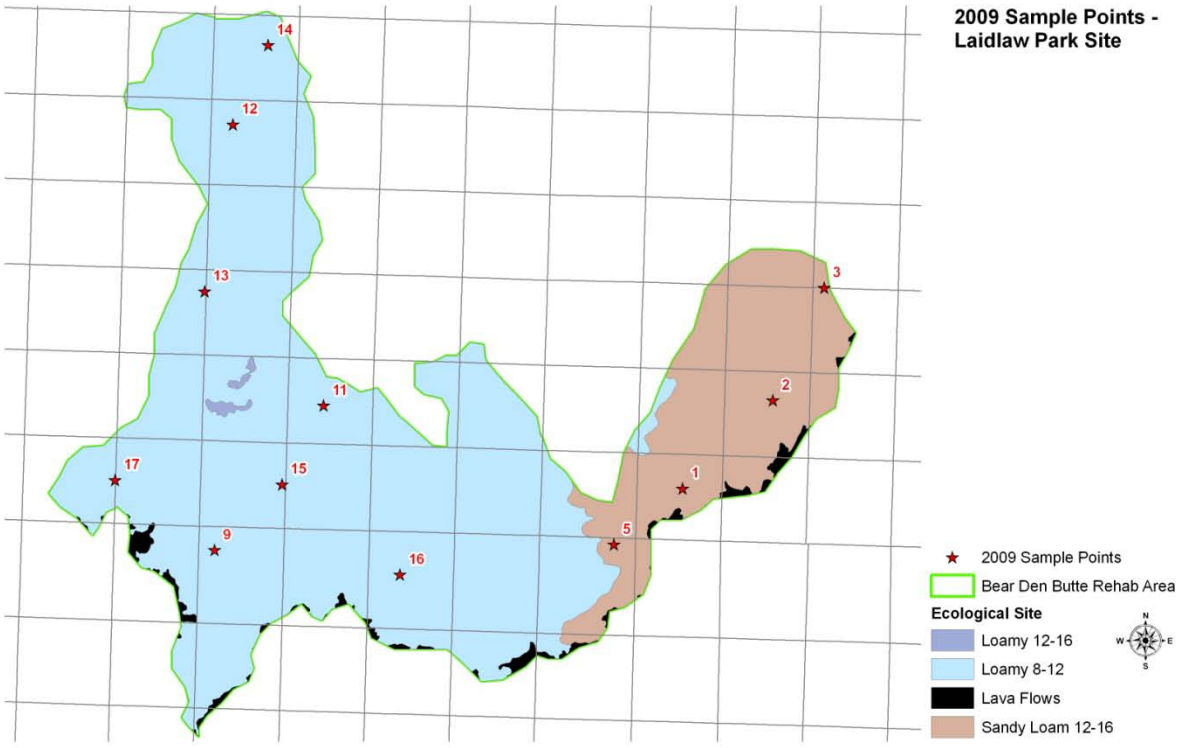

Figure 16. Map of treatment area for Laidlaw Park in Minidoka County, Idaho displaying ecological sites and the locations of sampling points established in 2009.

Development of Reference Community Descriptions

For the two ecological sites on the Idaho Laidlaw Park project, plant community descriptions for loamy and sandy loam ecological sites have been developed. Figure 17 displays the state and transition model for loamy ecological sites (8-12" precipitation zone) and figure 18 displays the state and transition model for sandy loam ecological sites (12-16" precipitation zone).

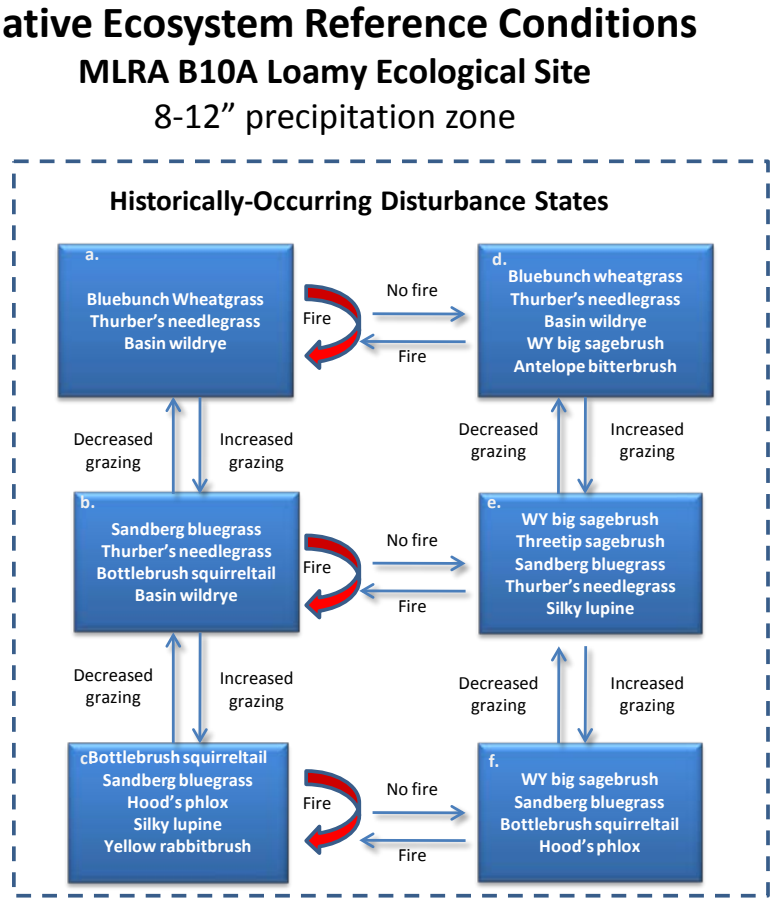

Figure 17. State and transition model for historical plant communities (states) for loamy ecological sites in the 8-12" precipitation zone in MLRA B10A in south central Idaho.

A. Light herbivory, short fire return interval plant community:

Dominant species: Bluebunch wheatgrass, Thurber's wheatgrass, Basin wildrye, longleaf phlox.
Other species: Sandberg bluegrass, bottlebrush squirreltail, common yarrow, fleabane, Hood's phlox, common wooly sunflower, silky lupine woolypod milkvetch, Douglas' dusty maiden, desert parsleynodding microseris, tapertip onion, fiddleneck, tall annual willowherb, trumpet, pale agoseris Hooker's balsamroot
Herbaceous productivity: 400-700 lbs/ac.

B. Moderate herbivory, short fire return interval plant community:

Dominant species: Dominant species: Sandberg bluegrass, Thurber's wheatgrass, Basin wildrye, Bottlebrush squirreltail, Hood's phlox.
Other species: Bluebunch wheatgrass, longleaf phlox Common yarrow, fleabane, common wooly sunflower, silky lupine woolypod milkvetch, Douglas' dusty maiden, desert parsley. nodding microseris, tapertip onion, fiddleneck, tall annual willowherb, trumpet, pale agoseris Hooker's balsamroot
Herbaceous productivity estimate : 350-650lbs/ac.

C. Heavy herbivory, short fire return interval plant community:

Dominant species: Bottlebrush squirreltail, Sandberg bluegrass, Hood's phlox, silky lupine
Other species: rubber rabbitbrush, yellow rabbitbrush, longleaf phlox, common yarrow, fleabane, common wooly sunflower, woolypod milkvetch, Douglas' dusty maiden, desert parsley, nodding microseris, tapertip onion, fiddleneck, tall annual willowherb, trumpet, pale agoseris Hooker's balsamroot
Herbaceous productivity estimate : 250-450 lbs/ac.

D. Light herbivory, long fire return interval plant community:

Dominant species: Bluebunch wheatgrass, Thurber's needlegrass, basin wildrye, big sagebrush, antelope bitterbrush, Saskatoon serviceberry, threetip sagebrush, longleaf phlox
Other species: Sandberg bluegrass, bottlebrush squirreltail, common yarrow, fleabane, Hood's phlox, common wooly sunflower, silky lupine woolypod milkvetch, Douglas' dusty maiden, desert parsleynodding microseris, tapertip onion, fiddleneck, tall annual willowherb, trumpet, pale agoseris, Hooker's balsamroot, spineless horsebrush
Herbaceous productivity estimate : 300-600 lbs/ac.

E. Moderate herbivory, long fire return interval plant community:

Dominant species: big sagebrush, Sandburg bluegrass, bottlebrush squirreltail, basin wildrye, threetip sagebrush, Thurber's needlegrass, Hood's phlox
Other species: bluebunch wheatgrass, common yarrow, fleabane, common wooly sunflower, silky lupine, longleaf phlox, woolypod milkvetch, Douglas' dusty maiden, desert parsley, nodding microseris, tapertip onion, fiddleneck, tall annual willowherb, trumpet, pale agoseris, Hooker's balsamroot, spineless horsebrush, Saskatoon serviceberry, antelope bitterbrush
Herbaceous productivity estimate : 250-500 lbs/ac.

F. Heavy herbivory, long fire return interval plant community:

Dominant species: big sagebrush, bottlebrush squirreltail, Sandberg bluegrass, Hood's phlox, silky lupine

Other species: bluebunch wheatgrass, common yarrow, fleabane, common wooly sunflower, longleaf phlox, woolypod milkvetch, Douglas' dusty maiden, desert parsley, nodding microseris, tapertip onion, fiddleneck, tall annual willowherb, trumpet, pale agoseris, Hooker's balsamroot, spineless horsebrush,
Herbaceous productivity estimate : 200-400 lbs/ac.

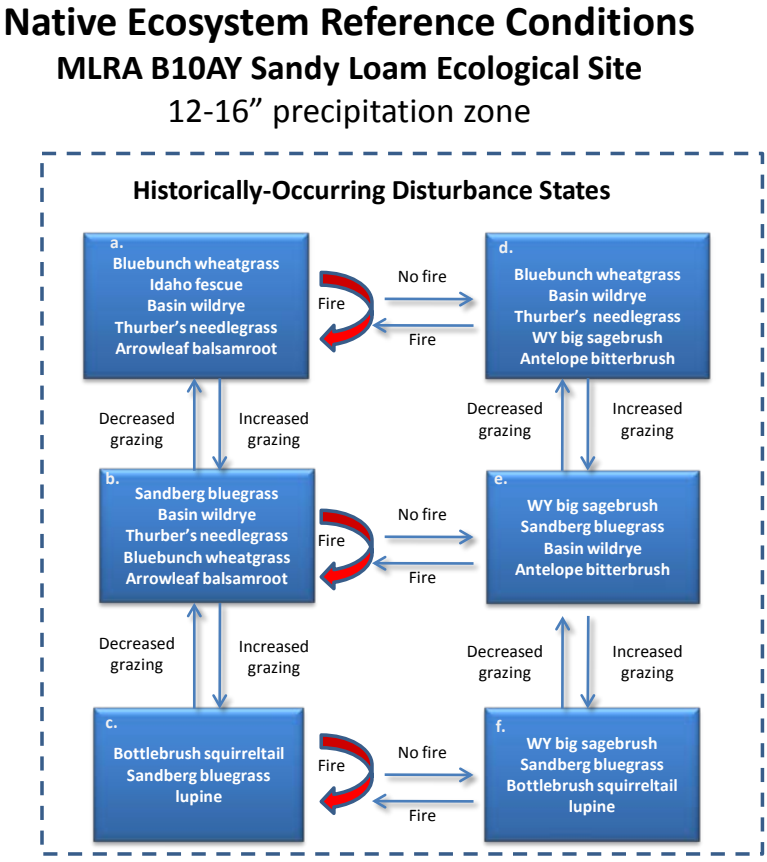

Figure 18. State and transition model for historical plant communities (states) on sandy loam ecological sites in the 12-16" precipitation zone for MLRA 10B in south central Idaho.

A. Light herbivory, short fire return interval plant community:

Dominant species: Bluebunch wheatgrass, Thurber's needlegrass, basin wildrye, arrowleaf balsamroot
Other species: Tapertip hawksbeard, phlox, desert parsley, Sandberg bluegrass, bottlebrush squirreltail, lupine, milkvetch
Herbaceous productivity estimate: 650-900lbs/ac.

B. Moderate herbivory, short fire return interval plant community:

Dominant species: Sandberg bluegrass, Bottlebrush squirreltail, Thurber's needlegrass, basin wildrye, Hood's phlox, arrowleaf balsamroot
Other species: Tapertip hawksbeard, desert parsley, bluebunch wheatgrass, lupine, milkvetch, yellow rabbitbrush
Herbaceous productivity estimate : 550-800lbs/ac.

C. Heavy herbivory, short fire return interval plant community:

Dominant species: Bottlebrush squirreltail, Sandberg bluegrass, Hood's plox, lupine, milkvetch, arrowleaf balsamroot
Other species: Bluebunch wheatgrass, basin wildrye, Thurber's needlegrass, tapertip hawksbeard, desert parsley, yellow rabbitbrush
Herbaceous productivity estimate : 300-500lbs/ac.

D. Light herbivory, long fire return interval plant community:

Dominant species: Bluebunch wheatgrass, Thurber's needlegrass, basin wildrye, big sagebrush, antelope bitterbrush, buckwheat, arrowleaf balsamroot
Other species: Tapertip hawksbeard, phlox, desert parsley, Sandberg bluegrass, bottlebrush squirreltail, lupine, milkvetch, spineless horsebrush
Herbaceous productivity estimate: 550-800lbs/ac.

E. Moderate herbivory, long fire return interval plant community:

Dominant species: Big sagebrush, Sandberg bluegrass, bottlebrush squirreltail, Thurber's needlegrass, Hood's phlox, arrowleaf balsamroot
Other species: Tapertip hawksbeard, desert parsley, bluebunch wheatgrass, lupine, milkvetch, basin wildrye, antelope bitterbrush, buckwheat, spineless hosrsebrush
Herbaceous productivity estimate : 450-750lbs/ac.

F. Heavy herbivory, long fire return interval plant community:

Dominant species: Big sagebrush, bottlebrush squirreltail, Sandberg bluegrass, Hood's plox, lupine, milkvetch, arrowleaf balsamroot
Other species: Bluebunch wheatgrass, basin wildrye, Thurber's needlegrass, tapertip hawksbeard, desert parsley, spineless horsebrush
Herbaceous productivity estimate : 300-500lbs/ac.

Reference Community for Loamy ecological sites in the 8-12" precipitation zone in MLRA 10B in south central Idaho.

The following reported and observed plant diversity of loamy sites was used as the reference community for use in comparisons of compositions using similarity indices:
big sagebrush: 0-35%, with a minimum of 15% to achieve a score of 100%, Indian ricegrass, bluebunch wheatgrass, Thurber needlegrass, and basin wildrye: 0-50% with a minimum of 10% to achieve a score of 100%, rhizomatous wheatgrass and needleandthread: 0-40%, squirreltail, Sandberg bluegrass, Douglas' sedge: 0-10%, with the total for all groupings of grasses not to exceed 75%, native forbs (basalt milkvetch, Picabo milkvetch, lupine, woollypod milkvetch, nodding microseris, desert parsley, textile onion, tapertip onion, Douglas' Dustymaiden, willowherb, spreading groundsmoke, silverleaf phacelia, lava aster, longleaf and prickly phlox, coyote tobacco, common yarrow, fleabane, common wooly sunflower, buckwheat, fiddleneck, agoseris, trumpet, Hooker's balsamroot) excluding Forb B species: 0-20% with a minimum of 10% to achieve a score of 100%, Forb B species (spiny phlox, Canadian horseweed, broom snakeweed, spineless horsebrush,and flatspine stickweed): 0-5%, antelope bitterbrush, Saskatoon serviceberry, and rabbitbrush: 0-5%,

Results

Sampling of this treatment area is occurring post treatment. Sampling of the area was done by ID Fish and Game prior to the wildfire that burned through the area in 2008. These data will be used to describe the site prior to the impacts of burning, and prior to the treatments. In 2009 and 2010 post-treatment sampling was conducted.

Site level sampling

Findings of the 2009 and 2010 sampling in the Laidlaw Park treatment area are listed in Table 7.

Table 7. Dominant plant species (with greater than 1% relative cover in any ecological site in any year) sampled at the Laidlaw Park, Idaho area in 2009 and 2010 for each ecological site and precipitation zone combination; presented as relative cover. Bolded numbers differed between 2009 and 2010 ($P<0.05$).

Species	Ecological Site					
	Loam 12-16" precipitation			Loam 8-12" precipitation		
	2009	2010	2011	2009	2010	2011
Indian ricegrass	0	1.07 (1.07)	P	0.06 (0.06)	.047 (.042)	P
Thurber's needlegrass	0	0	P	0	1.80 (1.80)	P
Crested wheatgrass	0	0	P	0.40 (0.27)	2.07 (0.70)	P
Cheatgrass	10.00 (5.65)	12.11 (7.81)	P	**6.49** (2.21)	**14.78** (4.69)	P
Douglas' Sedge	0	0.29 (0.29)	P	0.41 (0.27)	1.77 (1.24)	P
Bottlebrush	0.14	0.62	P	0.31	2.13	P

squirreltail	(0.14)	(0.62)		(0.20)	(1.36)	
Slender wheatgrass	0	0	P	0.76 (0.76)	3.03 (1.49)	P
Bulbous Bluegrass	0	0	P	0.37 (0.37)	1.46 (1.46)	P
Sandberg bluegrass	**30.10** (7.55)	**44.16** (9.01)	P	11.33 (1.96)	15.56 (4.52)	P
Diffuse knapweed	2.92 (1.98)	2.30 (2.08)	P	1.48 (1.48)	0.15 (0.15)	P
Sulfur-flower buckwheat	3.10 (2.13)	1.38 (1.00)	P	0	0	P
Needle and Thread	1.97 (1.97)	2.23 (2.23)	P	0.36 (0.36)	2.15 (1.59)	P
Prickly Lettuce	7.3 (2.82)	3.70 (1.49)	P	9.23 (2.88)	12.26 (4.08)	P
Common pepperweed	1.16 (0.71)	1.82 (1.58)	P	0.74 (0.40)	2.49 (1.18)	P
Sainfoin	0	**17.38** (3.61)	P	0.09 (0.09)	3.38 (2.28)	P
Rhizomatous wheatgrass	0	0.31 (0.18)	P	0	2.37 (1.23)	P
Bluebunch wheatgrass	1.78 (1.10)	3.60 (3.16)	P	3.78 (1.74)	6.72 (2.53)	P
Tall Tumblemustard	5.75 (1.41)	0.51 (0.51)	P	**34.70** (9.49)	**11.35** (5.05)	P
Spineless horsebrush	0	0	P	1.52 (1.52)	2.07 (2.07)	P
Yellow salsify	1.30 (0.29)	6.09 (1.80)	P	9.17 (5.61)	6.18 (2.48)	P
Intermediate wheatgrass	0	0	P	2.91 (1.80)	3.63 (2.69)	P
Yellow rabbitbrush	3.94 (3.94)	0	P	0	0	P
Fringed willowherb	13.73 (6.82)	0	P	0.97 (0.67)	0.08 (0.05)	p
Spreading groundsmoke	11.26 (7.37)	0.30 (0.30)	P	5.55 (2.84)	0.10 (0.06)	P
Lava aster	0	0	P	3.94 (1.86)	0	P
Granite prickly phlox	2.35 (2.35)	0	P	1.07 (0.59)	0	P

Mean (standard error) similarity index values, adjusted for exotic species, for the 2 ecological sites in Laidlaw Park were:

- Loamy 12-16” precipitation zone: 30.83 (7.58) in 2009 and 12.48 (3.83) in 2010,

- Loamy 8-12" precipitation zone: 9.60 (3.00) in 2009 and 14.81 (5.03) in 2010.

The similarity index for loamy 12-16" precipitation zone sites differed significantly ($P<0.05$) between 2009 and 2010. Obviously, these sites have very low quality conditions following the burn particularly due to the high levels of exotic plants occurring on the sites, and will require additional years for the treatments to be effective in restoring desired sagebrush ecosystems.

Landscape level results

For the Idaho Project there were seven wildlife species modeled for the landscape analysis: pronghorn antelope, sagebrush lizard, sage sparrow, sage thrasher, sagebrush vole, pygmy rabbit, and sage-grouse. Summary of the modeling results for each species are presented in Table 8. For maps of the modeling results for each species, see Appendix B.

Table 8. Results of habitat modeling for the Seeley site for the TBGPEA project. Numbers represent potential home ranges of species rated as high quality, medium quality, and low quality. Post-treatment analyses are still pending.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Pronghorn antelope	-	-	-	P**	P	P
Pygmy rabbit	2040	13	1	P	P	P
Sage thrasher	369	23	14	P	P	P
Sagebrush lizard	0	0	3153	P	P	P
Sage sparrow	951	216	80	P	P	P
Sagebrush vole	5894	3913	5687	P	P	P
Sage-grouse- nesting	5515	4032	552	P	P	P
Sage-grouse brood-rearing	1265	128	102	P	P	P
Sage-grouse- wintering	0	612	142	P	P	P

*Pre-high refers to pretreatment, high quality home ranges, Pre-medium refers to pretreatment medium quality home ranges, Pre-low refers to pretreatment low quality home ranges, Post-high refers to post-treatment high quality home ranges, Post-medium refers to post-treatment medium quality home ranges, and Post-low refers to post-treatment low quality home ranges.

**P refers to analyses that will be run with 2011 data when it is available

Ash Valley Ranch, California

The Ash Valley Ranch treatment area is a cooperative project with the Cooperative Sagebrush Steppe Restoration Initiative in Lassen County, California. The treatment site is a sagebrush area that has been invaded by juniper, with the primary treatment the removal of juniper to release sagebrush and grasses and forbs. The project is designed as a habitat restoration project in the Ash Valley Ranch area southeast of Adin, California. The project will restore degraded ecosystem conditions, improve wildlife habitat conditions, improve rangeland productivity, and improve water quality and quantity.

Ash Valley Ranch is located in MLRA 21, the Klamath and Shasta Valleys and Basins. The area is in a transition zone between the Basin and Range Province to the southeast, the Cascade and Klamath Mountains to the west and northwest, and the Sierra Nevada Mountains to the south. Ecological sites on the treatment area (Figure 19) included cool loam, stony loam, and shallow stony loams all in the 12-16" precipitation zone.

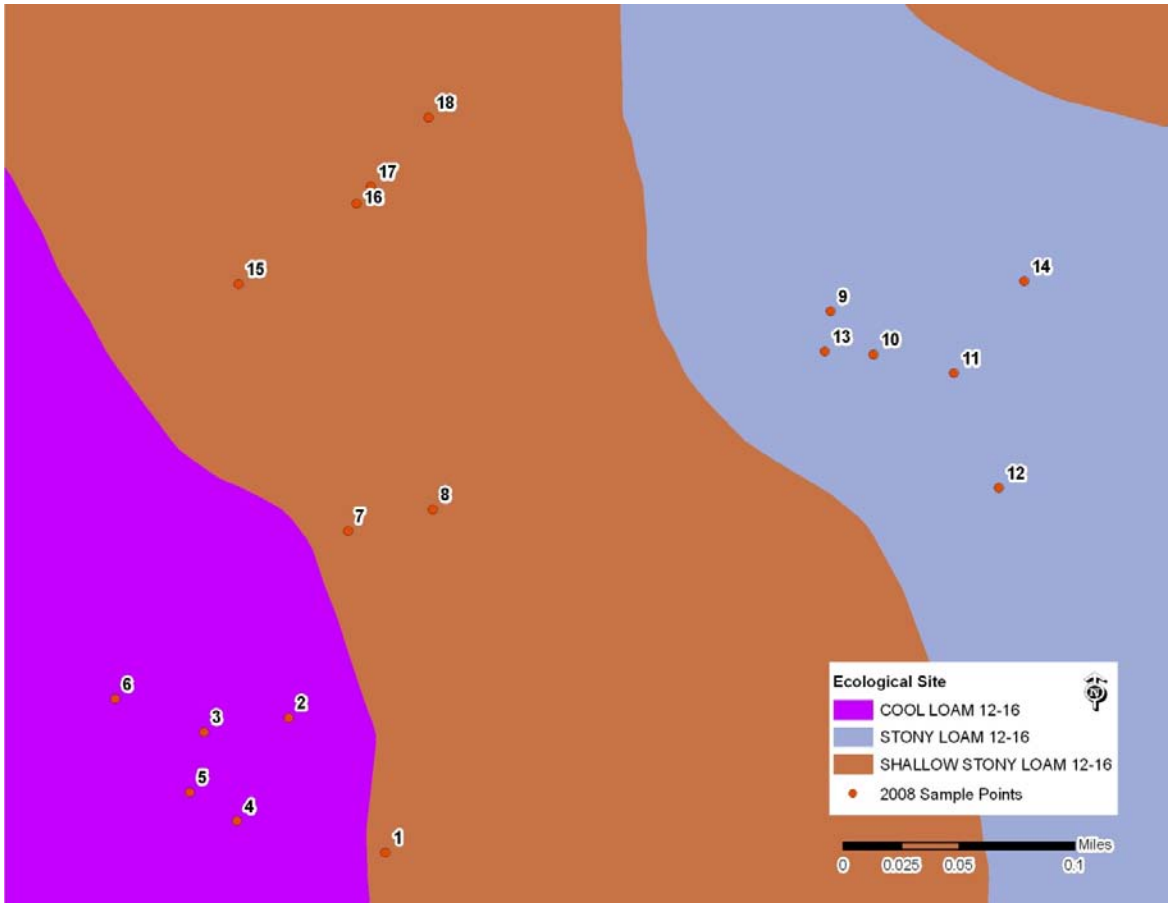

Figure 19. Ecological sites and sampling point locations in the Ash Valley Ranch treatment area in northern California.

The state and transition model for historically occurring plant communities on the stony loam ecological site for the 12-16" precipitation zone is shown in Figure 20.

Native Ecosystem Reference Conditions
MLRA 21 Stony Loam Ecological Site
12-16" precipitation zone

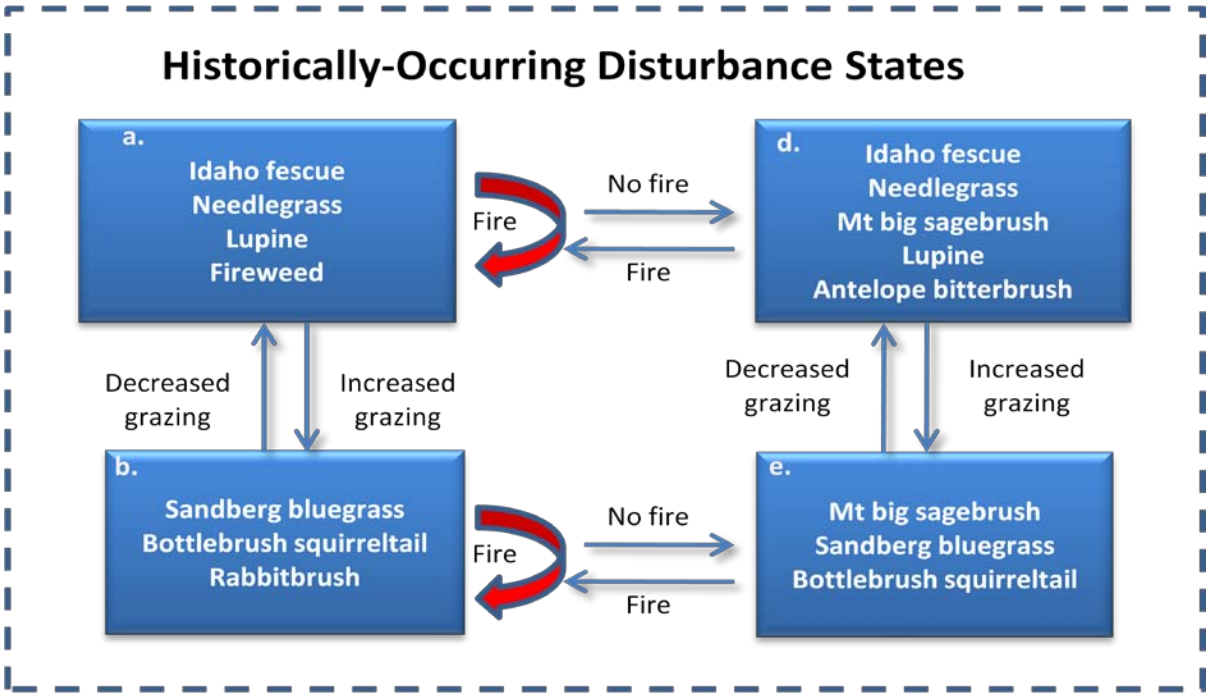

Figure 20. State and transition model for historically occurring plant communities for the stony loam ecological site for the 12-16" precipitation zone in MLRA 21 for northeastern California.

A. Short fire return interval, light herbivory

Dominant species: Idaho fescue, needlegrass, bluebunch wheatgrass, lupine, balsamroot.
Other characteristic species: Bottlebrush squirreltail, Sandberg bluegrass, prairie junegrass, slender phlox, currant, agoseris, rabbitbrush, hawksbeard, cryptantha, fleabane, aster, blazingstar, bastard toadflax, woodland star, flax, groundsmoke, maiden blue-eyed Mary.
Historical Grass and Forb Productivity Estimate: 600-1200 lbs/acre

B. Short fire return interval, moderate-heavy herbivory

Dominant species: Sandberg bluegrass, bottlebrush squirreltail, rabbitbrush

Other characteristic species: Spiny phlox, knotweed, agoseris, upland sedge, fleabane, aster, prairie junegrass, bastard toadflax, Idaho fescue, needlegrass.
Historical Grass and Forb Productivity Estimate: 500-1100 lbs/acre

C. Long fire return interval, light herbivory

Dominant species: big sagebrush, needle grass, Idaho fescue, bluebunch wheatgrass, balsamroot.
Other characteristic species: Bottlebrush squirreltail, Sandberg bluegrass, prairie junegrass, slender phlox, currant, antelope bitterbrush, agoseris, western juniper, curl-leaf mountain mahogany, rabbitbrush, hawksbeard, cryptantha, fleabane, aster, blazingstar, lupine, bastard toadflax, woodland star, flax, groundsmoke, maiden blue-eyed mary.
Historical Grass and Forb Productivity Estimate: 400-1000 lbs/acre.

D. Long fire return interval, moderate-heavy herbivory

Dominant species: Big sagebrush, Sandberg bluegrass, bottlebrush squirreltail, western juniper
Other characteristic species: Spiny phlox, knotweed, agoseris, upland sedge, fleabane, aster, prairie junegrass, bastard toadflax.
Historical Grass and Forb Productivity Estimate: 300-800 lbs/acre

Development of reference plant community

The reference plant community for stony loam ecological sites in MLRA 21 was developed based on the long fire-return interval, light herbivory historical plant community with the following characteristics:
Big sagebrush: 0-35%, with a minimum of 15% to achieve a maximum score of 100%, Idaho fescue, needlegrass, bluebunch wheatgrass: 0-50% with a minimum of 10% to achieve a score of 100%, bottlebrush squirreltail, prairie junegrass, Sandberg bluegrass, upland sedges: 0-10%, native forbs A (slender phlox, pussytoes, agoseris, milkvetch, Indian paintbrush, larkspur, hawksbeard, willowherb, cryptantha, fleabane, aster, blazingstar, whitestem frasera, desert parsley, lupine, buckwheat, phacelia, violet, wooly muleears, woodland star, stoneseed, flax, groundsmoke, maiden blue-eyed Mary, stemless mock goldenweed, death camus: 0-15% with at least 10% to achieve a maximum score of 100%, Native forbs B (spiny phlox, knotweed, bastard toadflax, sandwort, ragwort, thistle): 0-5%, woody species (little sagebrush, currant, rabbitbrush, curl-leaf mountain mahogany, antelope bitterbrush): 0-10%, western juniper: 0-1%.

The state and transition model for historically occurring plant communities on the shallow stony loam ecological site for the 12-16” precipitation zone of MLRA 21 in northeastern California is shown in Figure 21.

Native Ecosystem Reference Conditions
MLRA 421 Shallow Stony Loam Ecological Site
12-16" precipitation zone

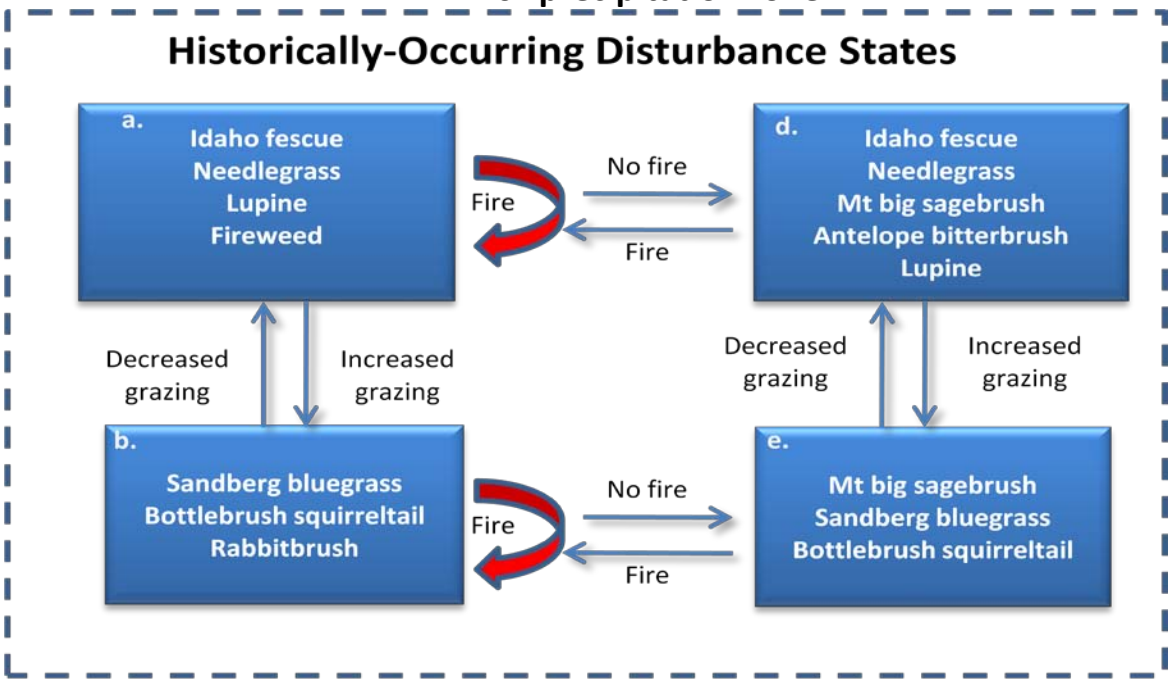

Figure 21. State and transition model for the shallow stony loam 12-18" precipitation zone ecological site.

A. Short fire return interval, light herbivory

Dominant species: Idaho fescue, needlegrass, bluebunch wheatgrass, lupine, balsamroot, wooly muleears.
Other characteristic species: Pussytoes, bottlebrush squirreltail, Sandberg bluegrass, prairie junegrass, slender phlox, sandwort, milkvetch, agoseris, rabbitbrush, hawksbeard, cryptantha, fleabane, aster, larkspur, willowherb, Oregon sunshine, whitestem frasera, desert parsley, blazingstar, bastard toadflax, woodland star, flax, groundsmoke, maiden blue-eyed Mary, stemless mock goldenweed.
Historical Grass and Forb Productivity Estimate: 600-1200 lbs/acre

B. Short fire return interval, moderate-heavy herbivory

Dominant species: Sandberg bluegrass, bottlebrush squirreltail, rabbitbrush
Other characteristic species: Spiny phlox, knotweed, agoseris, sandwort, upland sedge, fleabane, aster, prairie junegrass, bastard toadflax, larkspur, Idaho fescue, needlegrass.
Historical Grass and Forb Productivity Estimate: 500-1100 lbs/acre

C. Long fire return interval, light herbivory

Dominant species: big sagebrush, little sagebrush, needle grass, Idaho fescue, bluebunch wheatgrass, wooly muleears, balsamroot.
Other characteristic species: Bottlebrush squirreltail, Sandberg bluegrass, prairie junegrass, slender phlox, currant, antelope bitterbrush, agoseris, milkvetch, Indian paintbrush, larkspur, sandwort, western juniper, curl-leaf mountain mahogany, rabbitbrush, hawksbeard, willowherb, Oregon sunshine, cryptantha, fleabane, aster, blazingstar, whitestem frasera, desert parsley, lupine, bastard toadflax, woodland star, flax, groundsmoke, maiden blue-eyed Mary, stemless mock goldenweed.
Historical Grass and Forb Productivity Estimate: 400-1000 lbs/acre.

D. Long fire return interval, moderate-heavy herbivory

Dominant species: Big sagebrush, little sagebrush, Sandberg bluegrass, bottlebrush squirreltail, western juniper
Other characteristic species: Spiny phlox, knotweed, agoseris, sandwort, upland sedge, fleabane, aster, prairie junegrass, bastard toadflax.
Historical Grass and Forb Productivity Estimate: 300-800 lbs/acre

Development of reference plant community

The reference plant community for shallow stony loam ecological sites in MLRA 21 was developed based on the long fire-return interval, light herbivory historical plant community with the following characteristics:
Big sagebrush: 0-35%, with a minimum of 15% to achieve a maximum score of 100%, Idaho fescue, needlegrass, bluebunch wheatgrass: 0-50% with a minimum of 10% to achieve a score of 100%, bottlebrush squirreltail, prairie junegrass, Sandberg bluegrass, upland sedges: 0-10%, native forbs A (slender phlox, agoseris, milkvetch, Indian paintbrush, larkspur, sandwort, hawksbeard, willowherb, Oregon sunshine, cryptantha, fleabane, aster, blazingstar, whitestem frasera, desert parsley, lupine, buckwheat, phacelia, violet, wooly muleears, woodland star, flax, groundsmoke, maiden blue-eyed Mary, stemless mock goldenweed, death camus: 0-15% with at least 10% to achieve a maximum score of 100%, Native forbs B (spiny phlox, knotweed, bastard toadflax, ragwort, thistle): 0-5%, woody species (little sagebrush, currant, rabbitbrush, curl-leaf mountain mahogany, antelope bitterbrush): 0-10%, western juniper: 0-1%.

Figure 22 displays the state and transition model for historical plant communities (states) in the cool loam ecological site, 12-16” precipitation zone in MLRA 21 in northeastern California.

Native Ecosystem Reference Conditions
MLRA 421 Shallow Cool Loamy Ecological Site
12-16” precipitation zone

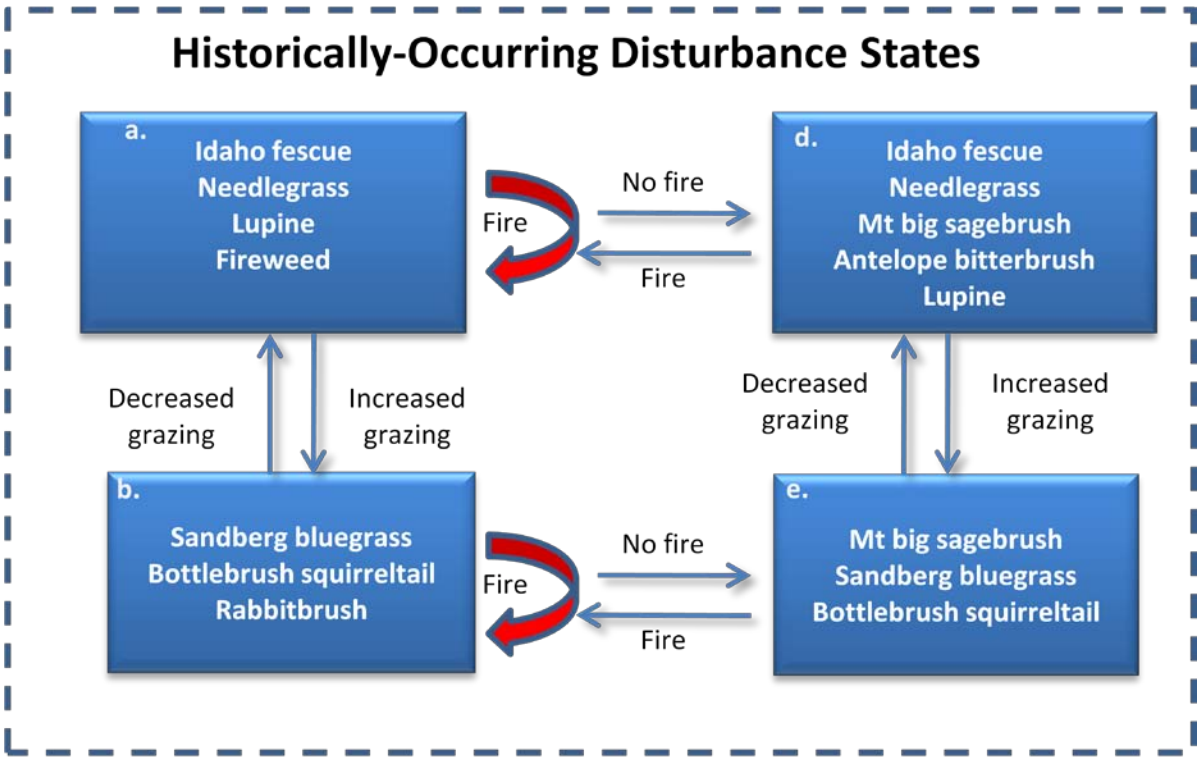

Figure 22. State and transition model for cool loamy ecological sites in the 12-16" precipitation zone of MLRA 21 in northeastern California.

A. Short fire return interval, light herbivory

Dominant species: Idaho fescue, needlegrass, bluebunch wheatgrass, lupine, balsamroot, wooly muleears.
Other characteristic species: bottlebrush squirreltail, Sandberg bluegrass, prairie junegrass, slender phlox, pussytoes, milkvetch, agoseris, rabbitbrush, hawksbeard, cryptantha, fleabane, aster, larkspur, willowherb, whitestem frasera, desert parsley, blazingstar, bastard toadflax, woodland star, flax, groundsmoke, maiden blue-eyed Mary, stemless mock goldenweed.
Historical Grass and Forb Productivity Estimate: 600-1200 lbs/acre

B. Short fire return interval, moderate-heavy herbivory

Dominant species: Sandberg bluegrass, bottlebrush squirreltail, rabbitbrush
Other characteristic species: Spiny phlox, knotweed, agoseris, upland sedge, fleabane, aster, prairie junegrass, bastard toadflax, larkspur, Idaho fescue, needlegrass.
Historical Grass and Forb Productivity Estimate: 500-1100 lbs/acre

C. Long fire return interval, light herbivory

Dominant species: big sagebrush, needle grass, Idaho fescue, bluebunch wheatgrass, wooly muleears, balsamroot.
Other characteristic species: Bottlebrush squirreltail, Sandberg bluegrass, prairie junegrass, slender phlox, currant, antelope bitterbrush, agoseris, milkvetch, Indian paintbrush, larkspur, western juniper, curl-leaf mountain mahogany, rabbitbrush, hawksbeard, willowherb, cryptantha, fleabane, aster, blazingstar, whitestem frasera, desert parsley, lupine, bastard toadflax, woodland star, flax, groundsmoke, maiden blue-eyed Mary, stemless mock goldenweed, western juniper.
Historical Grass and Forb Productivity Estimate: 400-1000 lbs/acre.

D. Long fire return interval, moderate-heavy herbivory

Dominant species: Big sagebrush, Sandberg bluegrass, bottlebrush squirreltail, western juniper
Other characteristic species: Spiny phlox, knotweed, agoseris, upland sedge, fleabane, aster, prairie junegrass, bastard toadflax.
Historical Grass and Forb Productivity Estimate: 300-800 lbs/acre

Development of reference plant community

The reference plant community for cool loamy ecological sites in MLRA 21 was developed based on the long fire-return interval, light herbivory historical plant community with the following characteristics:
Big sagebrush: 0-35%, with a minimum of 15% to achieve a maximum score of 100%, Idaho fescue, needlegrass, bluebunch wheatgrass: 0-50% with a minimum of 10% to achieve a score of 100%, bottlebrush squirreltail, prairie junegrass, Sandberg bluegrass, upland sedges: 0-10%, native forbs A (slender phlox, agoseris, milkvetch, Indian paintbrush, larkspur, hawksbeard, willowherb, cryptantha, fleabane, aster, blazingstar, whitestem frasera, desert parsley, lupine, buckwheat, phacelia, violet, wooly muleears, woodland star, flax, groundsmoke, maiden blue-eyed Mary, stemless mock goldenweed, death camus: 0-15% with at least 10% to achieve a maximum score of 100%, Native forbs B (spiny phlox, knotweed, bastard toadflax, ragwort, thistle): 0-5%, woody species (currant, rabbitbrush, curl-leaf mountain mahogany, antelope bitterbrush): 0-10%, western juniper: 0-1%.

Results

Vegetation sampling of plant communities was conducted pretreatment in 2008 and post-treatment in 2009 and 2010, with results shown in Table 12. In addition, landscape level analyses were conducted on the 7 sagebrush-associated species discussed in the Methods section.

Table 9. Dominant plant species (with greater than 1% relative cover in any ecological site in any year) sampled at the Ash Valley Ranch, California site in 2008, 2009 and 2010 for ecological sites in the treatment area, presented as relative cover (standard error).

Species	Ecological Site											
	Cool Loamy				Stony Loam				Shallow Stony Loam			
	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
Idaho fescue	23.66 (9.85)	-	P	P	34.18 (9.72)	18.52 (15.99)	P	P	4.77 (3.30)	2.15 (2.15)	P	P
Bluebunch wheatgrass	7.83 (5.30)	-	P	P	17.34 (6.45)	4.50 (2.92)	P	P	4.10 (2.20)	3.15 (2.11)	P	P
Sandberg bluegrass	36.35 (12.05)	9.11 (3.42)	P	P	5.93 (4.44)	3.13 (2.84)	P	P	19.41 (8.92)	14.49 (3.89)	P	P
Bottlebrush squirreltail	1.15 (0.53)	7.35 (3.22)	P	P	3.42 (1.60)	2.64 (2.07)	P	P	4.57 (2.19)	-	P	P
Needlegrass	0.52 (0.47)	25.18 (5.09)	P	P	1.53 (0.98)	18.18 (10.41)	P	P	2.60 (1.98)	5.98 (3.67)	P	P
Prairie Junegrass	-	-	P	P	-	-	P	P	-	1.94 (1.34)	P	P
Cheatgrass	-	1.10 (1.10)	P	P	-	1.26 (1.26)	P	P	-	3.61 (2.05)	P	P
Upland sedges	-	6.46 (1.77)	P	P	-	2.06 (2.34)	P	P	-	5.36 (2.85)	P	P
Agroseris	-	2.58 (0.89)	P	P	-	1.69 (0.92)	P	P	-	1.17 (0.52)	P	P
Pussytoes	-	-	P	P	-	-	P	P	2.68 (2.68)	10.31 (5.49)	P	P
Slender phlox	3.70 (1.59)	14.19 (1.99)	P	P	-	2.91 (1.64)	P	P	-	2.30 (0.62)	P	P
Spiny phlox	-	2.33 (1.26)	P	P	-	-	P	P	-	-	P	P
Cryptantha	-	1.25 (1.04)	P	P	-	2.11 (2.05)	P	P	-	-	P	P
Indian paintbrush	-	-	P	P	1.28 (1.28)	-	P	P	-	1.36 (1.10)	P	P
Maiden blue eyed Mary	1.65 (0.86)	-	P	P	-	-	P	P	-	-	P	P
Buckwheat	-	1.02 (1.02)	P	P	-	-	P	P	-	-	P	P

Whitestem Frasera	-	-	P	P	-	-	P	P	-	1.37 (0.66)	P	P
Ground Smoke	-	3.66 (3.20)	P	P	-	1.72 (0.23)	P	P	-	-	P	P
Lupine	8.87 (1.94)	3.42 (1.73)	P	P	2.86 (1.93)	1.29 (0.84)	P	P	-	0.36 (0.22)	P	P
Toadflax	-	2.70 (0.37)	P	P	-	7.45 (6.30)	P	P	-	-	P	P
Woodland Star	-	-	P	P	-	1.28 (1.19)	P	P	-	-	P	P
Fleabane	1.90 (1.86)	-	P	P	-	-	P	P	-	1.59 (1.14)	P	P
Cudweed	-	-	P	P	-	-	P	P	7.32 (7.32)	-	P	P
Sandwort	-	-	P	P	-	-	P	P	-	1.81 (0.99)	P	P
Desert parsley	-		P	P	1.86 (1.86)	-	P	P	1.70 (1.66)	1.64 (1.55)	P	P
Wooly muleears	1.19 (1.19)	-	P	P	-	6.54 (6.54)	P	P	-	-	P	P
Thistle	-	-	P	P	-	-	P	P	-	4.30 (4.30)	P	P
Big sagebrush	11.18 (5.76)	12.29 (4.35)	P	P	18.38 (7.80)	8.64 (3.85)	P	P	20.11 (10.21)	4.48 (2.84)	P	P
Little sagebrush	-	-	P	P	-	-	P	P	17.93 (6.12)	20.02 (6.61)	P	P
Antelope bitterbrush	-	1.63 (1.63)	P	P	-	-	P	P	7.87 (5.11)	4.84 (2.20)	P	P
Mountain mahogany	-	1.27 (1.27)	P	P	-	-	P	P	-	-	P	P
Wax currant	-	-	P	P	-	1.86 (1.86)	P	P	-	-	P	P
Western juniper	-	-	P	P	-	-	P	P	1.44 (1.44)	-	P	P
Rabbitbrush	-	-	P	P	4.00 (4.00)	1.38 (1.38)	P	P	-	-	P	P

Comparisons of the sampled plant communities to the reference plant communities determined the following similarity indices:

- The cool loamy sites had a mean similarity index (standard error) of 78.33 (6.27) in 2008, 56.52 (2.80) in 2009, and 58.46 (5.72) in 2010,
- The stony loam sites had a mean similarity index (standard error) of 78.82 (4.88) in 2008, 65.58 (9.20) in 2009, and 69.34 (6.73) in 2010,
- The shallow stony loam sites had a mean similarity index (standard error) of 41.93 (10.60) in 2008, 45.88 (6.72) in 2009, and 44.86 (7.92) in 2010.

None of these similarity index values differed significantly among sampling years.

Landscape level results

Modeling of pretreatment habitat conditions for the 7 sagebrush-associated species that can occur in the area produced estimates of home range qualities listed in Table 10. Habitat suitability and home range maps for the Ash Valley landscape are presented in Appendix B.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Pronghorn antelope	**0**	**0**	**2**	**P****	**P**	**P**
Pygmy rabbit	**47**	**31**	**19**	**P**	**P**	**P**
Sage thrasher	**1**	**30**	**6**	**P**	**P**	**P**
Sagebrush lizard	**1140**	**394**	**14**	**P**	**P**	**P**
Sage sparrow	**139**	**17**	**1**	**P**	**P**	**P**
Sagebrush vole	**0**	**291**	**426**	**P**	**P**	**P**
Sage-grouse- nesting	**1093**	**828**	**1341**	**P**	**P**	**P**
Sage-grouse brood-rearing	**9**	**260**	**123**	**P**	**P**	**P**
Sage-grouse- wintering	**123**	**48**	**76**	**P**	**P**	**P**

Table 10. Results of habitat modeling for the Ash Valley, California site. Numbers represent potential home ranges of species rated as high quality, medium quality, and low quality. Post-treatment analyses are still pending.

Anthro Mountain, Utah

The Anthro Mountain study, in the Ashley National Forest in northeastern Utah ranges in elevation from 7000 - 8000 feet. The area has been used for many years for livestock grazing, and still supports grazing leases. The study area supports grass and sagebrush vegetation that also has extensive pinyon-juniper. The treatment area was chained to reduce the densities of the pinyon-juniper in the 1960's, but the area has since grown back with substantial densities of these species. As a result, sagebrush plant communities in the project area have declined and do not support quality wildlife habitat or maximize other sagebrush ecosystem services. The sage-grouse population in the area is small. Poor habitat condition has been identified as a major factor contributing to local population declines.

From mid-late September 2009, contract crews used chainsaws to remove encroaching pinyon-juniper from the 400 acres of the study site. A lop and scatter method was used, with the 'lop' referring to the treatment of crews walking across the site and cutting down the pinyon and juniper with chainsaws and the 'scatter' referring to the slash that is left where it falls throughout the treatment area.

Results

Site level results

Results of the vegetation sampling conducted at Anthro MT in 2009 and 2010 are presented in Table 11.

	Ecological Site		
	Shallow Loamy		
Species	2009	2010	2011
Pussytoes	2.08 (0.46)	1.47 (0.32)	P**
Big sagebrush	34.79 (2.28)	41.15 (2.48)	P
Looseflower milkvetch	6.37 (0.96)	6.74 (1.00)	P
Smooth brome	29.55 (1.59)	28.70 (1.45)	P
Indian paintbrush	1.02 (0.26)	0.78 (0.16)	P
Fleabane	1.03 (0.40)	0.33 (0.14)	P
Buckwheat	2.35 (0.35)	1.26 (0.34)	P
Prairie Junegrass	1.53 (0.71)	-	P
Lupine	1.04 (0.36)	0.91 (0.24)	P
Field locoweed	1.27 (0.57)	0.64 (0.16)	P
Purple locoweed	1.77 (0.43)	-	P
Muttongrass	5.65 (0.81)	2.90 (1.21)	P
Sandberg bluegrass	1.57 (0.48)	-	P
Phlox	0.94 (0.18)	1.30 (0.20)	P
Needlegrass	-	8.48 (1.61)	P
Knotgrass	0.10 (0.05)	2.22 (0.38	P

Table 11. Results of vegetation sampling conducted on shallow loamy ecological sites of the Anthro Mt project area in Utah in 2009 and 2010.

Landscape level results

Modeling of pretreatment habitat conditions for the four sagebrush-associated species that can occur in the Anthro project area produced estimates of home range qualities listed in Table 12.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Sage thrasher	1	28	6	P	P	P
Sagebrush lizard	0	0	683	P	P	P
Sage sparrow	24	46	11	P	P	P
Sage-grouse- nesting	306	943	538	P	P	P
Sage-grouse brood-rearing	37	100	236	P	P	P
Sage-grouse- wintering	22	48	105	P	P	P

Table 12. Results of wildlife species modeling for the Anthro MT project area in Utah. P refers to pending analyses that will be completed following 2011 sampling.

Deadman's Bench, Utah

This project is being conducted cooperatively with Utah's Watershed Restoration Initiative, and is located in Uintah County in northeastern Utah. It is an area of relatively flat terrain supporting sagebrush. The sagebrush in the project area was not in a state to adequately provide the desired wildlife habitat. The sagebrush was also experience an expansion in invasive species and exhibited poor sagebrush structure and poor quality of understory vegetation. The greater sage-grouse population in this area is small and poor habitat condition has been identified as a significant contributor to the current situation.

Treatments being applied include: 1) broadcast seeding and a double pass from a Dixie harrow, and 2) seed broadcast on plots that will be strategically grazed by sheep to reduce canopy cover. A total of 560 acres in 10 plots will be treated using the Dixie harrow. The size of the plots to be treated mechanically will be no less than 40 acres each. Each treatment plot will have a control plot to be used for comparison to determine treatment effects on vegetation and greater sage-grouse use. A total of 64 acres will be used to implement the grazing treatments. Of this acreage, 40 acres will be used to conduct and actual grazing experiment. The remaining 24 acres will be used as a conditioning pasture to habituate the sheep to electric fencing, eating a supplement, and train them to eat sagebrush. The plot size for the grazing treatment will be no smaller than 10 acres. Control plots will also be established for comparison to document treatment effects.

Both the mechanical and grazed plots will be seeded and treated with Plateau herbicide. The conditioning pasture will not be treated with herbicide or reseeded. The supplement will provide sheep with additional energy and balanced nutrients in response to the increased intake of terpenes in their diet as they increase their intake sagebrush. The grazing permittee supports the project and will provide 1000 ewes to graze the plots.

The project area is within MLRA 34B, the Warm Central Desertic Basins and Plateaus. The primary ecological site in the project area is semidesert loam, although smaller portions of the project area are in the desert clay ecological site. This area is in the 8-12" precipitation zone. A map of the ecological sites is shown in Figure 23.

As described in the ESD for this site, the semidesert loam site occurs on alluvial fans, terraces, pediment foot slopes, toe slopes and occasionally in drainages. Characteristic soils in this site are deep and well-drained, formed in alluvium and colluvium derived mainly from mixed sedimentary parent materials. The soils are generally fine-loamy with a surface texture of loam, fine sandy loam or silty clay loam. A state and transition model for historically occurring states/plant communities is shown in Figure 24.

The desert clay ecological site occurs on approximately 10% of the project area. Characteristic soils in this site are deep over shale and well drained. They formed in residuum derived mainly from shale parent materials. Soil textures are clay to silty clay loam. A state and transition model for historically occurring states/plant communities for this site is shown in Figure 25.

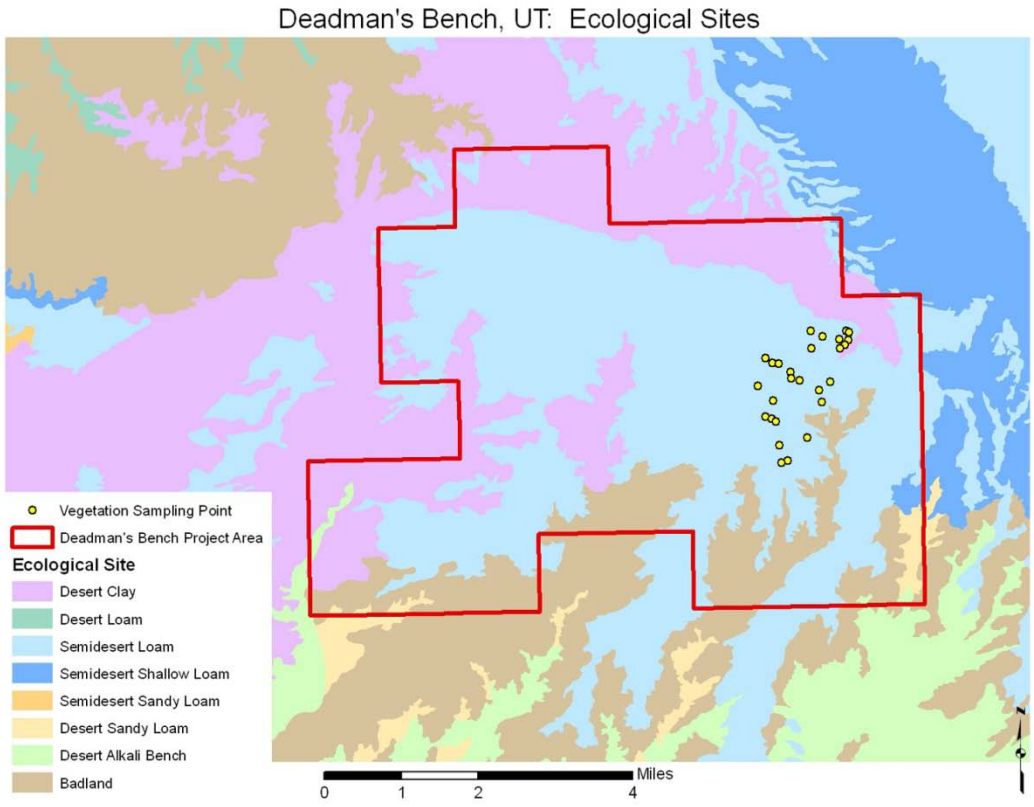

Figure 23. Ecological sites of the Deadman's Bench project area in Northeastern, UT.

MLRA 34B Warm Central Desertic Basins and Plateaus
Semidesert Loam Ecological Site State and Transition Model

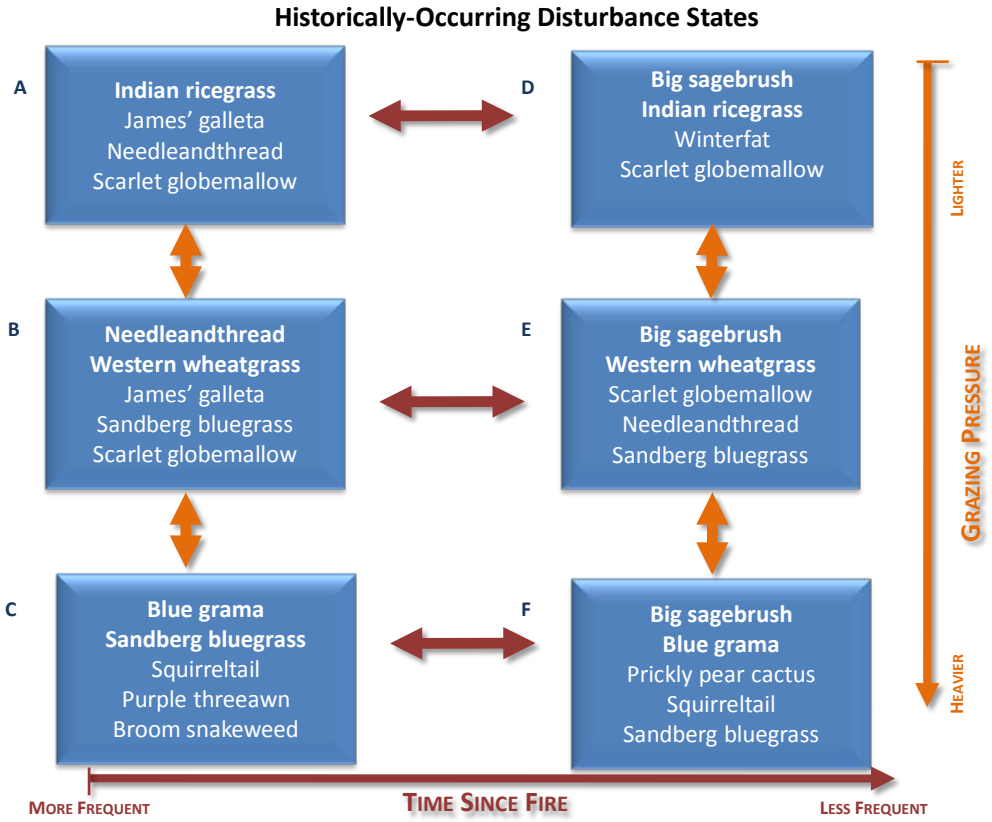

Figure 24. State and transition model for semidesert loamy sites in MLRA 34B in the 8-12" precipitation zone.

State/plant community descriptions

A. Short fire return interval, light herbivory

Dominant species: Indian rice grass, needleandthread, western wheatgrass, James' galleta, scarlet globemallow.
Other characteristic species: Saline wildrye, bottlebrush squirreltail, Sandberg bluegrass, sand dropseed, bulbous springparsley, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, cushion buckwheat, ipomopsis, mountain pepperweed, bisquitroot, whitestem blazingstar, beardtongue, phlox, western tansymustard, hedgemustard, rabbitbrush.
Historical Grass and Forb Productivity Estimate: 500-800 lbs/acre

B. Short fire return interval, moderate herbivory

Dominant species: Needleand thread, western wheatgrass, scarlet globemallow.
Other characteristic species: Bottlebrush squirreltail, Indian ricegrass, saline wildrye, James; galleta, Sandberg bluegrass, sand dropseed, blue grama, rabbitbrush, broom snakeweed, bulbous springparsley, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, cushion buckwheat, ipomopsis, mountain pepperweed, bisquitroot, whitestem blazingstar, beardtongue, phlox, western tansymustard, hedgemustard, plains pricklypear.
Historical Grass and Forb Productivity Estimate: 400-700 lbs/acre

C. Short fire return interval, heavy herbivory

Dominant species: Blue grama, bottlebrush squirreltail, Sandberg bluegrass, broom snakeweed, rabbitbrush.
Other characteristic species: western wheatgrass, sand dropseed, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, cushion buckwheat, ipomopsis, mountain pepperweed, whitestem blazingstar, beardtongue, phlox, western tansymustard, hedgemustard, plains pricklypear.

Historical Grass and Forb Productivity Estimate: 200-600 lbs/acre.

D. Long fire return interval, light herbivory

Dominant species: Big sagebrush, Indian rice grass, needleandthread, western wheatgrass, James' galleta, scarlet globemallow, winterfat.
Other characteristic species: Saline wildrye, bottlebrush squirreltail, Sandberg bluegrass, sand dropseed, bulbous springparsley, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, cushion buckwheat, ipomopsis, mountain pepperweed, bisquitroot, whitestem blazingstar, beardtongue, phlox, western tansymustard, hedgemustard, rabbitbrush, fourwing saltbrush, shadscale saltbrush, mormon tea.
Historical Grass and Forb Productivity Estimate: 400-700 lbs/acre

E. Long fire return interval, moderate herbivory

Dominant species: Big sagebrush, needleand thread, western wheatgrass, scarlet globemallow.
Other characteristic species: Bottlebrush squirreltail, Indian ricegrass, saline wildrye, James; galleta, Sandberg bluegrass, sand dropseed, blue grama, rabbitbrush, broom snakeweed, bulbous springparsley, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, cushion buckwheat, ipomopsis, mountain pepperweed, bisquitroot, whitestem blazingstar, beardtongue, phlox, western tansymustard, hedgemustard, plains pricklypear, spiny hopsage, fourwing saltbrush, shadscale saltbrush, mormon tea.
Historical Grass and Forb Productivity Estimate: 300-600 lbs/acre

F. Long fire return interval, heavy herbivory

Dominant species: Big sagebrush, blue grama, bottlebrush squirreltail, Sandberg bluegrass, broom snakeweed.
Other characteristic species: western wheatgrass, sand dropseed, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, mountain pepperweed, phlox, western tansymustard, hedgemustard, plains pricklypear, spiny hopsage.

Historical Grass and Forb Productivity Estimate: 200-500 lbs/acre.

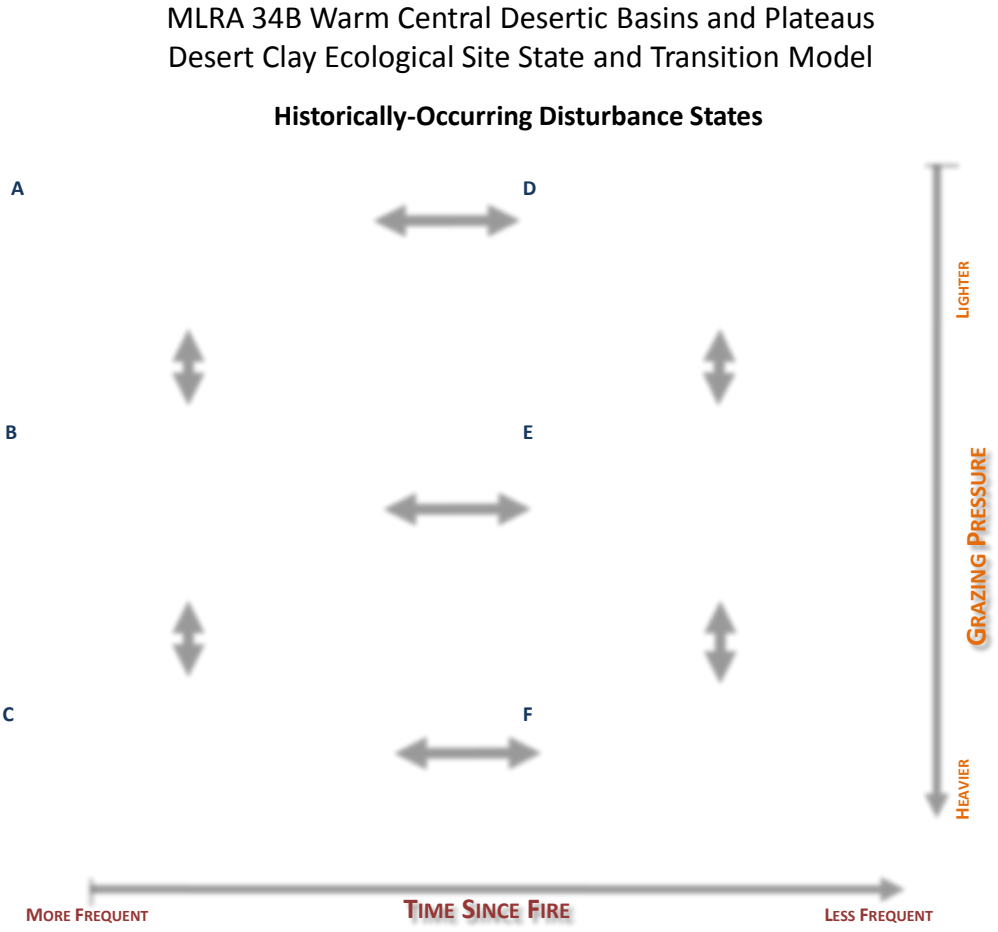

Figure 25. State and transition model for desert clay ecological sites in MLRA 34b, 8-12" precipitation zone.

State/plant community descriptions

A. Short fire return interval, light herbivory

Dominant species: Indian rice grass, western wheatgrass, scarlet globemallow.
Other characteristic species: Saline wildrye, bottlebrush squirreltail, Sandberg bluegrass, sand dropseed, bulbous springparsley, Shockley's buckwheat, common sunflower, desert

princesplume, wooly plantain, littleleaf pussytoes, sego lily, twolobed larkspur, fleabane, mountain pepperweed, beardtongue, phlox, western tansymustard, hedgemustard, rabbitbrush.
Historical Grass and Forb Productivity Estimate: 150-400 lbs/acre

B. Short fire return interval, moderate herbivory

Dominant species: Western wheatgrass, bottlebrush squirreltail, Sandberg bluegrass.
Other characteristic species: Indian ricegrass, saline wildrye, James; galleta, sand dropseed, blue grama, rabbitbrush, Nuttall's horsebrush, shortspine horsebrush, broom snakeweed, bulbous springparsley, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, Shockley's buckwheat, mountain pepperweed, beardtongue, phlox, western tansymustard, hedgemustard, plains pricklypear.
Historical Grass and Forb Productivity Estimate: 100-300 lbs/acre

C. Short fire return interval, heavy herbivory

Dominant species: Bottlebrush squirreltail, Sandberg bluegrass, broom snakeweed, rabbitbrush.
Other characteristic species: western wheatgrass, sand dropseed, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, Shockley's buckwheat, mountain pepperweed, phlox, western tansymustard, hedgemustard, Nuttall's horsebrush, shortspine horsebrush, plains pricklypear.
Historical Grass and Forb Productivity Estimate: 100-200 lbs/acre.

D. Long fire return interval, light herbivory

Dominant species: Big sagebrush, Indian rice grass, western wheatgrass, scarlet globemallow, winterfat.
Other characteristic species: Saline wildrye, bottlebrush squirreltail, Sandberg bluegrass, sand dropseed, bulbous springparsley, Shockley's buckwheat, common sunflower, desert princesplume, scarlet globemallow, wooly plantain, littleleaf pussytoes, sego lily, twolobed larkspur, fleabane, mountain pepperweed, beardtongue, phlox, western tansymustard, hedgemustard, valley saltbush, bud sagebrush, shadscale saltbush, rabbitbrush.
Historical Grass and Forb Productivity Estimate: 150-300 lbs/acre

E. Long fire return interval, moderate herbivory

Dominant species: Big sagebrush, western wheatgrass, bottlebrush squirreltail, Sandberg bluegrass.
Other characteristic species: Indian ricegrass, saline wildrye, James; galleta, sand dropseed, blue grama, rabbitbrush, Nuttall's horsebrush, shortspine horsebrush, broom snakeweed, bulbous springparsley, wooly plantain, scarlet globemallow, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, Shockley's buckwheat, mountain

pepperweed, beardtongue, phlox, western tansymustard, hedgemustard, plains pricklypear, valley saltbush, bud sagebrush, shadscale saltbush, rabbitbrush.
Historical Grass and Forb Productivity Estimate: 100-250 lbs/acre

F. Long fire return interval, heavy herbivory

Dominant species: Big sagebrush, bottlebrush squirreltail, Sandberg bluegrass, broom snakeweed.
Other characteristic species: western wheatgrass, sand dropseed, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, mountain pepperweed, phlox, western tansymustard, hedgemustard, plains pricklypear, valley saltbush, bud sagebrush, shadscale saltbush, rabbitbrush.
Historical Grass and Forb Productivity Estimate: 100-200 lbs/acre.

Development of Reference Plant Communities

The reference plant community for the semidesert loamy ecological sites and the desert clay ecological sites in MLRA 34B in the 8-12" precipitation zone were developed based on the long fire-return interval, light herbivory historical plant communities with the following characteristics:

Semidesert loamy ecological site
Big sagebrush: 0-35%, with a minimum of 15% to achieve a maximum score of 100%, Indian ricegrass, James galleta, saline wildrye: 0-50% with a minimum of 10% to achieve a score of 100%, western wheatgrass, needleand thread, 0-40%, bottlebrush squirreltail, Sandberg bluegrass, sand dropseed: 0-10%, native forbs A: scarlet globemallow, bulbous springparsley, wooly plantain, littleleaf pussytoes, woolly locoweed, sego lily, twolobed larkspur, fleabane, cushion buckwheat, ipomopsis, mountain pepperweed, bisquitroot, whitestem blazingstar, beardtongue, phlox, western tansymustard, hedgemustard, mormon tea: 0-15% with at least 10% to achieve a maximum score of 100%, Native forbs B: prickly pear cactus, broom snakeweed 0-5%, winterfat, fourwing saltbrush, shadscale saltbrush, rabbitbrush, mormon tea: 0-10%.

Desert clay ecological site
Big sagebrush: 0-35%, with a minimum of 15% to achieve a maximum score of 100%, Indian ricegrass, saline wildrye: 0-50% with a minimum of 10% to achieve a score of 100%, western wheatgrass: 0-40%, bottlebrush squirreltail, Sandberg bluegrass, sand dropseed: 0-15%, native forbs A: scarlet globemallow, bulbous springparsley, Shockley's buckwheat, common sunflower, desert princesplume, wooly plantain, littleleaf pussytoes, sego lily, twolobed larkspur, fleabane, mountain pepperweed, phlox, western tansymustard, hedgemustard: 0-15% with at least 10% to achieve a maximum score of 100%, Native forbs B: prickly pear cactus, broom snakeweed 0-5%, winterfat, bud sagebrush,fourwing saltbrush, shadscale saltbrush, valley saltbrush,rabbitbrush, mormon tea: 0-10%.

Results

Site level results

Results for pre-treatment vegetation sampling in 2010 for the semidesert loamy ecological site are listed in Table 13.

Table 13. Dominant plant species (with greater than 1% relative cover) sampled at the Deadman's Bench, Utah site in 2010 for the semidesert loam ecological site in the treatment area, presented as relative cover (standard error). P refers to pending results for 2011.

	Ecological Site	
	Loamy	
Species	2010	2011
Pale madwort	1.61 (0.53)	P
Big sagebrush	67.91 (2.15)	P
Beggarticks	3.74 (1.52)	P
Smooth brome	11.00 (2.10)	P
Bottlebrush squirreltail	9.14 (1.81)	P
Tall tumblemustard	1.01 (0.29)	P
Scarlet globemallow	2.71 (0.89)	P
Needlegrass	1.00 (0.45)	P

The similarity determined for the pre-treatment plant community was 39.26 (1.74).

Landscape level analysis

Wildlife species modeling results for Deadman's Bench will be added at a later date.

Rock Springs, Utah

The Rock Springs project being conducted cooperatively with Utah's Watershed Restoration Initiative is located on Rock Springs Mesa near Moon Ridge in the Book Cliffs area of northeastern Utah. Like the Anthro Mountain site, invading pinyon-juniper has decreased the quality of the sagebrush communities in this area. The treatment area was chained in the past, but new pinyon and juniper has invaded and now threatens to reduce other vegetation lowering the quality of this site for mule deer, elk, bison (recently reintroduced to the area) and sage-grouse.

This project is treating approximately 500 acres of pinyon-juniper. Pinyon and juniper trees will be mechanically removed using a rubber-tired bullhog machine. Trees will be shredded and

material will be left on-site. Due to the amount of herbaceous understory present in the project area, no seeding is planned. The site has been used for grazing, and this use is planned to be continued after treatment.

The Rock Springs project area is located in MLRA 48A- the Southern Rocky Mountain MLRA. Ecological sites in the general area of the project vary (Figure 26), but the treatment area supports only the upland loam ecological site, although small inclusions of other ecological sites could be present. This area is in the 12-14" precipitation zone. Descriptions of this ecological site were obtained from the Upland Loam ecological site description for MLRA 34B, the neighboring MLRA to the east. Slight differences might be expected in this setting within MLRA 48A, but the general plant community descriptions and dynamics are thought to be quite similar. Specific descriptions of this site for 48A are not currently available.

The upland loam ecological site occurs on alluvial fans, floodplains, pediment slopes and stable summits. Slopes are mostly 1 to 25 percent. Elevations range from 6,000 to 8,000 feet on all aspects. According to the Ecological Site Description for this site, "Characteristic soils in this site are very deep and well-drained. They formed in alluvium derived mainly from sandstone and shale parent materials. Soils are fine-loamy to coarse-loamy and have less than 35 percent rock fragments throughout the profile."

A state and transition model for this ecological site is shown in Figure 27. This model includes the historically occurring states/plant communities as well as states produced by a lack of fire, where pinyon-juniper is allowed to invade. Other athropogenic states including cheatgrass invaded sites can also be found but are not included in this state and transition model.

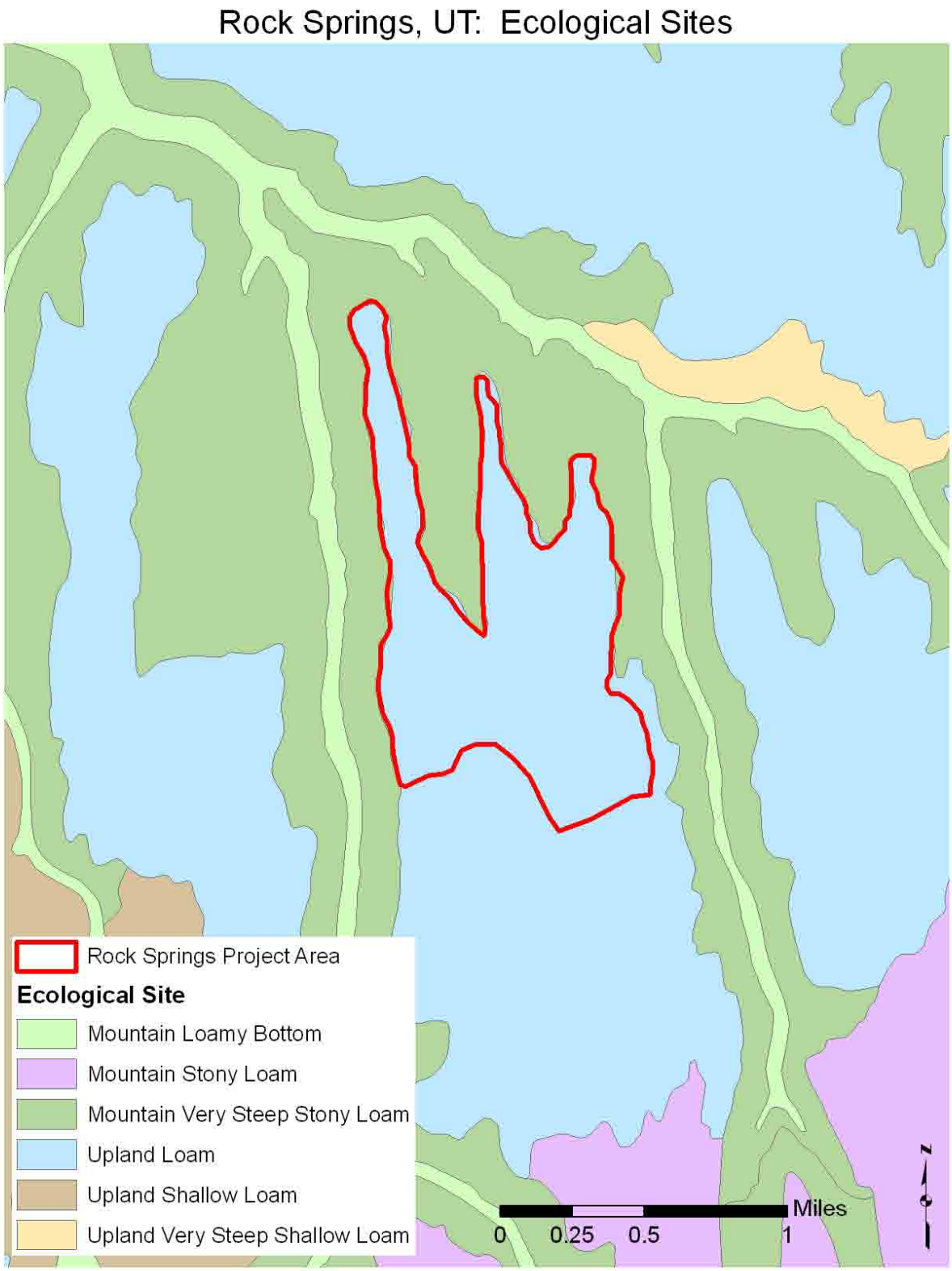

Figure 26. Map of ecological sites in the Rock Springs project area in Utah.

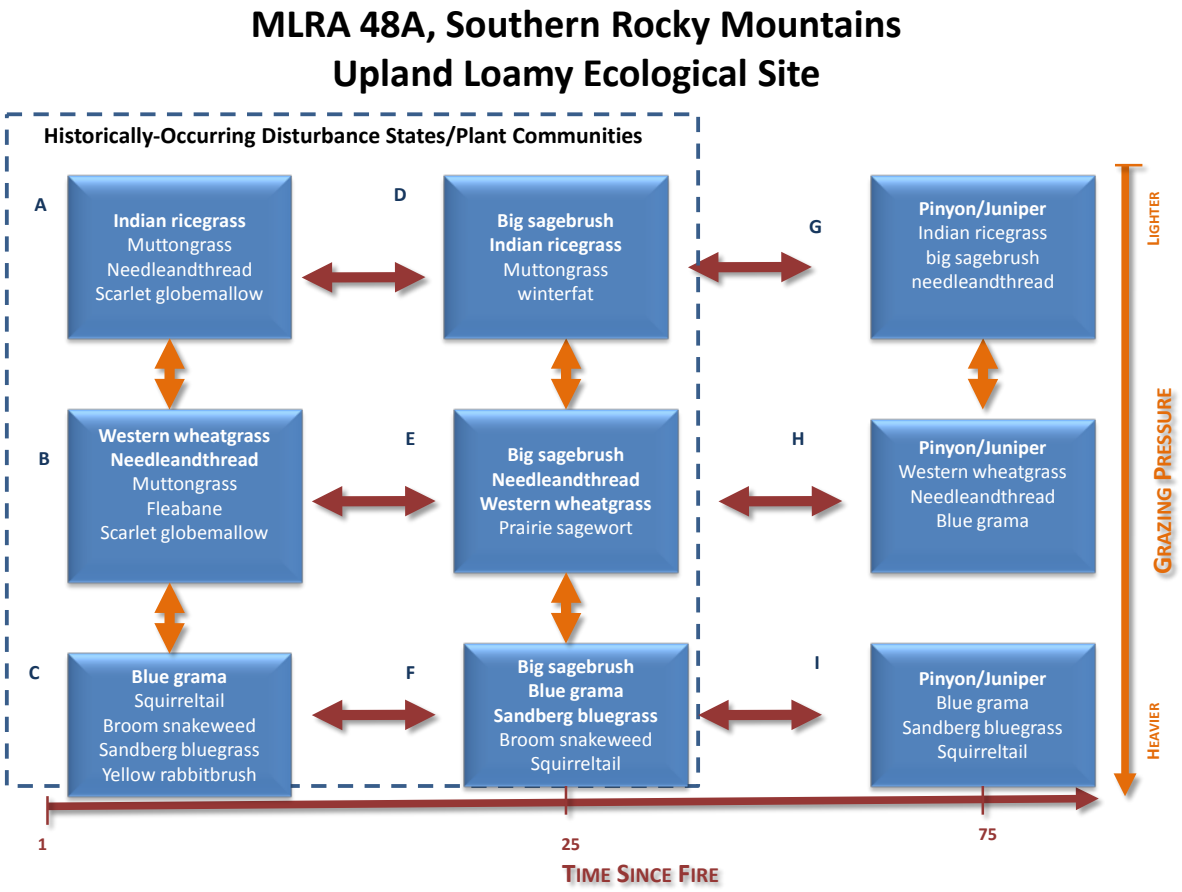

Figure 27. State and transition model for upland loamy ecological sites in MLRA 48A, 12-14" precipitation zone.

State/plant community descriptions

A. Short fire return interval, light grazing disturbance state/plant community

Dominant species: , Indian rice grass, muttongrass, needleandthread, bluebunch wheatgrass, western wheatgrass, tufted milkvetch, scarlet globemallow, mountain pepperweed.
Other characteristic species: Bottlebrush squirreltail, prairie junegrass, Sandberg bluegrass, James' galleta, sand dropseed, rabbitbrush, fleabane, roughseed cryptantha, western tansymustard, Indian paintbrush, Shockley's buckwheat, tailcup lupine, thickleaf beardtongue, hedgemustard, pincushion, gilia, penstemon, phlox, prairie sagewort.
Historical Grass and Forb Productivity Estimate: 800-1200 lbs/acre

B. Short fire return interval, moderate herbivory

Dominant species: Needleand thread, western wheatgrass, tufted milkvetch, scarlet globemallow, mountain pepperweed
Other characteristic species: Bottlebrush squirreltail, prairie junegrass, Sandberg bluegrass, James' galleta, sand dropseed, blue grama, rabbitbrush, broom snakeweed, fleabane, Indian

paintbrush, roughseed cryptantha, western tansymustard, Shockley's buckwheat, tailcup lupine, thickleaf beardtongue, hedgemustard, pincushion, gilia, penstemon, phlox, prairie sagewort.
Historical Grass and Forb Productivity Estimate: 700-1100 lbs/acre

C. Short fire return interval, heavy herbivory

Dominant species: Blue grama, bottlebrush squirreltail, Sandberg bluegrass, broom snakeweed, prairie sagewort, rabbitbrush, mountain pepperweed, scarlet globemallow.
Other characteristic species: western wheatgrass scarlet globemallow, prairie junegrass, James' galleta, sand dropseed, fleabane, Indian paintbrush, roughseed cryptantha, western tansymustard, Shockley's buckwheat, tailcup lupine, pincushion, gilia, penstemon, phlox, hedgemustard.
Historical Grass and Forb Productivity Estimate: 400-700 lbs/acre.

D. Intermediate fire return interval, light herbivory

Dominant species: Big sagebrush, Indian rice grass, muttongrass, needleandthread, bluebunch wheatgrass, western wheatgrass, tufted milkvetch, scarlet globemallow, mountain pepperweed, winterfat, antelope bitterbrush.
Other characteristic species: Bottlebrush squirreltail, prairie junegrass, Sandberg bluegrass, James' galleta, sand dropseed, rabbitbrush, fleabane, Indian paintbrush, roughseed cryptantha, western tansymustard, Shockley's buckwheat, tailcup lupine, thickleaf beardtongue, pincushion, gilia, penstemon, phlox, hedgemustard, prairie sagewort, fourwing saltbush.
Historical Grass and Forb Productivity Estimate: 800-1200 lbs/acre

E. Intermediate fire return interval, moderate herbivory

Dominant species: Big sagebrush, needleandthread, western wheatgrass, scarlet globemallow, mountain pepperweed, antelope bitterbrush.
Other characteristic species: Bottlebrush squirreltail, prairie junegrass, blue grama, Sandberg bluegrass, James' galleta, sand dropseed, Indian rice grass, muttongrass, rabbitbrush, fleabane, Indian paintbrush, roughseed cryptantha, western tansymustard, tufted milkvetch, Shockley's buckwheat, tailcup lupine, thickleaf beardtongue, pincushion, gilia, penstemon, phlox, hedgemustard, prairie sagewort, broom snakeweed, fourwing saltbush and winterfat.
Historical Grass and Forb Productivity Estimate: 700-1100 lbs/acre

F. Intermediate fire return interval, heavy herbivory

Dominant species: Big sagebrush, blue grama, bottlebrush squirreltail, Sandberg bluegrass, broom snakeweed, scarlet globemallow, mountain pepperweed.
Other characteristic species: Western wheatgrass, prairie junegrass, James' galleta, sand dropseed, rabbitbrush, fleabane, Indian paintbrush, roughseed cryptantha, western tansymustard, pincushion, gilia, penstemon, phlox, hedgemustard, prairie sagewort.

Historical Grass and Forb Productivity Estimate: 300-600 lbs/acre

G. Long fire return interval, light herbivory

Dominant species: Pinyon-juniper, big sagebrush, Indian rice grass, muttongrass, needleandthread, bluebunch wheatgrass, western wheatgrass, tufted milkvetch, scarlet globemallow, mountain pepperweed, winterfat, antelope bitterbrush.
Other characteristic species: Bottlebrush squirreltail, prairie junegrass, Sandberg bluegrass, James' galleta, sand dropseed, rabbitbrush, fleabane, Indian paintbrush, roughseed cryptantha, western tansymustard, Shockley's buckwheat, tailcup lupine, thickleaf beardtongue, pincushion, gilia, penstemon, phlox, hedgemustard, prairie sagewort, fourwing saltbush.
Historical Grass and Forb Productivity Estimate: 400-800 lbs/acre

H. Long fire return interval, moderate herbivory

Dominant species: Pinyon-juniper, big sagebrush, needleandthread, western wheatgrass, scarlet globemallow, mountain pepperweed, antelope bitterbrush.
Other characteristic species: Bottlebrush squirreltail, prairie junegrass, blue grama, Sandberg bluegrass, James' galleta, sand dropseed, Indian rice grass, muttongrass, Indian paintbrush, fleabane, roughseed cryptantha, western tansymustard, tufted milkvetch, Shockley's buckwheat, tailcup lupine, thickleaf beardtongue, pincushion, gilia, penstemon, phlox, hedgemustard, prairie sagewort, broom snakeweed, fourwing saltbush and winterfat.
Historical Grass and Forb Productivity Estimate: 300-600 lbs/acre

I. Long fire return interval, heavy grazing

Dominant species: Pinyon –juniper, big sagebrush, blue grama, bottlebrush squirreltail, Sandberg bluegrass, broom snakeweed, scarlet globemallow, mountain pepperweed.
Other characteristic species: Western wheatgrass, prairie junegrass, sand dropseed, fleabane, Indian paintbrush, roughseed cryptantha, western tansymustard, pincushion, gilia, penstemon, phlox, hedgemustard, prairie sagewort.
Historical Grass and Forb Productivity Estimate: 200-400 lbs/acre

Development of reference plant community

The reference plant community for upland loamy ecological sites in MLRA 48A in the 12-14" precipitation zone was developed based on the intermediate fire-return interval, light herbivory historical plant community with the following characteristics:
Big sagebrush: 0-35%, with a minimum of 15% to achieve a maximum score of 100%, Indian ricegrass, muttongrass, bluebunch wheatgrass, James' galleta: 0-50% with a minimum of 10% to achieve a score of 100%, western wheatgrass, needleand thread, 0-40, bottlebrush squirreltail, prairie junegrass, blue grama, Sandberg bluegrass, sand dropseed: 0-10%, native forbs A: tufted milkvetch, scarlet globemallow, mountain pepperweed, fleabane, roughseed cryptantha, Indian

paintbrush, western tansymustard, Shockley's buckwheat, tailcup lupine, thickleaf beardtongue, pincushion, gilia, penstemon, phlox, hedgemustard, 0-15% with at least 10% to achieve a maximum score of 100%, Native forbs B: prairie sagewort, broom snakeweed 0-5%, winterfat, antelope bitterbrush, rabbitbrush, fourwing saltbrush 0-10%, western juniper: 0-1%.

Results

Vegetation was sampled on the site pre-treatment in 2010. Shrub cover was only measured along the line intercept, rather than in both the Daubenmire frames and the line intercept. The cover for grass and forb species measured in the Daubenmire frames were averaged for each species, and the shrub cover determined for each species from the line intercept was then used to calculate the relative cover of each species. Table 14 lists the cover for each species measured in 2010.

Table 14. Dominant plant species (with greater than 1% relative cover in any year) sampled at the Rock Springs, Utah site in 2010 for the upland loamy ecological site in the treatment area, presented as relative cover (standard error). P refers to pending sampling to be conducted in 2011.

	Ecological Site	
	Loamy	
Species	2010	2011
Big sagebrush	44.15 (6.36)	P
Milkvetch	4.35 (2.73	P
Mountain mahogany	7.71 (5.85)	P
Yellow rabbitbrush	1.49 (0.92)	P
Gilia	1.99 (1.16)	P
Prairie junegrass	2.49 (1.32)	P
Western wheatgrass	2.35 (1.42)	P
Phlox	6.83 (1.91)	P
Mutton grass	2.21 (2.21)	P
Sandberg bluegrass	11.89 (4.21)	P
Needlegrass	8.20 (2.62)	P

Landscape analyses

The analysis of wildlife species at the landscape scale will be added later.

DEVELOPMENT OF A CREDIT TRADING SYSTEM

This section will be added at a later time.

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Appendix A. Species habitat suitability models used in the sagebrush mitigation metric system.

Pronghorn

The pronghorn model is primarily based on the work of Allen, et al. (1984). This model suggests that winter is the most limiting time of year for pronghorn and as a result the model is focused on a variety of shrub variables, the primary winter food of pronghorn.

The primary variable determining the quality of pronghorn winter habitat is shrub cover (Figure A-1). Other variables used in the model include shrub height (Figure A-2), shrub diversity (Figure A-3), herbaceous cover (Figure A-4), and topographic diversity (FigureA-5).

The HSI scores for each of the five pronghorn habitat variables were combined using the following equation: [Shrub Cover * (Shrub Height * Shrub Diversity * Herbaceous Cover)$^{1/3}$] * Topographic Diversity. This equation produced the final HSI scores. The scores were then used to populate a final GIS layer that depicts habitat quality for pronghorn within the modeling landscape. The resulting layer was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER. The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 110 lb pronghorn is 362 acres, or 40x40 grid cells within the GIS layer.

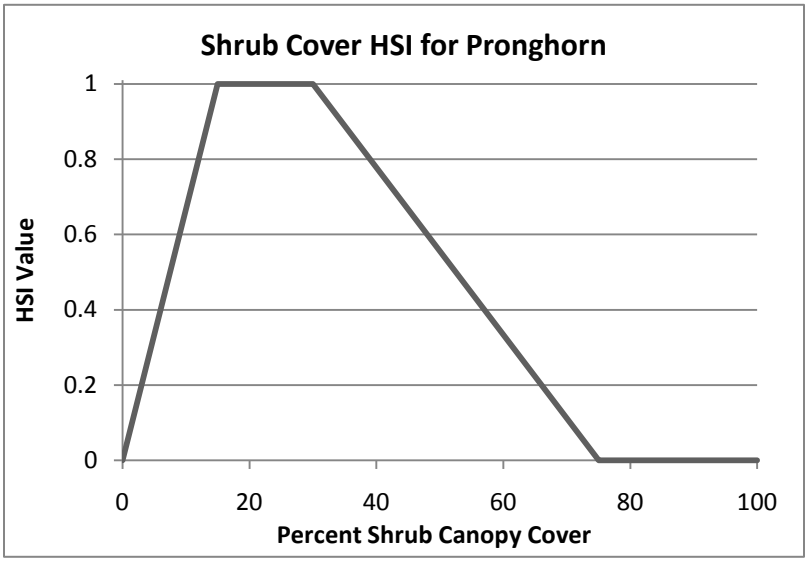

Figure A-1. Shrub cover HSI for pronghorn. The equation between 0 and 15 is y=0.0667x and the equation between 30 and 75 is y=-0.0222x + 1.6667.

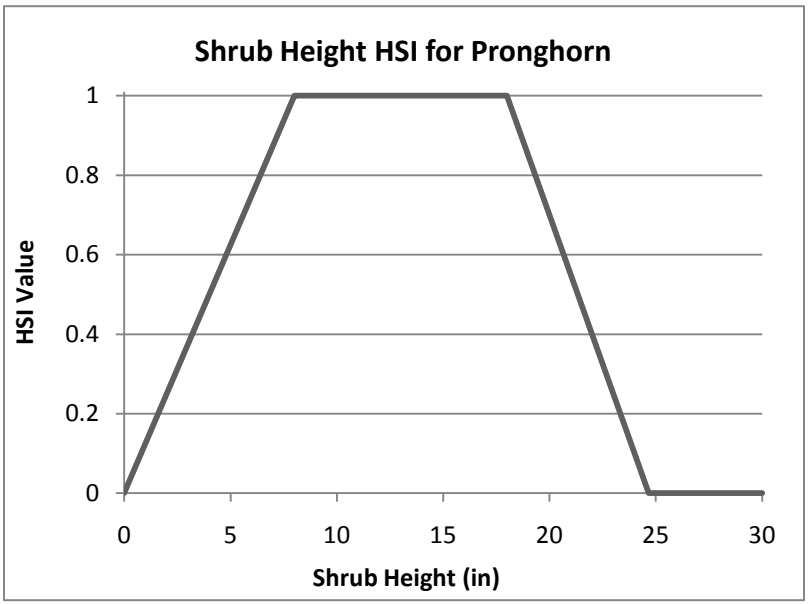

Figure A-2. Shrub height HSI for pronghorn. The equation between 0 and 8 is y=0.125x and the equation between 18 and 25 is y=-0.15x + 3.7.

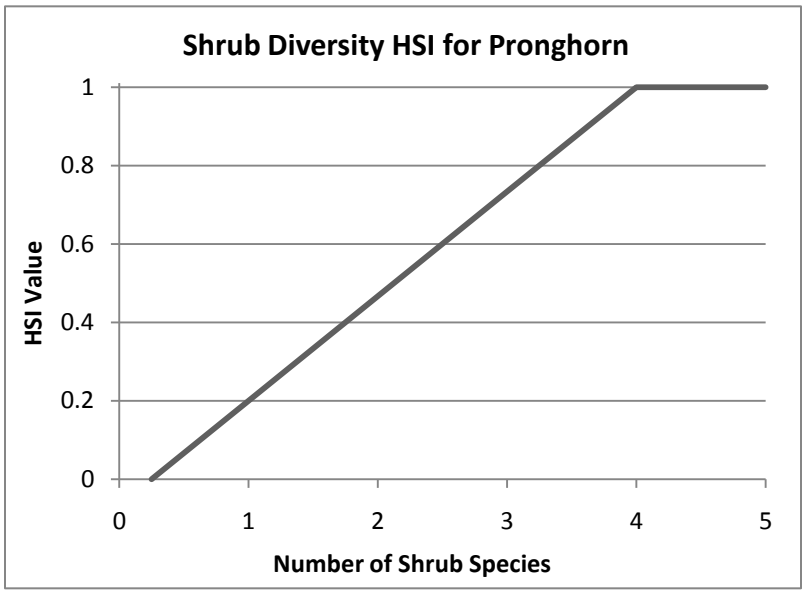

Figure A-3. Shrub diversity HSI for pronghorn. The equation between 0.25 and 4 is y=0.2667x - 0.0667.

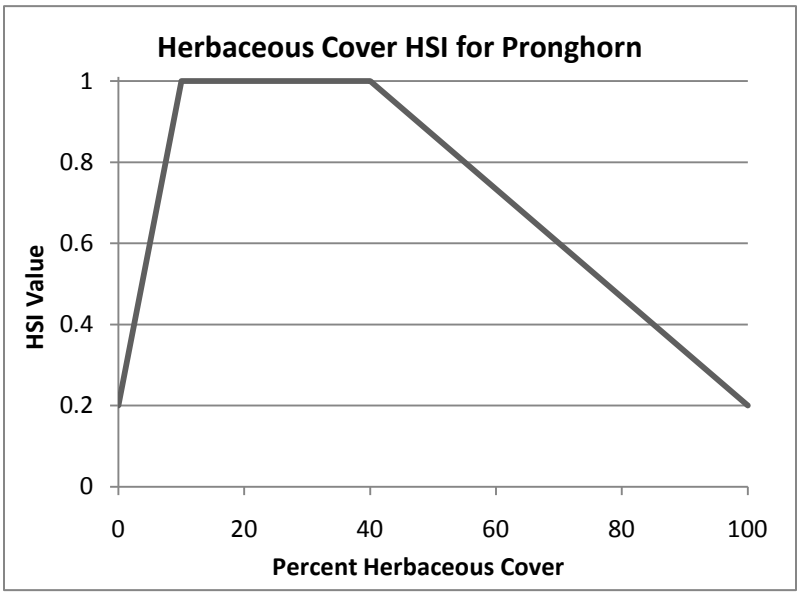

Figure A-4. Herbaceous cover HSI for pronghorn. The equation between 0 and 10 is y=0.08x +0.2 and the equation between 40 and 100 is y=-0.0133x + 1.5333.

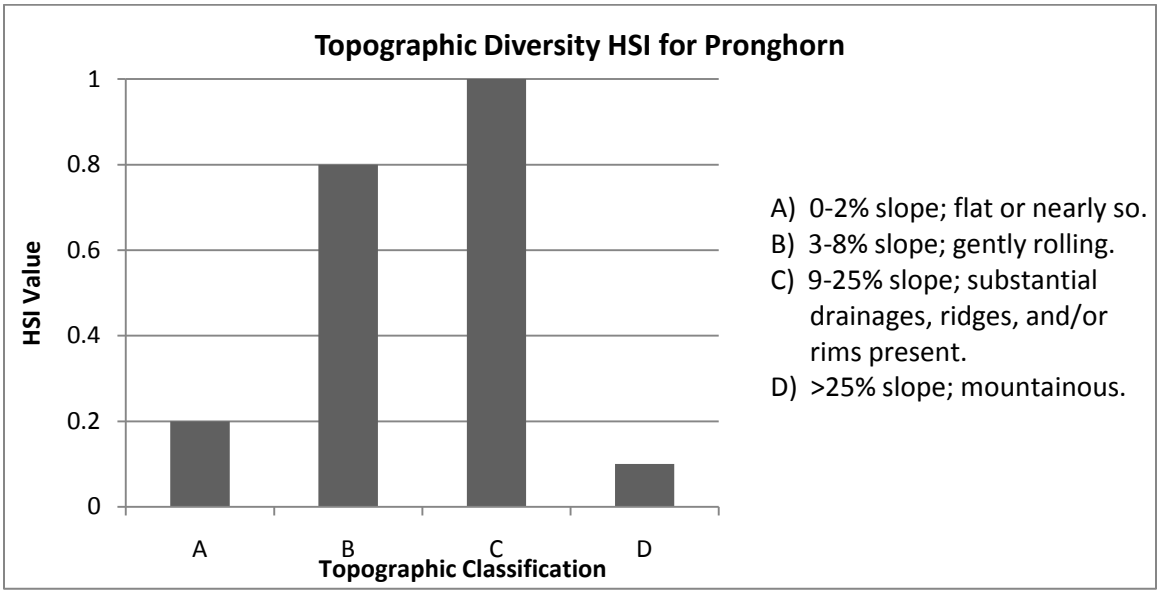

Figure A- 5. Topographic diversity HSI for pronghorn.

Sagebrush Lizard

Sagebrush lizards are typically found in open areas with nearby cover and primarily prey on small arthropods (Rose 1976). They are the most successful foraging in areas with sandy soils and scattered clumps of shrubs or rocks for cover from the sun and predators (Marcellini and Mackey 1970). Green et al. (2001) found the highest densities of lizards in areas with high amounts of bare ground, low amounts of cheatgrass cover, and scattered antelope bitterbrush and sagebrush.

The sagebrush lizard model used the following habitat variables: percent bare ground (Figure A-6), percent shrub cover (Figure A-7), percent herbaceous cover (Figure A-8), percent cheatgrass cover (Figure A-9), and soil type (Figure A-10). Soil types other than clayey, loamy, or sandy were not considered suitable for sagebrush lizards. It is important to note that the cheatgrass variable was only used for locations with field sampling data. The LANDIFRE data did not contain information on cheatgrass cover. When the habitat variables were combined for a total HSI score this variable was omitted for LANDIFRE sites.

The HSI scores for each of the five sagebrush lizard habitat variables were combined using the following equation: (Bare Ground * Shrub Cover * Herbaceous Cover * Cheatgrass Cover)$^{1/4}$ * Soil Type. This equation produced the final HSI scores. The scores were then used to populate a final GIS layer that depicts habitat quality for sagebrush lizard within the modeling landscape. The small size and low metabolic rate of the sagebrush lizard results in a allometric home range smaller than the minimum mapping size of 900 m^2 (30m x 30m cell). A base grid was not calculated for this species.

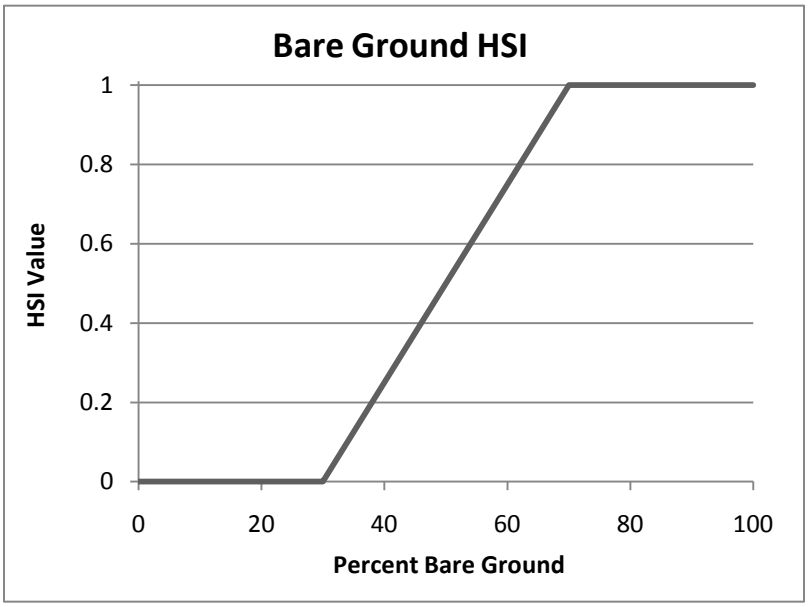

Figure A-6. Bare ground HSI for sagebrush lizard. The equation between 30 and 70 is y=0.025x - 0.75.

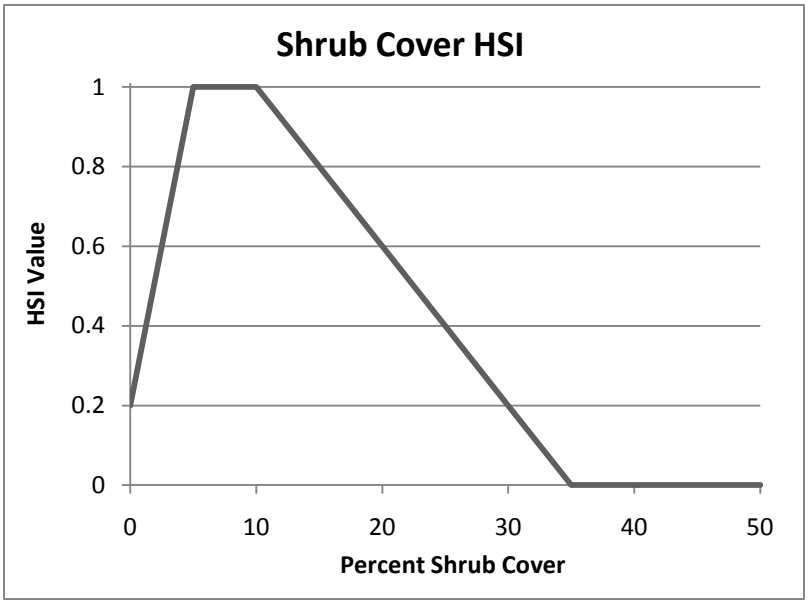

Figure A-7. Shrub cover HSI for sagebrush lizard. The equation between 0 and 5 is y=0.16X+0.2 and the equation between 10 and 35 is y=-0.04x+1.4.

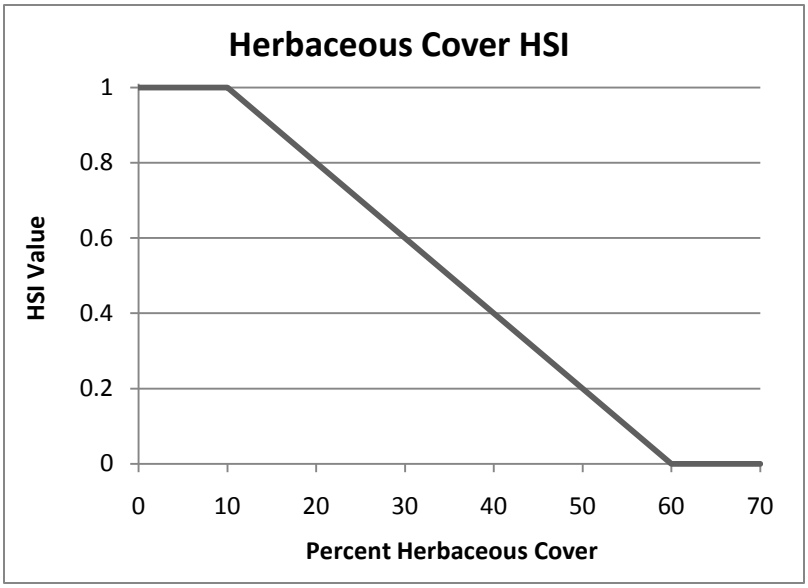

Figure A-8. Herbaceous cover HSI for sagebrush lizard. The equation between 10 and 60 is y=-0.02x+1.2.

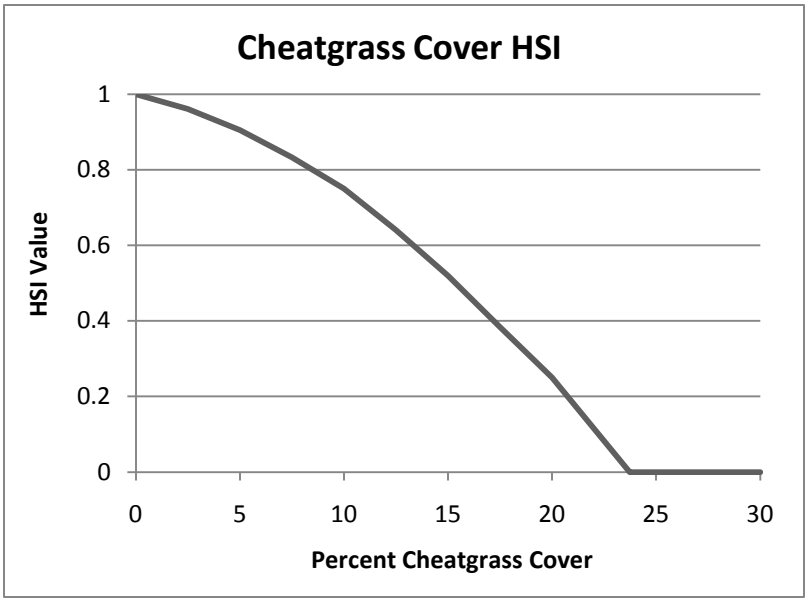

Figure A-9. Cheatgrass cover HSI for sagebrush lizard. The equation between 0 and 23.725 is $y=-0.0013x^2-0.0125x+1$.

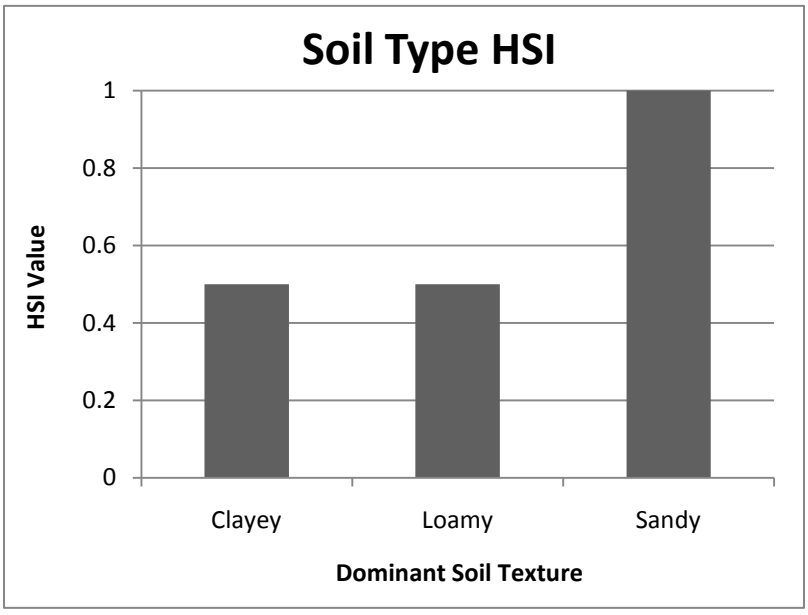

Figure A-10. Soil type HSI for sagebrush lizard.

Pygmy Rabbit

Pygmy rabbits depend almost exclusively on big sagebrush for food and cover, particularly in the winter (Katzner an Parker 1997). Laccucea and Brussard (2008) determined that the probability of occurrence for pygmy rabbits increased with increasing sagebrush cover, and decreased with the presence of cheatgrass. Ideal conditions for pygmy rabbits have also been described as areas having mild terrain, a moderate amount of clay in the soil, and moderate densities of sagebrush (Rachlow and Svancara 2006).

The pygmy rabbit model used the following habitat variables: degree slope (Figure A-11), percent clay in soil (Figure A-12), and sagebrush cover (Figure A-13). The HSI scores for the three pygmy rabbit habitat variables were combined using a geometric mean to produce the final HSI scores. The scores were then used to populate a final GIS layer that depicts habitat quality for pygmy rabbit within the modeling landscape. The resulting layer was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER. The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 0.93 lb pygmy rabbit is 2.72 acres, or 3x4 grid cells within the GIS layer.

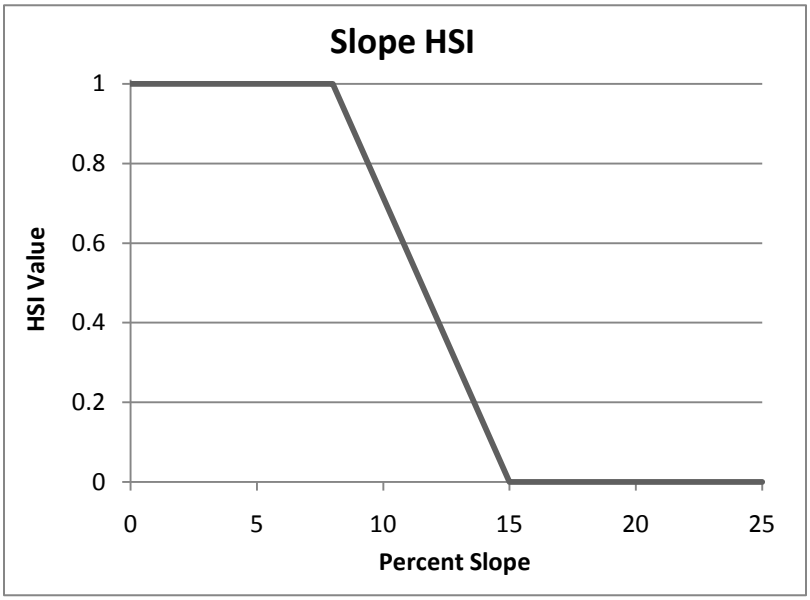

Figure A-11. Percent slope HSI for pygmy rabbit. The equation between 8 and 15 is y=-0.1429x+ 2.1429.

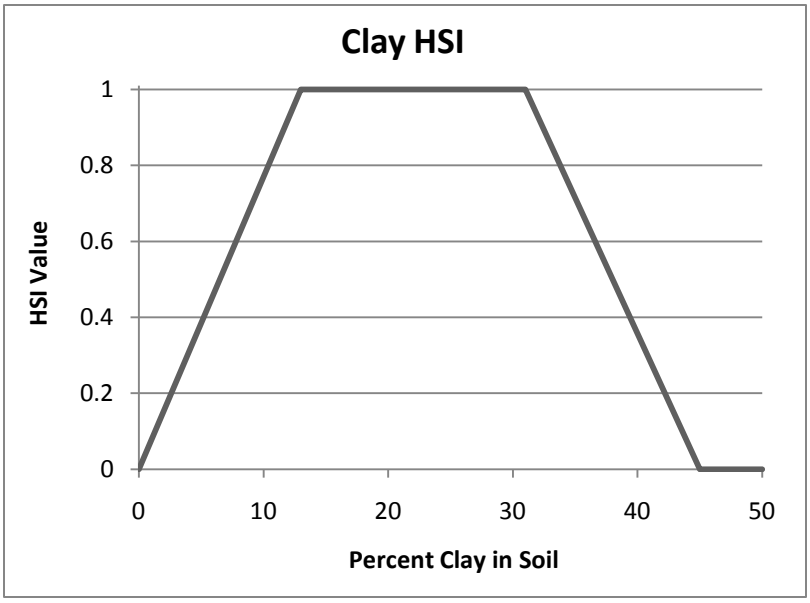

Figure A-12. Soil composition HSI for pygmy rabbit. The equation between 0 and 13 is y=0.0769x and the equation between 31 and 45 is y=-0.0714x+3.2143.

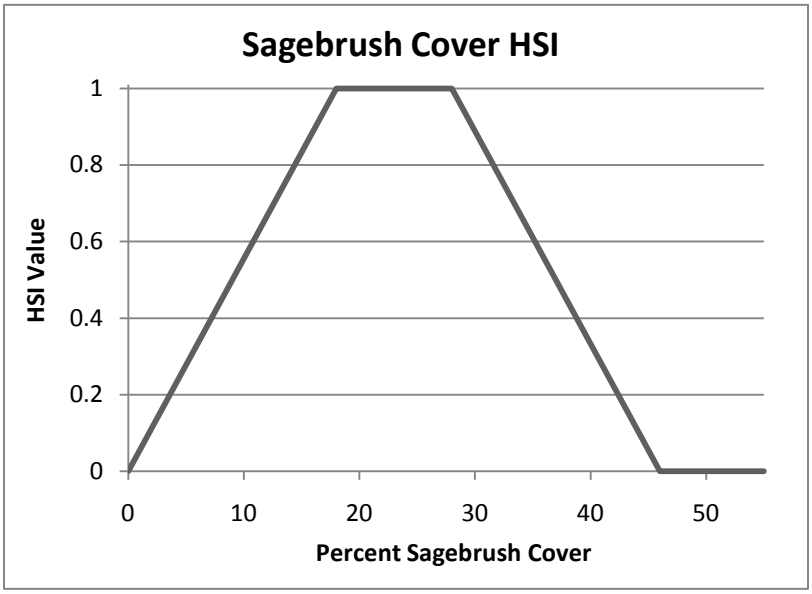

Figure A-13. Sagebrush cover HSI for pygmy rabbit. The equation between 0 and 18 is y=-0.0556x and the equation between 28 and 46 is y=-0.0556x+2.5556.

Sage Sparrow

Sage sparrows depend on shrubs to provide nesting cover and generally nest under shrubs in areas with higher amounts of bare ground then surrounding sites (Misenhelter and Rotenberry 2000). Nests have also been found to be more successful in larger patches of sagebrush versus more fragmented sites (Duberstein et al. 2008). Shrub height is also important with taller shrubs, relative to surrounding shrubs, having higher rates of occupancy and nesting success (Misenhelter and Rotenberry 2000, Duberstein et al. 2008).

The sage sparrow model used the following habitat variables: shrub cover (Figure A-14), herbaceous cover (Figure A-15), and shrub height (Figure A-16). There were two additional variables that were calculated in the GIS. The other two variables in the sage sparrow model were landscape patchiness and stand age. For landscape patchiness there were two scores. If greater than 50% of a circle with a radius of 1 km is covered by sage the area is assigned the HSI value of 1. If less than 50% of the circle contains sage then the area is assigned the HSI value of 0.75. Stand age is calculated based on the time since the last fire. If an area burned within the past 30 years the area is assigned the HSI value of 0.75. If it has been more than 30 years since the last fire the area is assigned the HSI value of 1. These variables are both calculated for each 30m x 30m cell that constitutes the modeling landscape.

The HSI scores for the five sage sparrow habitat variables were combined using a geometric mean to produce the final HSI scores. The scores were then used to populate a final GIS layer that depicts habitat quality for sage sparrow within the modeling landscape. The resulting layer was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER. The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 0.67 oz sage sparrow is 1 acre, or 2x2 grid cells within the GIS layer.

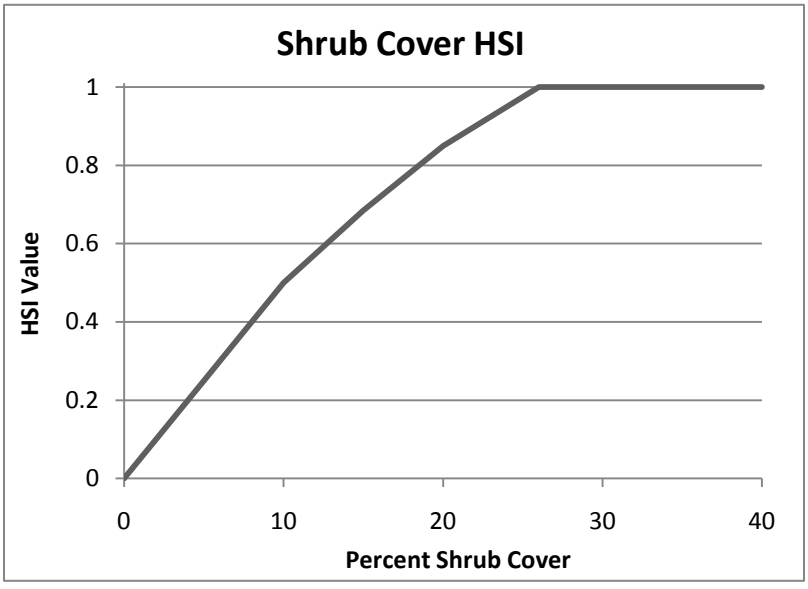

Figure A-14. Shrub cover HSI for sage sparrow. The equation between 0 and 26 is $y=-0.0007x^2+0.0564x-0.0041$.

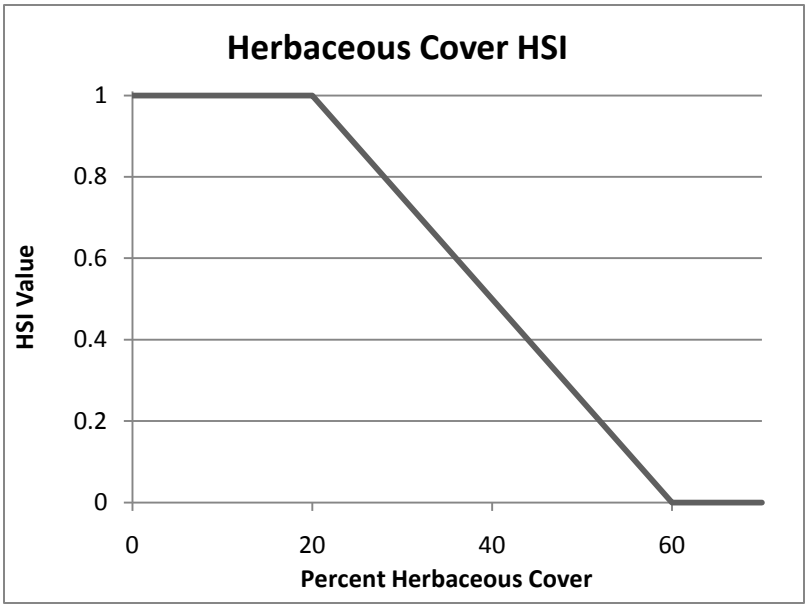

Figure A-15. Herbaceous cover HSI for sage sparrow. The equation between 20 and 60 is y=-0.025x +1.5.

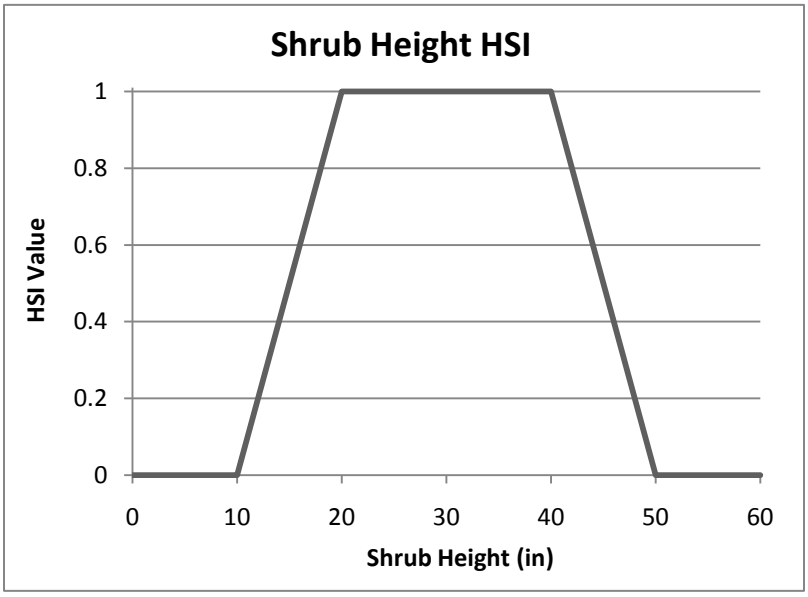

Figure A-16. Shrub height HSI for sage sparrow. The equation between 10 and 20 is y=0.1x-1 and the equation between 40 and 50 is y=-0.1x+5.

Sage Thrasher

Sage thrashers occur at the highest density in shrub-steppe vegetation types (Reinkensmeyer et al. 2007). Their presence and abundance are positively correlated with increasing shrub cover, vertical shrub density, increasing amounts of bare ground, and decreasing cover of juniper (*Juniperus* spp.), hopsage, and budsage (Wiens et al. 1987, Knick and Rotenberry 1995, Noson et al. 2006, Reinkensmeyer et al. 2007). Thrashers typically nest in sagebrush or on the ground underneath sagebrush (Reynolds 1981). Thrashers are more prevalent on sites characterized as good to fair range condition compared to sites supporting poor range conditions, with poor sites being characterized as low grass and shrub cover and high cover of invasive exotic plants (Vander Haegen et al. 2000). Sandy and loamy ecological sites typically have the highest densities of Thrashers (Vander Haegen et al. 2000).

The sage thrasher model used the follow variables: Sagebrush cover (Figures A-17), percent bare ground (Figure A-18), and ecological site (Figure A-19). The HSI scores for each of the three sage thrasher habitat variables were combined together with a geometric mean to produce final HSI scores. The scores were then used to populate a final GIS layer that depicts habitat quality for sage thrasher within the modeling landscape. The resulting layer was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER. The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 1.6 oz sage thrasher is 2.9 acres, or 3x4 grid cells within the GIS layer.

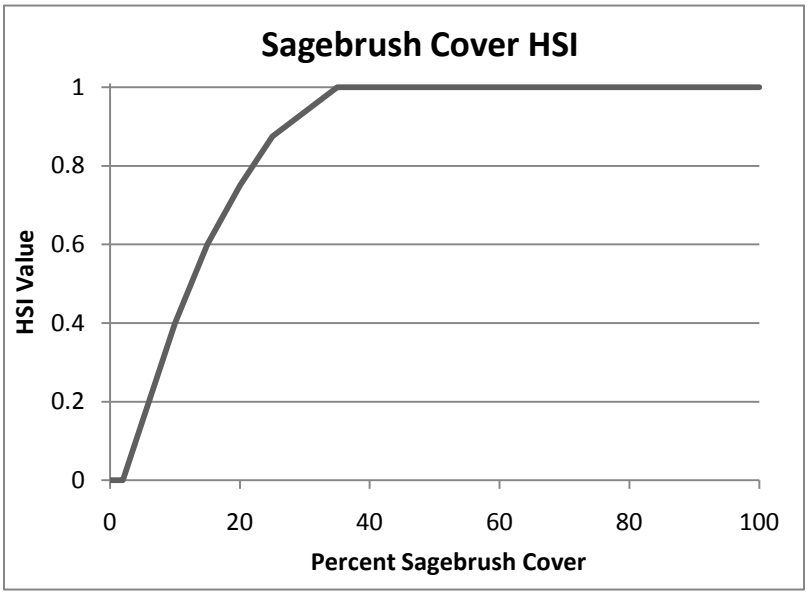

Figure A-17. Sagebrush cover HSI for sage thrasher. The equation between 2 and 35 is $y=-0.0008x^2+0.0593x-0.1191$.

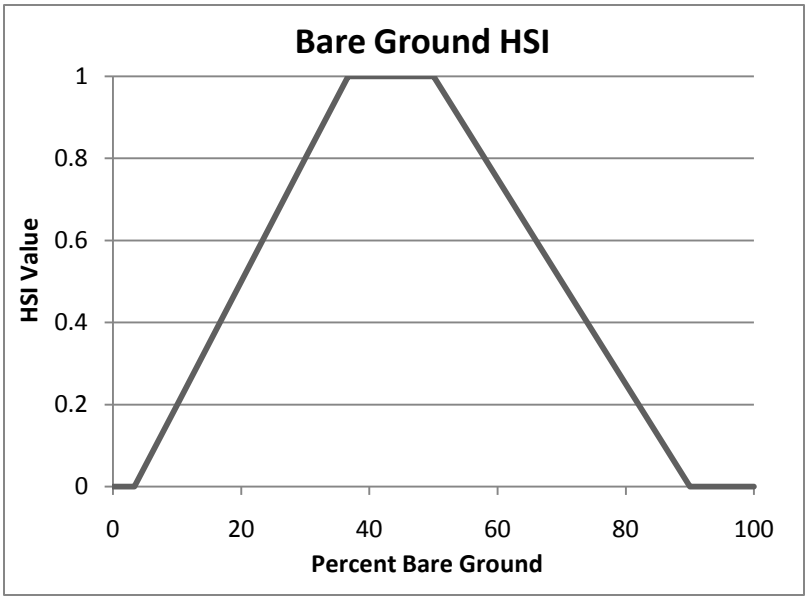

Figure A-18. Bare ground HSI for sage thrasher. The equation between 3.33 and 36.67 is y=0.03x-0.1 and the equation between 50 and 90 is y=-0.025x+2.25.

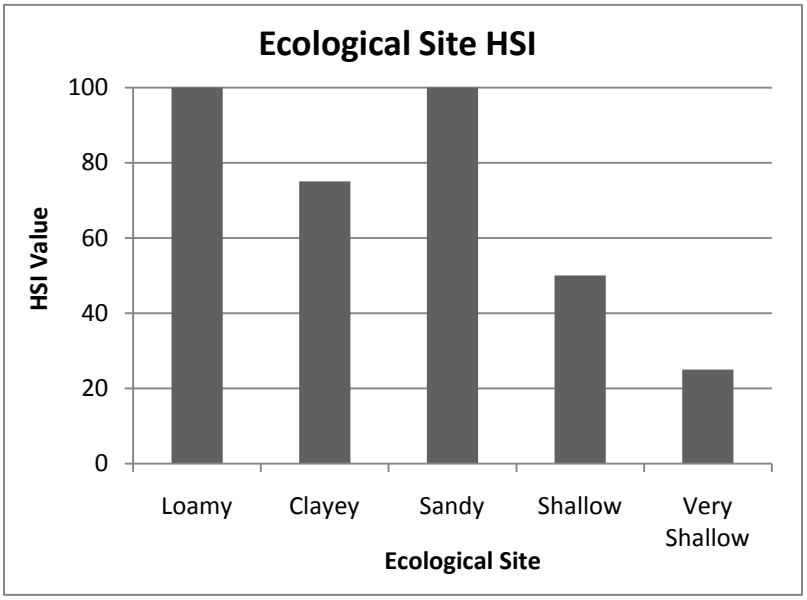

Figure A-19. Ecological site HSI for sage thrasher.

Sagebrush Vole

The sagebrush vole exhibits considerable seasonal variation in their diet with annual grasses, perennial grasses, and forbs dominant during summer months and sagebrush (both clipped by voles and stolen from deer mice food caches) the dominant food during the winter months (Maser et al. 1974, Mullican and Keller 1986). The highest reported densities of sagebrush voles are in vegetation types characterized as big sagebrush-bluebunch wheatgrass communities. Within this community, ideal habitat consists of dense vegetation with high absolute cover (Mullican and Keller 1986, O'Farrell 1972). In general, voles are found at higher elevations on sites characterized by mesic, productive ecological sites (O'Farrell 1972).

The sagebrush vole model used the follow variables: grass cover (Figure A-20), sagebrush cover (Figure A-21), and percent bare ground (Figure A-22). The HSI scores for each of the three sagebrush vole habitat variables were combined together with a geometric mean to produce final HSI scores. The scores were then used to populate a final GIS layer that depicts habitat quality for sagebrush vole within the modeling landscape. The small size of the sagebrush vole results in a allometric home range smaller than the minimum mapping size of 900 m^2 (30m x 30m cell). A base grid was not calculated for this species.

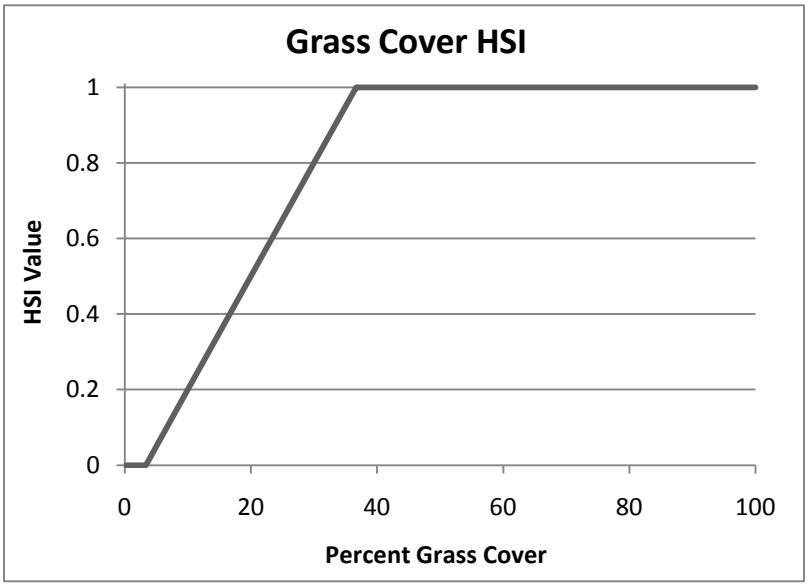

Figure A-20. Grass cover HSI for sagebrush vole. The equation between 3.33 and 36.67 is y=0.03x-0.1.

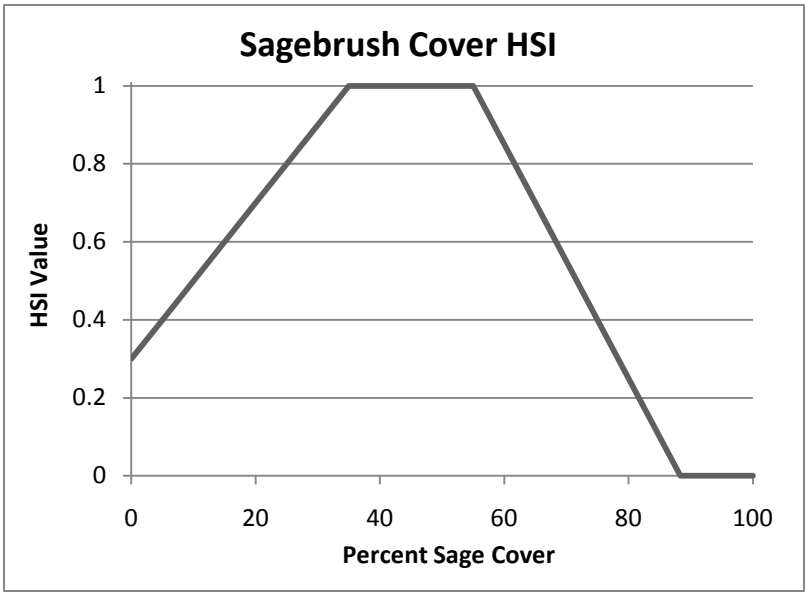

Figure A-21. Sagebrush cover HSI for sagebrush vole. The equation between 0 and 35 is y=0.02x+0.3 and the equation between 55 and 83.3 is y=-0.03x+2.65.

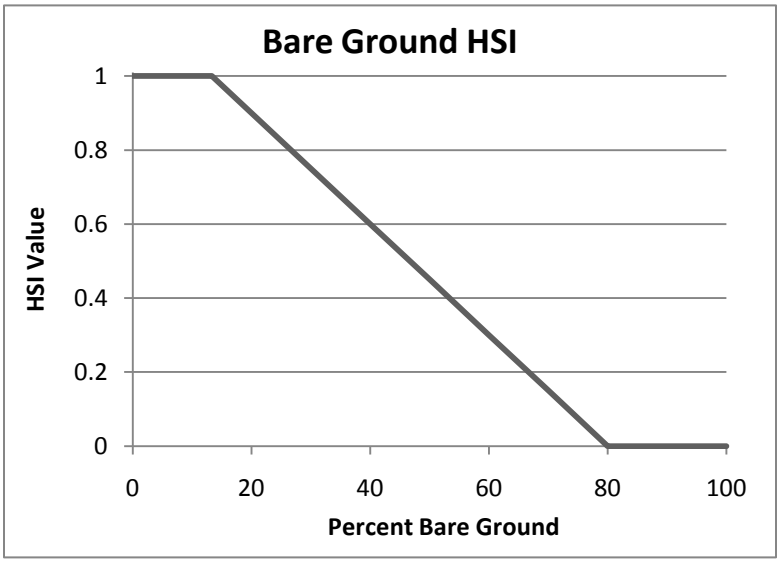

Figure A-22. Bare ground HSI for sagebrush vole. The equation between 13.3 and 80 is y=-0.015x +1.2.

Sage-Grouse

Three models were developed for sage-grouse relative to the limiting habitat factors unique to each study site. The models take into account the three major phases of sage-grouse life history; nesting, brood rearing, and wintering.

Preferred sage-grouse nesting habitat consists of 10-30% sagebrush canopy cover, 30-60% herbaceous plant cover, and grass height > 7 inches (Connelly et al. 2000). Preferred brood rearing habitat consists of 10-30% sagebrush cover and 25-65% herbaceous plant cover (Connelly et al. 2000). Preferred sage grouse wintering habitat consists of 10 to 30% sagebrush canopy cover exposed above the snow level (Connelly et al. 2000). For wintering habitat the cover of grasses and forbs is not considered a critical need because of the nearly complete reliance of sage-grouse upon sagebrush during this period. The height of sagebrush is also important with 25 to 35 cm exposed above snow level considered optimum (Connelly et al. 2000). In general, higher productivity ecological sites such as loamy, sandy, and clayey will allow for denser, more robust sagebrush cover.

The sage-grouse nesting model used the follow variables: Sagebrush cover (Figure A-23), herbaceous cover (Figure A-24), and grass height (Figure A-25). The sage-grouse brood rearing model used the variables sagebrush cover (Figure A-26) and herbaceous plant cover (Figure A-27). The sage grouse winter model used the sagebrush cover variable (Figure A-28).

For the nesting and brood rearing models the HSI scores for each habitat variable were combined together with a geometric mean to produce the final HSI scores. The scores were then used to populate 3 separate GIS layers that depict habitat quality for each sage-grouse life history stage within the modeling landscape. Each of the he resulting layers was contoured using a moving window analysis to produce the final input layers needed for HOMEGROWER. The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 3 lb female sage grouse is 5 acres, or 5x5 grid cells within the GIS layer.

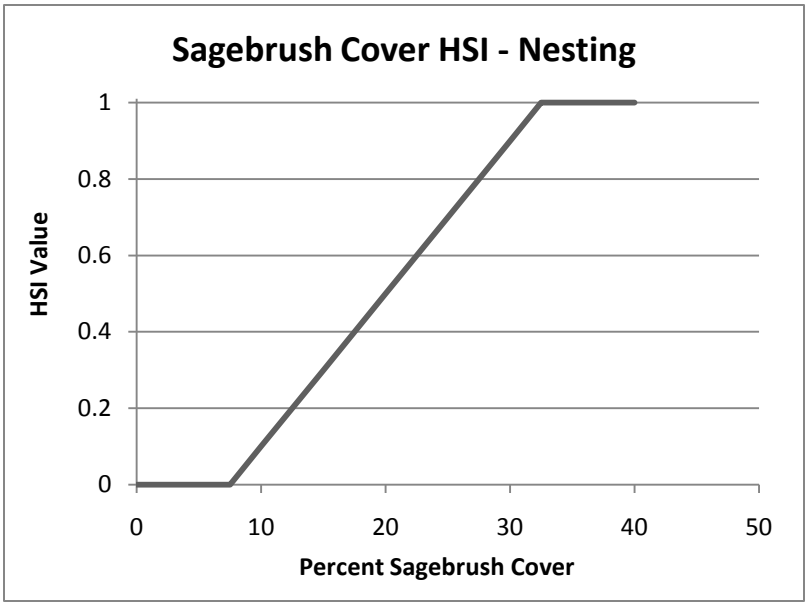

Figure A-23. Sagebrush cover HSI for sage-grouse nesting. The equation between 7.5 and 32.5 is y=0.04x-0.3.

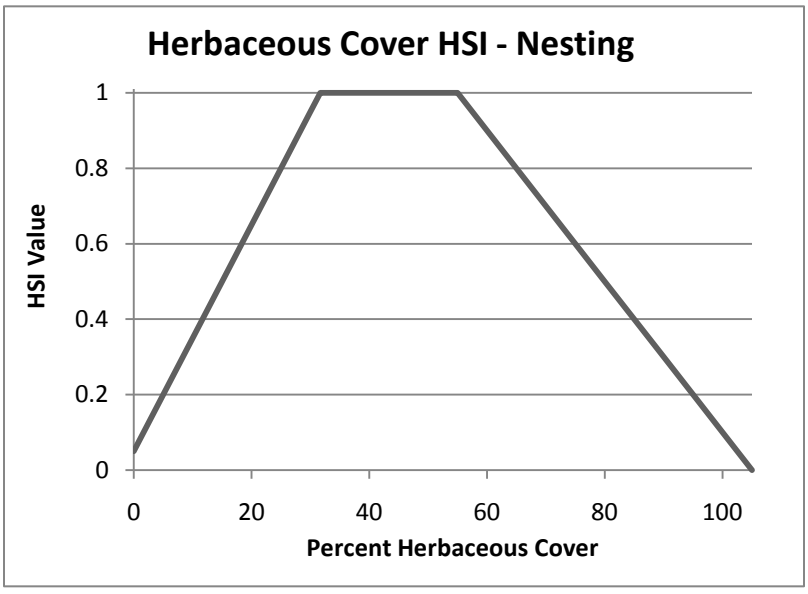

Figure A-24. Herbaceous cover HSI for sage-grouse nesting. The equation between 0 and 31.67 is y=0.03x+0.05 and the equation between 55 and 105 is y=-0.02x +2.1.

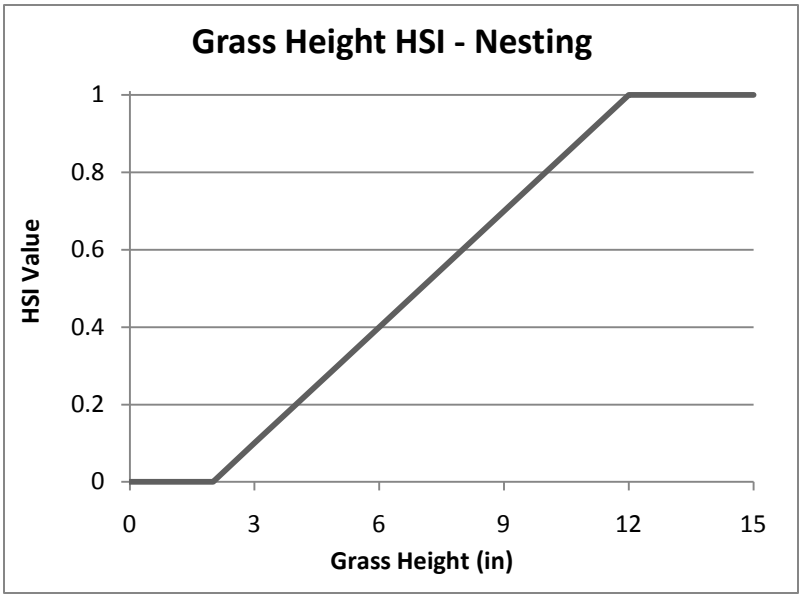

Figure A-25. Grass height HSI for sage-grouse nesting. The equation between 2 and 12 is y=0.1x-0.2.

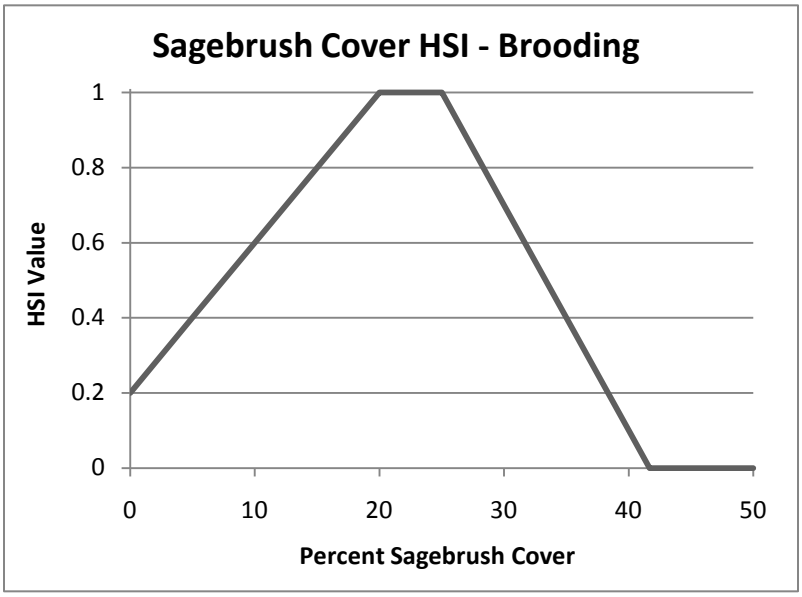

Figure A-26. Sagebrush cover HSI for sage-grouse brood rearing. The equation between 0 and 20 is y=0.04x+0.2 and the equation between 25 and 41.67 is y=-0.06x+2.5.

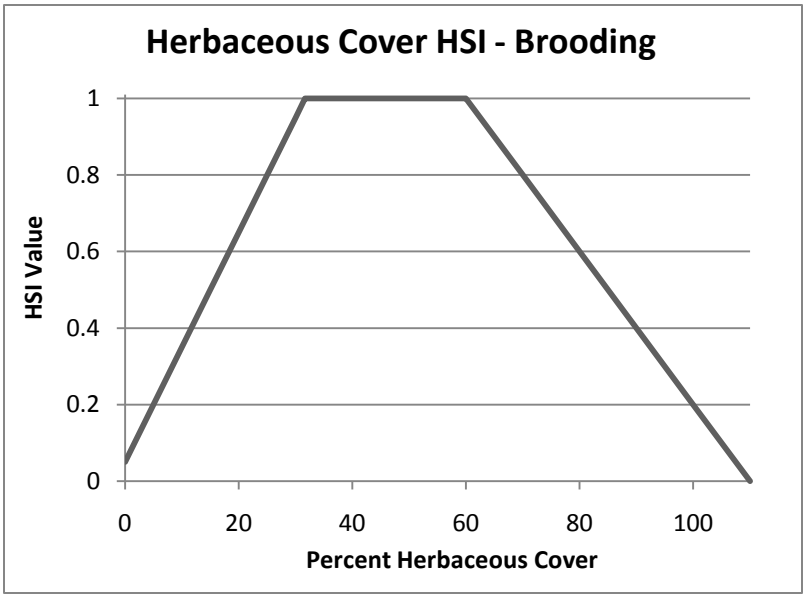

Figure A-27. Herbaceous cover HSI for sage-grouse brood rearing. The equation between 0 and 31.67 is y=0.03x+0.05 and the equation between 60 and 110 is y=-0.02x+2.2.

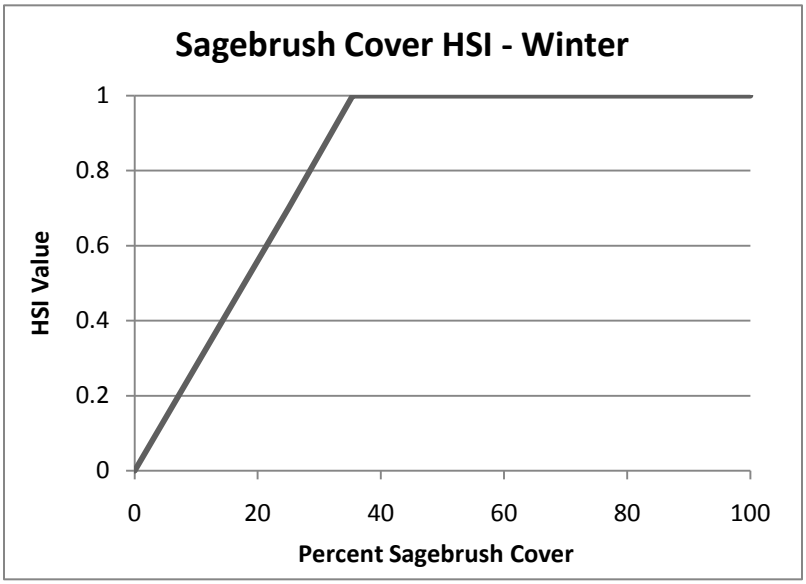

Figure A-28. Sagebrush cover HSI for sage-grouse wintering. The equation between 0 and 35.4 is y=0.0282x-0.0018.

Appendix B. Habitat suitability and home range maps for project areas.

Fidelity site

<u>Pronghorn Antelope</u>

The modeling landscape for this species was a 5 mile buffer of the site analysis area. The HSI map for pronghorn is depicted in Figure B-1. Three iterations were processed in HOMEGROWER. The target home range area was 2 times the allometric home range or 724 acres. The number of seeds was 100,000 and the growth window was 10 cells. Figure B-2 depicts the results for home range quality under existing, pre-treatment conditions. There were no high quality home ranges.

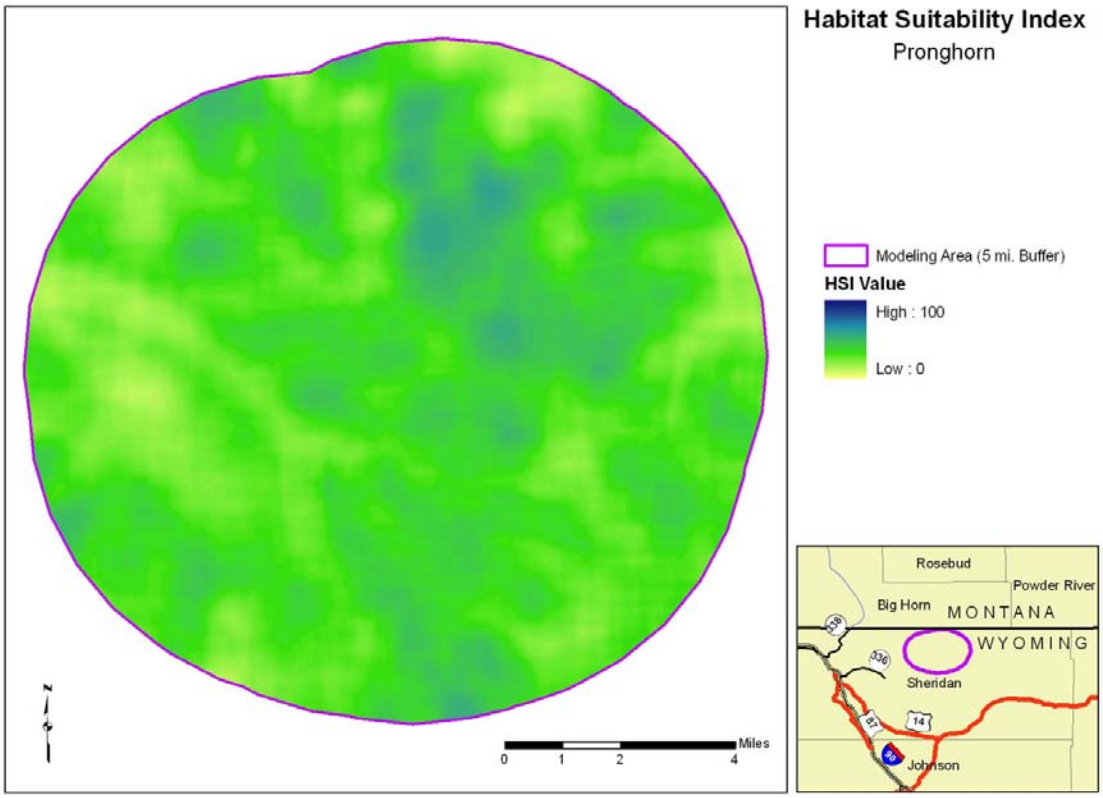

Figure B-1. Pre-treatment habitat suitability index for pronghorn in the Fidelity project area.

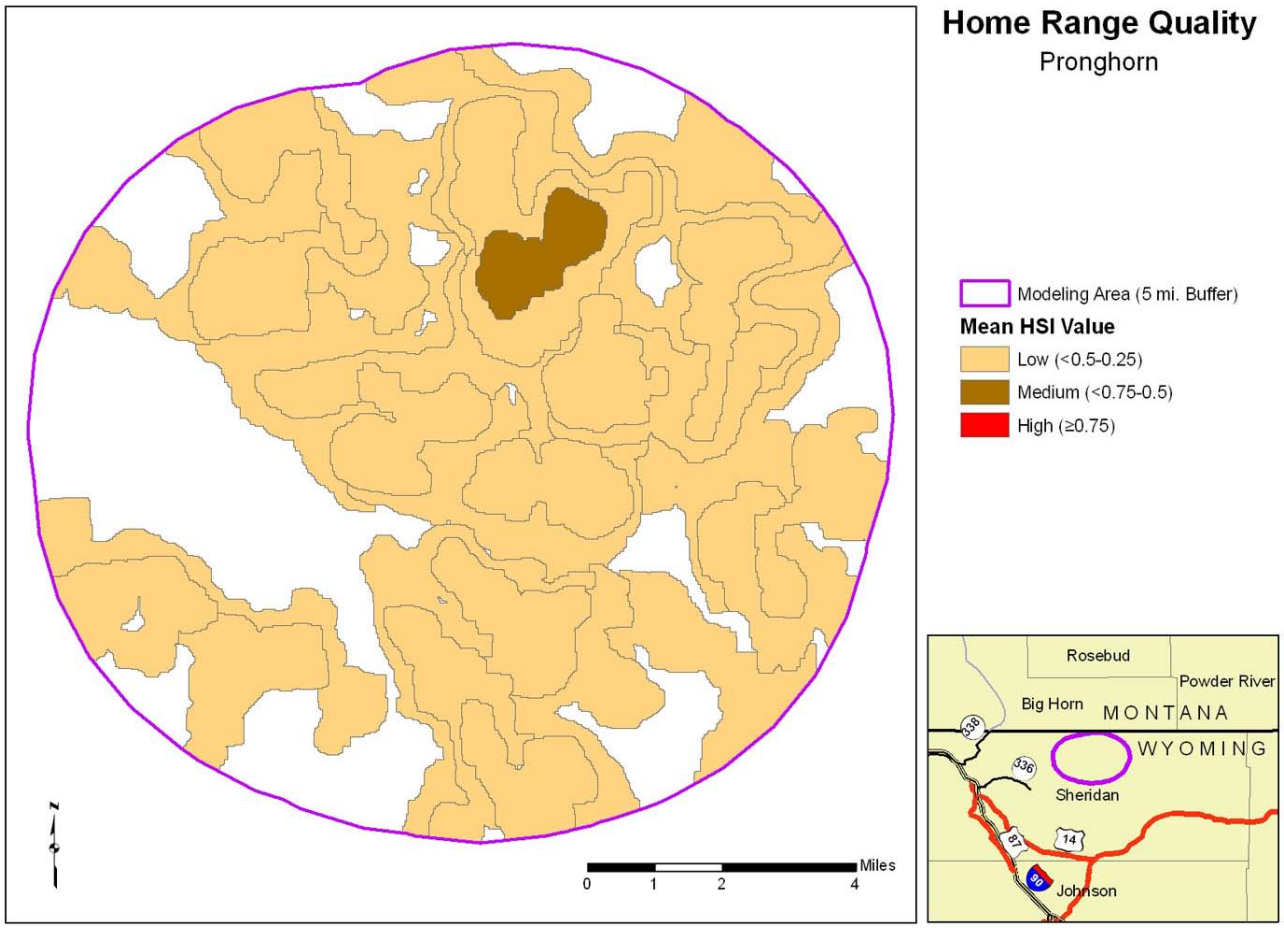

Figure B-2. Pre-treatment home range quality for pronghorn in the Fidelity project area.

Sagebrush Lizard

The final HSI grid for sagebrush lizard used for HOMEGROWER is shown in Figure B-3. As noted previously, the modeling landscape for this species was a 1 mile buffer of the site analysis area. Three iterations were processed in HOMEGROWER. The target home range area was 2 times the allometric home range or 0.44 acres. The number of seeds was 30,000 and the growth window was 1 cell. Figure B-4 depicts the results for home range quality under existing, pre-treatment conditions. There were no high or medium quality home ranges.

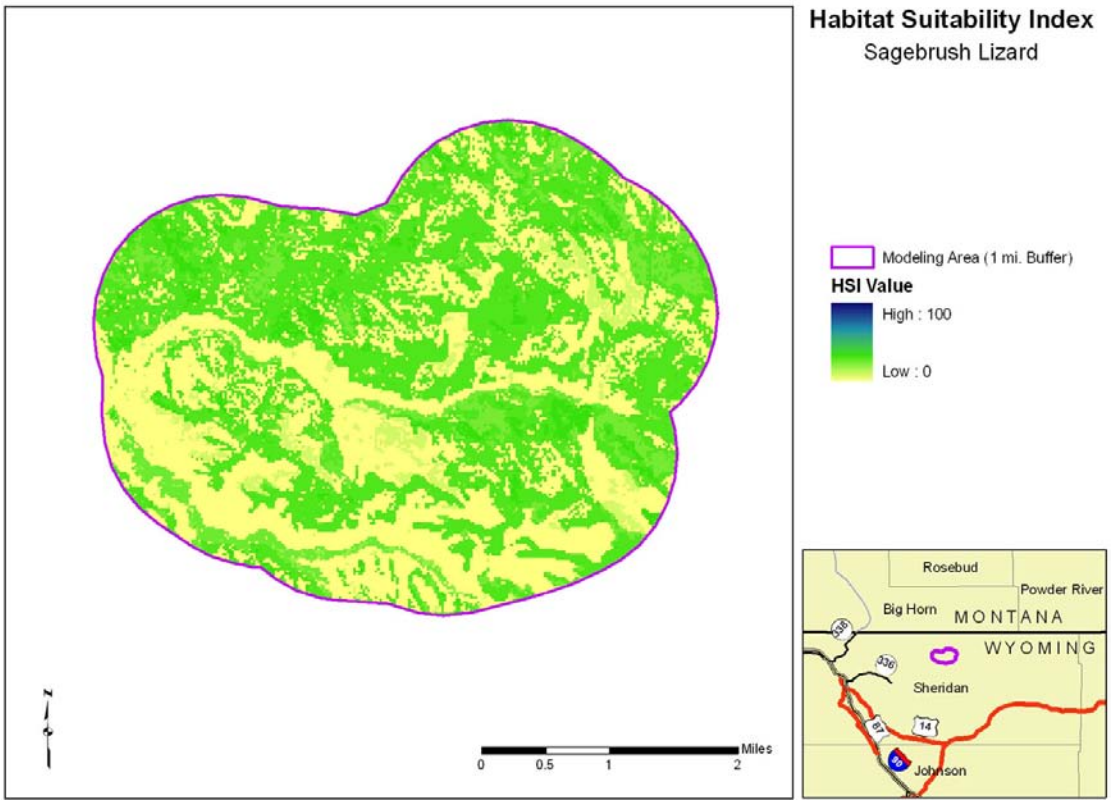

Figure B-3. Pre-treatment habitat suitability for sagebrush lizard in the Fidelity project area.

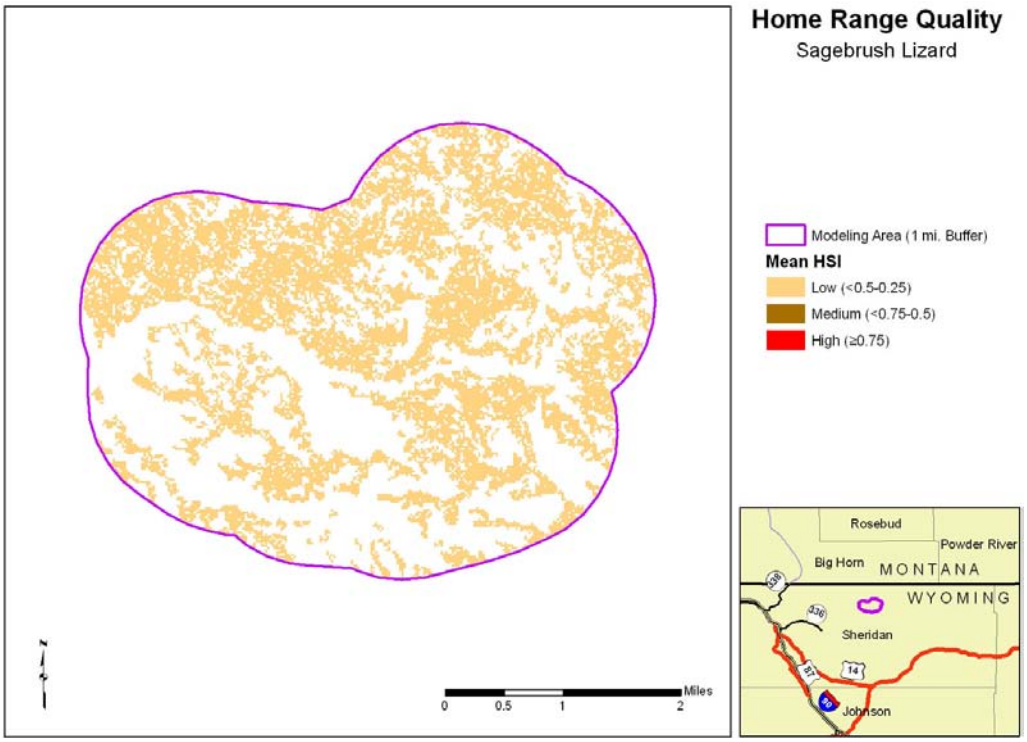

Figure B-4. Pre-treatment home range quality for sagebrush lizard in the Fidelity project area.

Sage Sparrow

The final HSI grid for sage sparrow used for HOMEGROWER is shown in Figure B-5. As noted previously, the modeling landscape for this species was a 1 mile buffer of the site analysis area. Three iterations were processed in HOMEGROWER. The target home range area was 10 times the allometric home range or 8.9 acres. The number of seeds was 40,000 and the growth window was 3 cells. Figure B-6 depicts the results for home range quality under existing, pre-treatment conditions.

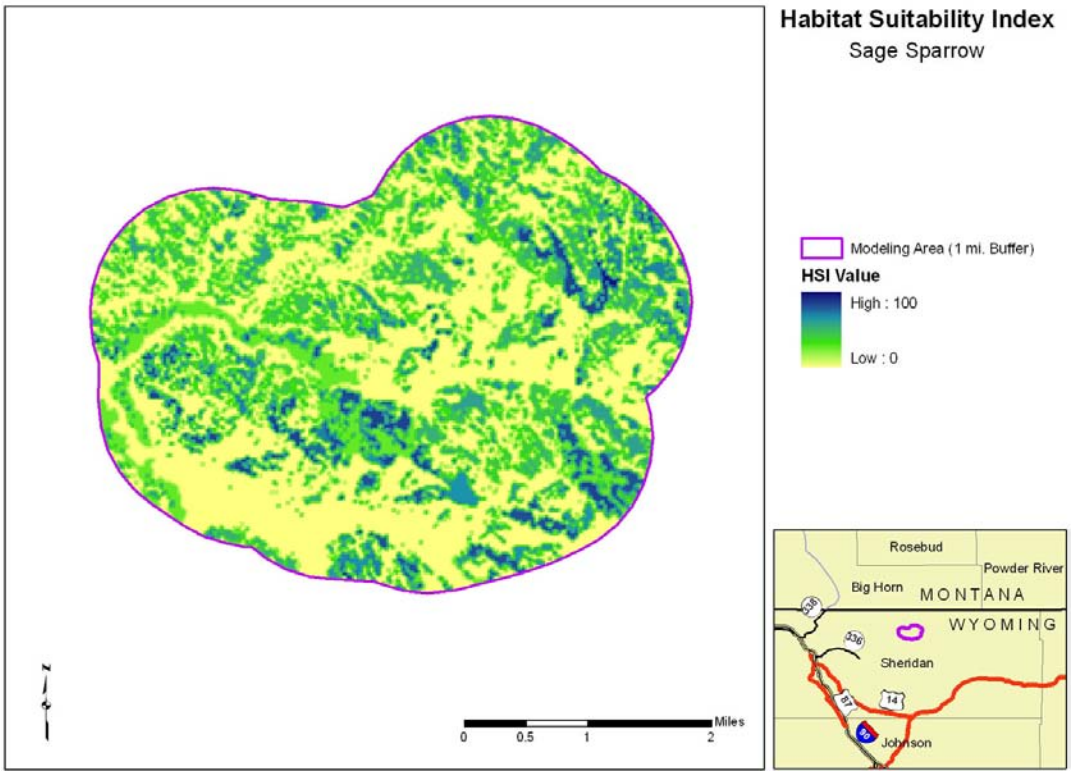

Figure B-5. Pre-treatment habitat suitability index for sage sparrow in the Fidelity project area.

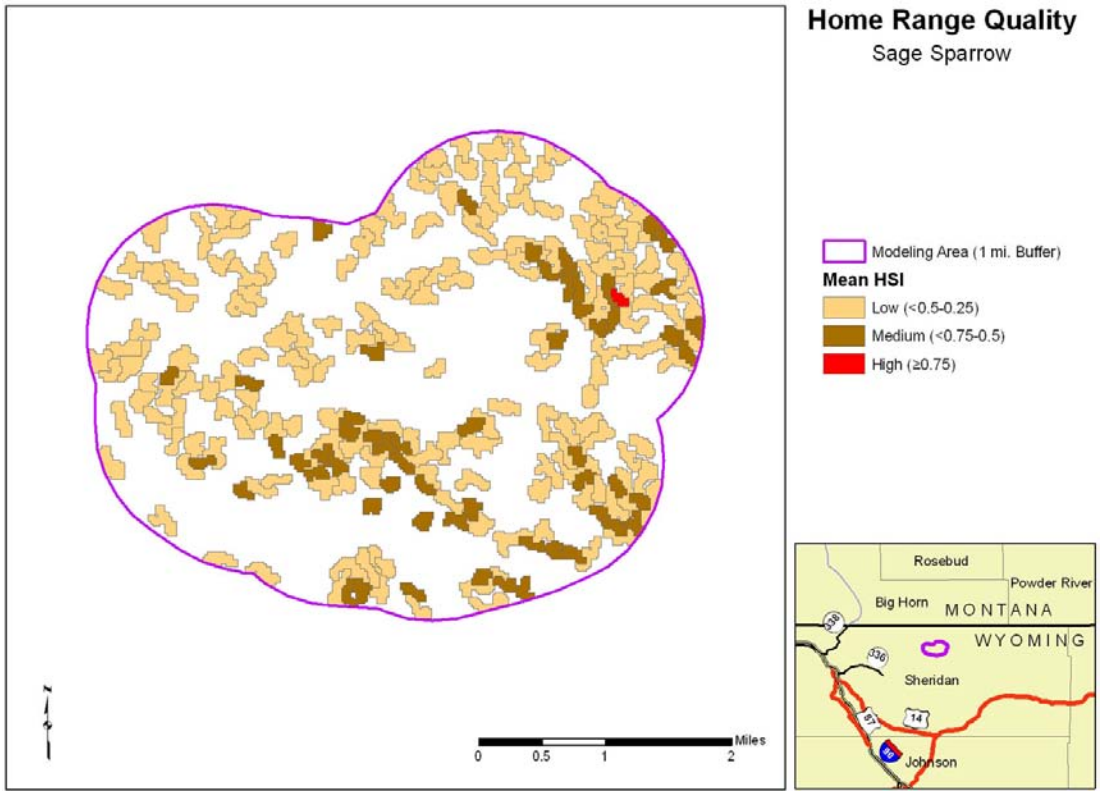

Figure B-6. Pre-treatment home range quality for sage sparrow in the Fidelity project area.

Sage Thrasher

The final HSI grid for sage thrasher used for HOMEGROWER is shown in Figure B-7. As noted previously, the modeling landscape for this species was a 1 mile buffer of the site analysis area. Three iterations were processed in HOMEGROWER. The target home range area was 10 times the allometric home range or 29.7 acres. The number of seeds was 40,000 and the growth window was 5 cells. Figure B-8 depicts the results for home range quality under existing, pre-treatment conditions.

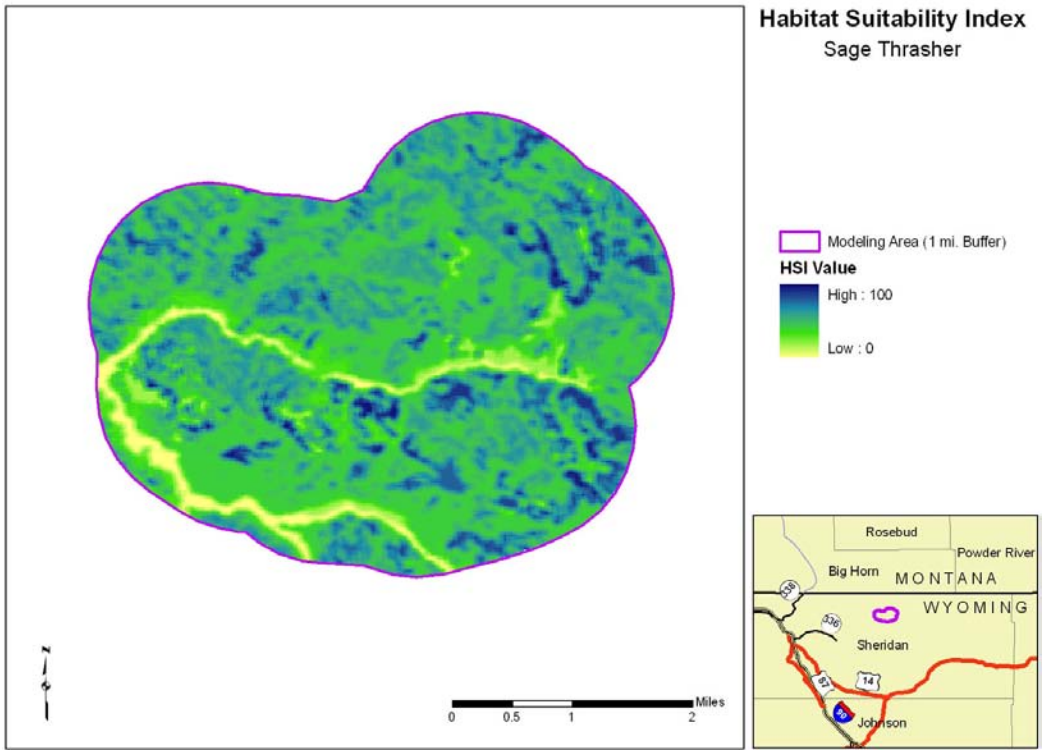

Figure B-7. Pre-treatment habitat suitability index for sage thrasher in the Fidelity project area.

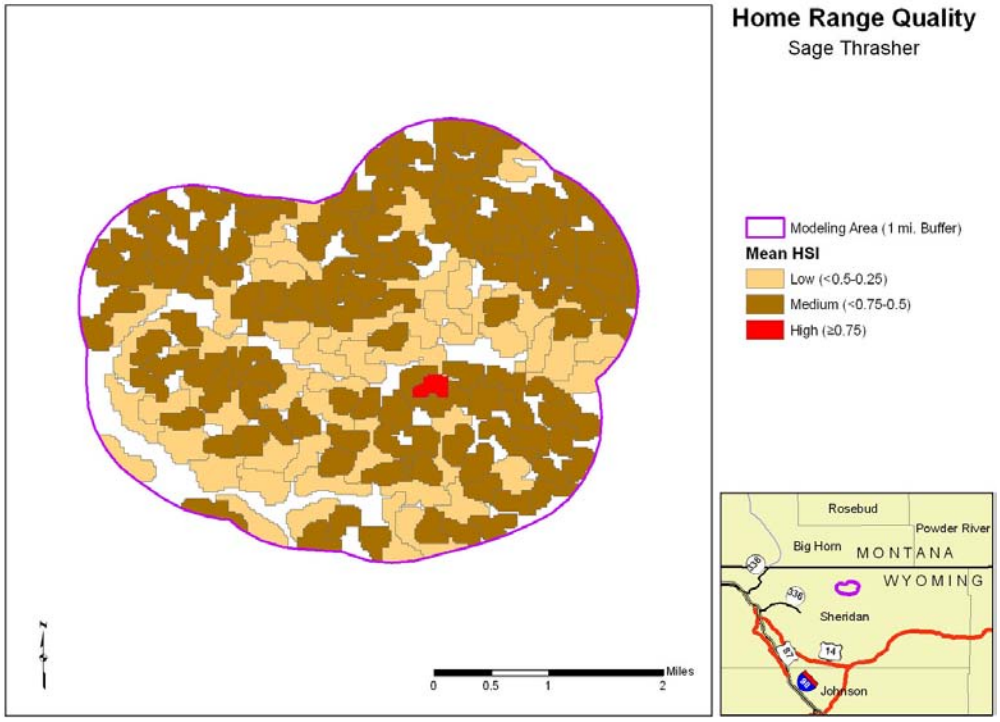

Figure B-8. Pre-treatment potential home range quality for sage thrasher in the Fidelity project area.

Sagebrush Vole

The final HSI grid for sagebrush vole used for HOMEGROWER is shown in Figure B-9. As noted previously, the modeling landscape for this species was a 1 mile buffer of the site analysis area. Three iterations were processed in HOMEGROWER. The target home range area was 5 times the allometric home range or 0.94 acres. The number of seeds was 40,000 and the growth window was 2 cells. Figure B-10 depicts the results for home range quality under existing, pre-treatment conditions.

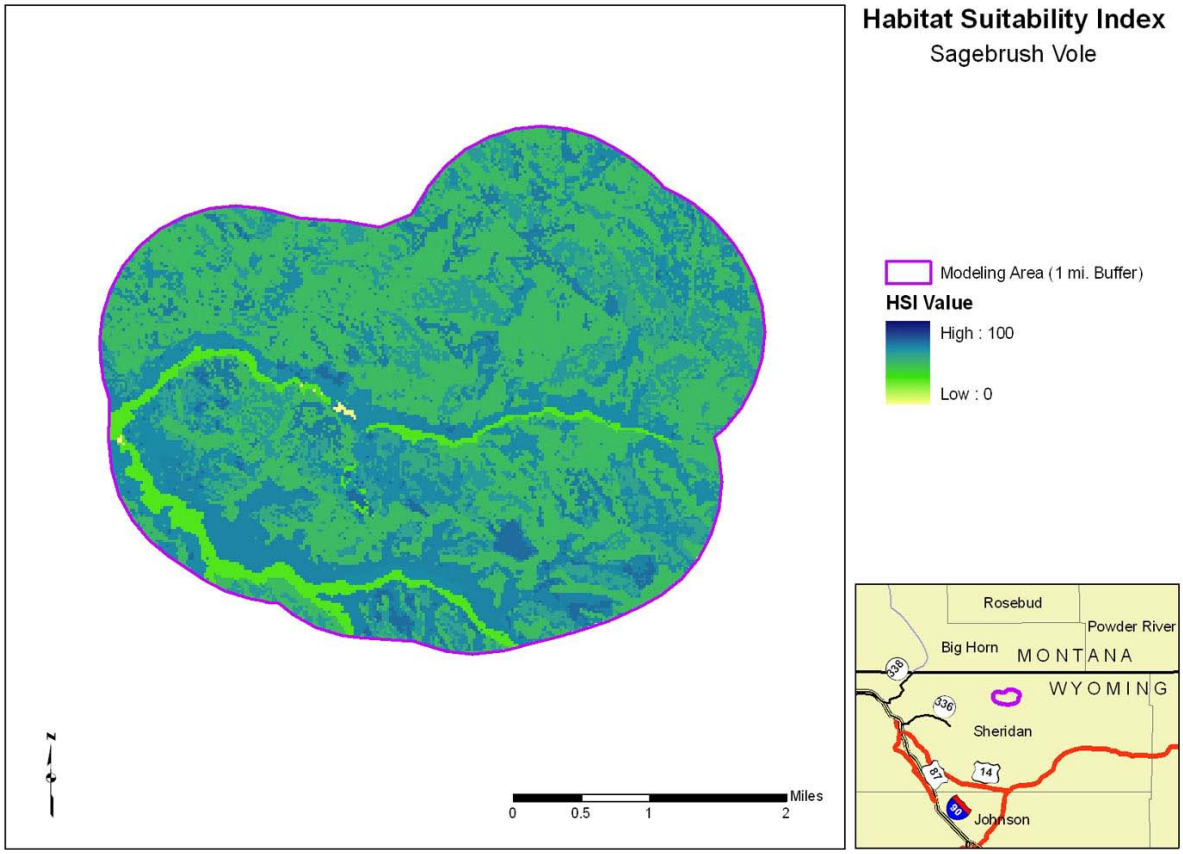

Figure B-9. Pre-treatment habitat suitability index for sagebrush vole in the Fidelity project area.

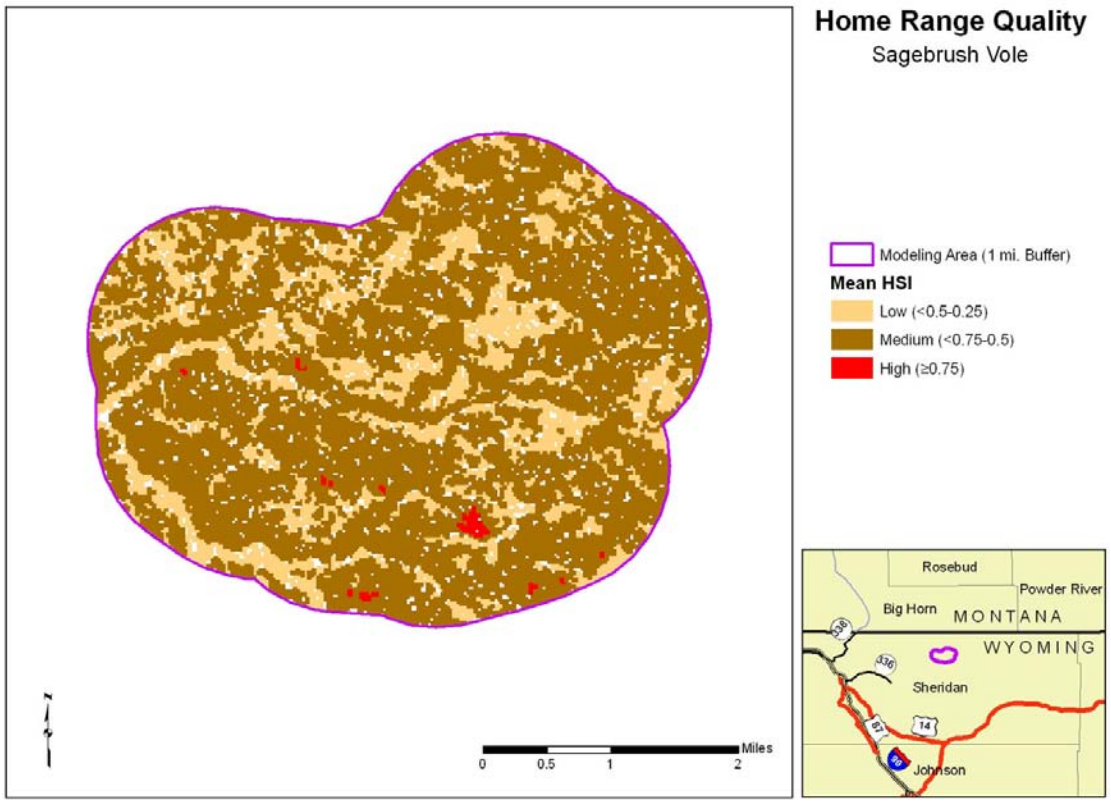

Figure B-10. Pre-treatment home range quality for sagebrush vole in the Fidelity project area.

Sage-Grouse

The final HSI grid for sage-grouse nesting habitat used for HOMEGROWER is shown in Figure B-11. As noted previously, the modeling landscape for this species was a 5 mile buffer of the site analysis area. Three iterations were processed in HOMEGROWER. The target home range area was minimum habitat area or 5.6 acres. The number of seeds was 200,000 and the growth window was 3 cells. Figure B-12 depicts the results for home range quality under existing, pre-treatment conditions.

The final HSI grid for sage-grouse brood rearing habitat used for HOMEGROWER is shown in Figure B-13. Three iterations were processed in HOMEGROWER. The target home range area was 10 times minimum habitat area or 55.6 acres. The number of seeds was 200,000 and the growth window was 10 cells. Figure 14 depicts the results for home range quality under existing, pre-treatment conditions.

The final HSI grid for sage-grouse wintering used for HOMEGROWER is shown in Figure 15. Three iterations were processed in HOMEGROWER. The target home range area was 10 times

minimum habitat area or 55.6 acres. The number of seeds was 100,000 and the growth window was 5 cells. Figure 16 depicts the results for home range quality under existing, pre-treatment conditions.

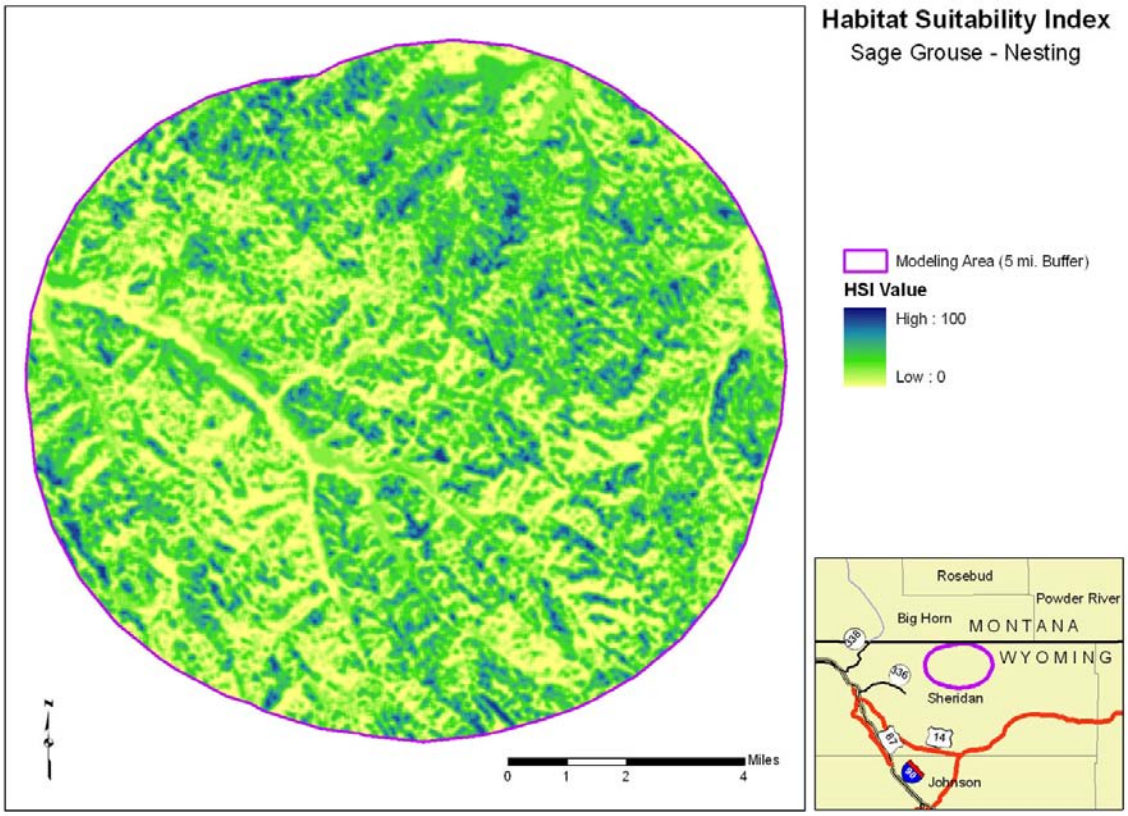

Figure B-11. Pre-treatment habitat suitability index for sage grouse -nesting in the Fidelity project area.

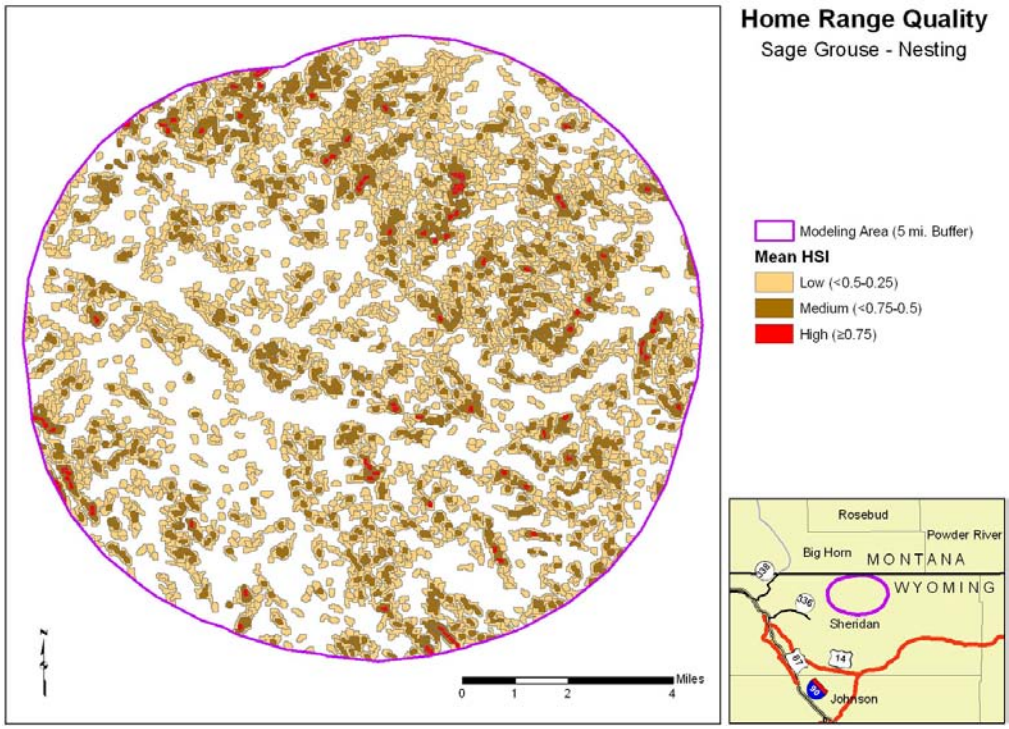

Figure B-12. Pre-treatment home range quality for sage grouse - nesting in the Fidelity project area.

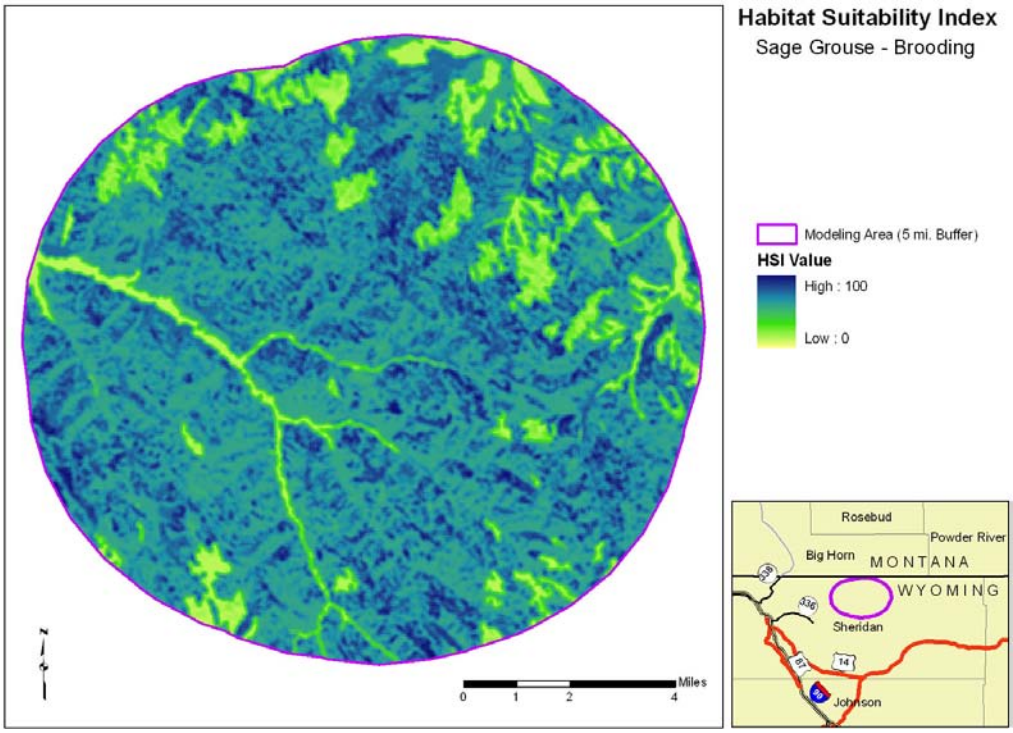

Figure B-13. Pre-treatment habitat suitability index for sage grouse –brood rearing in the Fidelity project area.

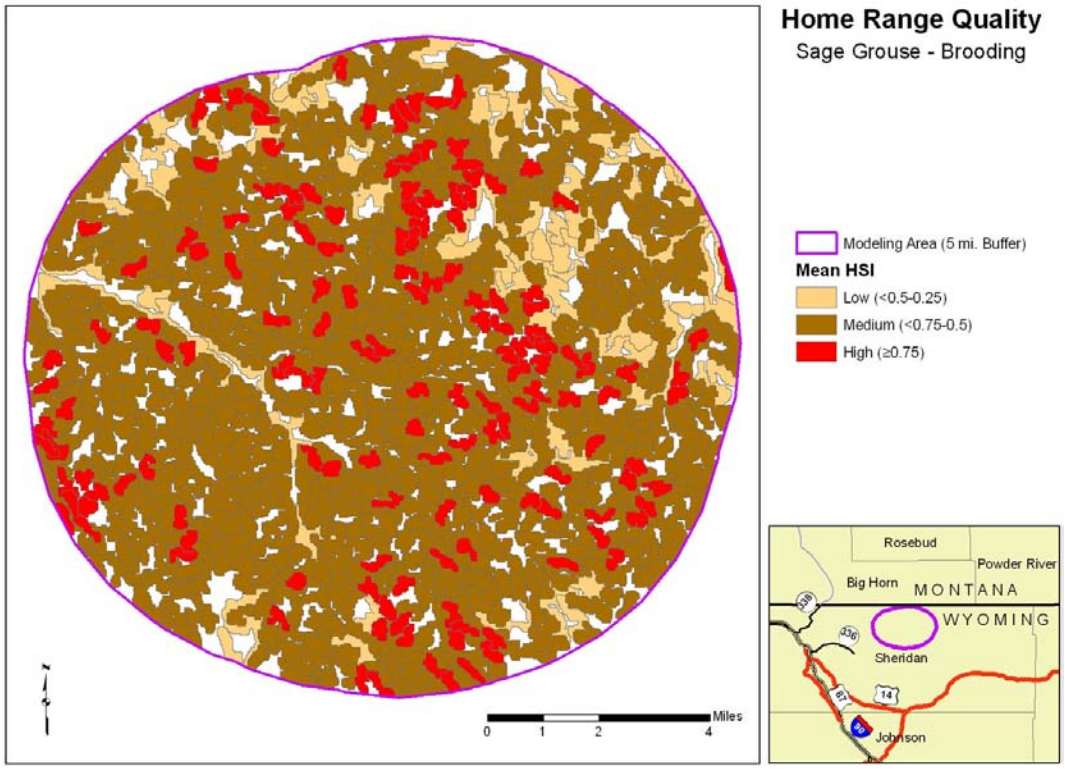

Figure B-14. Pre-treatment home range quality for sage-grouse – brood rearing in the Fidelity project area.

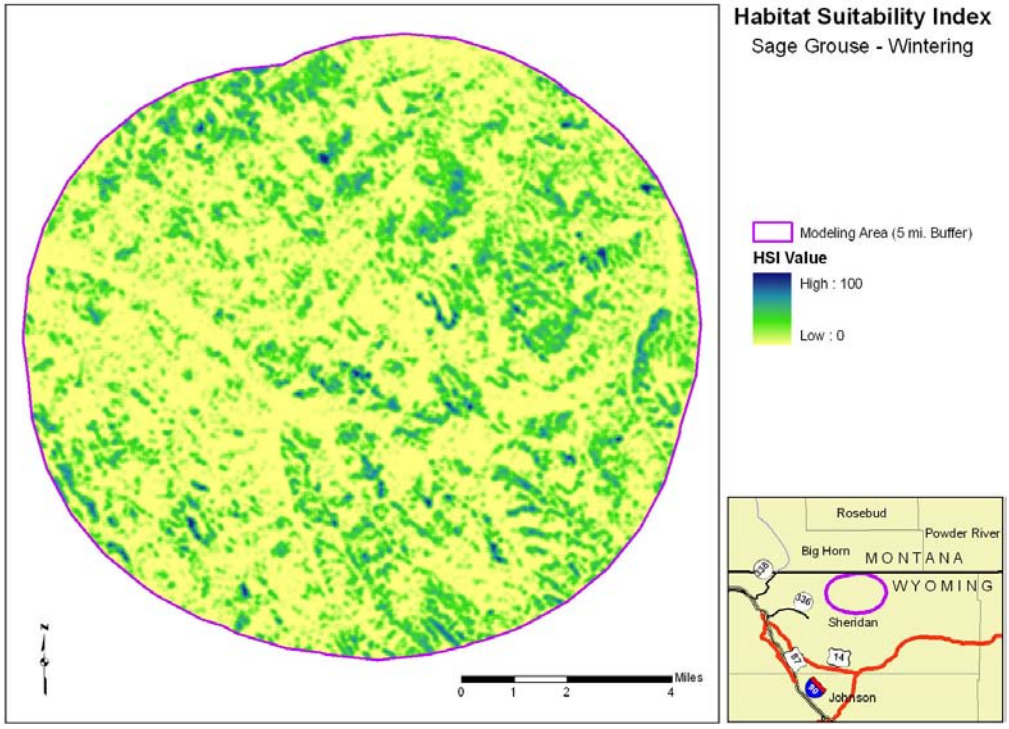

Figure B-15. Pre-treatment habitat suitability index for sage-grouse -wintering in the Fidelity project area.

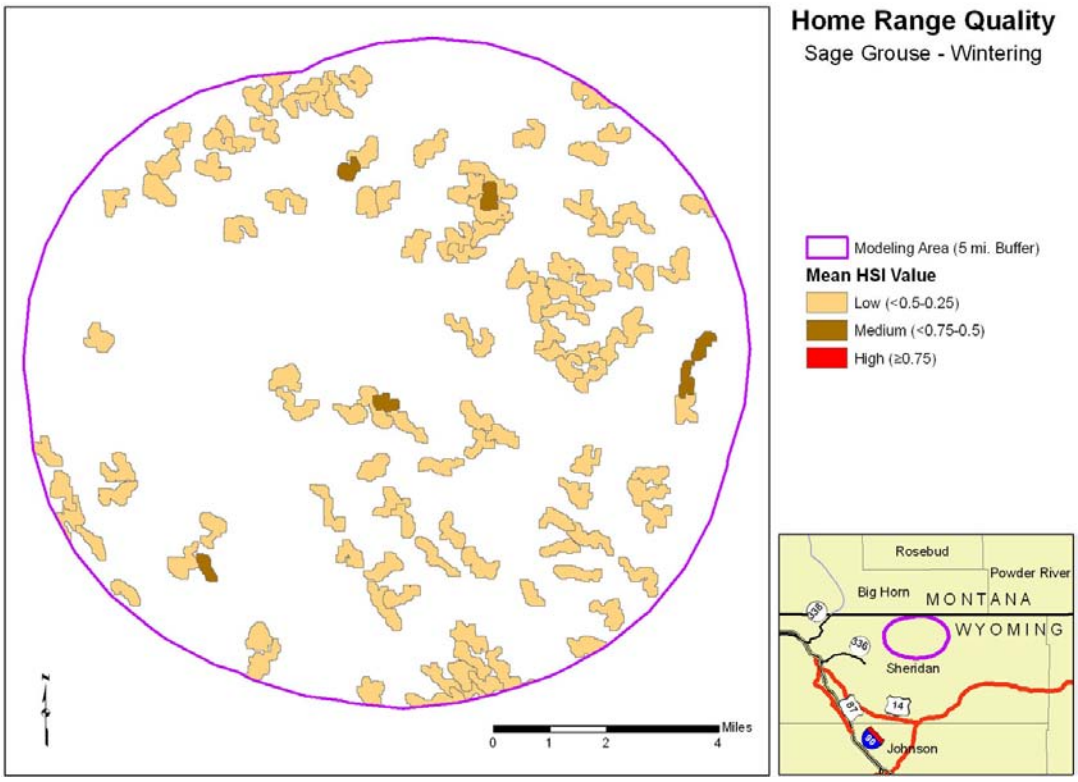

Figure B-16. Pre-treatment home range quality for sage-grouse - wintering in the Fidelity project area.

ASH VALLEY SITE

HSI and home range maps for the Ash Valley Site in northeastern California are depicted in Figures B-17- B-34.

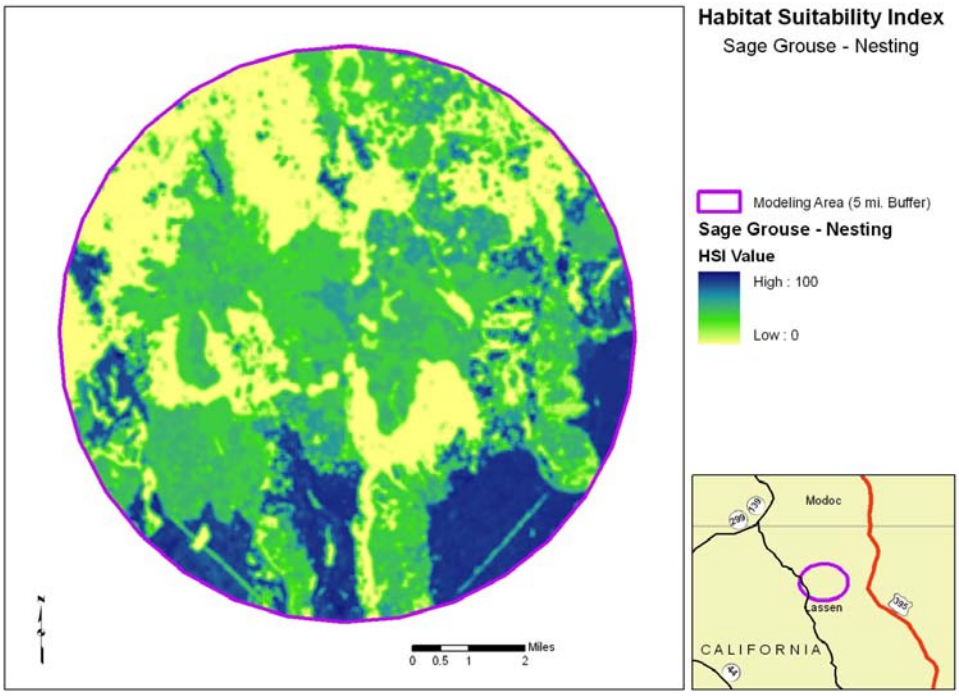

Figure B-17. Habitat suitability map for nesting sage-grouse in Ash Valley Ranch, California.

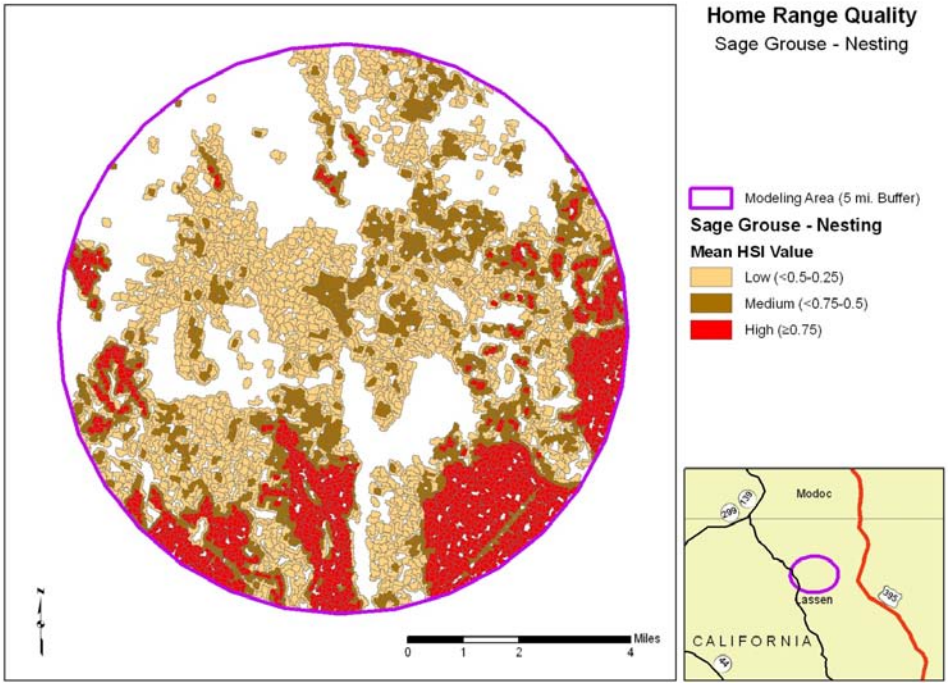

Figure B-18. Home range analysis of sage-grouse nesting habitat in Ash Valley Ranch, California. Home ranges are used as an index of relative resource availability and proximity of quality habitat.

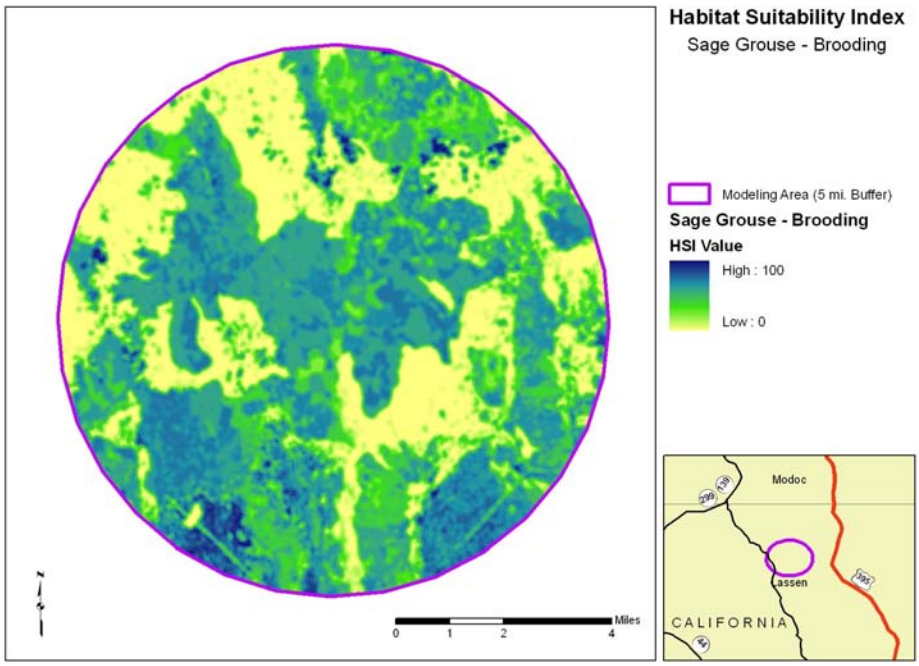

Figure B-19. Habitat suitability map for sage-grouse brood-rearing habitat in Ash Valley Ranch, California.

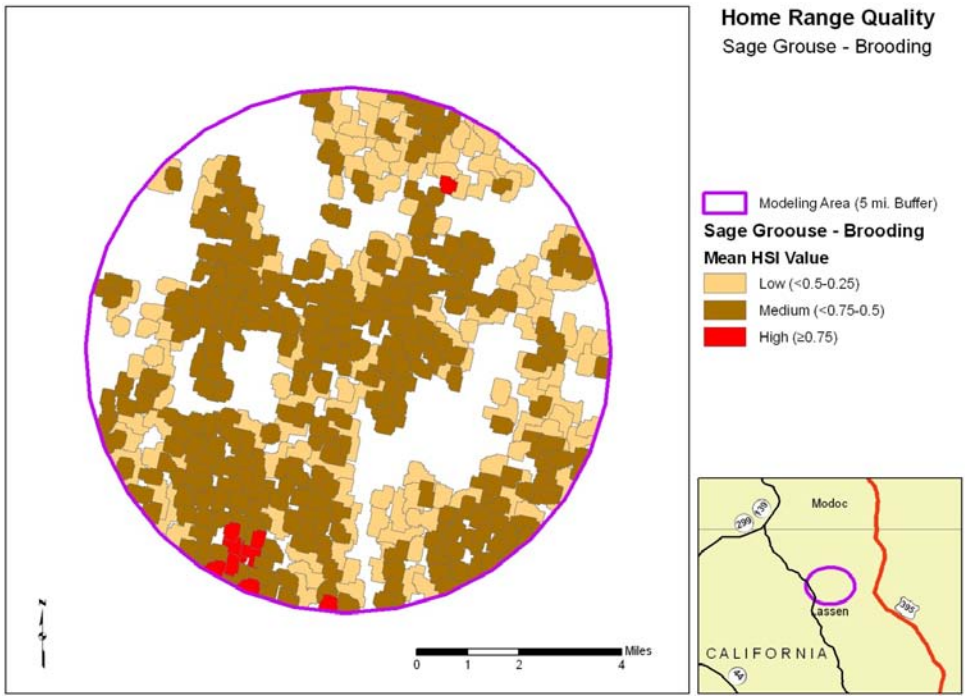

Figure B-20. Home range analysis of brood-rearing habitat for sage-grouse in the Ash Valley Ranch, California. Home ranges are used as an index of relative resource availability and proximity of quality habitat.

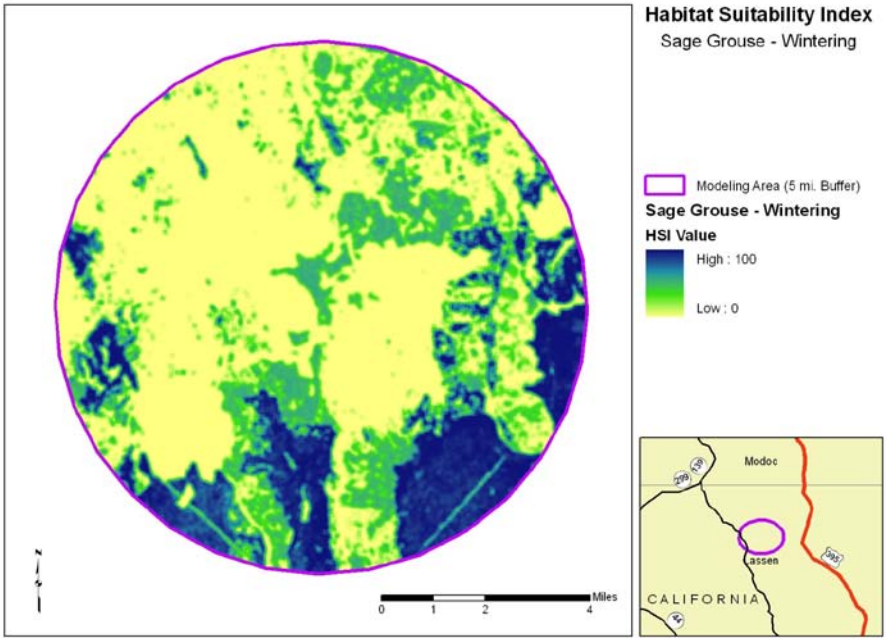

Figure B-21. Habitat suitability map for wintering sage-grouse habitat in the Ash Valley Ranch, California.

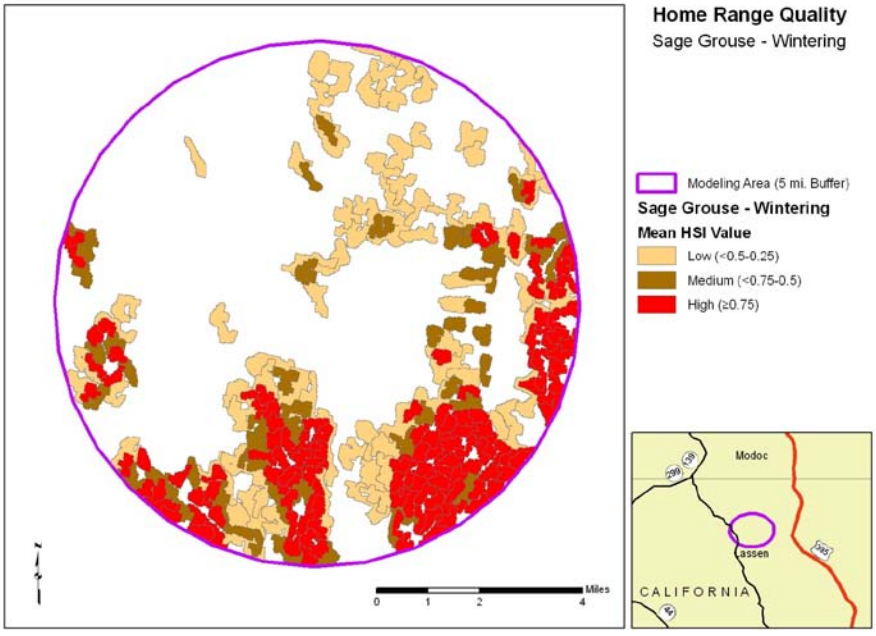

Figure B-22. Home range analysis of sage-grouse wintering habitat in Ash Valley Ranch, California. Home ranges are used as an index of relative resource availability and proximity of quality habitat.

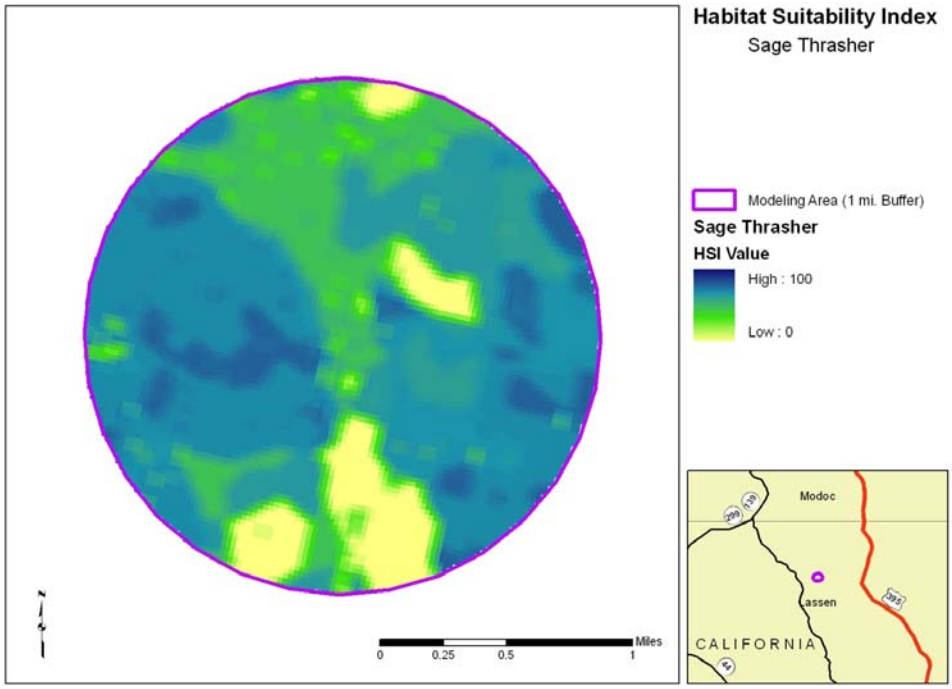

Figure B-23. Habitat suitability map of sage thrasher habitat in Ash Valley Ranch, California.

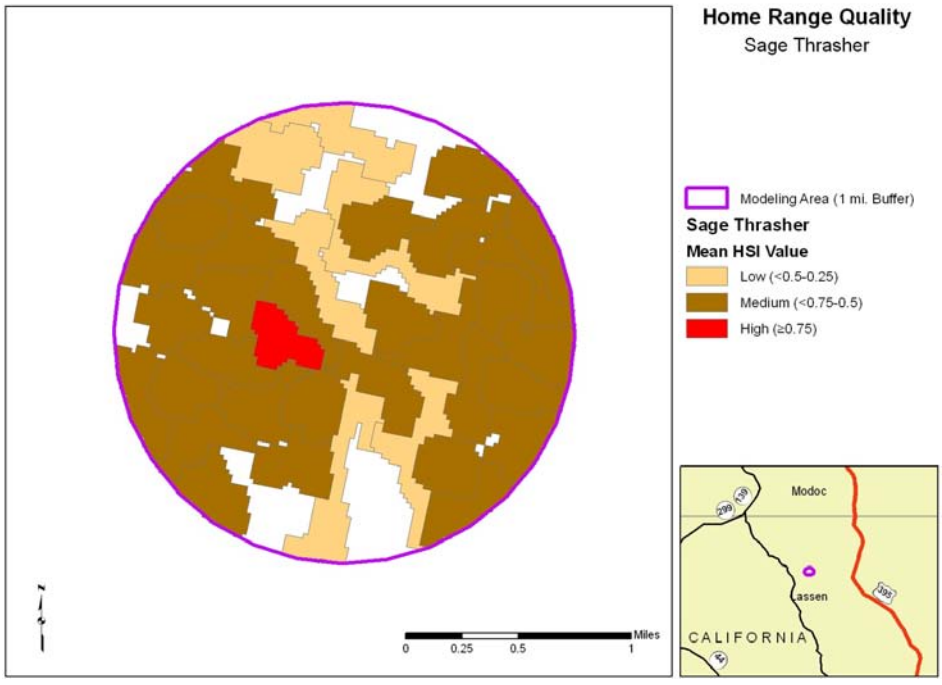

Figure B-24. Home range analysis of sage thrasher habitat in Ash Valley Ranch, California.

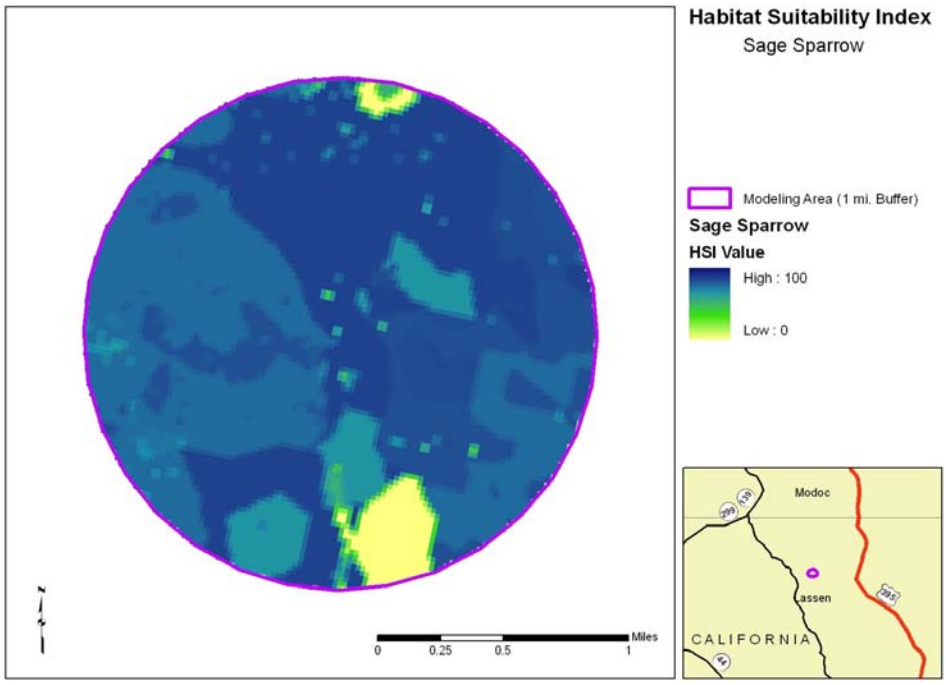

Figure B-25. Habitat suitability map for sage sparrows in Ash Valley Ranch, California.

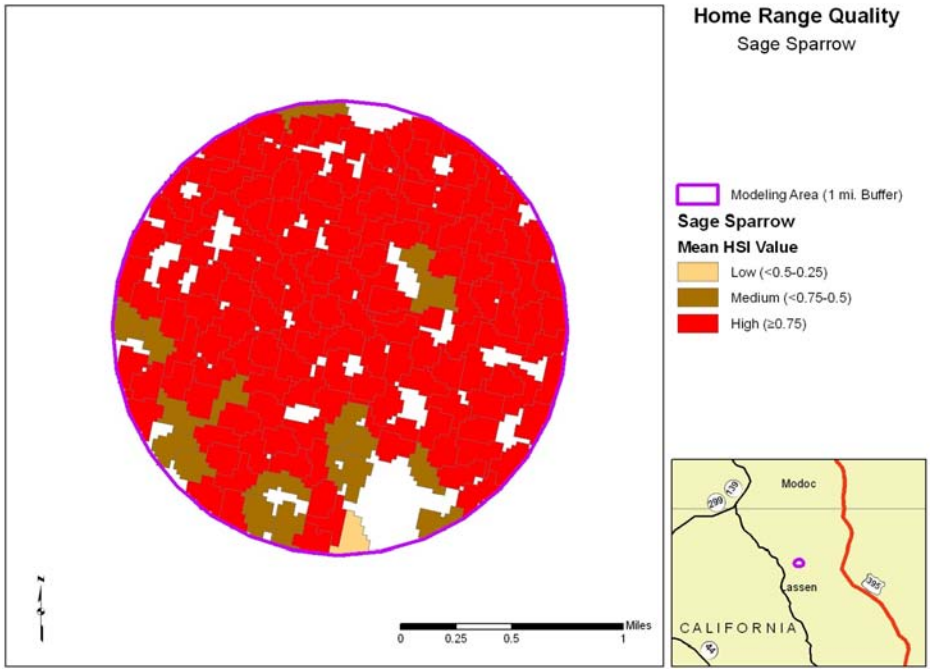

Figure B-26. Home range analysis of sage sparrow habitat in Ash Valley Ranch, California.

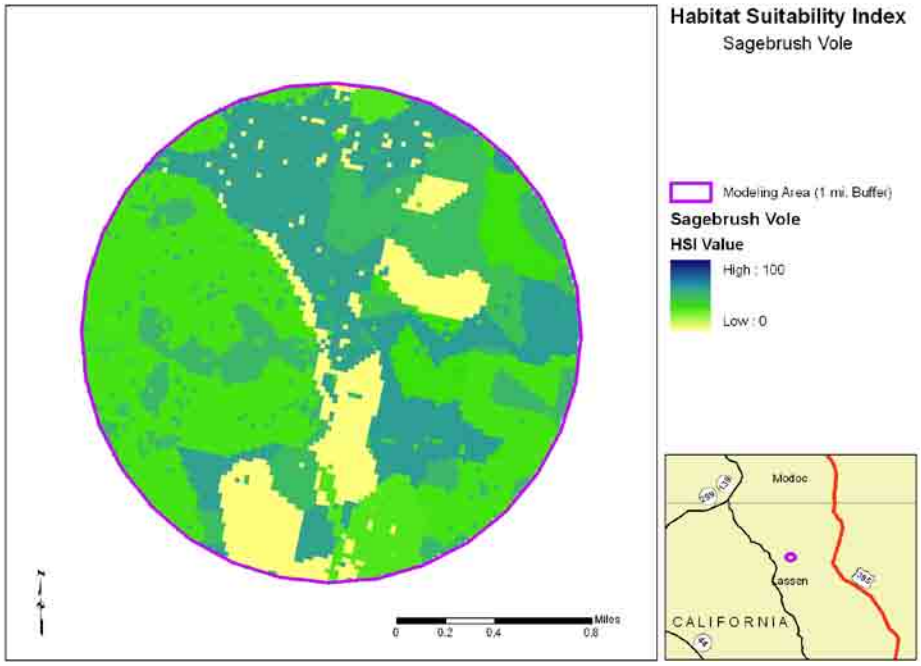

Figure B-27. Habitat suitability map for sagebrush voles in Ash Valley Ranch, California.

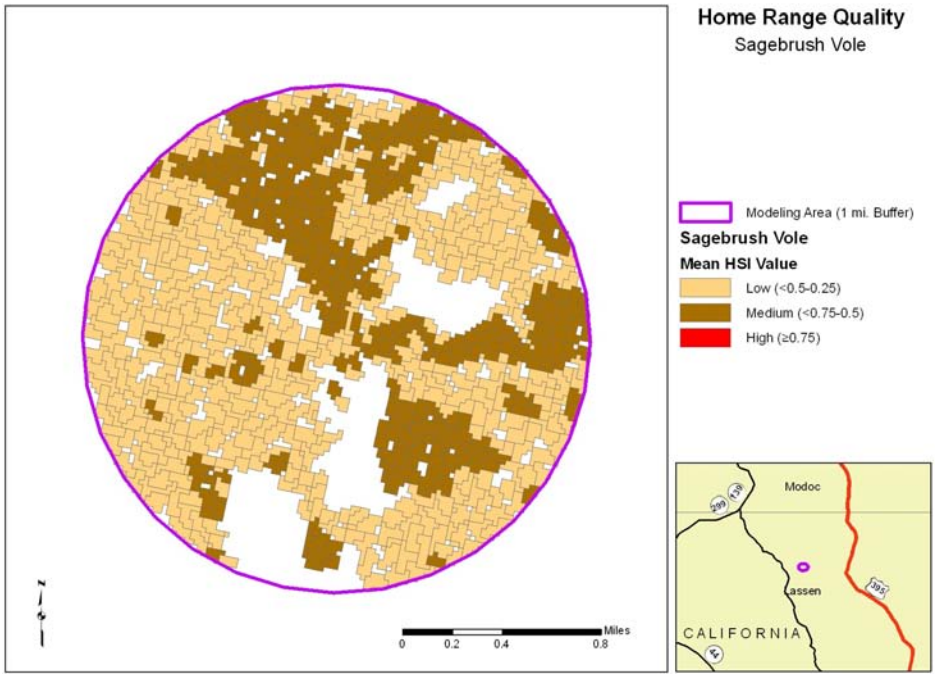

Figure B-28. Home range analysis of sagebrush vole habitat in Ash Valley Ranch, California. Home ranges are used as an index of relative resource availability and proximity of quality habitat.

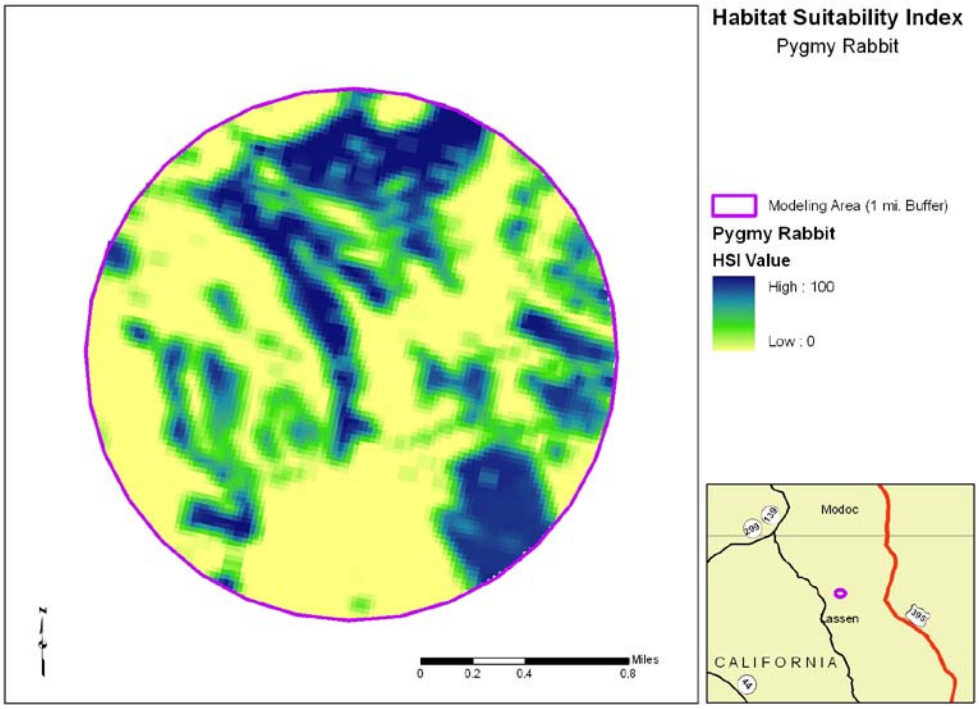

Figure B-29. Habitat suitability map for pygmy rabbits in Ash Valley Ranch, California.

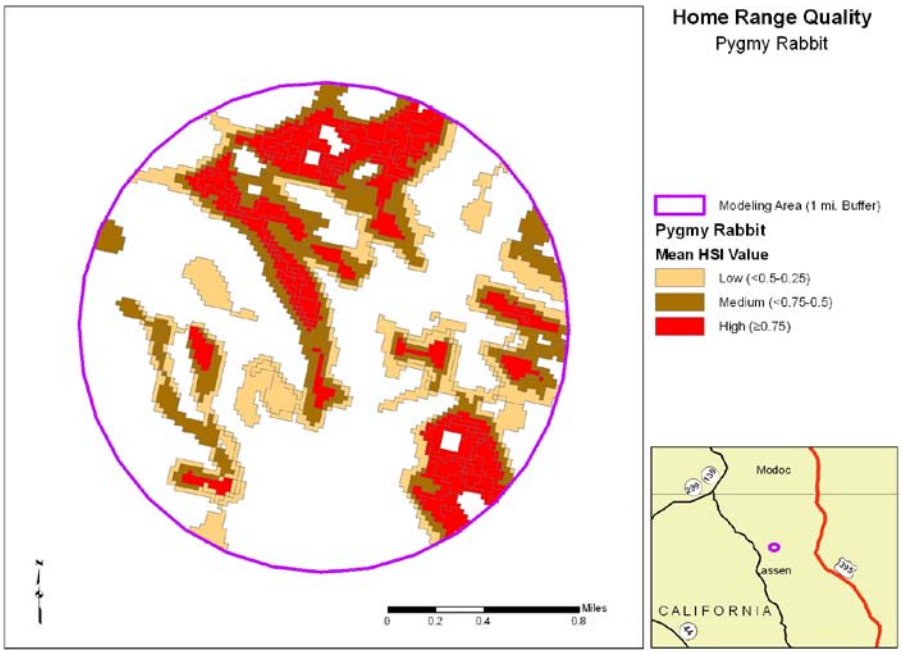

Figure B-30. Home range analysis of pygmy rabbit habitat in Ash Valley Ranch, California.

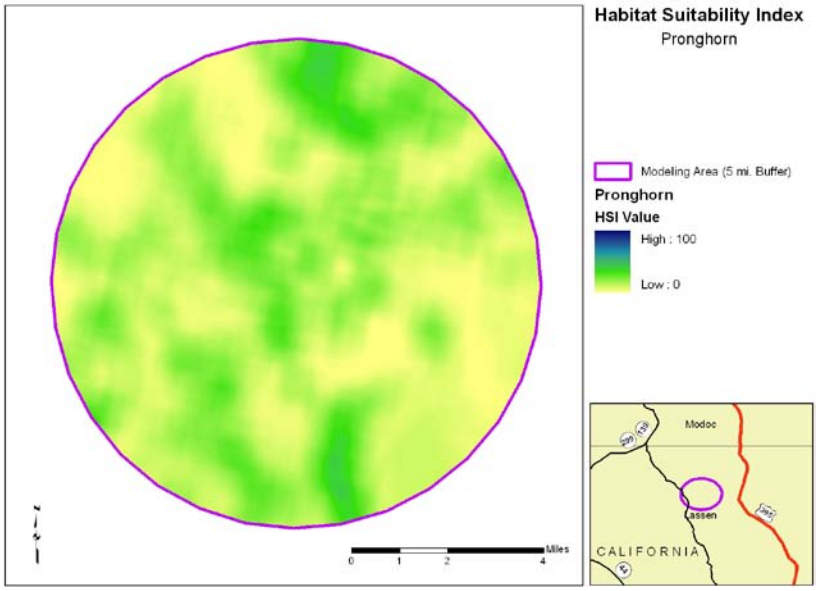

Figure B-31. Habitat suitability map for pronghorn antelope in Ash Valley Ranch, California.

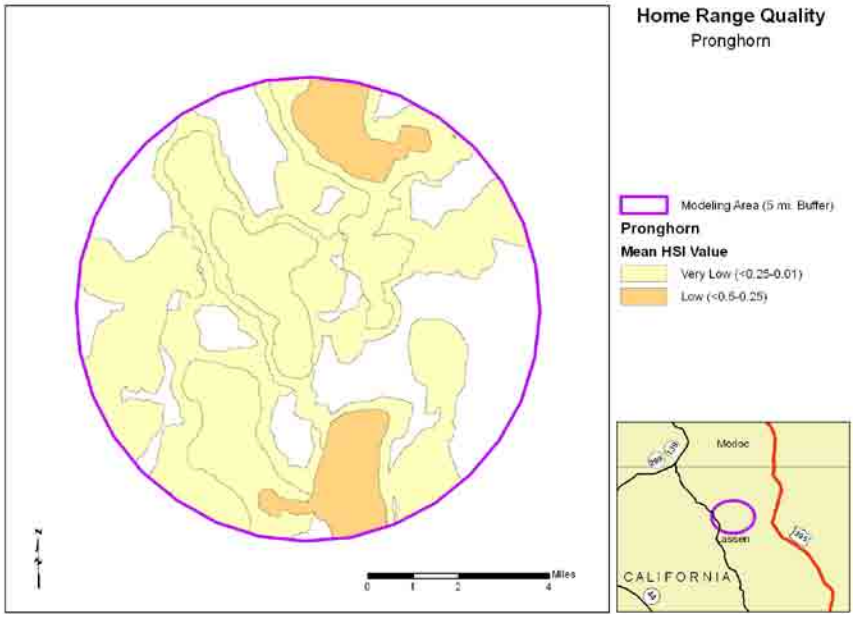

Figure B-32. Home range analysis of pronghorn antelope habitat in Ash Valley Ranch, California.

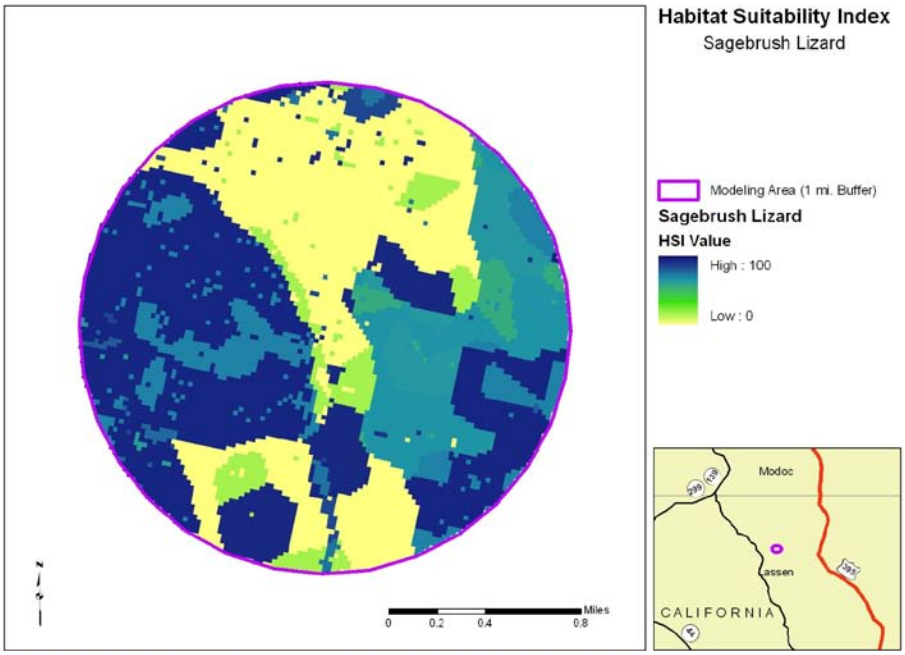

Figure B-33. Habitat suitability map for sagebrush lizards in Ash Valley Ranch, California.

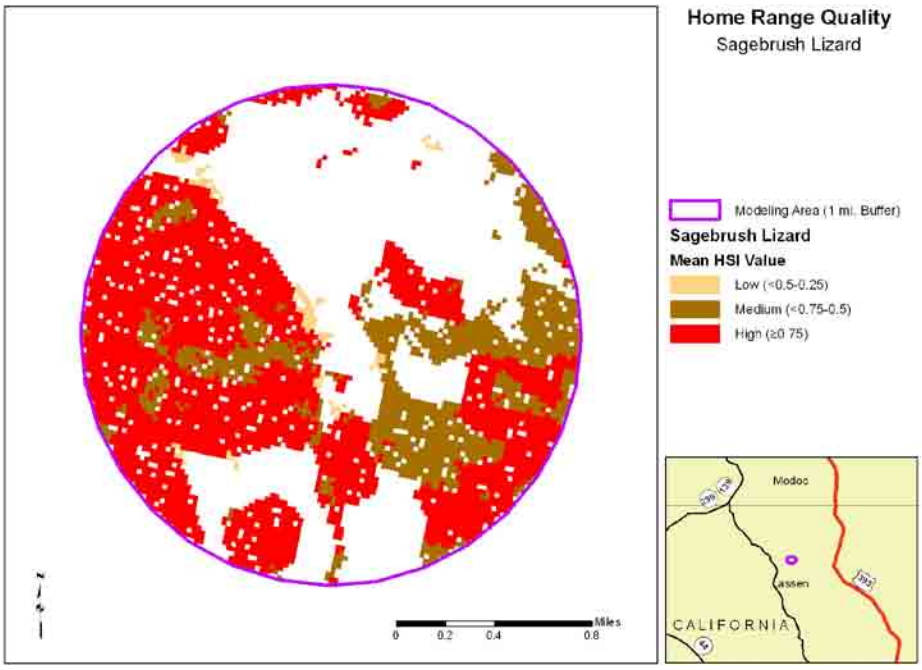

Figure B-34. Home range analysis of sagebrush lizard habitat in Ash Valley Ranch, California.

TBGPEA- Seeley Ranch. The habitat quality and home range maps for the TBGPEA/Seeley Ranch project area are displayed in Figures B-35- B-50.

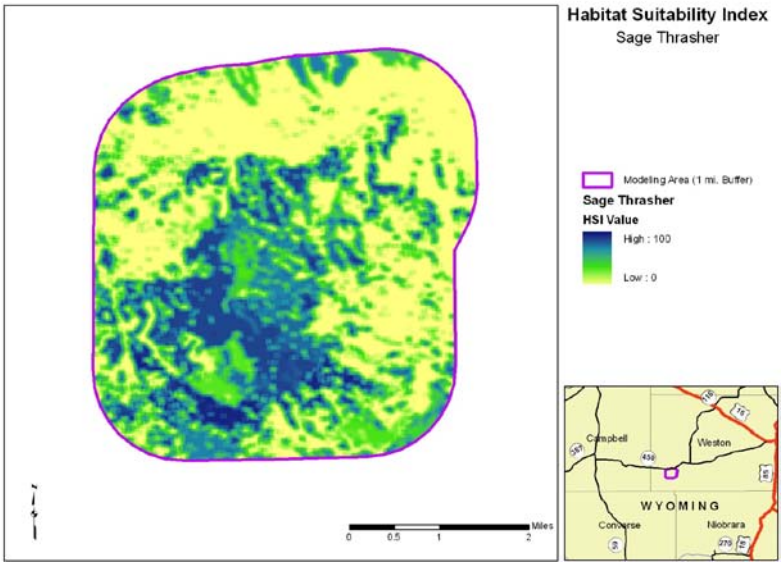

Figure B-35. Habitat suitability map for sage thrashers for the Seeley Ranch project site in northeastern Wyoming.

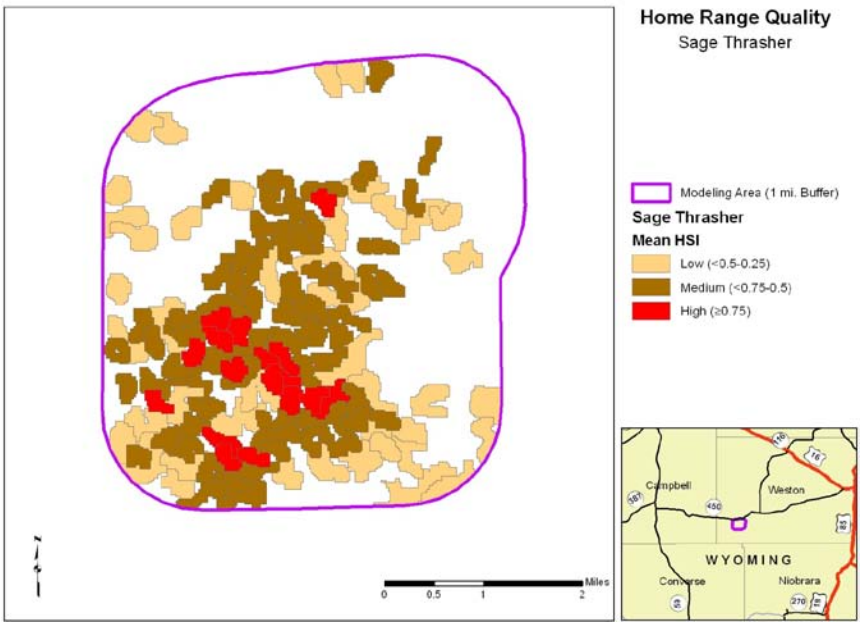

Figure B-36. Potential home range map for sage thrashers for the Seeley Ranch project site in northeastern Wyoming.

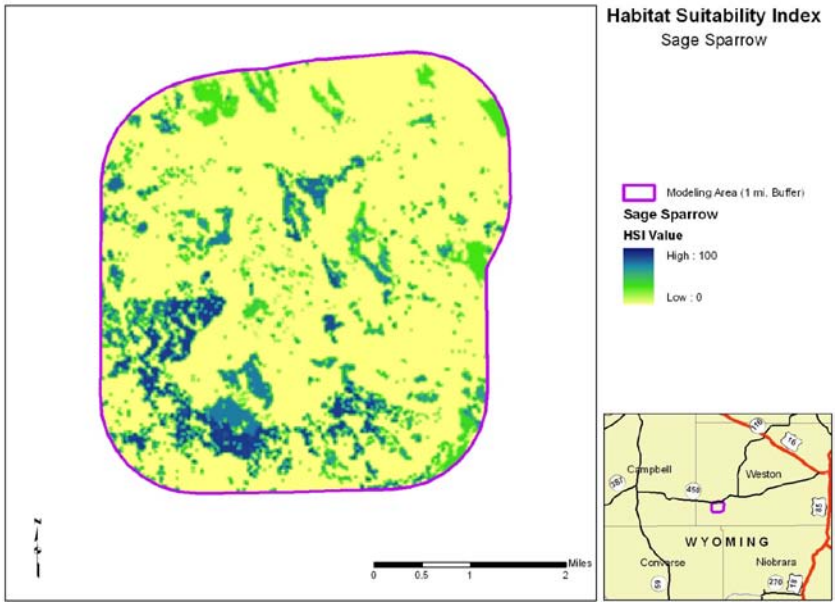

Figure B-37. Habitat suitability map for sage thrashers for the Seeley Ranch project site in northeastern Wyoming.

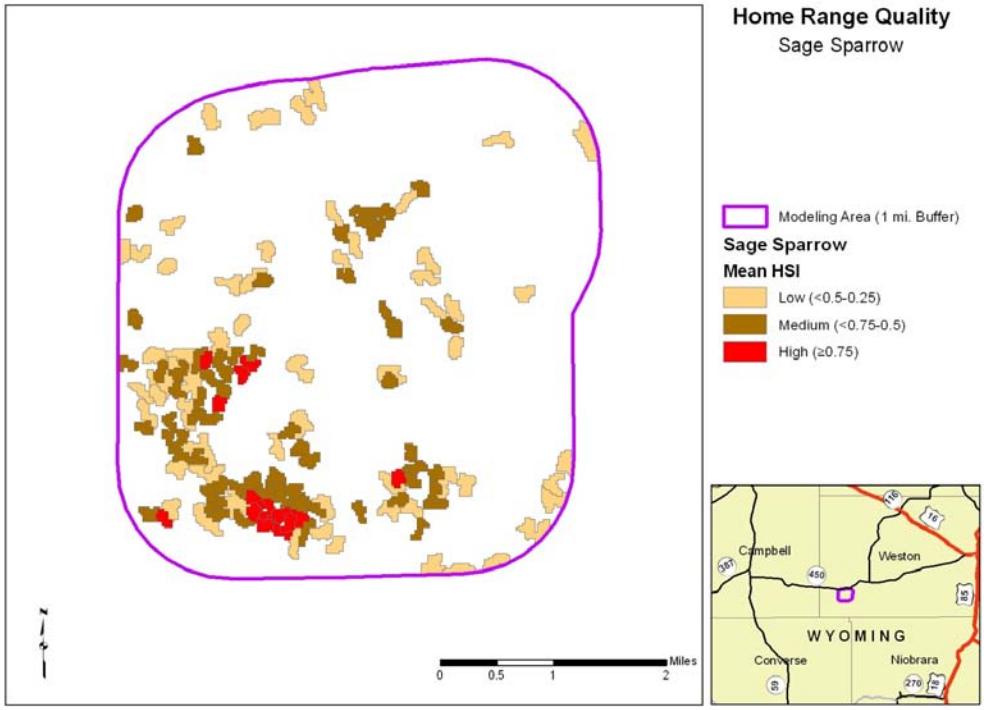

Figure B-38. Potential home range map for sage sparrows for the Seeley Ranch project site in northeastern Wyoming.

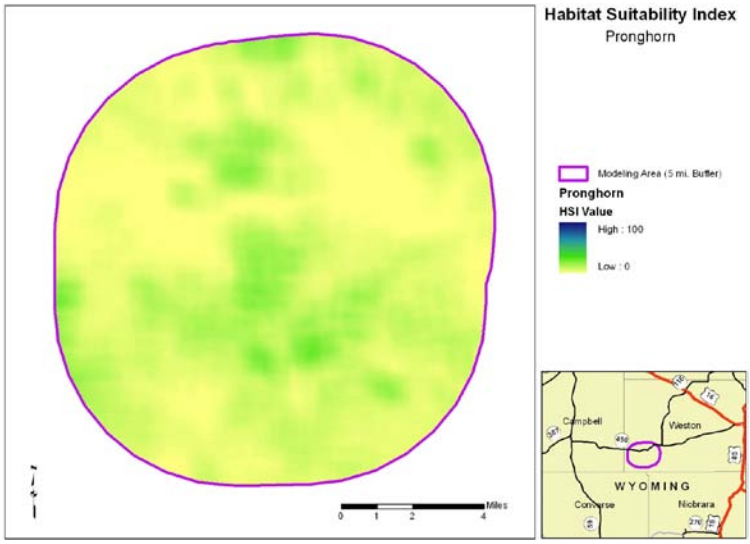

Figure B-39. Habitat suitability map for pronghorn antelope for the Seeley Ranch project site in northeastern Wyoming.

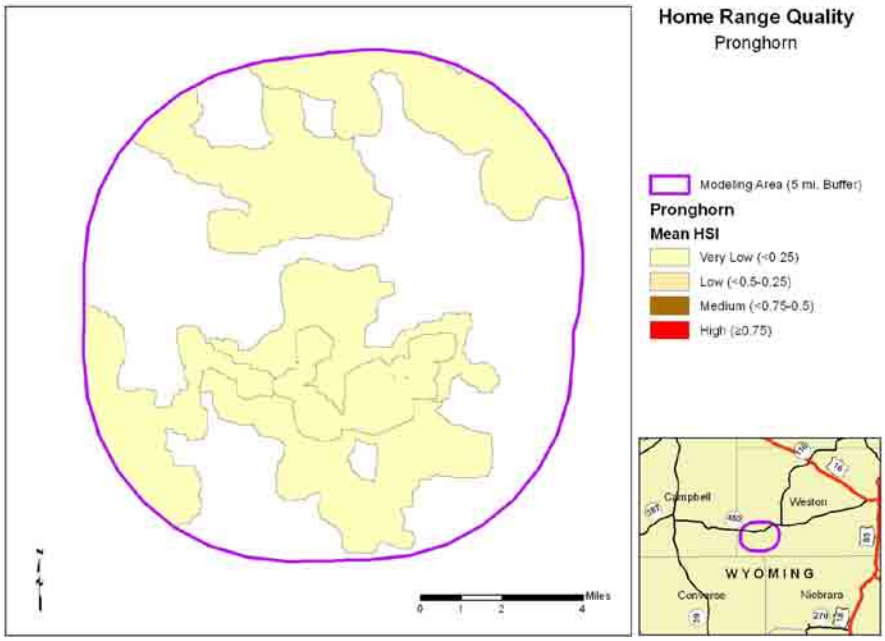

Figure B-40. Potential "home range" map for pronghorn antelope for the Seeley Ranch project site in northeastern Wyoming. While home ranges aren't used by antelope in this manner, this assessment of available resources provides information on the relative abundance of quality habitat for this species.

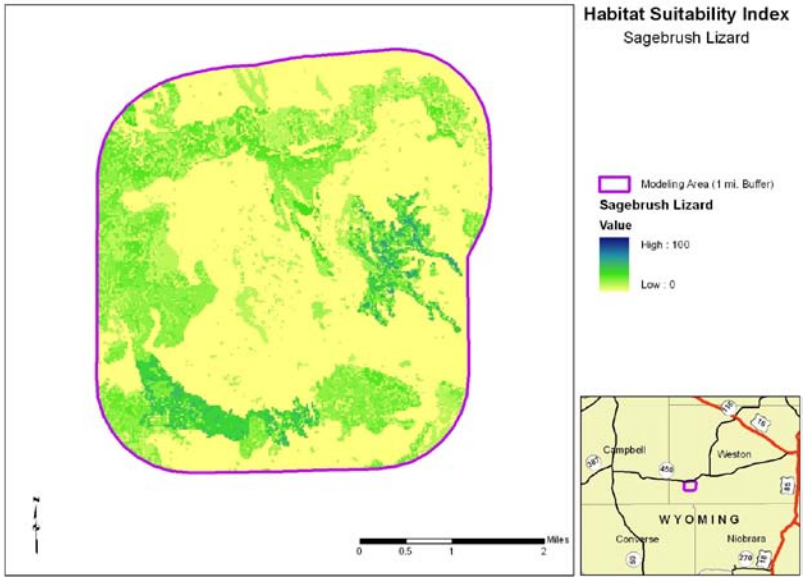

Figure B-41. Habitat suitability map for sagebrush lizard for the Seeley Ranch project site in northeastern Wyoming.

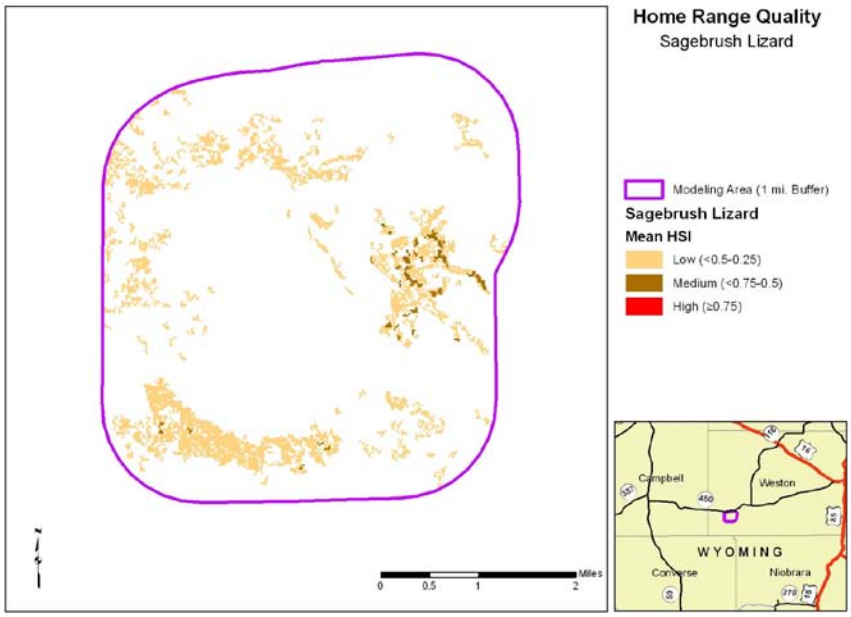

Figure B-42. Potential home range map for sagebrush lizards for the Seeley Ranch project site in northeastern Wyoming.

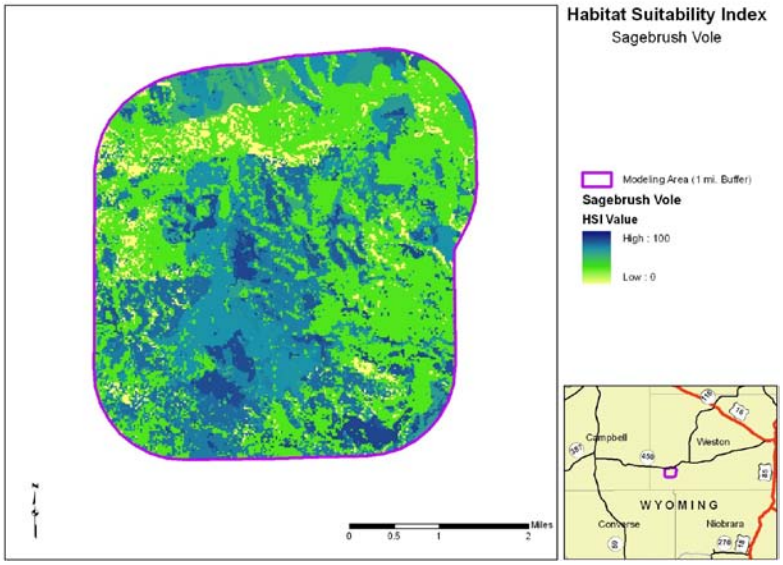

Figure B-43. Habitat suitability map for sagebrush voles for the Seeley Ranch project site in northeastern Wyoming.

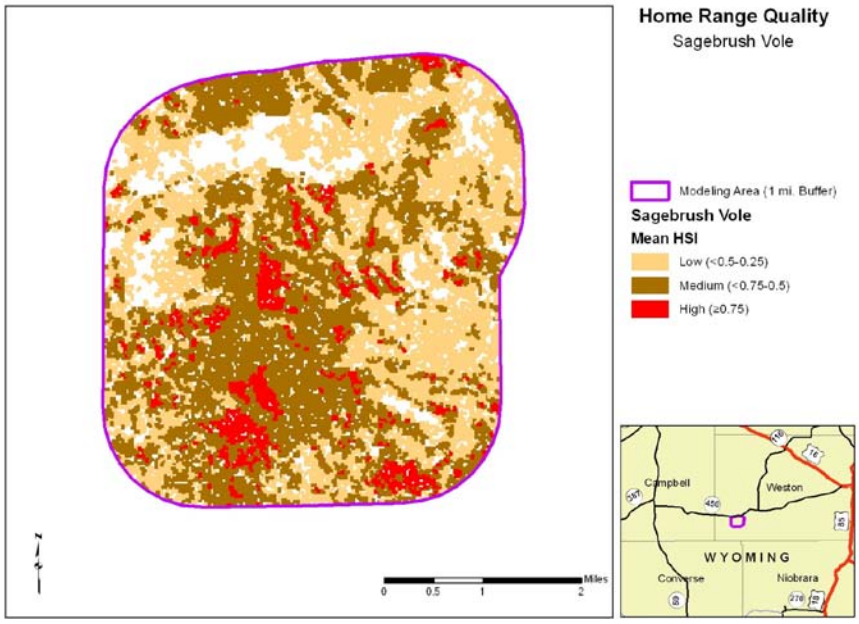

Figure B-44. Potential home range map for sagebrush voles for the Seeley Ranch project site in northeastern Wyoming.

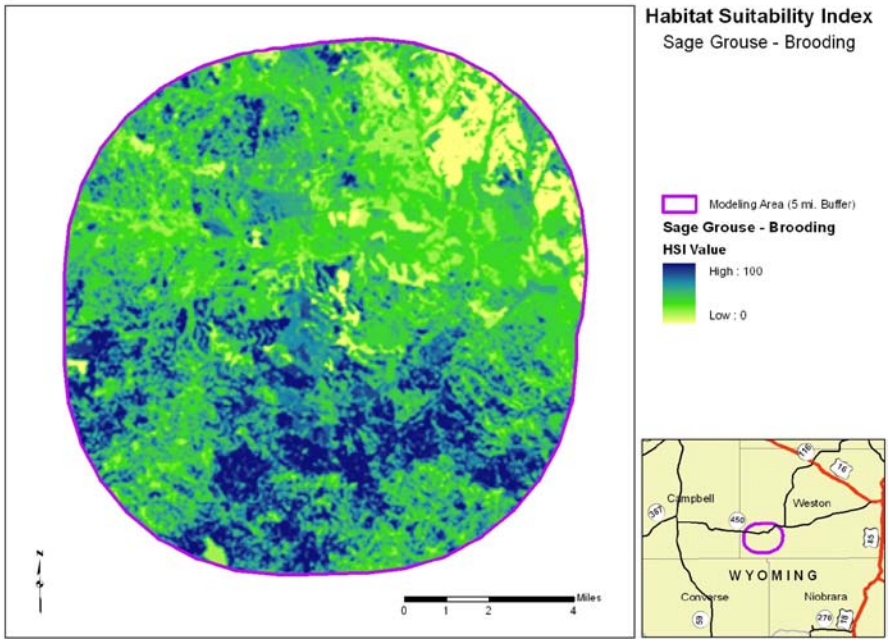

Figure B-45. Habitat suitability map for sage-grouse brood habitat for the Seeley Ranch project site in northeastern Wyoming.

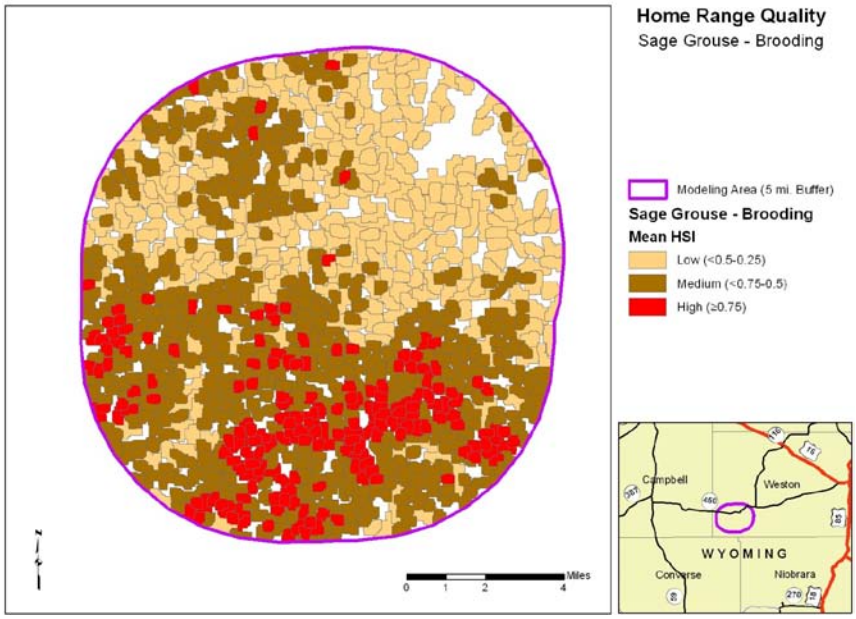

Figure B-46. Potential "home range" map for sage-grouse brood habitat for the Seeley Ranch project site in northeastern Wyoming. While home ranges are not used by sage-grouse in the normal sense, this analysis compiles information on available resources for sage-grouse broods and allows an interpretation of number of sage-grouse broods that might be supported in the area.

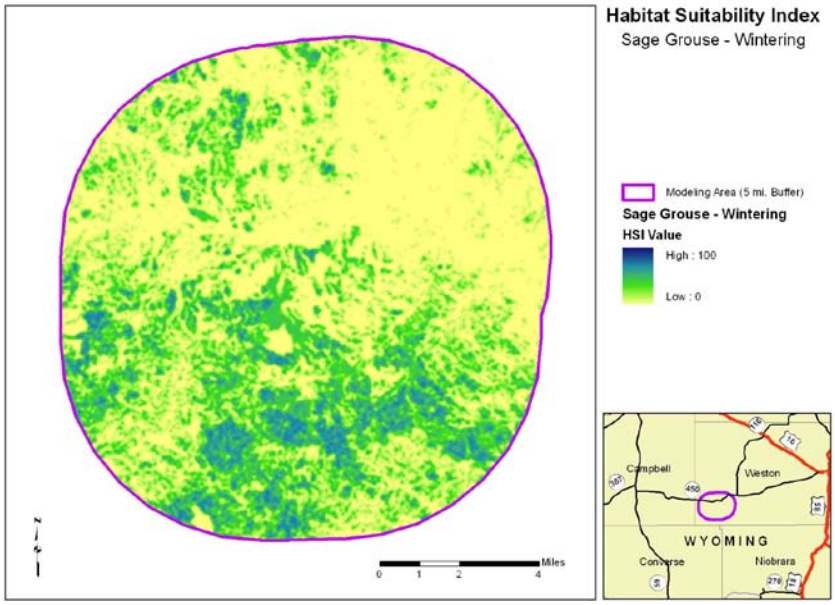

Figure B-47. Habitat suitability map for sage-grouse wintering habitat for the Seeley Ranch project site in northeastern Wyoming.

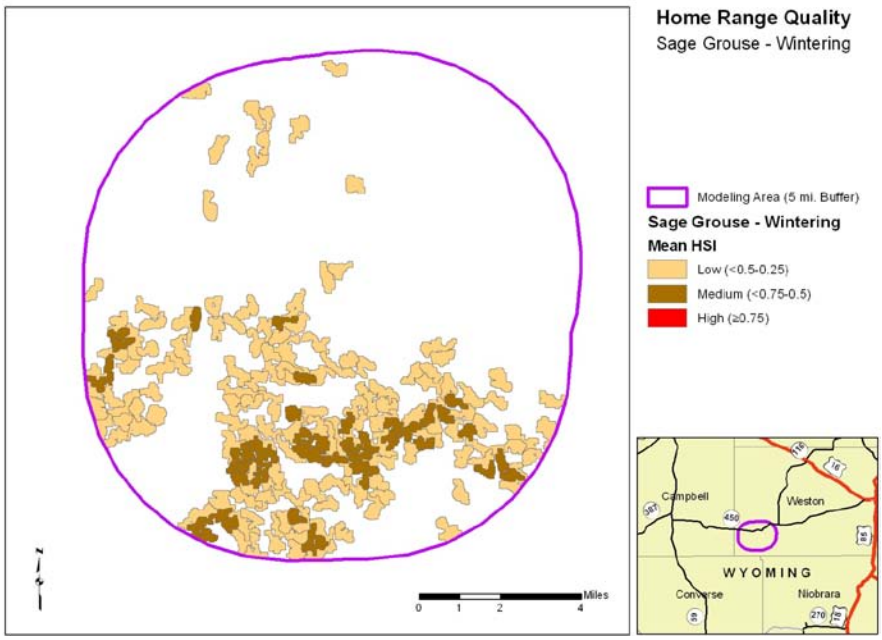

Figure B-48. Potential "home range" map for wintering sage-grouse for the Seeley Ranch project site in northeastern Wyoming. While home ranges are not used by this species for wintering areas, this analysis compiles information about availability of resources for sage-grouse, and represents an assessment of possible numbers that could be supported.

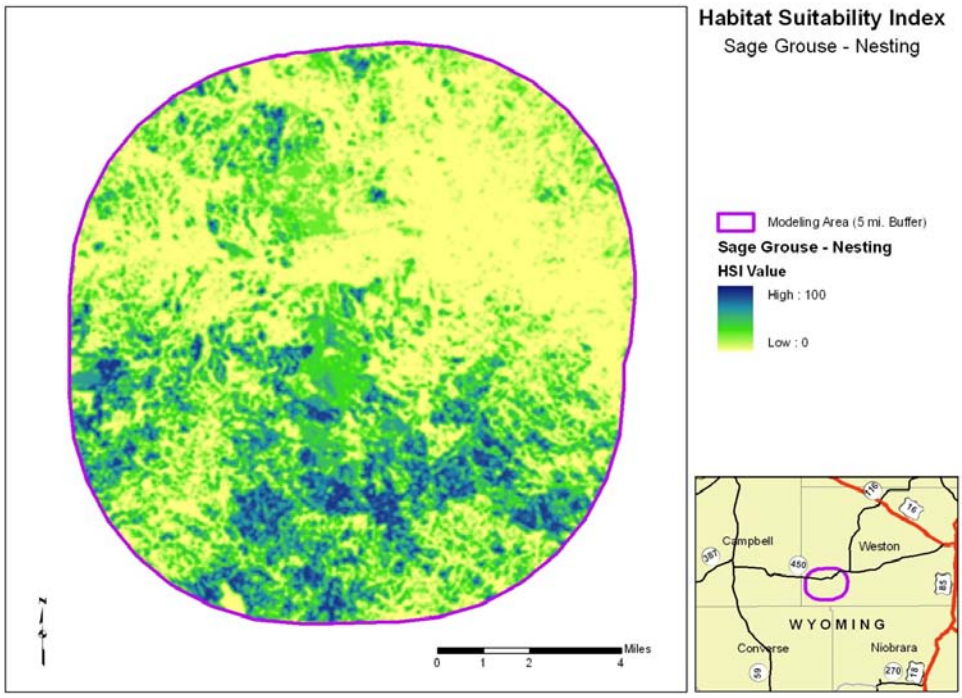

Figure B-49. Habitat suitability map for sage-grouse nesting habitat for the Seeley Ranch project site in northeastern Wyoming.

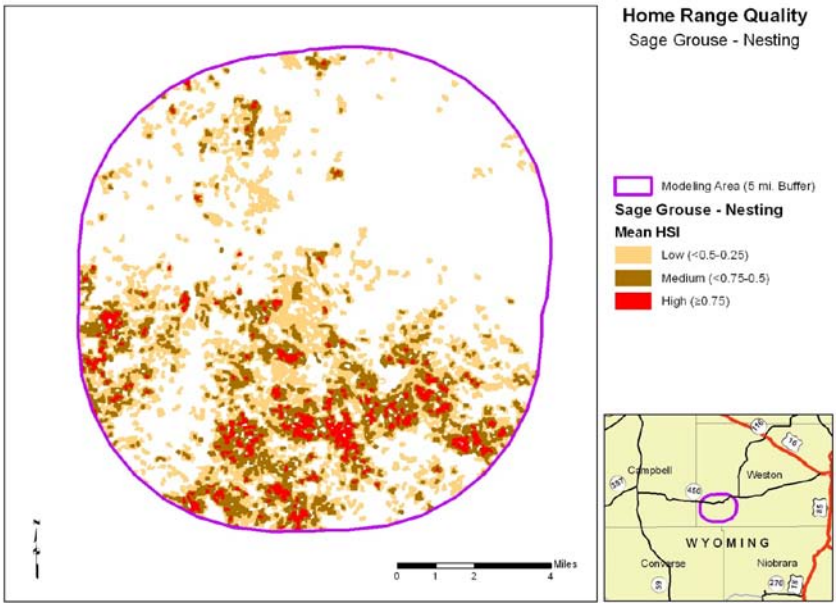

Figure B-50. Potential "home range" map for nesting sage-grouse for the Seeley Ranch project site in northeastern Wyoming. While this species does not establish home ranges for nesting, this map compiles information on available resources and provides an assessment of possible numbers of sage-grouse that might be supported.

Laidlaw Park, Idaho Project Site

The habitat quality and home range maps for the Laidlaw Park project area in central Idaho are displayed in Figures B-50 through B-66.

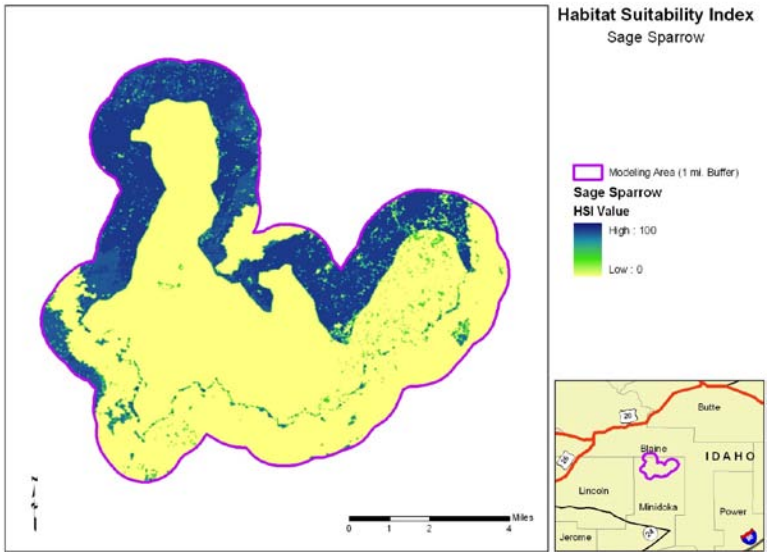

Figure B-51. Habitat suitability map for sage sparrow habitat for the Laidlaw Park project site in central Idaho.

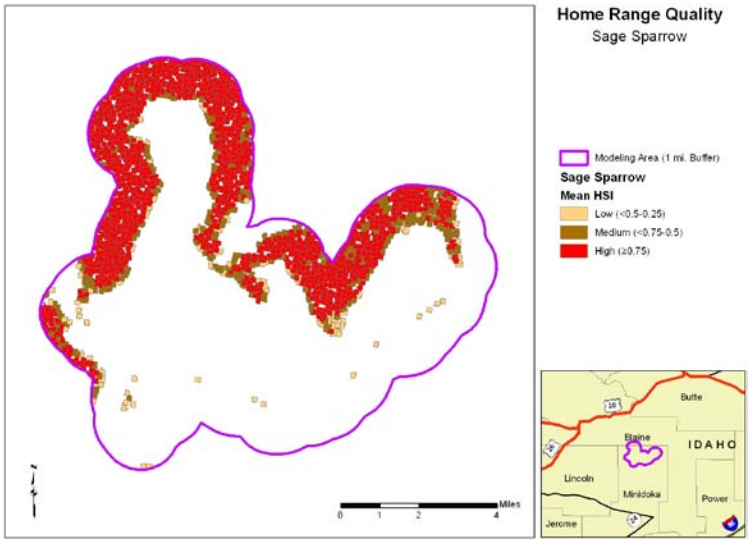

Figure B-52. Potential home range map for sage sparrows for the Laidlaw Park project site in central Idaho.

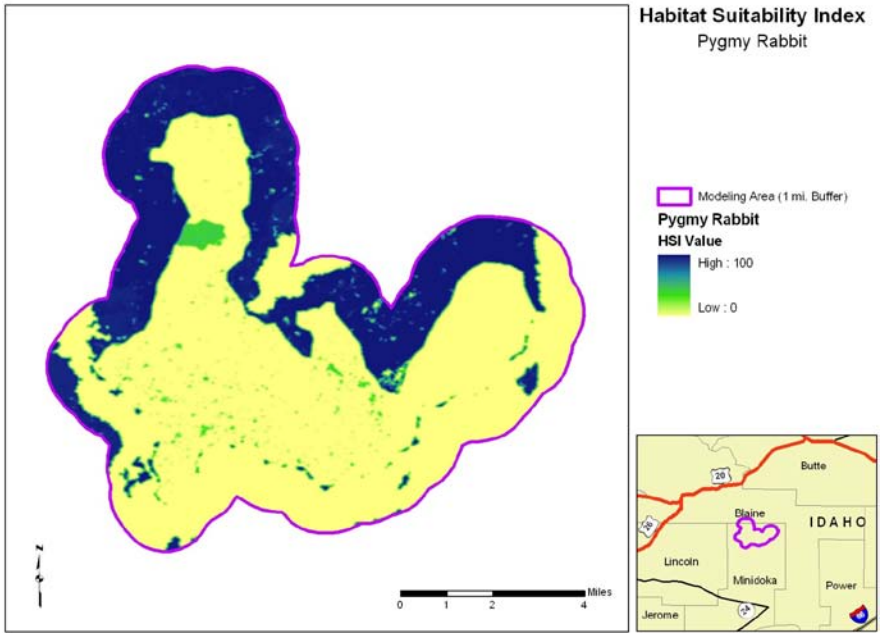

Figure B-53. Habitat suitability map for pygmy rabbit habitat for the Laidlaw Park project site in central Idaho.

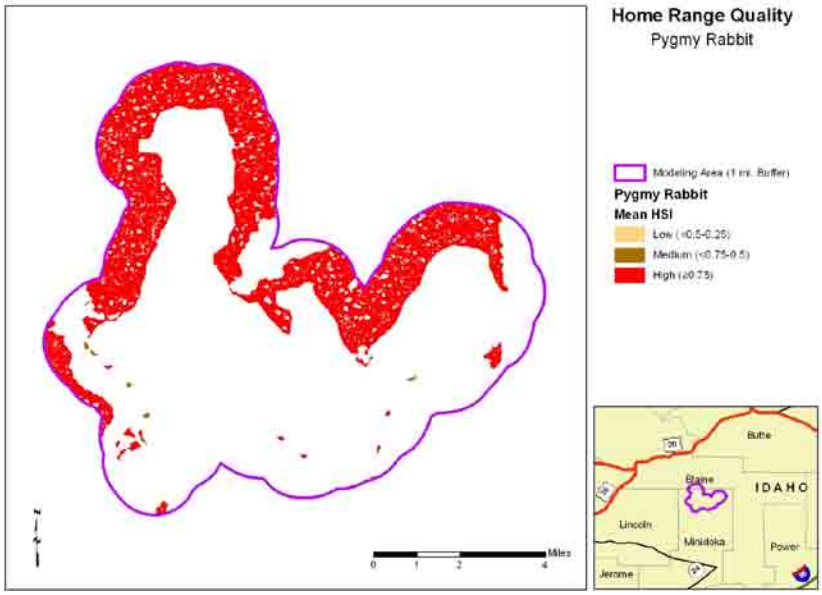

Figure B-54. Potential home range map for pygmy rabbits for the Laidlaw Park project site in central Idaho.

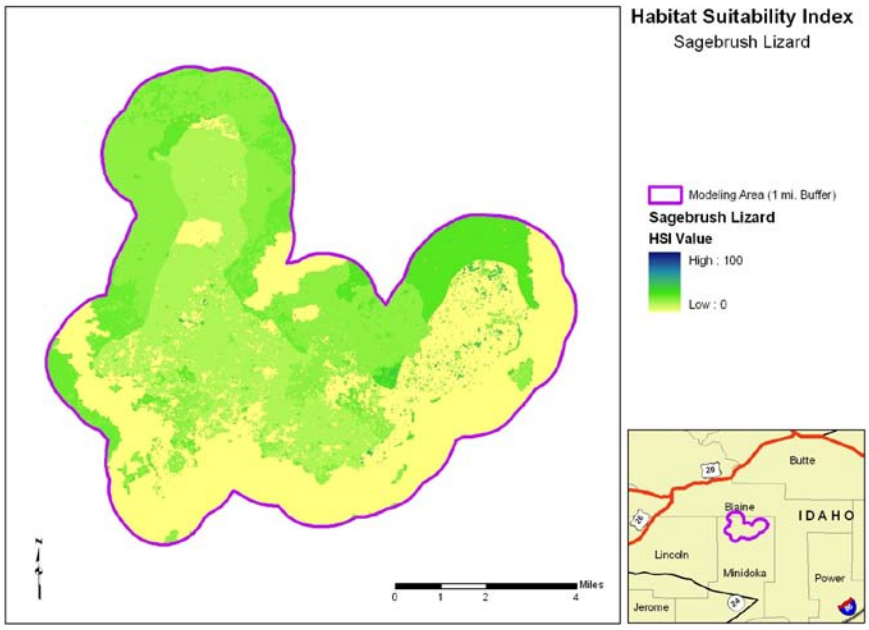

Figure B-55. Habitat suitability map for sagebrush lizard habitat for the Laidlaw Park project site in central Idaho.

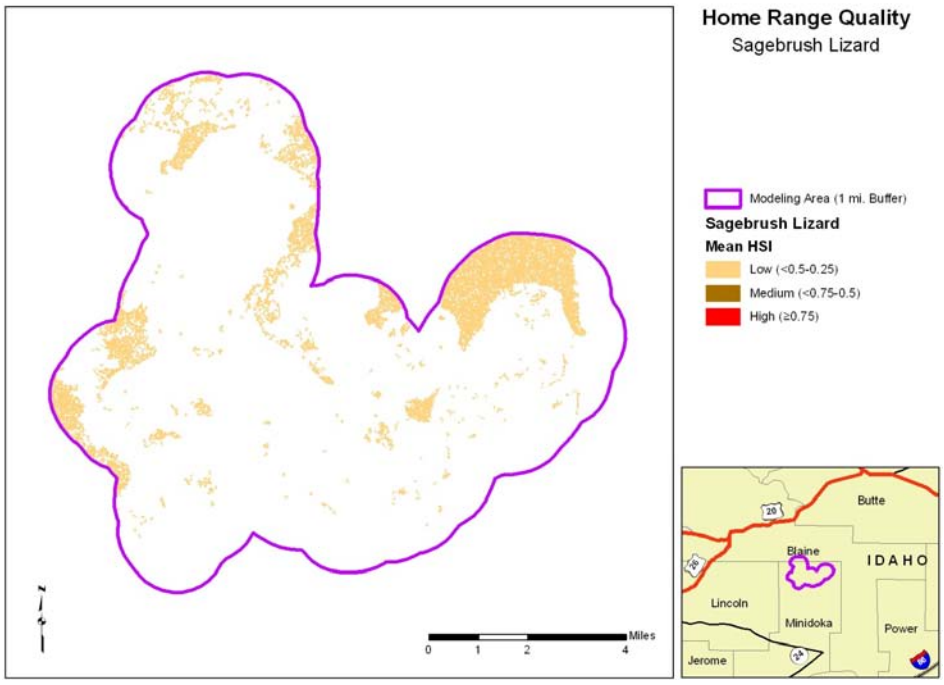

Figure B-56. Potential home range map for sagebrush lizards for the Laidlaw Park project site in central Idaho.

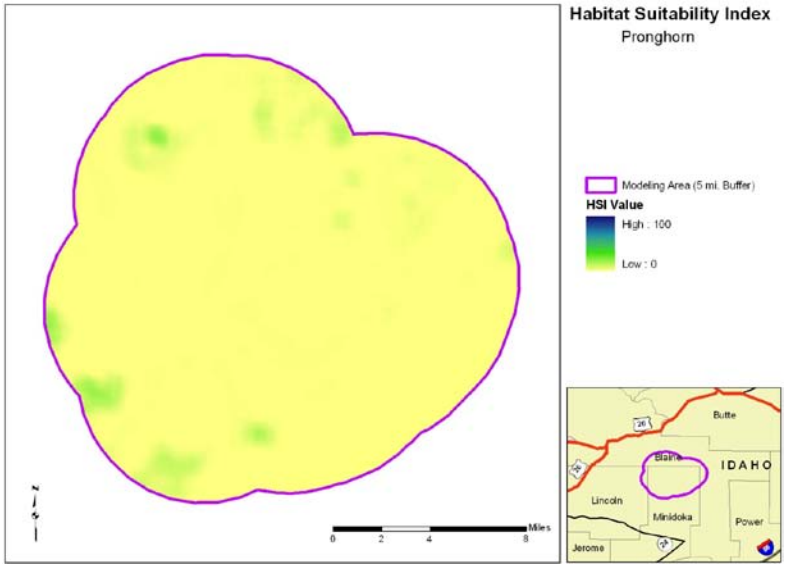

Figure B-57. Habitat suitability map for pronghorn antelope habitat for the Laidlaw Park project site in central Idaho.

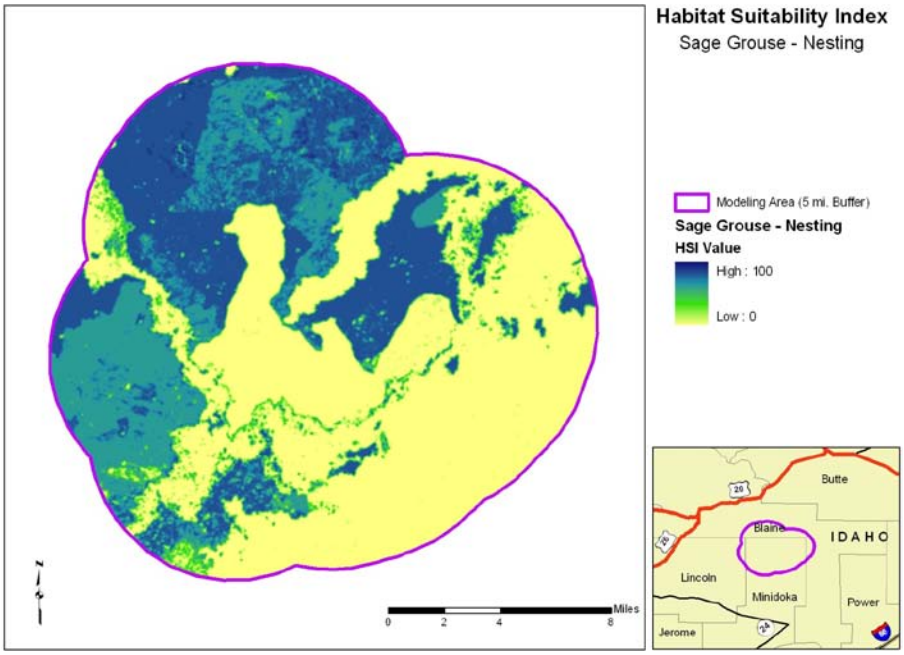

Figure B-58. Habitat suitability map for sage-grouse nesting habitat for the Laidlaw Park project site in central Idaho.

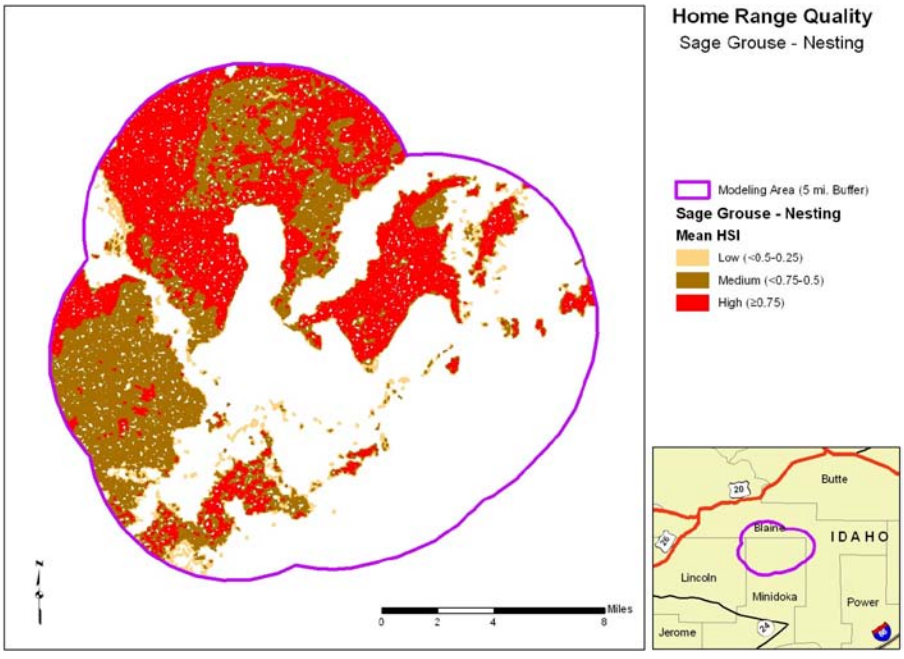

Figure B-59. Potential "home range" map for nesting sage-grouse for the Laidlaw Park project site in central Idaho. While home ranges are not used by this species for nesting areas, this analysis compiles information about availability of resources for sage-grouse, and represents an assessment of possible numbers that could be supported.

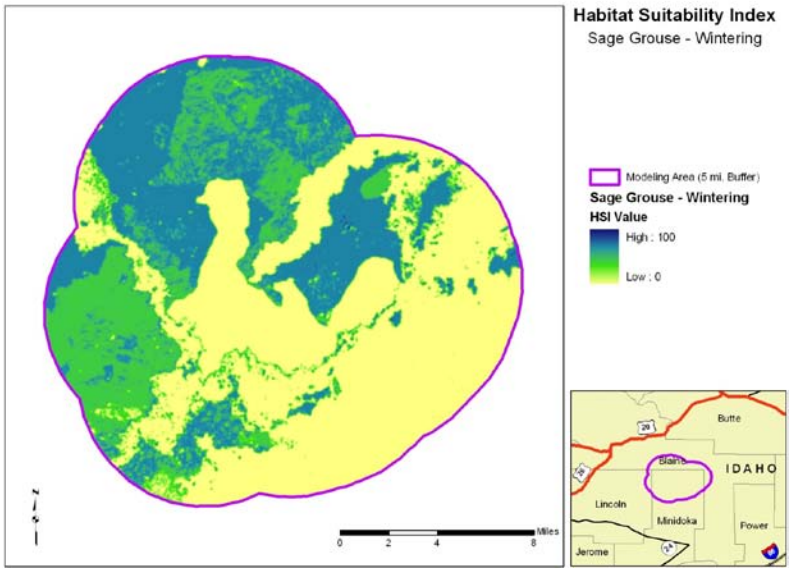

Figure B-60. Habitat suitability map for sage-grouse wintering habitat for the Laidlaw Park project site in central Idaho.

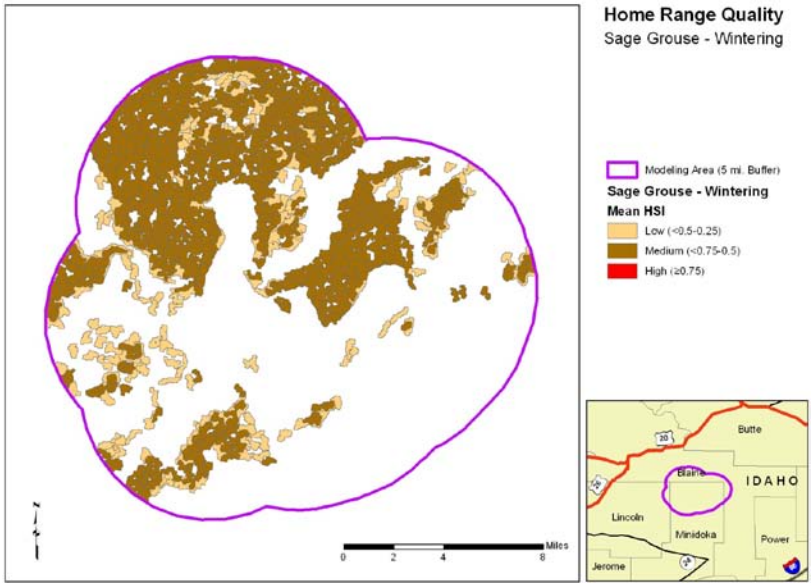

Figure B-61. Potential “home range” map for sage-grouse wintering areas for the Laidlaw Park project site in central Idaho. While home ranges are not used by this species for wintering areas, this analysis compiles information about availability of resources for sage-grouse.

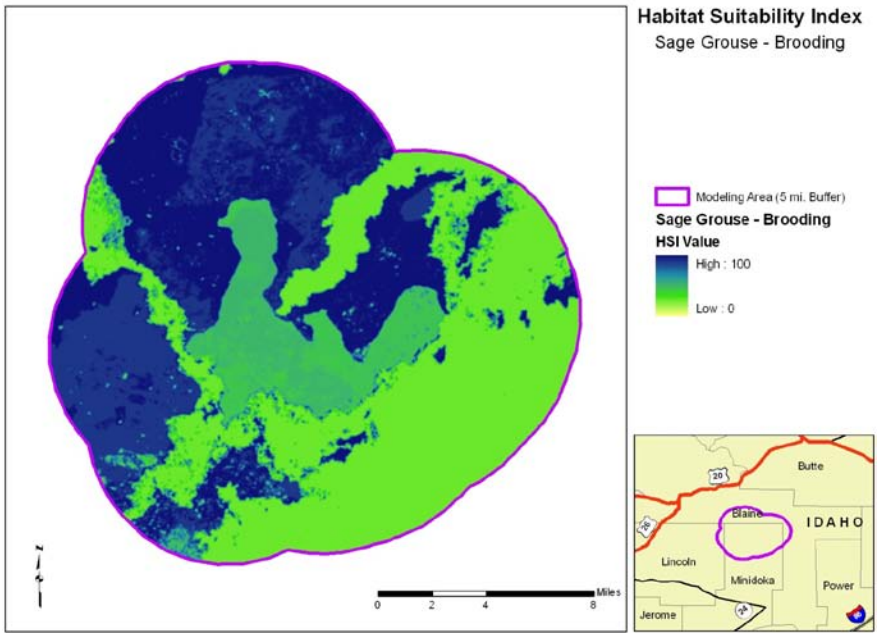

Figure B-62. Habitat suitability map for sage-grouse brood habitat for the Laidlaw Park project site in central Idaho.

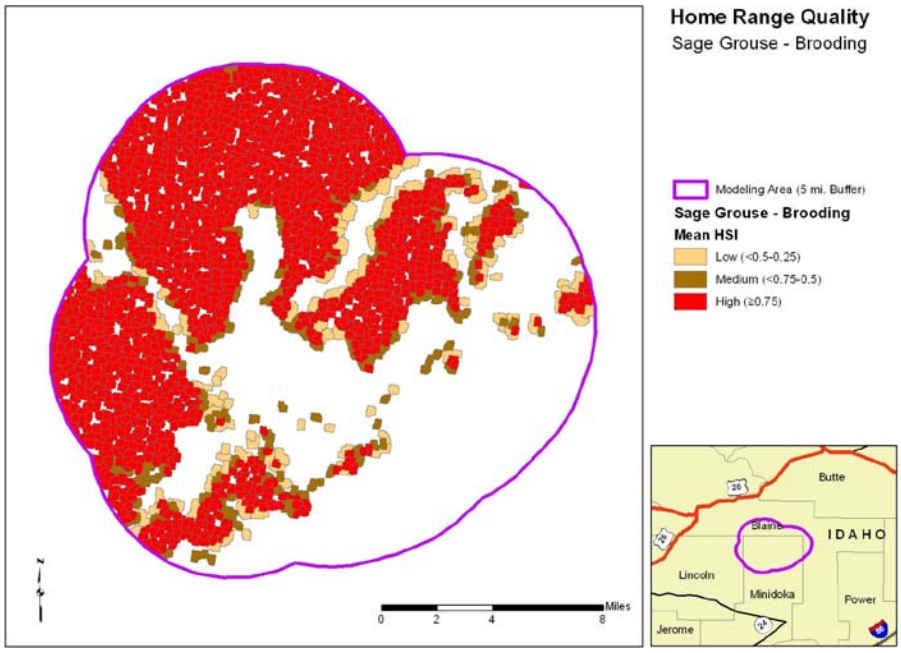

Figure B-62. Potential "home range" map for sage-grouse brood areas for the Laidlaw Park project site in central Idaho. While home ranges are not used by this species for brooding areas, this analysis compiles information about availability of resources for sage-grouse, and represents an assessment of possible numbers that could be supported.

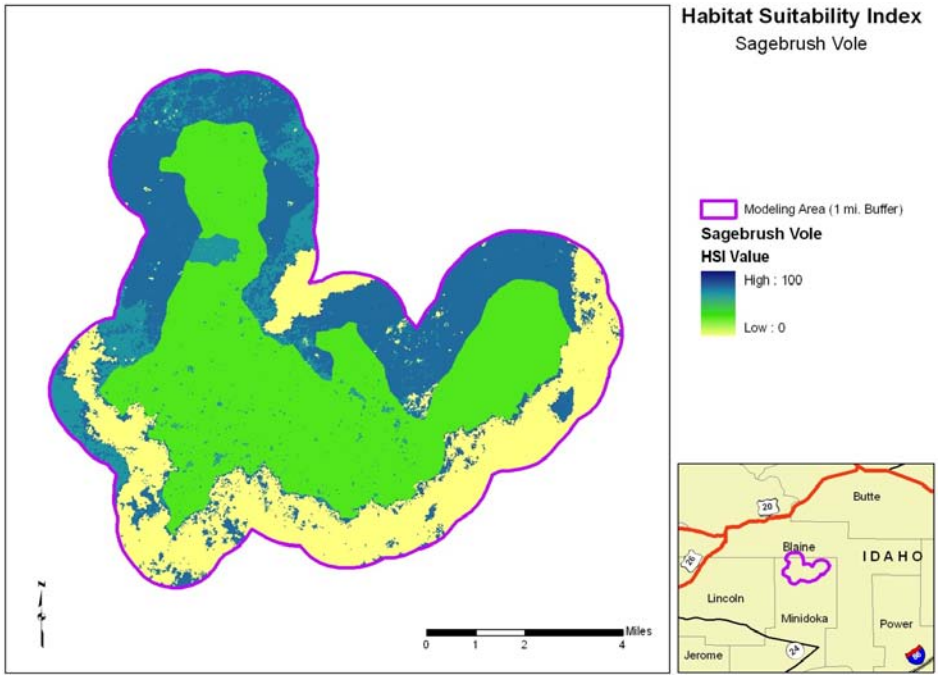

Figure B-63. Habitat suitability map for sagebrush vole habitat for the Laidlaw Park project site in central Idaho.

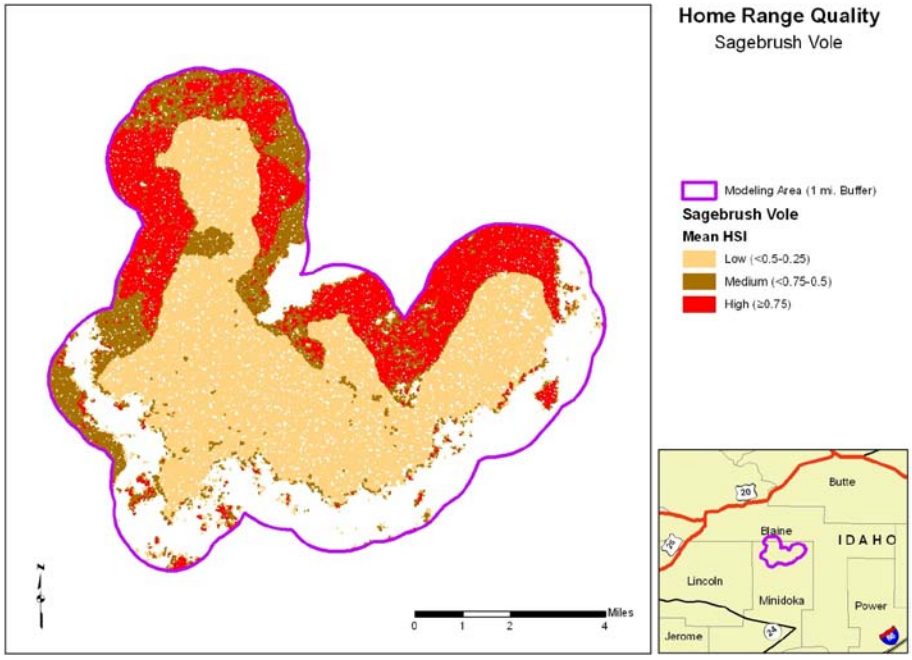

Figure B-64. Potential home range map for sagebrush voles for the Laidlaw Park project site in central Idaho.

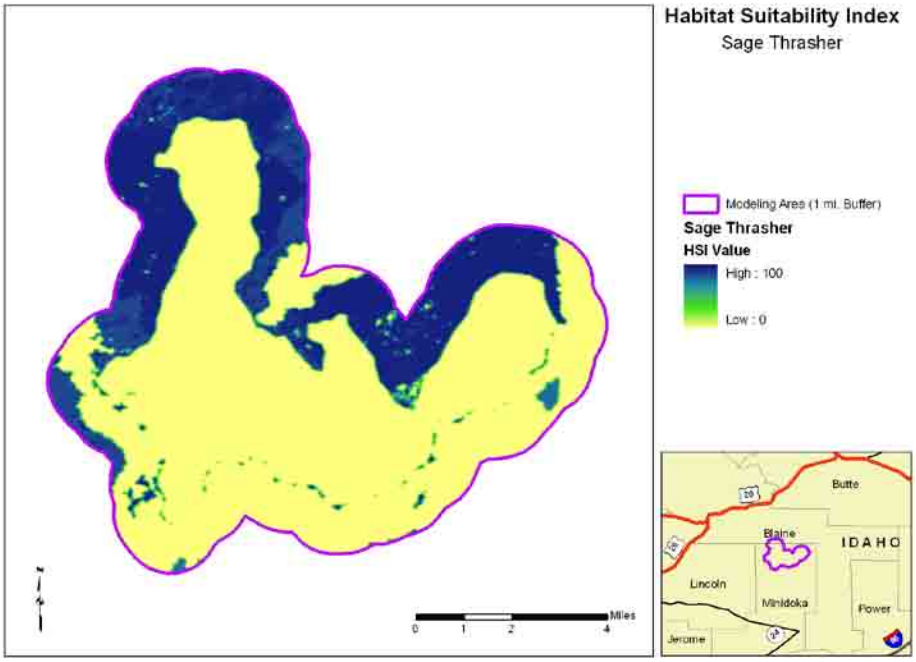

Figure B-65. Habitat suitability map for sage thrasher habitat for the Laidlaw Park project site in central Idaho.

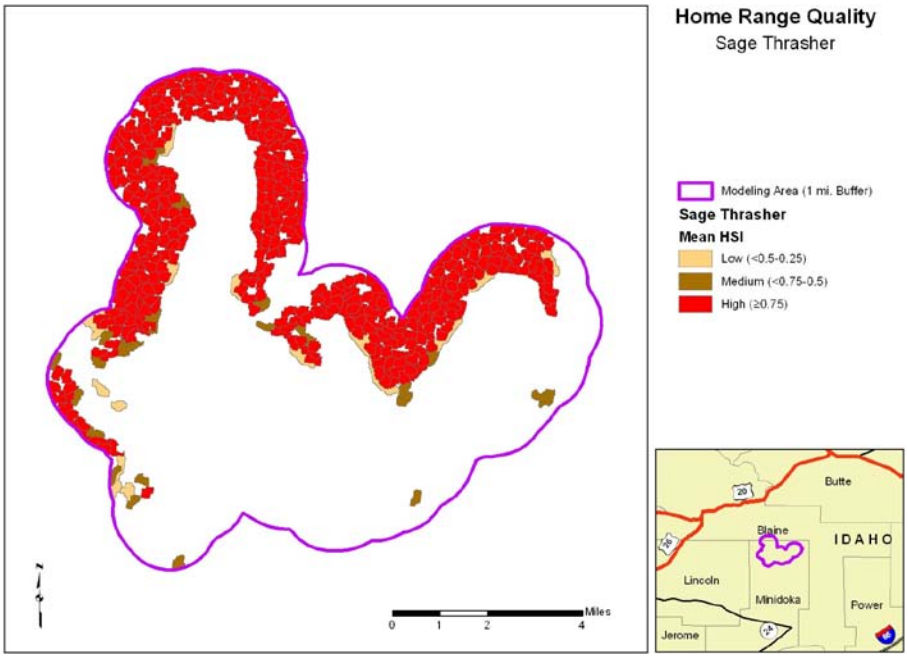

Figure B-66. Potential home range map for sage thrashers for the Laidlaw Park project site in central Idaho.

Antro MT project area, Utah. The habitat quality and home range maps for the Anthro Mt project area in northeastern Utah are displayed in Figures B-67 through B-78.

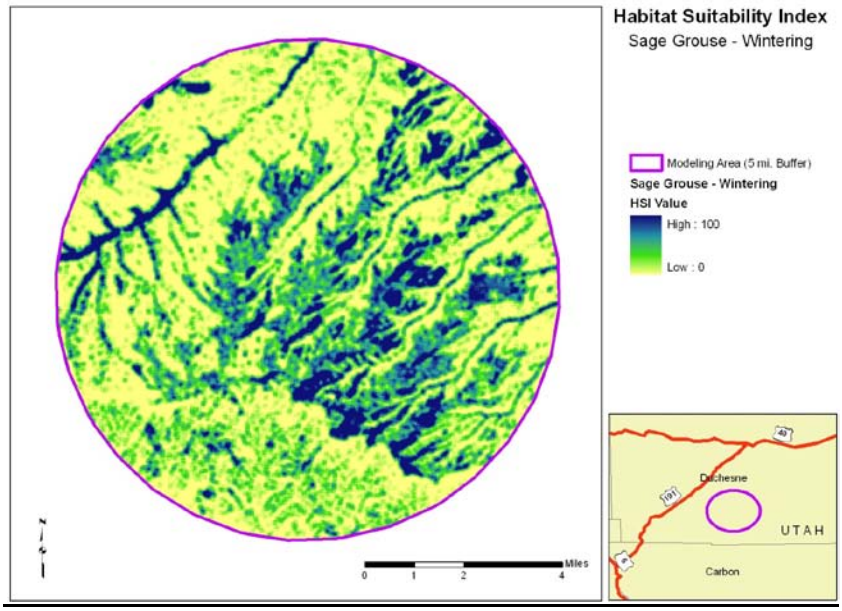

Figure B-67. Habitat suitability map for sage-grouse wintering habitat for the Anthro Mt project site in northeastern Utah.

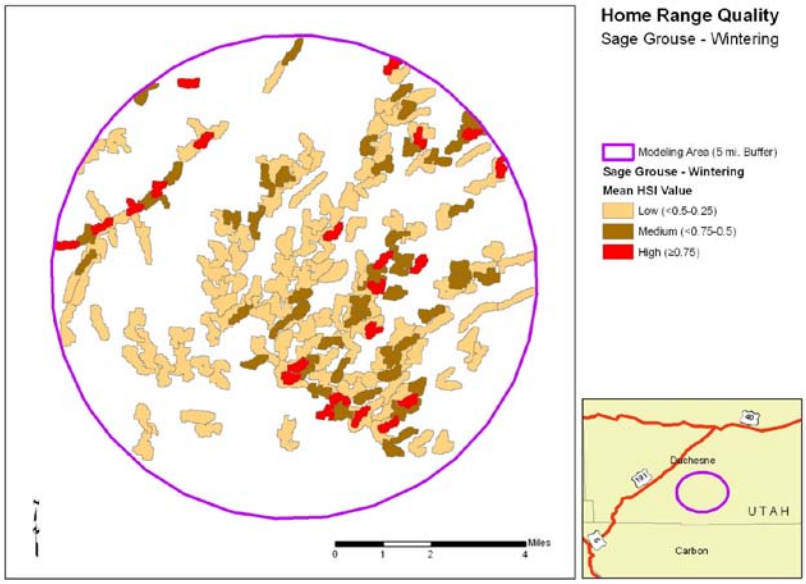

Figure B-68. Potential "home range" map for sage-grouse wintering areas for the Anthro MT project site in central northeastern Utah. While home ranges are not used by this species for wintering areas, this analysis compiles information about availability of resources for sage-grouse, and represents an assessment of possible numbers that could be supported.

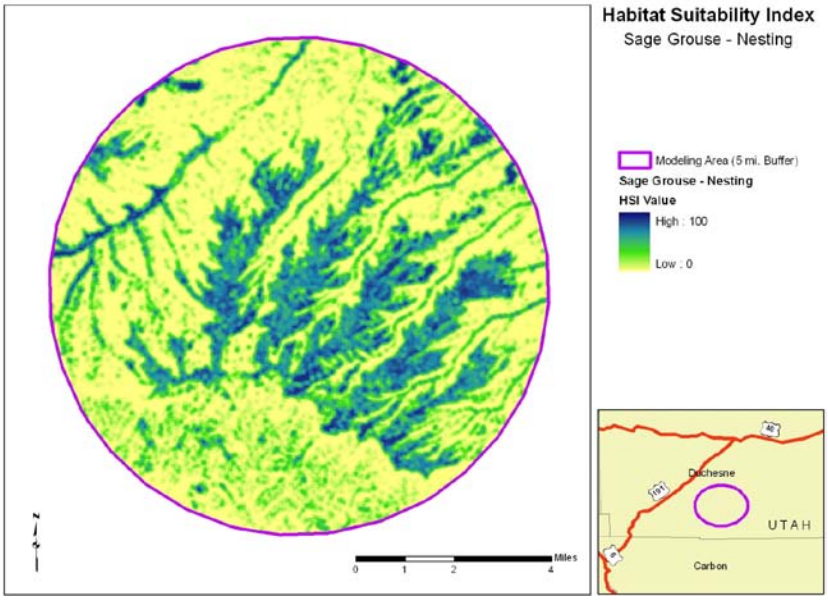

Figure B-69. Habitat suitability map for sage-grouse nesting habitat for the Anthro Mt project site in northeastern Utah.

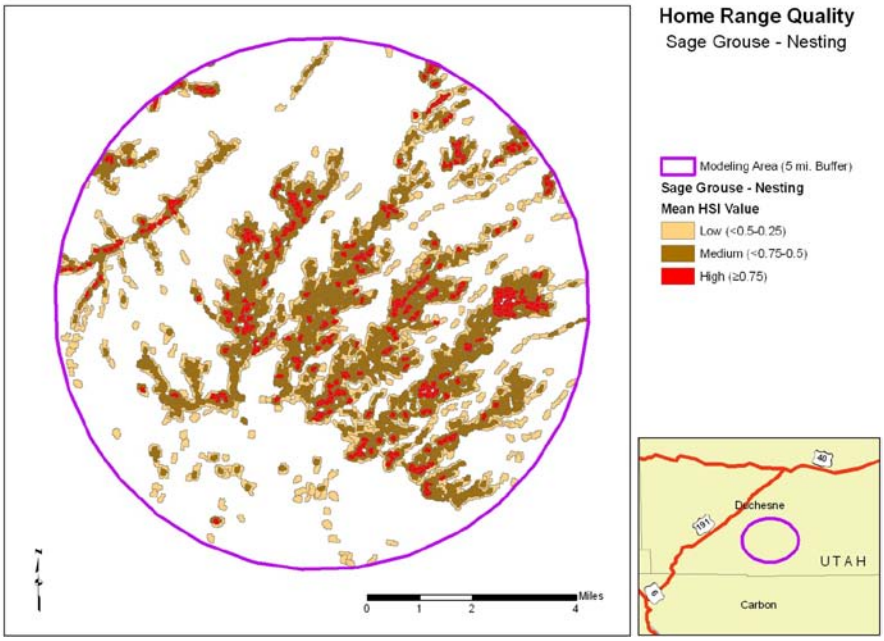

Figure B-70. Potential "home range" map for sage-grouse nesting areas for the Anthro Mt project site in northeastern Utah. While home ranges are not used by this species for nesting areas, this analysis compiles information about availability of resources for sage-grouse, and represents an assessment of possible numbers that could be supported.

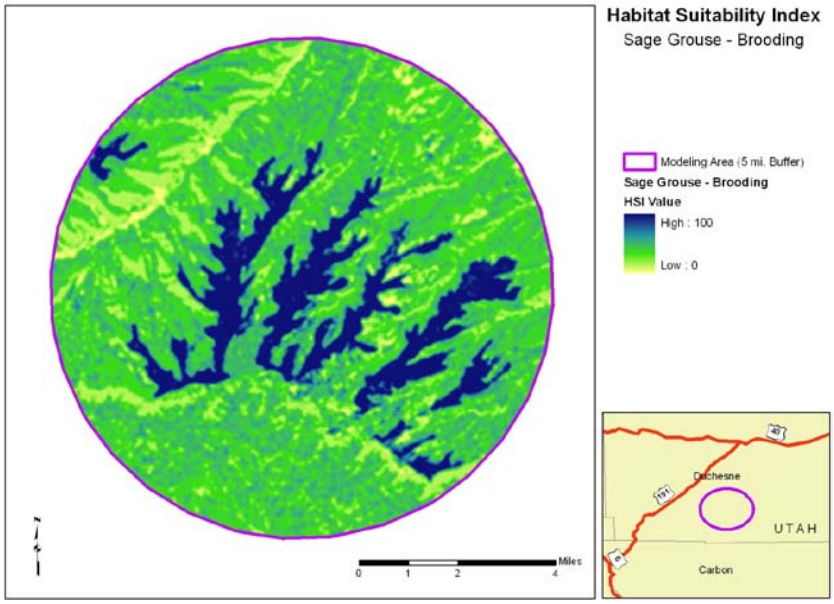

Figure B-71. Habitat suitability map for sage-grouse brood habitat for the Anthro Mt project site in northeastern Utah.

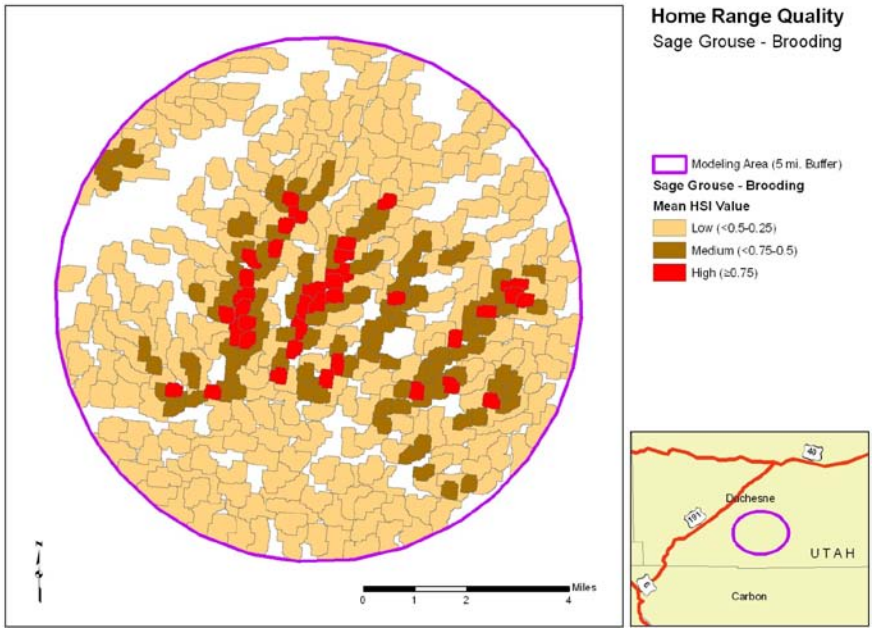

Figure B-72. Potential "home range" map for sage-grouse brooding rearing areas for the Anthro Mt project site in northeastern Utah. While home ranges are not used by this species for brood areas, this analysis compiles information about availability of resources for sage-grouse, and represents an assessment of possible numbers that could be supported.

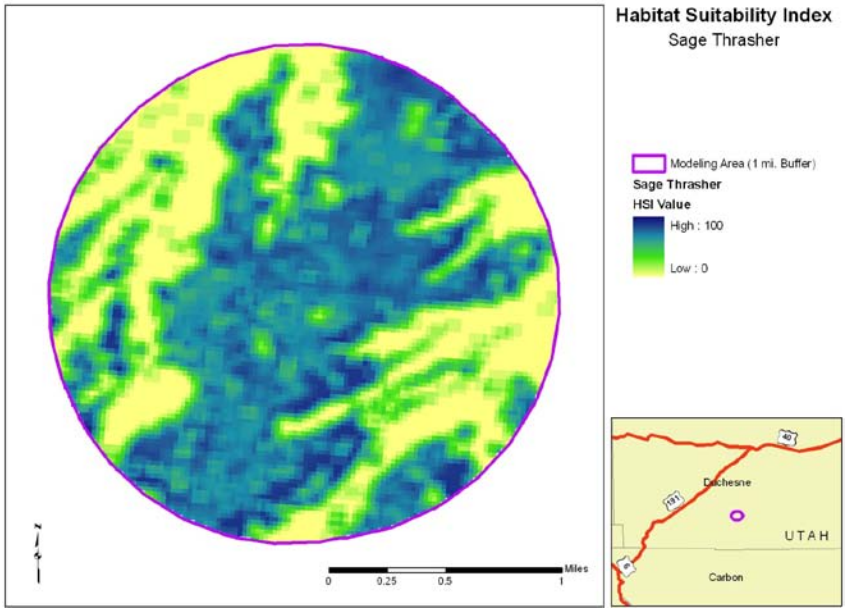

Figure B-73. Habitat suitability map for sage thrasher habitat for the Anthro Mt project site in northeastern Utah.

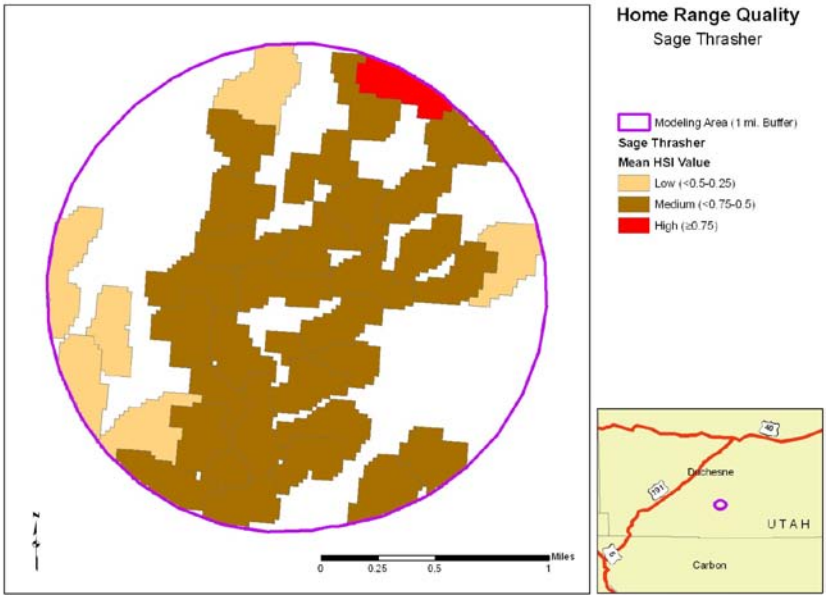

Figure B-74. Potential home range map for sage thrashers for the Anthro Mt project site in northeastern Utah.

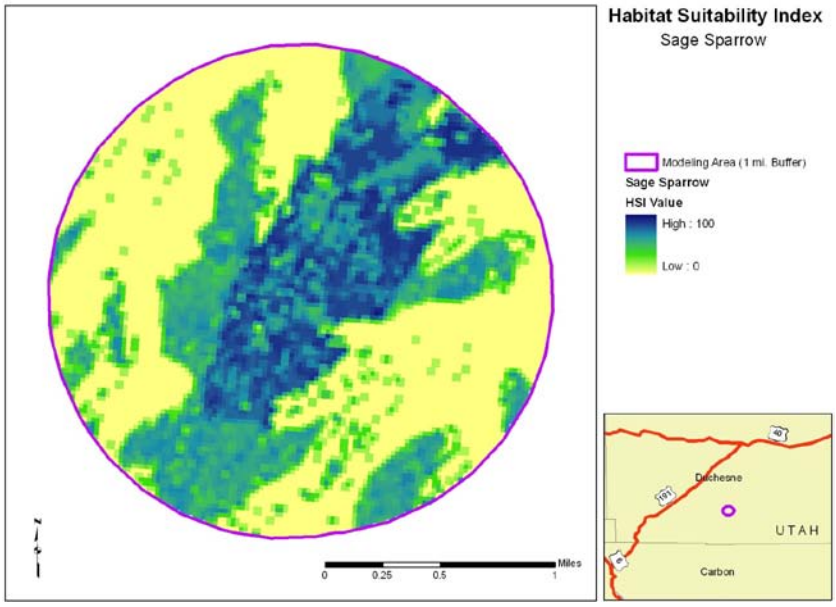

Figure B-75. Habitat suitability map for sage sparrow habitat for the Anthro Mt project site in northeastern Utah.

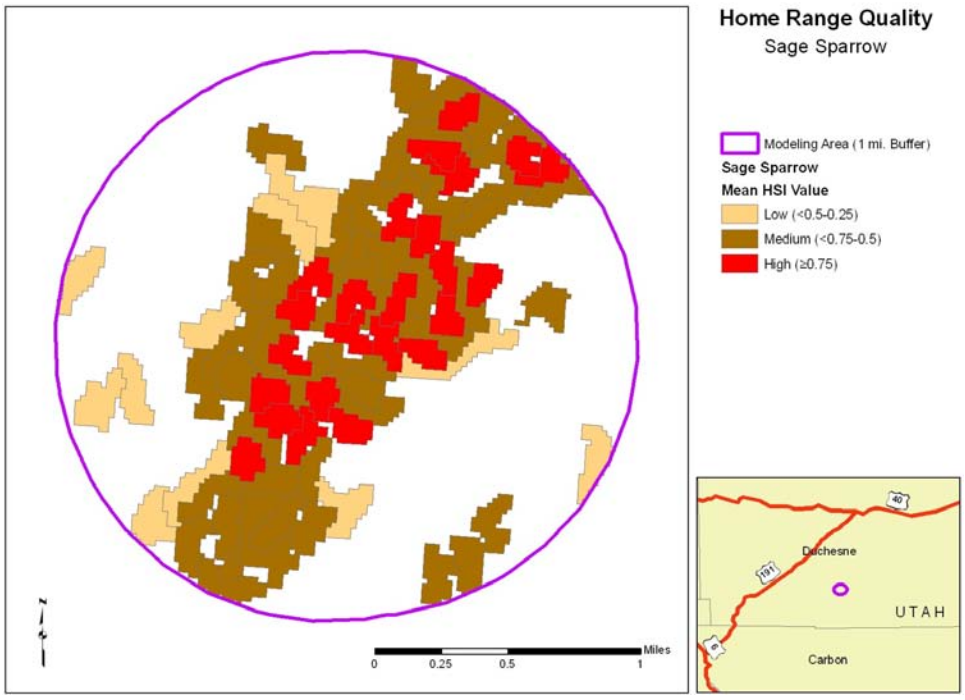

Figure B-76. Potential home range map for sage sparrow for the Anthro Mt project site in northeastern Utah.

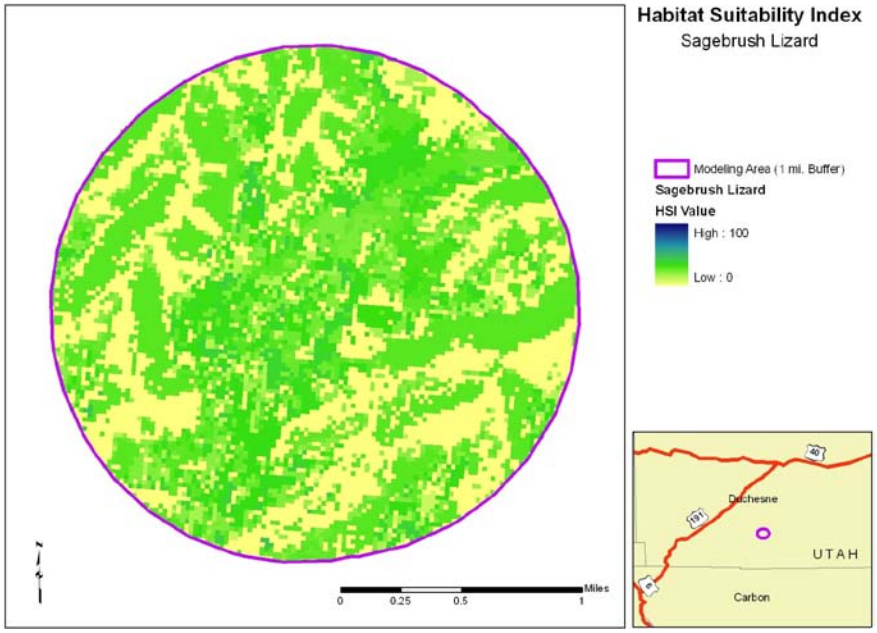

Figure B-77. Habitat suitability map for sagebrush lizard habitat for the Anthro Mt project site in northeastern Utah.

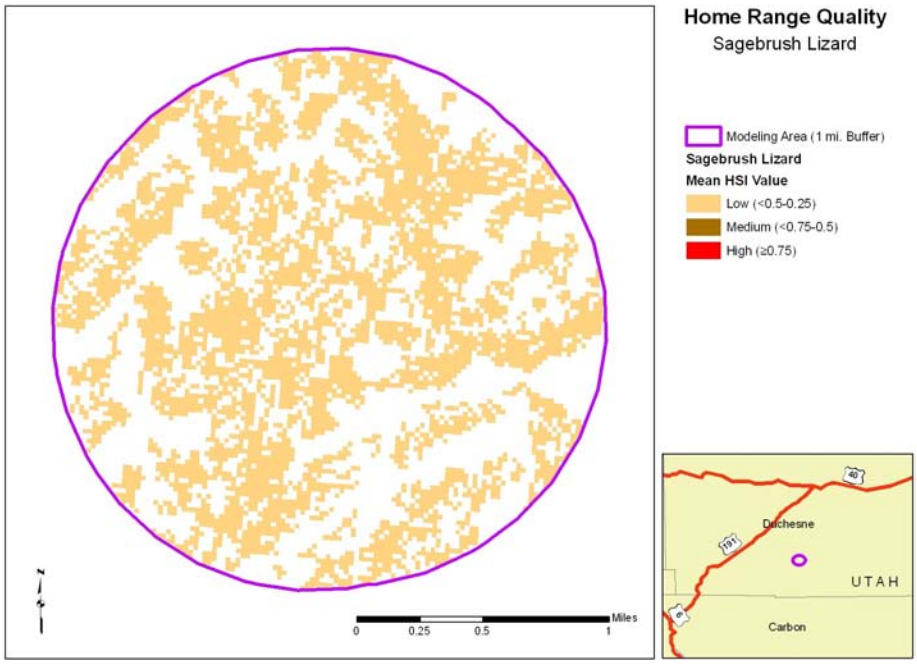

Figure B-78. Potential home range map for sagebrush lizards for the Anthro Mt project site in northeastern Utah.

Appendix C. Scientific names of species referred to in this report.

To be added later.