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

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1.0 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 assessment 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 are to:

1. Report on the effectiveness of NRCS ecological sites as a basis for mitigation metrics of ecosystem services,
2. Test a market-based offset system within working landscapes across western states,
3. 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,
4. Engage western industry, agriculture, conservation groups, and state and federal agencies in a new economic relationship,

5. Create demonstrations of habitat and species credit trading arrangements with broad applicability to other regions and resource sectors, and
6. 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 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 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.*

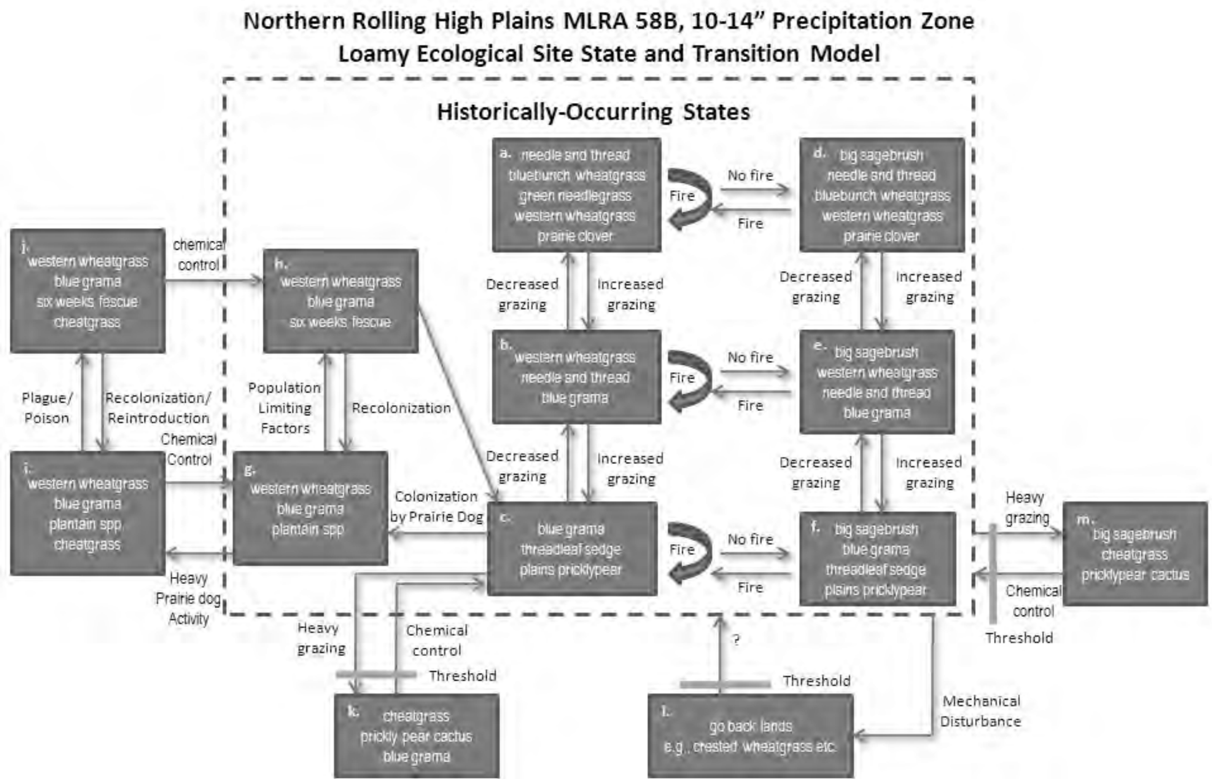

Figure 1*–State and transition model for loamy ecological sites within the 10-14" precipitation zone of MLRA 58B, the Northern Rolling High Plains. States identified outside of the dashed box did not occur historically but rather are the result of recent anthropogenic changes.*

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.

2.0 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:

1. A map of ecological site(s) for impact and/or mitigation areas,
2. 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
3. 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. EMRI conducted the sampling at the Fidelity, Laidlaw Park, and Ash Valley sites in all years. The Thunder Basin Grasslands Prairie Ecosystem Association conducted sampling at the Thunder Basin site. Utah State University (USU), under the direction of Dr. Terry Messmer, conducted sampling at the three Utah sites.

EMRI's sampling protocol was as follows. 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 30m transect was delineated, as was a 15m X 25m macroplot (Figure 3).

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.

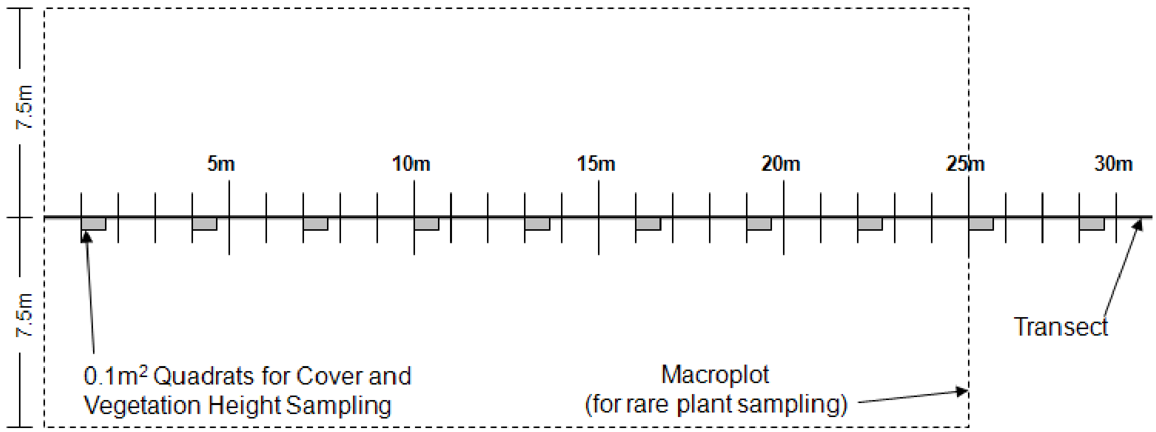

Figure 3. Diagram of plot layout used for vegetation sampling including the 30m transect for line intercept of wood vegetation, the 15m X 25M macroplot for rare plants, and the placement of small quadrats (Daubenmire frames) for vegetation cover and height measurements.

Vegetation sampling in Thunder Basin followed the above protocol, except that in 2010, photos were taken of each Daubenmire frame, and cover of each species of vegetation was estimated from these photos rather than from field estimates of cover. Sampling in Utah was designed to produce similar measures of vegetation, but the specific methodology differed from the EMRI protocol. USU provided the vegetation data they collected to EMRI for analysis in determining appropriate metrics for each site.

Plant communities were sampled in treatment areas prior to treatment, and then from 1-3 years post-treatment, depending on when the actual treatment occurred 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% (although no plots ever 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 for invasive exotic species based on a curve we developed to show the relationship between level of invasive 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 invasive 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. At each site, we evaluated the exotic species present, and assigned those listed as invasive species or noxious weeds to include in the exotic species deduction.

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 %** 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. Invasive exotic species are totaled, and the amount of these species derives 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			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		75	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	PEARG				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

Common name	PLANTS Code	Actual %	Actual % sum	Cutoff%	Similarity index %	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

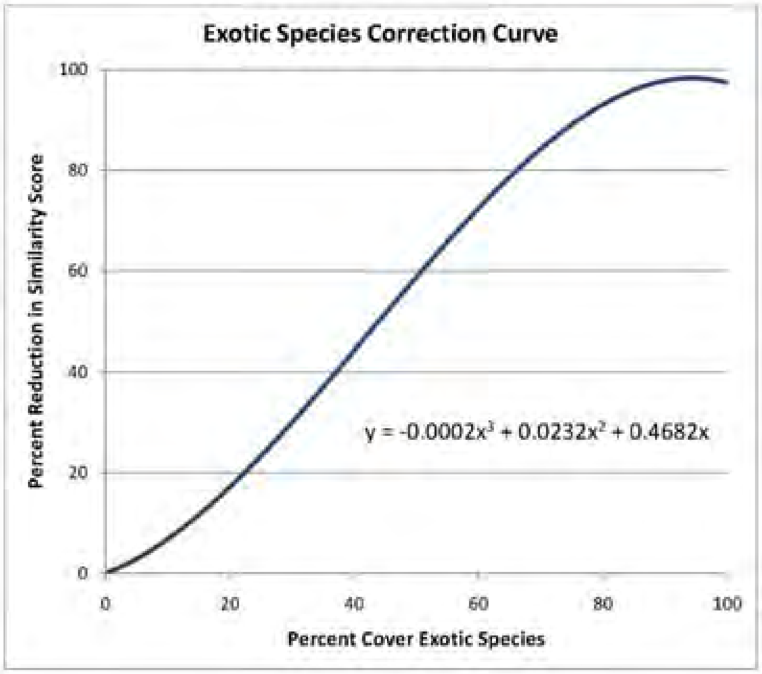

Figure 4. Curve of the estimated relationship (percent reduction in similarity index value) between the level of exotic species in a plot to the ecological integrity of the plant community represented by that plot.

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 the final year of post-treatment sampling 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 the 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 Mountainn	X			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. The changes to vegetation produced by the mitigation treatments was accurately determined from the vegetation sampling, so changes in habitat quality from these treatments can be calculated. The quality of habitat in the surrounding landscape determined based on the LANDFIRE imagery may not have been accurate, but it was at least consistent relative to the changes produced by the mitigation treatments, and any errors in this mapping would be the same in pre and post treatment comparisons. Thus, changes in habitat quality resulting from mitigation treatments would be evaluated using a consistent surrounding landscape. 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 1 acre, its targeted home range requirements would be 10 acres or 10 HSI units. This could be met with a home range of 10 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, 10 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 19 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.

3.0 RESULTS

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, Wyoming

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. At the start of the sagebrush improvement project, much of the area was invaded by cheatgrass, field brome, and clasping pepperweed. The property also had a substantial invasion of leafy spurge, primarily in some of the draws. Thus, the property supported a sagebrush ecosystem, but was in reduced condition and at considerable risk because of the level of invasive species. A good diversity of native grasses and forbs was present, but these were suppressed in many areas by the invasive species. Greater amounts of sagebrush cover could be encouraged, as the density of sagebrush was low relative to the needs of sage grouse and other sagebrush-obligate species. However, the presence of the active lek was an indicator that sagebrush densities were at least adequate to support various sagebrush-associated species. Figure 5 displays NAIP imagery of the treatment portion of this property and the location of the active sage grouse lek.

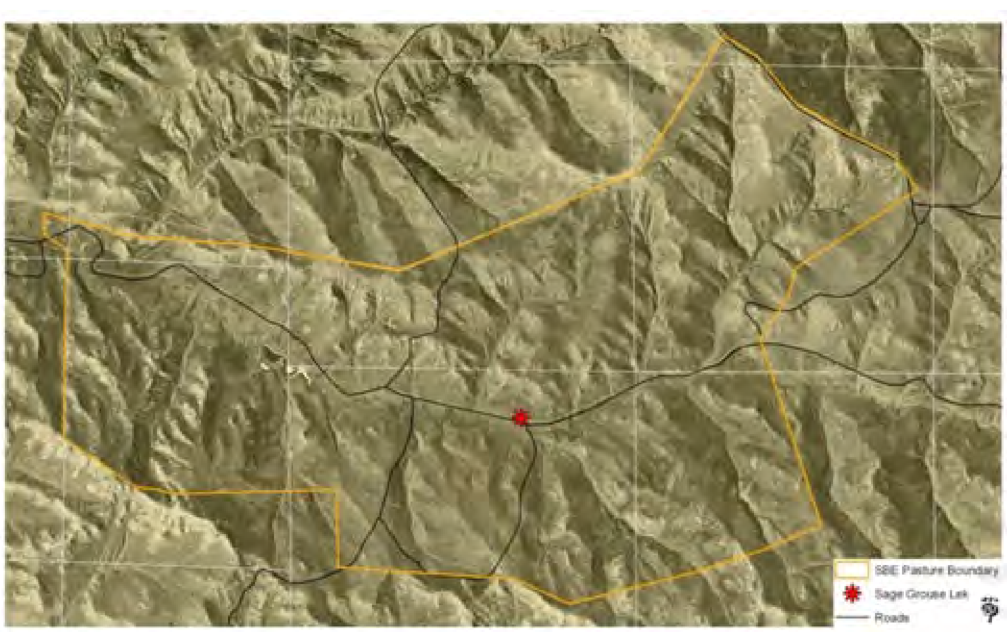

Figure 5. NAIP imagery of the Seven Brothers East Ranch treatment pasture showing the location of the active sage grouse lek.

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 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."

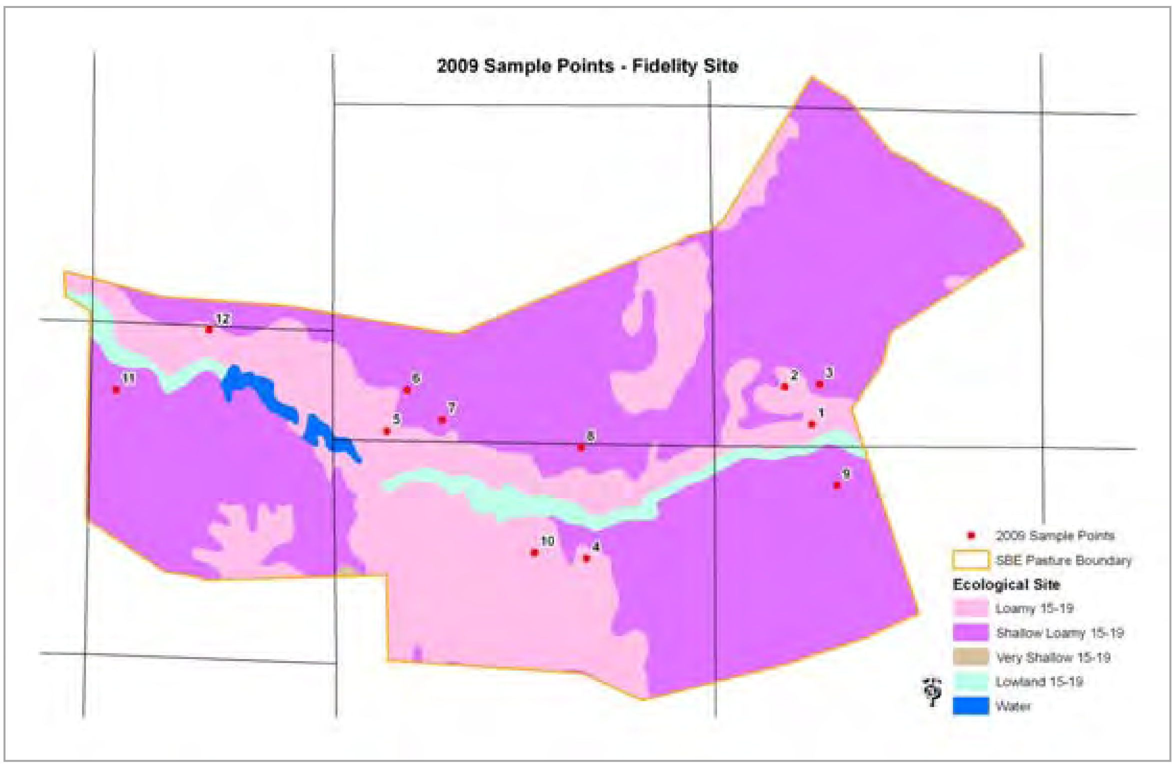

Figure 6. Ecological sites and vegetation sampling point locations for the treatment pasture of the Fidelity Seven Brothers East Ranch project area in northeastern Wyoming. Treatments were targeted at the Loamy and Shallow Loamy 15-19" precipitation zone ecological sites.

Reference Plant 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.

Loamy Ecological Site

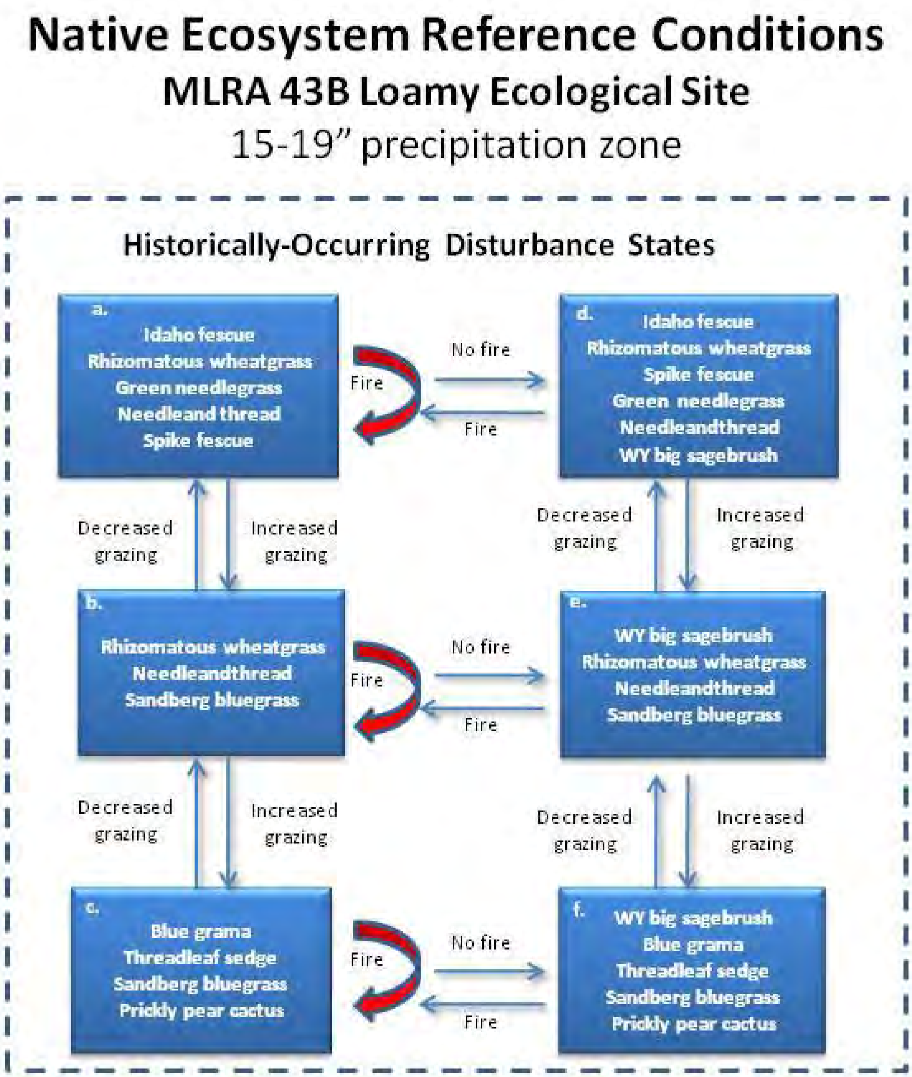

Figure 7. State and transition model displaying historically-occurring plant communities for loamy ecological sites in the 15-19" precipitation zone in MLRA 43B, Central Rockies.

- **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.

Shallow Loamy Ecological Site

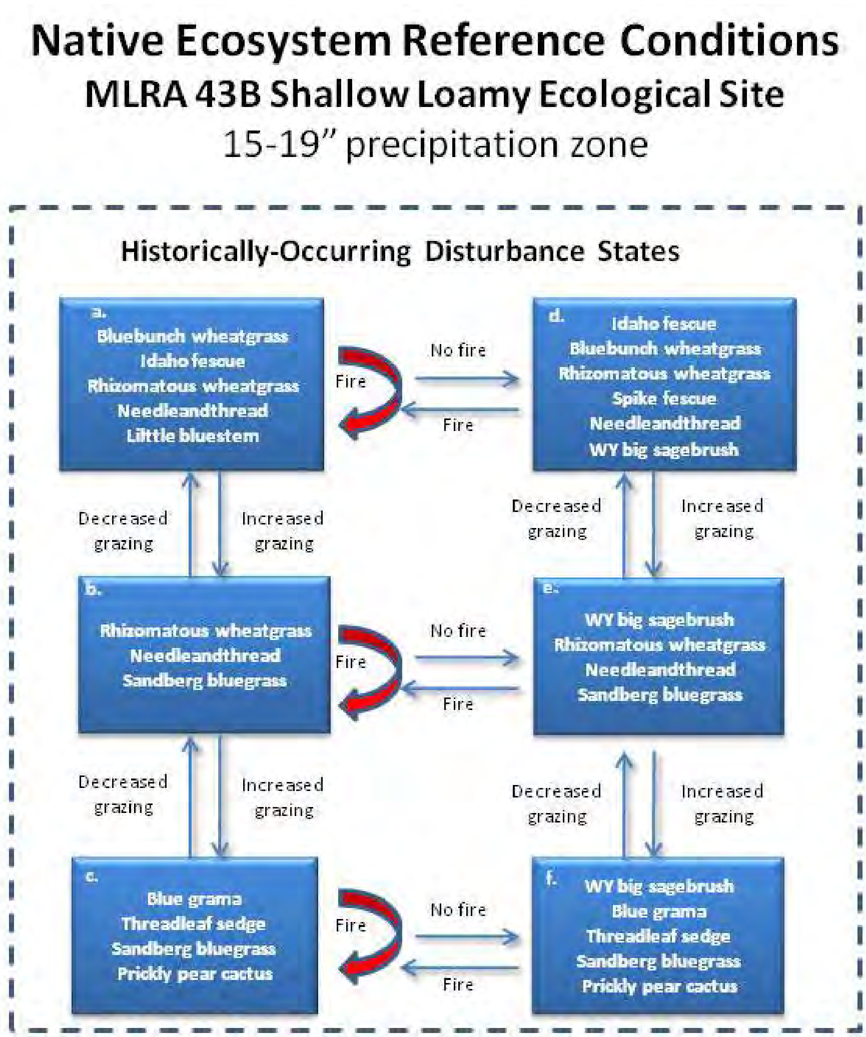

Figure 8. State and transition model for historical plant communities that occurred on the shallow loamy 15-19" precipitation zone ecological site in MLRA 43B.

- **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.

Recommended Reference Plant Community

A recommended reference plant community for both the loamy and shallow loamy ecological sites for the Fidelity project site is the light herbivory-long fire return interval 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 wheatgrasses, 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 A (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): 0-20%, with a minimum of 10% to achieve a score of 100%
- native forbs B (prairie sagewort, spinystar, plains pricklypear, beaked skeletonweed, broom snakeweed, wavy thistle, curlycup gumweed, and bastard toadflax): 0-5%
- Wood's rose, gardner's saltbrush, chokecherry, skunkbush sumac, common snowberry, winterfat, and rabbitbrush: 0-5%

Treatments

The site was treated with Plateau herbicide 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. Follow up control of small patches of cheatgrass occurred using ground crews on ATV's or backpack sprayers in Fall 2010.

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.

Plant Community Sampling

Site Level Results

Sampling results for 2009 (pre-treatment) and 2010 and 2011 (1^{st} and 2^{nd} year post-treatment) for the shallow loamy and loamy ecological sites are listed in Table 3.

The results demonstrate that a good diversity of native plants occurred on the Fidelity project area. The results also display the level of invasive species that were 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 could be harmful to various desired species of shrubs. Therefore, shrub patches were also mapped, so that treatments could be planned to avoid negative effects on these desired species. Figures 9 and 10 display the results of this mapping in 2009.

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 2009 (pre-treatment) and 2011 (post-treatment).

	Ecological Site					
	Loamy			Shallow Loamy		
Species	**2009**	**2010**	**2011**	**2009**	**2010**	**2011**
common yarrow	2.82 (1.71)	9.35 (7.5)	4.75 (2.46)	-	2.5 (1.64)	1.18 (0.98)
rosy pussytoes	1.32 (1.21)	0	1.34 (1.34)	1.03 (0.59)	1.34 (1.34)	0
silver sagebrush	1.93 (1.58)	3.79 (2.74)	3.33 (2.57)	1.96 (1.86)	1.32 (1.21)	1.61 (1.46)
prairie sagewort	1.17 (0.49)	0	0	7.3 (2.94)	6.05 (2.2)	1.95 (0.74)
big sagebrush	16.61 (5.67)	16.68 (5.8)	19.01 (6.95)	12.72 (2.3)	13.4 (2.39)	13.34 (2.38)
prairie milkvetch	0	0	0	0	3.94 (2.67)	1.51 (0.95)
twogrooved milkvetch	0	0	0	2.08 (1.36)	2.36 (2.21)	0
blue grama	**1.72 (0.63)**	15.64 (4.86)	**4.46 (1.2)**	1.07 (0.41)	2.43 (0.89)	1.89 (0.47)
field brome	**11.09 (4.97)**	0	**0**	**9.14 (5.05)**	1.38 (0.97)	**0**
threadleaf sedge	1.26 (0.92)	2.66 (1.54)	1.4 (1.22)	6.33 (3.43)	9.79 (5.05)	5.59 (2.35)
prairie sandreed	0	0	0	1.45 (1.31)	9.64 (6.19)	6.77 (4.6)
tiny trumpet	1.16 (1.14)	0	0	0	0	0
bastard toadflax	0	1.82 (1.82)	0	2.2 (1.18)	3.62 (1.91)	1.13 (0.9)
Idaho fescue	1.14 (0.83)	1.62 (1.05)	1.72 (1.1)	3.06 (1.93)	0	1.26 (1.26)
scarlet beeblossom	0	0	0	**2.53 (0.87)**	0	**0**
broom snakeweed	2.94 (2.03)	0	0	1.45 (0.51)	2.35 (0.86)	2.87 (1.36)
needle and thread	1.88 (1.18)	4.49 (2.85)	7.18 (5.09)	1.73 (1.08)	2.89 (1.78)	6.13 (3.56)
hairy false goldenaster	0	0	0	1.04 (1.04)	0	1.37 (1.1)
prairie Junegrass	3.61 (1.52)	1.1 (0.56)	1.78 (0.67)	4.27 (0.97)	2.74 (0.76)	3.49 (1.3)
clasping pepperweed	**4.75 (1.23)**	0	**0**	**2.75 (0.66)**	0	**0**
green needlegrass	5.59 (1.26)	7.76 (1.69)	9.52 (2.67)	1.91 (1.46)	1.75 (0.84)	0
western wheatgrass	**9.45 (1.43)**	6.68 (1.12)	**18.91 (2.8)**	2.45 (1.23)	2.78 (1.42)	2.51 (1.28)
spiny phlox	**5.06 (2.23)**	2.69 (0.95)	**1.7 (0.8)**	5.09 (1.53)	3.17 (0.95)	2.76 (0.88)
Sandberg bluegrass	**0**	1.73 (0.8)	**1.19 (0.41)**	0	1.41 (0.65)	1.65 (0.66)
bluebunch wheatgrass	7.84 (3.98)	7.34 (2.87)	9.35 (3.85)	18.21 (3.52)	10.92 (1.44)	27.24 (3.79)
slimflower scurfpea	0	0	1.18 (0.81)	1.63 (0.9)	2.02 (1.39)	2.85 (1.61)
little bluestem	0	0	0	0	0	1.37 (0.98)
scarlet globemallow	3.14 (0.86)	3.01 (0.77)	2.38 (0.67)	0	0	0
white prairie aster	0	1.19 (0.61)	1.79 (0.82)	0	2.04 (1.52)	3.24 (1.92)
common dandelion	**7.81 (6.35)**	1.27 (0.62)	**0**	0	0	0
American vetch	2.38 (1.01)	4.02 (1.66)	3.89 (1.86)	0	1.06 (0.67)	1.75 (0.83)

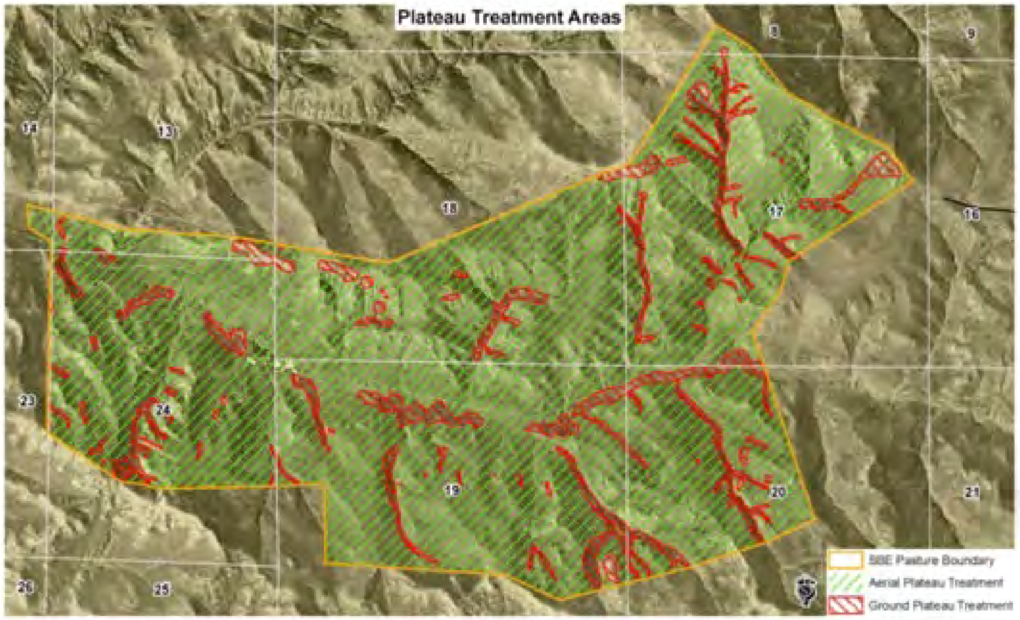

Figure 9. Map of shrub patches (labeled ground Plateau treatment areas) and areas designated for aerial herbicide application to control cheatgrass, field brome, and clasping pepperweed on the Fidelity project area in northeastern, Wyoming.

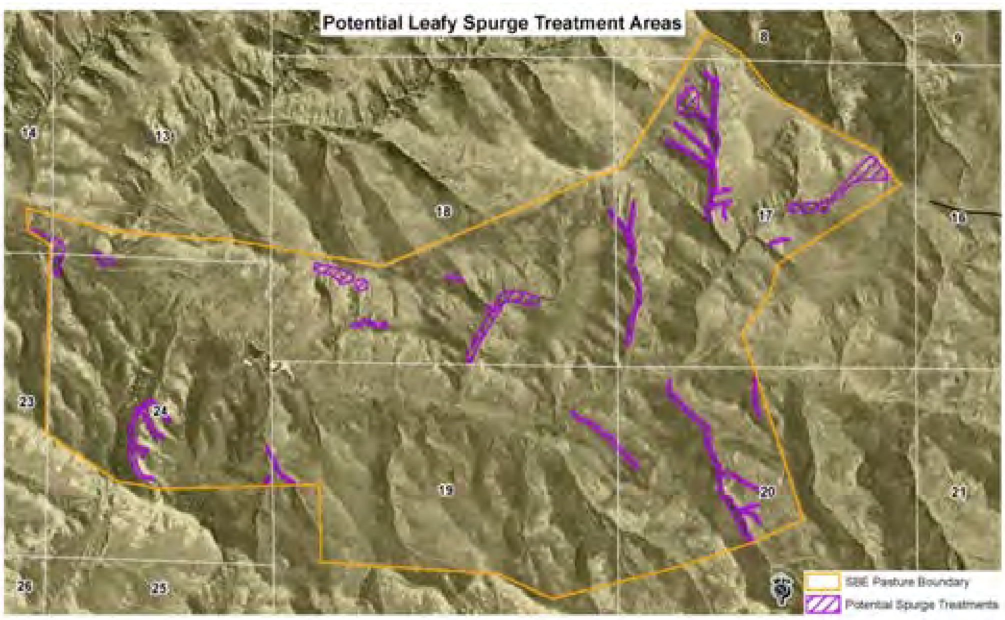

Figure 10. Map of drainages with leafy spurge invasion on Seven Brothers East Ranch. Ground application of herbicide occurred in summer 2010 for control of spurge in these areas.

Vegetation sampling in 2010 and 2011 showed the significant decrease in field brome and clasping pepperweed produced by the herbicide treatment on both loamy and shallow loamy ecological sites. Western wheatgrass displayed a significant increase on plots of the loamy ecological site in 2011, after showing declines in 2010. It is possible that the Plateau treatment may have slightly impacted this species in 2010, but then allowed it to respond vigorously in 2011 as residual levels of the herbicide would have dropped between years. Blue grama also showed significant increases on loamy sites between 2009 and 2011. Scarlet beeblossom occurred on plots in the shallow loamy sites in 2009 and was not observed in these plots in either 2010 or 2011. It is possible that the herbicide impacted this species, although other factors could also have been responsible for the declines. It should be noted that both 2010 and 2011 were good moisture years. Needle and thread showed an increasing trend on both loamy and shallow loamy sites through the 3 years of sampling, although mean values did not differ significantly between 2009 and 2011. Big sagebrush also showed small increases over the 3 years as these plants continued to grow during the study.

The similarity indices calculated for the Fidelity site for both 2009 and 2011 are listed in Table 4.

Table 4. Comparison of pre- and post-treatment similarity index values for sample plots at the Fidelity, WY site. Raw refers to scores not adjusted for invasive exotic species while With Quality Reduction refers to scores adjusted with the invasive exotic species modifier.

PRE-TREATMENT			**POST-TREATMENT**		
Loamy Ecological Site			**Loamy Ecological Site**		
Plot	Raw	With Quality Reduction	Plot	Raw	With Quality Reduction
1	72.78	64.57	1	93.43	92.83
2	46.11	22.40	2	81.77	81.60
4	79.54	73.79	4	86.57	86.29
5	71.72	67.28	5	81.96	81.87
10	85.62	81.24	10	96.27	96.20
11	76.17	74.65	11	84.03	83.54
12	52.59	50.34	12	90.50	89.98
MEAN	**69.22**	**62.04**	MEAN	**87.79**	**87.47**
STD ERR	5.46	7.57	STD ERR	2.16	2.15
Shallow Loamy Ecological Site			**Shallow Loamy Ecological Site**		
Plot	Raw	With Quality Reduction	Plot	Raw	With Quality Reduction
3	58.00	40.01	3	90.08	89.83
6	68.00	50.75	6	97.81	96.70
7	67.83	65.85	7	81.97	81.86
8	82.41	81.44	8	77.72	77.52
9	73.22	71.54	9	93.92	93.50
MEAN	**69.89**	**61.92**	MEAN	**88.30**	**87.88**
STD ERR	3.98	7.40	STD ERR	3.72	3.58

The similarity values were significantly increased on both ecological sites as a result of the control of the invasive species. A review of the individual plot values shows that plot values pre-treatment showed more variation, with some plots having fairly high similarity values while other plots having much lower similarity values. This was the result of some pre-treatment plots having relatively high levels of field brome and clasping pepperweed while other plots had low levels of invasive species, so that their values were fairly high. Post-treatment, none of the plots had any substantial amounts of invasive species, and the similarity values were consistently high. This demonstrates the effectiveness of the treatments in controlling the invasive species and improving the overall quality of the site. The mean similarity value of the loamy sites increased by 25.43, while the shallow loamy sites increased by 25.96. Applying these increases to the 545 acres of loamy site and 1157 acres of shallow loamy site generated a production of 439 mitigation units for the Fidelity site in 2011.

It should be noted that both 2010 and 2011 were years with good precipitation for the Fidelity site, better than the 2009 year. If these had been dry years, the response by desired species may not have been as great. However, observations of surrounding untreated areas in both 2010 and 2011 revealed high levels of cheatgrass, field brome, and clasping pepperweed. While not quantified, these observations indicate the effectiveness of the treatments, and justify the production of the mitigation credits for this area. How long the control of invasive species will last is uncertain. A light grazing regime (<35% utilization) will be applied to the pasture for the next 10 years. It is hoped that this will allow the desired native species to continue to respond and to minimize the invasion by the exotic species.

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 5. For maps of the modeling results for each species, see Appendix B.

The landscape level analyses of the 6 selected sagebrush-associated species showed an increase in potential quality of home ranges or habitat conditions for sage-thrasher, sagebrush vole, and sage grouse nesting and brood-rearing. Decreases in potential habitat quality were noted for sagebrush lizard and sage sparrow. For the sagebrush lizard, which prefers more open understory beneath a canopy of sagebrush, the increase in grasses and forbs reduced the quality of habitat for this species. Similarly, the sage sparrow is a species that nests in sagebrush, and is favored by high amounts of sagebrush cover (see Appendix A for description of the sage sparrow habitat model). However, they prefer lower levels of grass and forb cover beneath the sagebrush. With the increase in grass and forb cover noted on the Fidelity site in 2011, the quality of potential habitat, expressed as number of potential high, medium, and low home ranges for this species, declined.

Table 5. Results of habitat modeling for the Fidelity site. Numbers represent potential home ranges of species rated as high quality, medium quality, and low quality. Pre-treatment results were for conditions in 2009, post-treatment results were for conditions in 2011.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Pronghorn antelope	0	1	28	0	2	27
Sage thrasher	1	114	47	10	135	49
Sagebrush lizard	0	0	2449	0	0	1983
Sage sparrow	1	37	164	0	34	178
Sagebrush vole	30	3789	958	573	3708	730
Sage grouse- nesting	91	1015	958	79	1106	2384
Sage grouse brood-rearing	151	650	69	103	765	81
Sage grouse- wintering	0	6	106	0	6	109

*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.

While habitat quality for sage lizard and sage sparrow decreased following the treatments, habitat quality for the other 4 species modeled for the Fidelity site increased or stayed the same (pronghorn antelope). In particular, high quality habitat for sage thrasher, sagebrush voles, and sage grouse nesting and brood rearing showed substantial improvements. The Fidelity mitigation treatments were considered to be a positive improvement for the overall suite of wildlife species included in the analyses. The generation of the 439 mitigation units is thus supported by the landscape level analyses of wildlife responses.

Thunder Basin Project (TBGPEA), Wyoming

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 was the Thunder Basin Grasslands Prairie Ecosystem Association (TBGPEA).

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

This area was 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.

Reference Plant Community Development

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, shallow sandy, and sands/sandy ecological sites in this area are shown in Figures 13-15.

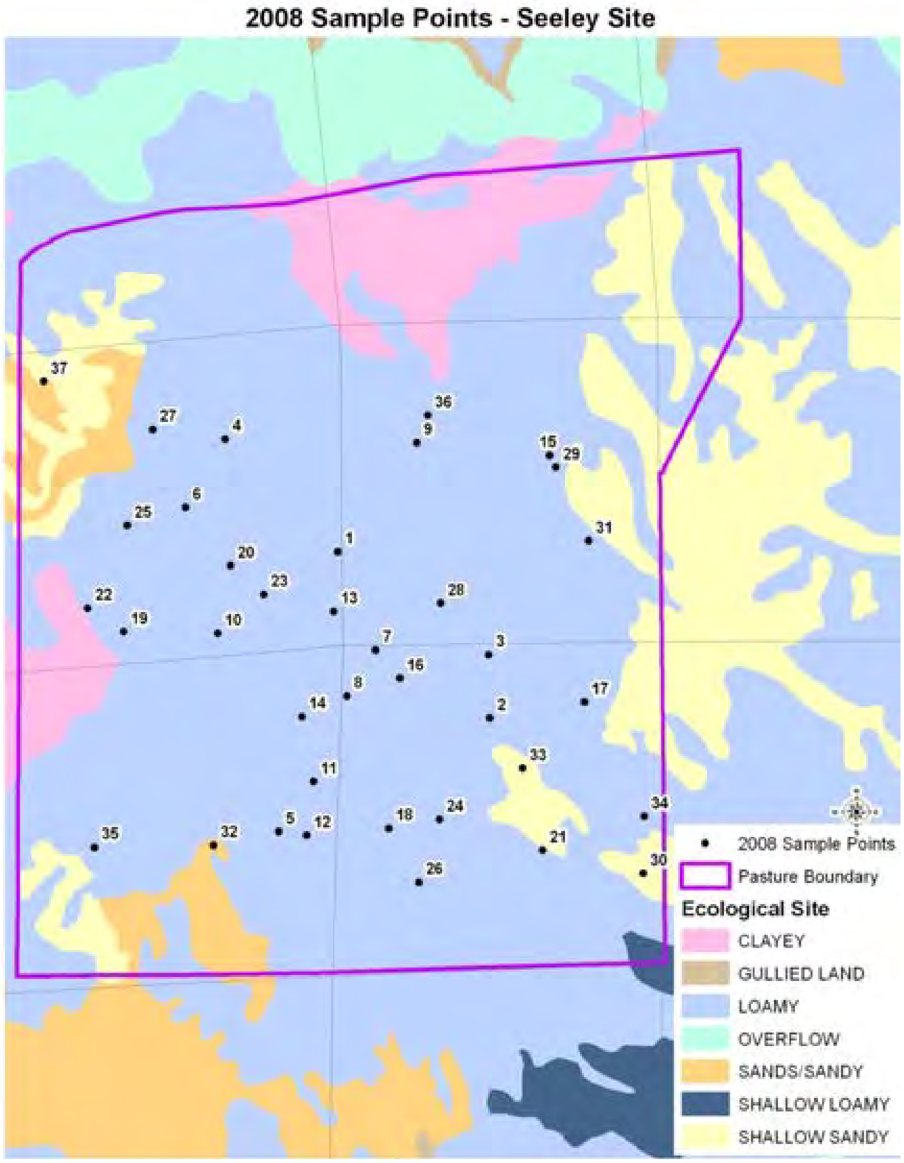

Figure 12. Ecological sites on the Seeley pasture in the Thunder Basin project area, and sample points included in vegetation sampling in 2008, 2009, 2010, and 2011.

Loamy Ecological Site

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."

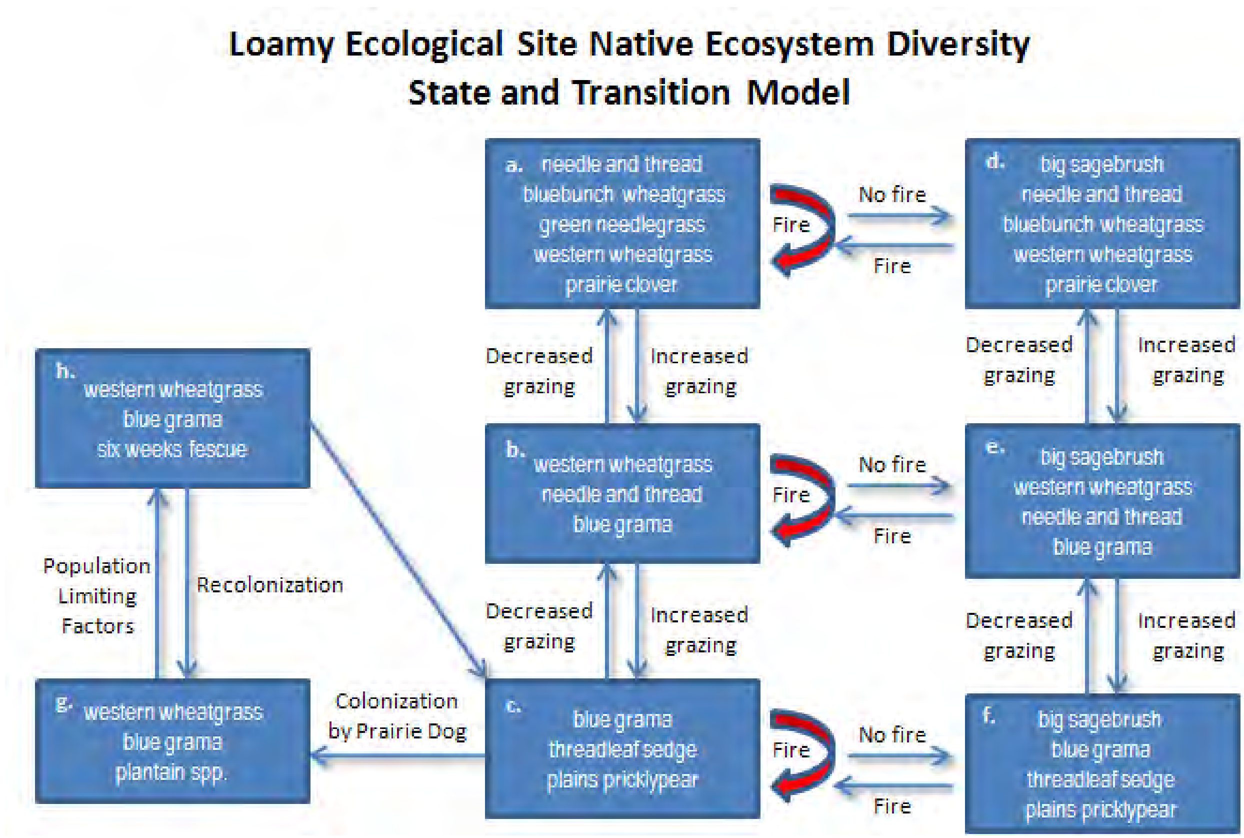

Figure 13. State and transition model for loamy sites in MLRA 58B, the Northern Rolling High Plains, for the 10-14" precipitation zone. Each box is a potentially occurring historical plant community.

Historical plant communities described for the loamy ecological site are as follows.

- **A. Light herbivory - short fire return interval plant community**

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. Moderate herbivory - short fire return plant community**

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. Heavy herbivory - short fire return interval plant community**

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. Light herbivory - long fire return interval plant community**

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. Moderate herbivory - long fire return interval plant community**

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. Heavy herbivory - long fire return interval plant community**

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 a 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 were 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 Site

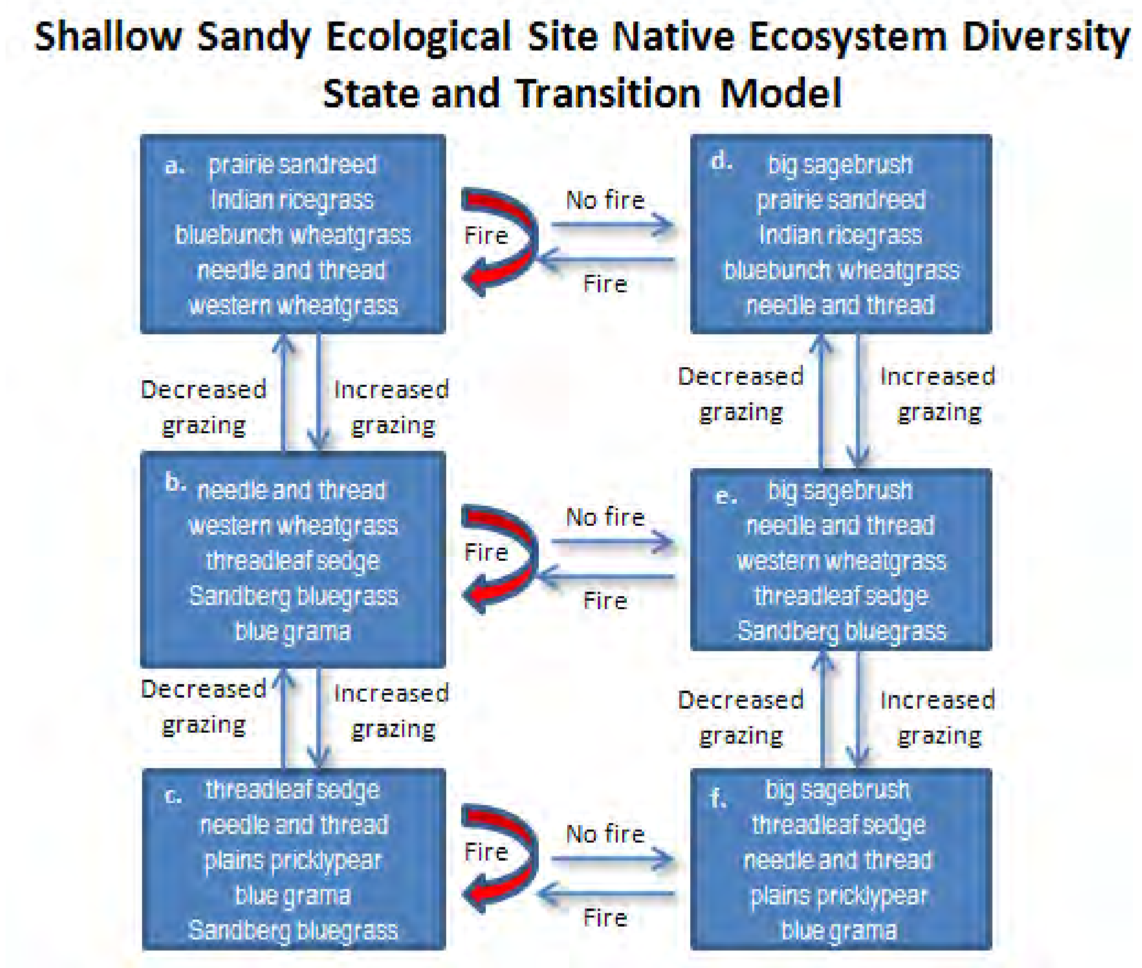

Figure 14. State and transition model for historical plant communities occurring on shallow sandy sites in the 10-14" precipitation zone of MLRA 58B, Northern Rolling High Plains.

- **A. Light herbivory - short fire return interval plant community**

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. Moderate herbivory - short fire return interval plant community**

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. Heavy herbivory - short fire return interval plant community**

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. Light herbivory - long fire return interval plant community**

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. Moderate herbivory - long fire return interval plant community**

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. Heavy herbivory - long fire return interval plant community**

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 Site

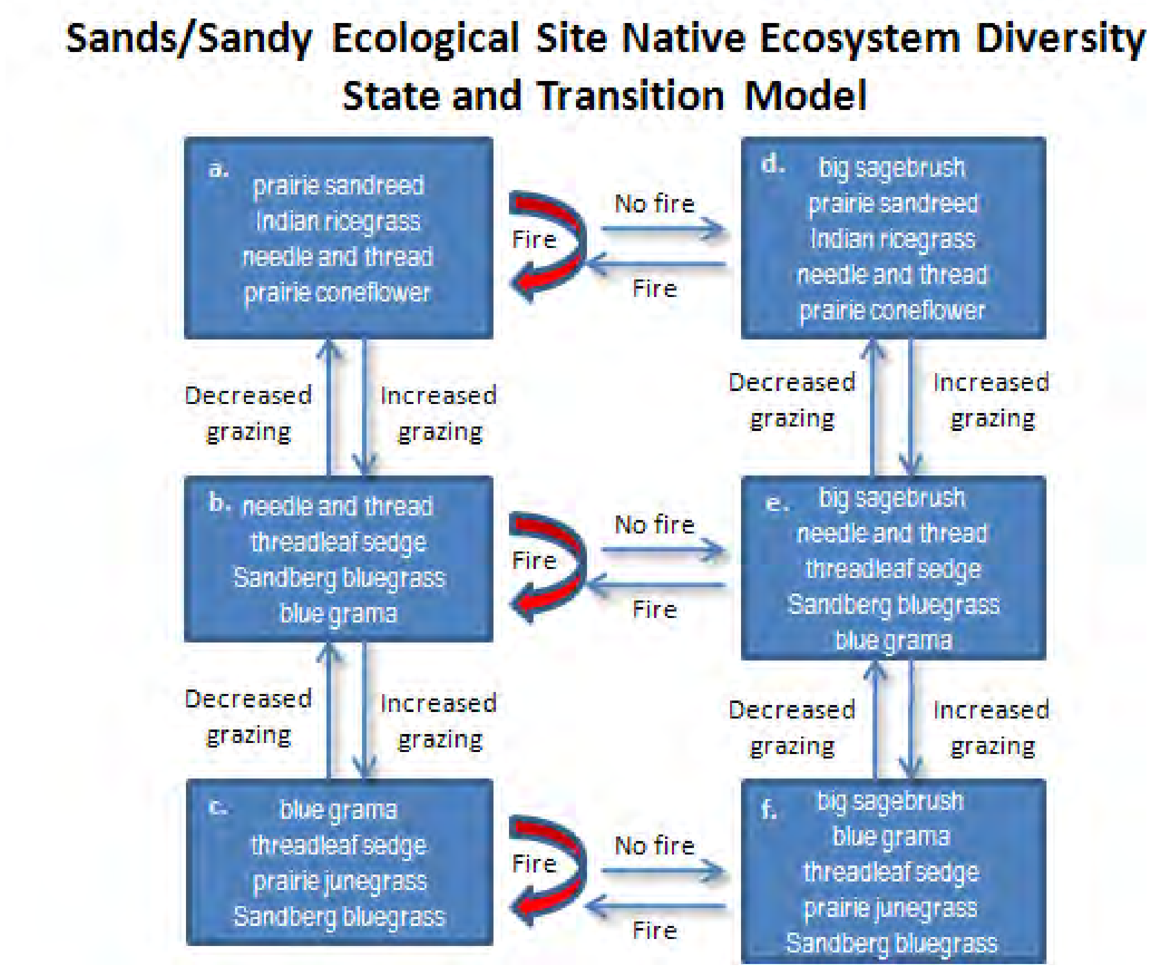

Figure 15. State and transition model showing historically occurring plant communities for sands/sandy ecological sites in the 10-14" precipitation zone of MLRA 58B, Northern Rolling High Plains.

- **A. Light herbivory - short fire return interval plant community**

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. Moderate herbivory - short fire return interval plant community**

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. Heavy herbivory - short fire return interval plant community**

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. Light herbivory - long fire return interval plant community**

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. Moderate herbivory - long fire return interval plant community**

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. Heavy herbivory - long fire return interval plant community**

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.

Recommended Reference Plant Community

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 wheatgrasses: 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%
- primrose, Gardner's saltbrush, skunkbush sumac, common snowberry, winterfat, and rabbitbrush: 0-5%

Treatments

The Thunder Basin Grassland Prairie Ecosystem Association worked with the Seeley family to identify treatments on one of their pastures. The site was a sagebrush-grassland area with moderate levels of cheatgrass, other grasses including western wheatgrass, needleandthread, and blue grama, and a relatively low diversity of forbs. Treatments included an aerial application of Plateau herbicide that produced mixed results in the cheatgrass. Consequently a follow-up treatment the next year to treat remaining patches was applied. The site was also seeded with a mixture of native forbs. Initial treatment occurred in Fall 2009 with the follow-up treatment and seeding occurring in the Fall 2010.

Plant Community Sampling

Sampling points for the treatment area in Thunder Basin were established in 2008, prior to the initiation of the CIG project, at locations shown in Figure 12. These sampling points were sampled in 2008-2011 by the Thunder Basin Grasslands Prairie Ecosystem Association as discussed previously in Methods.

Site Level Results

Results of the vegetation sampling in the Thunder Basin treatment area are listed in Table 6. Mean (standard error) similarity index values, adjusted for exotic species, for the three ecological sites for 2008 and 2011 are listed in Table 7.

Table 6. 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.

	Loamy Ecological Site			
	2008	**2009**	**2010**	**2011**
crested wheatgrass	1.71 (1.67)	1.42 (1.42)	2.27 (2.27)	1.6 (1.55)
prairie sagewort	1.13 (0.43)	2.03 (0.51)	3.03 (0.78)	2.5 (0.65)
purple threeawn	**3.03 (1.32)**	1.37 (0.95)	3.54 (1.91)	**0**
big sagebrush	7.67 (1.37)	7.83 (1.48)	11.37 (2.1)	6.21 (1.2)
blue grama	16.54 (2.26)	13.93 (1.95)	16.32 (2.31)	16.54 (2.9)
field brome	0	0	0	1.58 (1.12)
cheatgrass	5.5 (1.81)	3.18 (1.32)	1.78 (1.13)	7.45 (2.12)
threadleaf sedge	**13.44 (2.91)**	11.61 (2.67)	11.67 (2.87)	**5.59 (1.78)**
needle and thread	21.72 (2.17)	32.09 (2.3)	20.22 (2.4)	17.68 (2.41)
common pepperweed	**0**	0	0	**1.8 (0.34)**
plains pricklypear	**7.84 (1.48)**	6.56 (1.16)	11.25 (1.57)	**11.01 (1.69)**
western wheatgrass	14.86 (2.54)	16.77 (2.69)	12.86 (2.31)	12.59 (2.38)
woolly plantain	**0**	0	0	**1.33 (0.31)**
Sandberg bluegrass	**0**	0	0	**1.51 (0.33)**
prickly Russian thistle	**3.34 (1.64)**	0	0	**0**
sixweeks fescue	**0**	0	1.36 (0.31)	**6.37 (1.61)**

Table 7. Comparison of pre- and post-treatment similarity index values for sample plots at the Thunder Basin, WY site. Pre-treatment was in 2008, compared to the 2011, post-treatment conditions.

PRE-TREATMENT (2008)			POST-TREATMENT (2011)		
Loamy Ecological Site			**Loamy Ecological Site**		
Plot	Raw	With Quality Reduction	Plot	Raw	With Quality Reduction
1	62.82	62.63	1	58.75	55.93
2	41.62	41.62	2	40.43	40.29
3	38.82	38.82	3	57.85	57.83
4	73.65	73.62	4	65.58	65.19
5	58.73	58.73	5	75.15	75.15
6	64.92	64.90	6	59.45	59.21
7	40.86	37.24	7	36.02	25.94
8	70.50	70.27	8	71.59	65.20
9	50.92	47.15	9	54.56	51.45
10	62.48	60.06	10	69.37	67.77
11	44.01	43.29	11	74.06	72.87
12	78.41	73.96	12	55.66	47.52
13	53.39	40.40	13	57.69	48.57
14	34.49	31.22	14	26.67	25.25
15	55.81	52.08	15	54.75	52.46
16	41.23	41.21	16	28.00	27.98
17	58.57	55.53	17	66.96	54.81
18	38.58	38.58	18	50.06	50.05
19	45.16	44.74	19	37.95	36.50
20	71.22	70.29	20	56.52	54.58
21	37.51	28.34	21	36.18	20.75
22	68.44	68.20	22	43.26	42.95
23	52.88	52.86	23	21.96	21.88
24	42.58	42.58	24	40.29	40.29
25	46.62	18.37	25	41.32	19.04
26	29.13	29.13	26	47.06	46.65
27	34.26	33.80	27	18.30	18.00
28	43.37	43.37	28	44.13	43.94
29	52.66	45.67	29	72.86	70.69
31	57.49	57.13	31	67.78	66.65
34	35.38	9.49	34	61.73	58.72
35	49.51	49.49	35	59.94	59.23
36	37.64	27.68	36	34.28	16.63
MEAN	*50.72*	*47.04*	*MEAN*	*51.10*	*47.27*
VAR	*171.01*	*255.21*	*VAR*	*249.10*	*302.60*
STD ERR	*2.28*	*2.78*	*STD ERR*	*2.75*	*3.03*
Sandy/Shallow Sandy Ecological Site			**Sandy/Shallow Sandy Ecological Site**		
Plot	Raw	With Quality Reduction	Plot	Raw	With Quality Reduction
30	51.04	50.02	30	59.68	59.37
32	70.25	64.88	32	56.40	52.95
33	39.51	38.00	33	65.71	64.66
37	40.43	40.43	37	46.81	46.08
MEAN	*50.31*	*48.33*	*MEAN*	*57.15*	*55.77*
VAR	*204.14*	*148.59*	*VAR*	*62.38*	*64.60*
STD ERR	*7.14*	*6.09*	*STD ERR*	*3.95*	*4.02*

The vegetation sampling on the Thunder Basin site revealed few differences produced by the treatments. Purple threeawn was not observed on the vegetation plots in 2011 while it had been present the previous 3 years. Cheatgrass, while showing a downward trend the first two years following treatment, was not significantly different than its pre-treatment level in 2011, in fact displaying an increasing trend. Threadleaf sedge and prickly Russian thistle decreased in relative cover between 2001 and 2011, while prickly pear, six weeks fescue, wooly plantain, and Sandberg bluegrass increased. The similarity indices for the two primary ecological sites did not significantly differ between 2008 and 2011, and were nearly the same on the predominant loamy site. Based on these vegetation results, the treatments did not produce any mitigation units in 2011. Why the treatments failed to produce positive results is uncertain. The control of cheatgrass was unsuccessful, with amounts returning to similar or greater levels by year 3 post-treatment than pre-treatment. Planting of desired forbs may not have had sufficient time post-treatment to show a measurable response. It is possible that in future years, this treatment may result in increased similarity values. However, if the cheatgrass remains or expands, then values for the site may remain relatively low.

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 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. *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.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Pronghorn antelope	0	0	0	0	0	0
Sage thrasher	19	60	41	7	43	54
Sagebrush lizard	0	63	775	0	157	763
Sage sparrow	16	57	64	14	77	85
Sagebrush vole	622	2901	1706	1145	2510	1687
Sage grouse- nesting	93	744	1301	95	771	1297
Sage grouse brood-rearing	177	466	278	193	471	264
Sage grouse- wintering	0	43	134	0	49	132

With few differences noted between pre-treatment and post-treatment in terms of the vegetation, it is not surprising that the results of the species modeling showed few differences either. Sagebrush vole habitat improved slightly, apparently in response to slight increases in understory vegetation. Sage grouse nesting habitat was nearly identical pre and post treatment, while brood-rearing habitat appeared to slightly increase. It should be noted that the site was considered very low habitat quality for pronghorn antelope, although we did not list very low quality home range estimates in this report. The relatively equivalent species habitat quality between pre and post treatment conditions supports the lack of generation of mitigation units in the post-treatment condition.

Laidlaw Park Project, Idaho

Idaho Department of Fish and Game was the primary cooperator on this project area. The treatment area was 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 was likely to become an exotic annual grassland and lose its value to native sagebrush/grass dependent wildlife species. The BLM conducted seeding on 19,000 acres and the Idaho Department of Fish & Game and the Idaho Department of Lands proposed to rehabilitate 1,600 acres of state land. Ecological sites in the treatment area were predominantly loamy sites in the 8-12" precipitation zone 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.

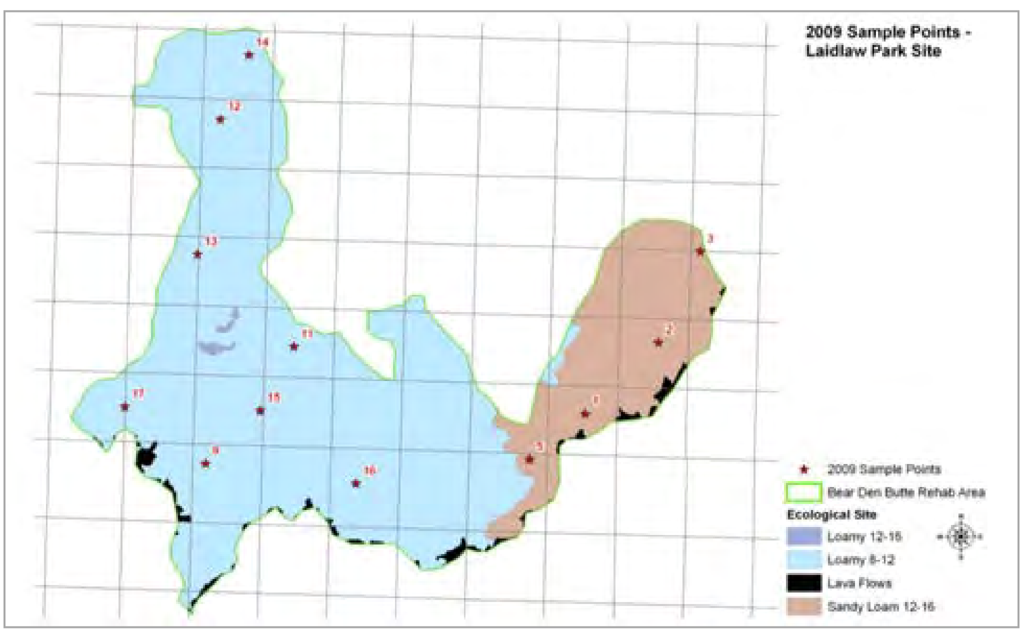

Figure 16. Map of treatment area for Laidlaw Park in Minidoka County, Idaho displaying ecological sites and the locations of sampling points established in 2009.

Reference Plant Community Development

For the two ecological sites on the Idaho Laidlaw Park project, plant community descriptions for loamy and sandy loam ecological sites were 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).

Loamy Ecological Site

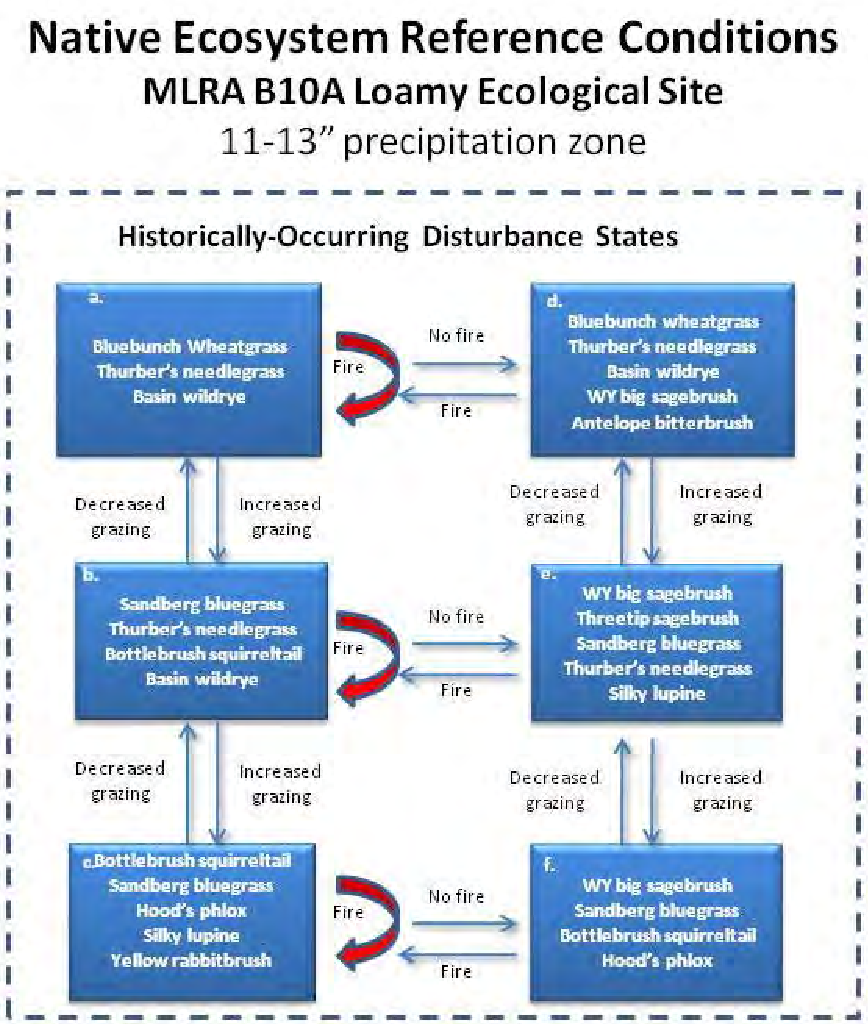

Figure 17. State and transition model for historical plant communities (states) for loamy ecological sites in the 8-12" precipitation zone in MLRA B10A in south central Idaho.

- **A. Light herbivory - short fire return interval plant community:**

Dominant species: Bluebunch wheatgrass, Thurber's wheatgrass, Basin wildrye, longleaf phlox.

<u>Other species</u>: Sandberg bluegrass, bottlebrush squirreltail, common yarrow, fleabane, Hood's phlox, 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.

<u>Herbaceous productivity</u>: 400-700 lbs/ac.

- **B. Moderate herbivory - short fire return interval plant community:**

<u>Dominant species</u>: <u>Dominant species</u>: Sandberg bluegrass, Thurber's wheatgrass, Basin wildrye, Bottlebrush squirreltail, Hood's phlox.

<u>Other species</u>: 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

<u>Herbaceous productivity estimate</u> : 350-650lbs/ac.

- ***C.* Heavy herbivory - short fire return interval plant community:**

<u>Dominant species</u>: Bottlebrush squirreltail, Sandberg bluegrass, Hood's phlox, silky lupine

<u>Other species</u>: 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

<u>Herbaceous productivity estimate</u> : 250-450 lbs/ac.

- **D. Light herbivory - long fire return interval plant community:**

<u>Dominant species</u>: Bluebunch wheatgrass, Thurber's needlegrass, basin wildrye, big sagebrush, antelope bitterbrush, Saskatoon serviceberry, threetip sagebrush, longleaf phlox

<u>Other species</u>: 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

<u>Herbaceous productivity estimate</u> : 300-600 lbs/ac.

- **E. Moderate herbivory - long fire return interval plant community:**

<u>Dominant species</u>: big sagebrush, Sandburg bluegrass, bottlebrush squirreltail, basin wildrye, threetip sagebrush, Thurber's needlegrass, Hood's phlox

<u>Other species</u>: 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.

Sandy Loam Ecological Site

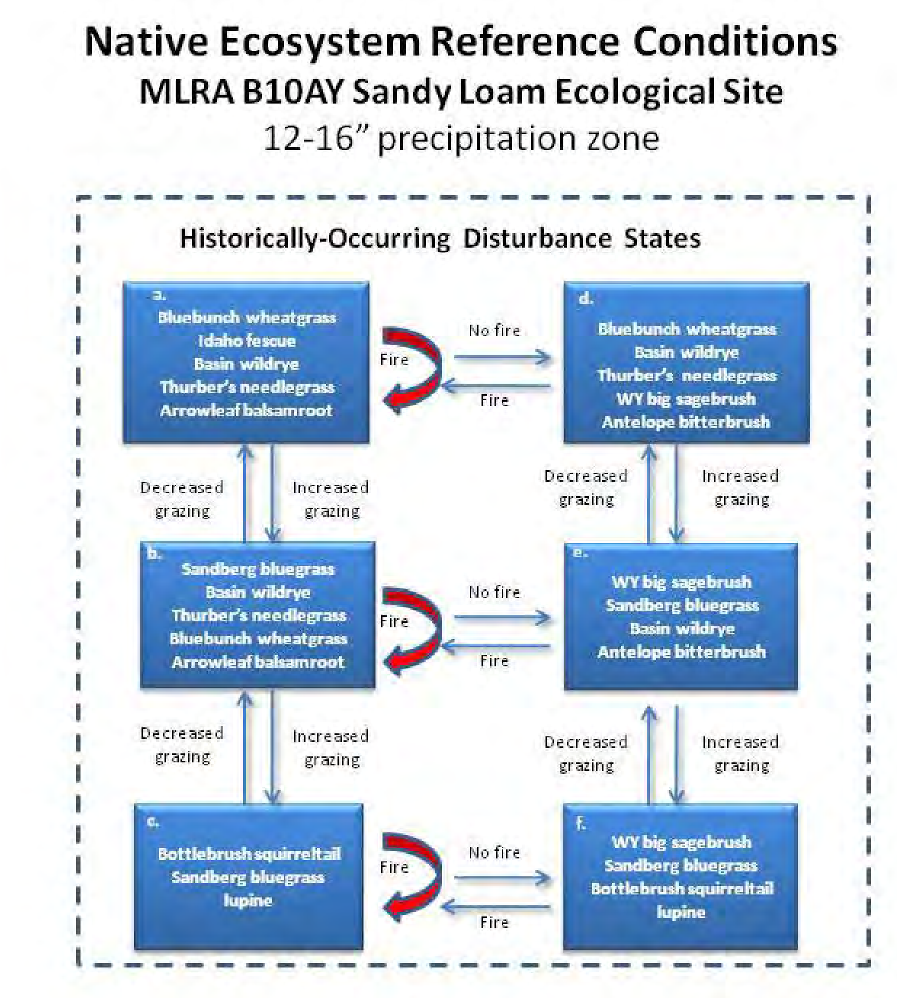

Figure 18. State and transition model for historical plant communities (states) on sandy loam ecological sites in the 12-16" precipitation zone for MLRA 10B in south central Idaho.

- 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.

- 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.

Recommended Reference Plant Community

The following reported and observed plant diversity of loamy sites was used as the reference community 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 wheatgrasses 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%,

Treatments

The project site was treated by Idaho Fish and Game through an aerial seeding of a mix of grass and forb species including both native and exotic species. The exotic species, such as Siberian wildrye were included to establish a more desirable plant community than the mix of annual forbs that dominated the site following the burn. This was followed up by a separate seeding of sagebrush. Both of these were applied to burned areas, so the "pre-treatment" conditions were those resulting from the wildfire.

Plant Community Sampling

Sampling of this treatment area occurred from 2009-2011. Sampling of the area was done by ID Fish and Game prior to the wildfire that burned through the area in 2007, but have little application to the mitigation practices applied to the area, as the fire dramatically altered the vegetation communities, and the mitigation treatments were designed to move the post-fire conditions closer to desired plant communities. The sampling in 2009-2011 was therefore considered post-treatment sampling, and shows a progressive response as the desired vegetation became established on the site.

Site Level Sampling

Findings of the 2009-2011 sampling in the Laidlaw Park treatment area are listed in Table 9.

Table 9. Dominant plant species (with greater than 1% relative cover in any ecological site in any year) sampled at the Laidlaw Park, Idaho area in 2009-2011 for each ecological site and precipitation zone combination; presented as relative cover. Bolded numbers differed among years (P<0.05).

	Ecological Site					
Plant Name	**Loamy 12-16"**			**Loamy 8-12"**		
	2009	**2010**	**2011**	**2009**	**2010**	**2011**
Indian ricegrass	0	1.07 (1.07)	0	0	0	0
Thurber's needlegrass	0	0	0	0	1.72 (1.72)	5.04 (5.04)
crested wheatgrass	0	0	0	0	2.15 (0.76)	0
Siberian wheatgrass	0	0	0	**0**	0	**9.45 (3.03)**
textile onion	0	0	1.02 (0.6)	0	0	0
cheatgrass	10.15 (5.62)	12.02 (7.84)	6.45 (1.57)	6.73 (2.39)	14.96 (4.72)	10.11 (2.56)
Douglas' sedge	0	0	1.64 (1.64)	0	1.75 (1.23)	1.24 (0.9)
diffuse knapweed	2.99 (1.98)	2.3 (2.08)	0	1.48 (1.48)	0	0
Douglas' dustymaiden	0	0	0	0	0	2.48 (2.36)
yellow rabbitbrush	2.07 (2.07)	0	0	0	0	0
bull thistle	0	0	0	1.17 (1.17)	0	0
western tansymustard	0	0	3.02 (2.55)	**0**	0	**8.61 (2.55)**
squirreltail	0	0	0	0	2.12 (1.36)	0
thickspike wheatgrass	0	0	7.08 (7.08)	0	0	5.14 (3.49)
slender wheatgrass	-	-	-	-	3.08 (1.5)	-
tall annual willowherb	14.43 (7.45)	0	6.76 (3.73)	0	0	0
rubber rabbitbrush	0	2.25 (2.25)	0	0	0	0
sulphur-flower buckwheat	3.3 (2.32)	1.35 (1.01)	0	0	0	0
Wilcox's woollystar	0	0	4.88 (2.37)	0	0	0
spreading groundsmoke	11.26 (7.37)	0	1.68 (0.78)	5.7 (2.88)	0	0
broom snakeweed	0	0	0	0	0	1.23 (1.03)
Lava aster	0	0	0	4.13 (2.00)	0	0
needle and thread	1.97 (1.97)	2.23 (2.23)	3.56 (2.45)	0	2.14 (1.59)	0
prickly lettuce	7.42 (2.79)	3.53 (1.34)	3.66 (0.84)	9.31 (2.87)	12.37 (4.1)	5.1 (1.58)
common pepperweed	1.2 (0.72)	1.8 (1.58)	2.7 (1.81)	0	2.45 (1.15)	2.74 (1.5)
granite prickly phlox	2.36 (2.34)	0	0	1.07 (0.59)	0	0
sagebrush false dandelion	0	0	0	0	1.02 (1.02)	0
sainfoin	0	16.76 (3.04)	0	0	3.39 (2.91)	0
western wheatgrass	0	0	0	0	2.31 (1.19)	0
silverleaf phacelia	0	1.18 (1.18)	1.06 (1.06)	0	0	0
longleaf phlox			1.13 (0.66)			
bulbous bluegrass	0	0	0	0	1.46 (1.46)	0
Sandberg bluegrass	**30.5 (7.34)**	43.25 (9.18)	**47 (9.1)**	11.51 (2)	16 (4.81)	18.11 (4.36)
bluebunch wheatgrass	1.78 (1.11)	3.58 (3.17)	1.23 (1.23)	3.82 (1.74)	6.8 (2.53)	12.25 (5.34)
tall tumblemustard	**5.89 (1.44)**	0	0	**34.97 (9.44)**	11.39 (5.04)	**0**
intermediate wheatgrass	0	0	0	2.91 (1.8)	3.63 (2.69)	0
tall wheatgrass	0	0	0	0	0	3.16 (1.47)
yellow salsify	1.32 (0.28)	5.84 (1.57)	3.09 (1.1)	9.17 (5.61)	6.24 (2.48)	6.61 (1.99)

Similarity index values for the Laidlaw Park ecological sites for 2009 and 2011 are listed in Table 10.

Table 10. Comparison of pre- and post-treatment similarity index values for sample plots at the Laidlaw Park, ID site.

PRE-TREATMENT (2009)			POST-TREATMENT (2011)		
Sandy Loam 12"-16" PZ Ecological Site			**Sandy Loam 12"-16" PZ Ecological Site**		
Plot	Raw	With Quality Reduction	Plot	Raw	With Quality Reduction
1	36.96	29.60	1	39.21	36.10
2	38.07	33.14	2	62.65	56.71
3	40.20	20.34	3	41.14	35.88
5	32.96	26.11	5	25.15	24.46
MEAN	*37.05*	*27.30*	*MEAN*	*42.04*	*38.29*
VAR	*9.23*	*29.75*	*VAR*	*239.64*	*180.32*
STD ERR	*1.52*	*2.73*	*STD ERR*	*7.74*	*6.71*
Loamy 8"-12" PZ Ecological Site			**Loamy 8"-12" PZ Ecological Site**		
Plot	Raw	With Quality Reduction	Plot	Raw	With Quality Reduction
9	25.05	7.23	9	65.90	64.67
11	37.73	15.96	11	37.75	32.44
12	33.62	21.41	12	66.39	62.90
13	4.84	3.24	13	45.53	30.17
14	38.00	17.97	14	32.86	29.79
15	18.71	4.39	15	50.01	46.37
16	29.91	8.50	16	45.36	38.83
17	11.32	2.10	17	27.24	22.65
MEAN	***24.90***	***10.10***	*MEAN*	***46.38***	***40.98***
VAR	*151.76*	*54.08*	*VAR*	*202.85*	*246.61*
STD ERR	*4.36*	*2.60*	*STD ERR*	*5.04*	*5.55*

Obviously, these sites had very low quality conditions following the burn particularly due to the high levels of exotic plants occurring on the sites. However, by 2011, the sites showed dramatic and significant improvements to the treatments. It should be noted that some of the planted species were exotics such as Siberian wheatgrass, and as such did not contribute to the similarity score. This point was noted by the cooperators, with the suggestion that for this site, a similarity score be developed that included the planted species, even though they were exotic species. We did not develop a modified similarity index with the planted species, but acknowledge that this would serve as an interim index while the site is recovering from the effects of the burn. The vegetation sampling showed high variability, with few significant differences between 2009 and 2011, although several noteworthy trends were significant including the establishment of Siberian wheatgrass from the seeding in 2011, the decline in tall tumblemustard, and the expansion of Sandberg bluegrass. Cheatgrass remained a substantial presence on the site, and western tansymustard showed up in significant amounts in 2011. The similarity for the site was significantly increased from 2009 to 2011 on the loamy 8-12” precipitation zone sites, going from a score of 10.10 to 40.98. While the site still has a long way to go to be high quality in terms of its plant community, the metric system did document the significant gains achieved by the treatments over the 3 years of monitoring.

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 11. For maps of the modeling results for each species, see Appendix B.

Table 11. Results of habitat modeling for the Laidlaw Park site in Idaho. Numbers represent potential home ranges of species rated as high quality, medium quality, and low quality.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Pronghorn antelope	0	0	0	0	0	0
Pygmy rabbit	2022	14	1	1979	16	0
Sage thrasher	369	27	16	368	27	14
Sagebrush lizard	0	0	3151	0	0	2771
Sage sparrow	1045	126	32	1059	137	59
Sagebrush vole	5872	3923	5724	5895	3899	5736
Sage grouse- nesting	5292	4174	609	5281	4202	595
Sage grouse brood-rearing	1274	122	97	1103	101	67
Sage grouse- wintering	0	613	136	0	605	143

*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.

The species modeling for Laidlaw Park may appear confusing. The treatment site itself has a relatively low similarity score, yet the HOMEGROWER results show many high quality home ranges for many of the sagebrush-associated species. The reason for this is the high quality habitat that still exists in areas surrounding the treatment site, as examination of the maps for this site that are included in Appendix B reveals. With the buffers used in the landscape analyses, these high quality areas surrounding the treatment site are providing high quality habitat while the treatment site itself is very low quality habitat. What should be noted are the differences between pre and post-treatment numbers, which changed little as a result of the treatments. Over time, as the treatments become better established, we would expect to see the changes in habitat quality produced on the treatment sites.

Ash Valley Ranch Project, California

The Ash Valley Ranch treatment area was a cooperative project with the Cooperative Sagebrush Steppe Restoration Initiative in Lassen County, California. The treatment site was a sagebrush area that has been invaded by juniper, with the primary treatment being the removal of juniper to release sagebrush, grasses and forbs. The project was designed as a habitat restoration project in the Ash Valley Ranch area southeast of Adin, California. The project was designed to 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.

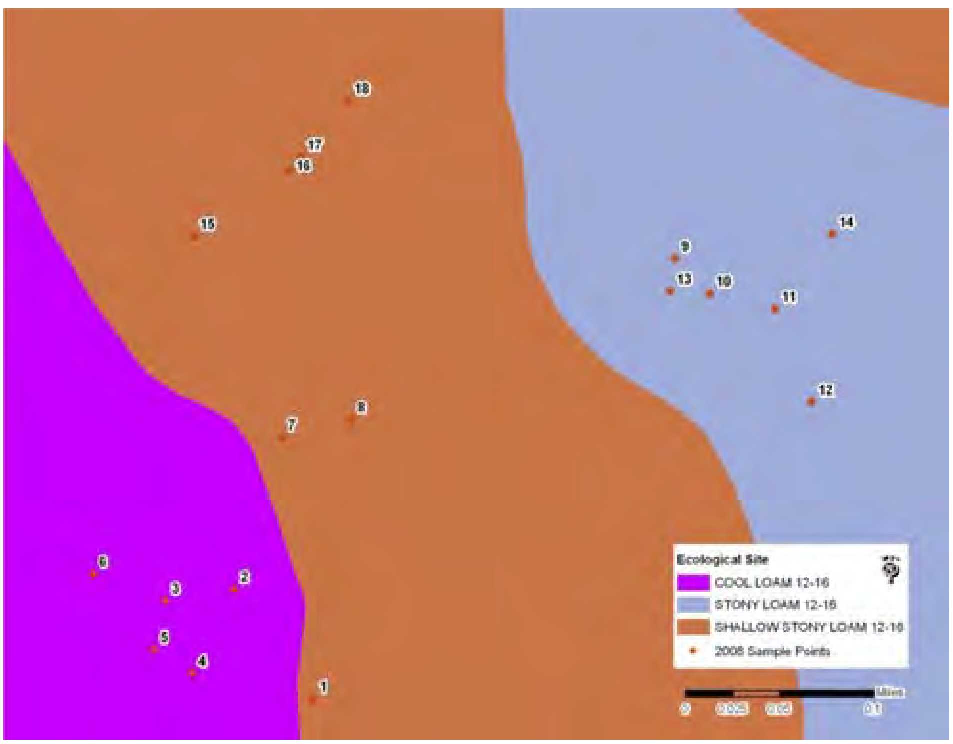

Figure 19. Ecological sites and sampling point locations in the Ash Valley Ranch treatment area in northern California.

Reference Plant Community Development

Stony Loam Ecological Site

The state and transition model for historically occurring plant communities on the stony loam ecological site for the 12-18” precipitation zone is shown in Figure 20.

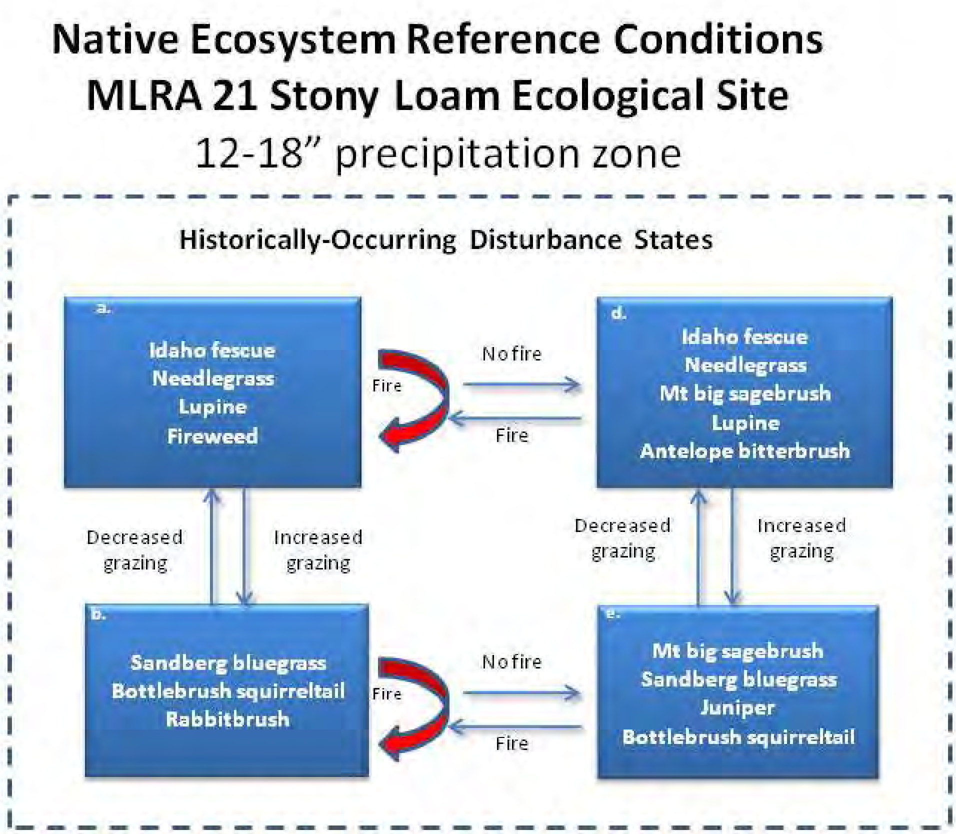

Figure 20. State and transition model for historically occurring plant communities for the stony loam ecological site for the 12-18” precipitation zone in MLRA 21 for northeastern California.

- **A. Light herbivory - short fire return interval plant community**

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. Heavy herbivory - short fire return interval plant community**

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. Light herbivory - long fire return interval plant community**

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. Heavy herbivory - long fire return interval plant community**

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

Shallow Stony Loam Ecological Site

The state and transition model for historically occurring plant communities on the shallow stony loam ecological site for the 12-18" precipitation zone of MLRA 21 in northeastern California is shown in Figure 21.

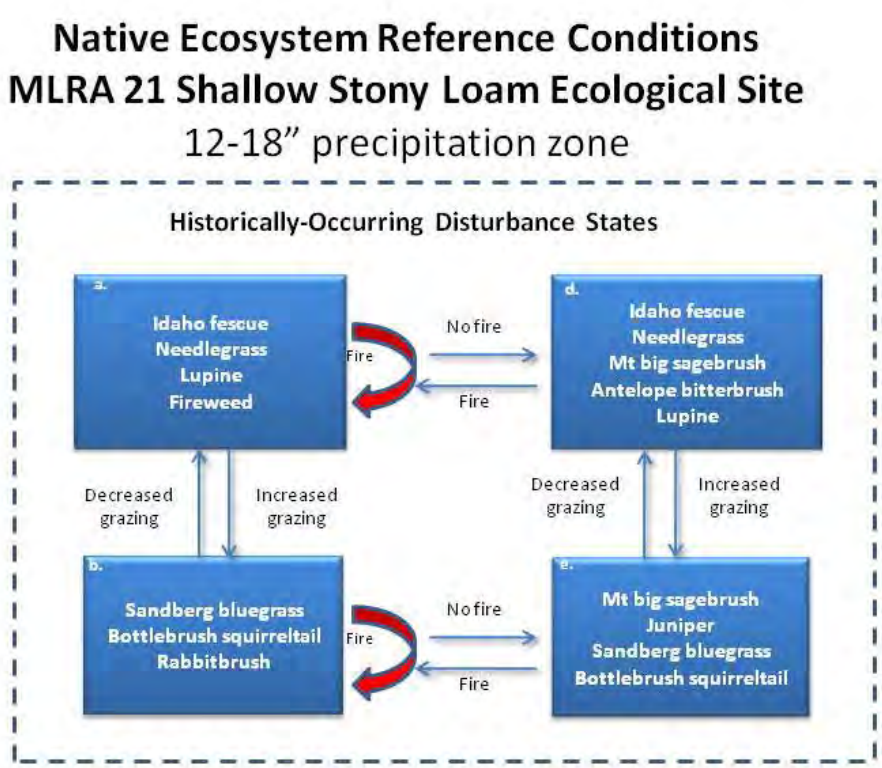

Figure 21. State and transition model for the shallow stony loam 12-18" precipitation zone ecological site.

- **A. Light herbivory - short fire return interval plant community**

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. Heavy herbivory - short fire return interval plant community**

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. Light herbivory - long fire return interval plant community**

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. Heavy herbivory - long fire return interval plant community**

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

Cool Loam Ecological Site

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.

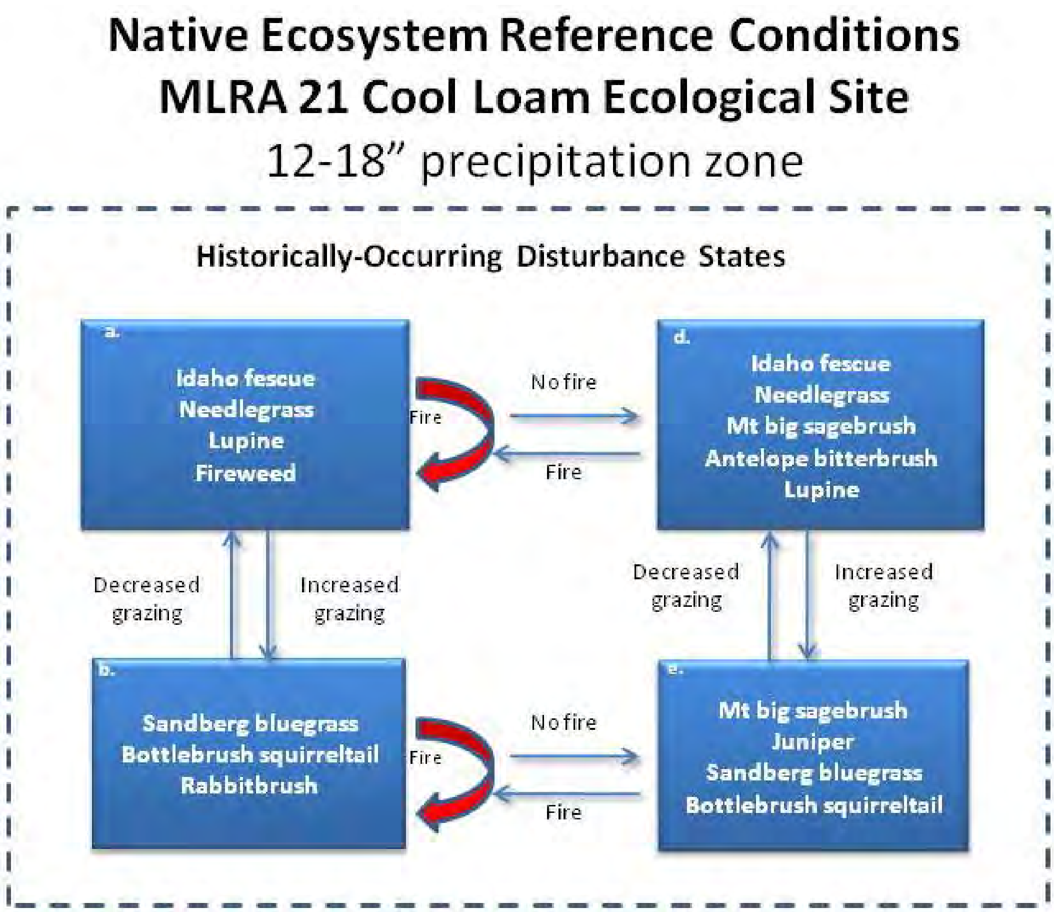

Figure 22. State and transition model for cool loamy ecological sites in the 12-16" precipitation zone of MLRA 21 in northeastern California.

- ### A. Light herbivory - short fire return interval plant community

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. Heavy herbivory - short fire return interval plant community

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. Light herbivory - long fire return interval plant community**

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. Heavy herbivory - long fire return interval plant community**

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

Recommended 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 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%.

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%.

Treatments

Juniper was removed from the site using mechanical treatments in Fall 2008. Juniper was cut and skidded to collection areas where it was chipped with the chips hauled to a biomass utilization facility. The site was rested from grazing following the treatment.

Plant Community Sampling

Site Level Results

Vegetation sampling of plant communities was conducted pretreatment in 2008 and post-treatment in 2009- 2011, 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 12. 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 (pretreatment), and 2009-2011 (post-treatment) for ecological sites in the treatment area, presented as relative cover (standard error).

	Ecological Site											
	Cool Loam				Stony Loam				Shallow Stony Loam			
<u>Species</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>
Thurber's needlegrass	0	27.83 (4.85)	0	0	2.43 (1.51)	21.87 (13.61)	3.48 (2.61)	6.42 (6.15)	3.72 (2.59)	8.69 (5.17)	0	0
agoseris	**0**	0	3.17 (1.19)	**1.83 (0.61)**	0	1.85 (1.02)	2.12 (0.97)	5.1 (2.73)	0	1.44 (0.66)	1.25 (0.47)	1.97 (0.97)
rosy pussytoes	0	2.88 (0.9)	0	0	0	0	0	0	3.78 (3.78)	11.89 (5.96)	14.37 (7.43)	12.56 (6.73)
little sagebrush	0	0	0	0	0	0	0	0	9.86 (1.65)	5.12 (1.86)	5.72 (1.98)	7.77 (3.28)
sandwort	0	0	0	0	0	0	0	0	0	2.14 (1.1)	0	0
big sagebrush	5.4 (1.97)	3.57 (1.38)	3.67 (1.19)	4.83 (1.62)	3.88 (1.57)	1.49 (0.52)	1.89 (0.67)	2.52 (0.8)	8.47 (3.9)	1.43 (0.88)	1.49 (1.09)	2.2 (1.49)
arrowleaf balsamroot	0	0	0	0	0	6.54 (6.54)	2.19 (2.19)	1.69 (1.69)	0	0	0	0
cheatgrass	0	1.37 (1.37)	4.7 (4.7)	5.28 (4.99)	1.58 (1.58)	1.38 (1.38)	3.34 (2.24)	11.73 (11.47)	0	5.01 (2.77)	1.02 (0.61)	9.85 (4.85)
upland sedges	0	7.04 (1.71)	0	0	0	0	0	0	0	6.13 (3.21)	4.95 (2.74)	2.96 (1.88)
Indian paintbrush	0	0	0	0	0	0	0	0	0	1.52 (1.19)	0	0
thistle	0	0	0	0	0	0	0	0	0	5.31 (5.31)	0	0
trumpet	0	0	0	0	0	0	1.28 (0.92)	0	0	0	0	0
maiden blue eyed Mary	0	0	1.63 (1.03)	3.66 (1.46)	2.36 (1.09)	0	1.44 (0.79)	2.2 (0.67)	0	0	0	0
cryptantha	0	1.28 (1.03)	0	0	0	2.32 (2.24)	1.4 (1.04)	0	0	0	0	0
squirreltail	1.03 (0.63)	8.66 (4)	6.52 (2.61)	6.04 (2.21)	4.5 (3.11)	3.69 (1.58)	4.12 (2.37)	3.87 (2.65)	4.63 (1.52)	6.02 (3.01)	5.85 (2.42)	7.22 (2.9)
willowherb	0	0	0	0	0	0	0	0	**0**	0		**1.45 (0.43)**
buckwheat	0	1.26 (1.26)	0	0	0	0	0	0	0	0	0	0
fleabane	0	0	0	0	0	0	0	0	0	1.97 (1.45)	2.18 (1.46)	-
common woolly sunflower	0	0	0	0	0	0	0	0	0	1.09 (1.09)	1.75 (0.88)	2.09 (1.25)
rubber rabbitbrush	0	0	0	0	2.29 (2.29)	0	0	0	0	0	0	0

Table 12. Continued

	Ecological Site											
	Cool Loam				Stony Loam				Shallow Stony Loam			
Species	**2008**	**2009**	**2010**	**2011**	**2008**	**2009**	**2010**	**2011**	**2008**	**2009**	**2010**	**2011**
aster	0	0	0	0	0	0	0	0	4.67 (4.61)	0	0	0
Idaho fescue	29.7 (11.93)	0	28.67 (6.88)	37.43 (9.93)	43.41 (8.87)	20.84 (17.54)	34.5 (9.62)	34.34 (13.8)	7.14 (4.6)	2.66 (2.66)	11.3 (5.42)	7.96 (3.58)
whitestem frasera	0	0	0	0	0	0	0	0	0	2.17 (1.08)	4.47 (2.3)	2.67 (1.43)
groundsmoke	0	3.74 (3.18)	1.38 (0.76)	0	0	0	0	0	0	-	1.67 (1.67)	0
cudweed	0	0	0	0	0	0	0	0	8.26 (8.26)	0	0	0
stickseed	0	0	0	0	0	7.7 (7.7)	11.45 (11.45)	3.2 (3.2)	0	0	0	0
prairie Junegrass	0	0	0	0	0	0	0	0	0	3.57 (2.72)	1.34 (1.34)	1.77 (1.4)
western juniper	0	0	0	0	9.67 (7.61)	0	1.63 (1.63)	2.3 (2.3)	0	0	0	0
toadflax	0	3.12 (0.52)	0	1.31 (0.81)	0	8.08 (6.93)	0	2.85 (1.68)	0	1.36 (1.05)	0	1.03 (0.75)
granite prickly phlox	1.18 (0.73)	0	0	0	1.3 (0.79)	0	0	0	0	0	0	0
desertparsley	0	0	0	0	0	0	0	3.2 (3.09)	2.62 (2.32)	1.98 (1.8)	2.4 (1.49)	3.93 (2.41)
lupine	9.38 (1.97)	3.65 (1.69)	3.68 (1.38)	5.39 (2.81)	2.03 (1.43)	0	0	0	0	0	0	0
slender phlox	2.41 (0.74)	16.27 (2.55)	2.24 (0.58)	8.12 (3.42)	0	3.2 (1.8)	4.14 (1.39)	6.2 (2.9)	0	2.86 (0.78)	3.01 (1.28)	2.82 (1.51)
beardtongue	0	0	0	0	0	0	0	0	3.44 (2.25)	0	0	0
phacelia	0	1.06 (0.66)	2.93 (1.72)	0	0	0	0	0	0	0	0	0
spiny phlox	0	2.86 (1.57)	2.7 (1.31)	2.78 (1.93)	0	0	0	0	0	0	0	0
Sandberg bluegrass	32.09 (13.54)	10.42 (3.77)	27.01 (8.85)	11.26 (4.44)	7.95 (3)	6.74 (4.85)	3.68 (1.06)	3.04 (0.49)	26.54 (9.48)	17.91 (4.14)	22.53 (6.15)	16.68 (6.22)
bluebunch wheatgrass	9.64 (6.03)	0	-	3.19 (3.19)	14.08 (5.92)	5.6 (3.81)	18.32 (6.99)	3.66 (2.63)	9.68 (4.59)	5.58 (4.21)	5.58 (3.71)	4.46 (2.91)
antelope bitterbrush	1.87 (1.03)	0	1.16 (0.8)		0	0	0	0	4.56 (2.55)	1.32 (0.6)	2.43 (1.45)	2.59 (1.59)
ragwort	0	1.08 (0.68)	1.26 (0.59)	0	0	0	0	0	0	0	0	0
vetch	0	0	2.75 (2.75)	1.28 (0.84)	0	0	0	0	0	0	0	0

There were few significant differences noted in the plant composition sampled in 2008 and 2011 on the Ash Valley site. One possible explanation was the timing of the sampling of the pre-treatment plant community. This sampling was conducted very late in the year due to timing of the project approval and the need to sample prior to the initiation of treatments. The plant community at that time of the year was very dried out and had been grazed, so good measures of pre-treatment conditions were not obtained for this site.

Comparisons of the sampled plant communities to the reference plant communities determined the similarity indices for 2008 compared to the same values for 2011 with results shown in Table 13.

Table 13. Comparison of pre- and post-treatment similarity index values for sample plots at the Ash Valley Ranch, California site.

PRE-TREATMENT (2008)			**POST-TREATMENT (2009)**		
Cool Loam Ecological Site			**Cool Loam Ecological Site**		
Plot	Raw	With Quality Reduction	Plot	Raw	With Quality Reduction
2	37.39	37.39	2	66.93	66.93
3	47.33	46.71	3	61.40	47.06
4	68.33	68.33	4	57.20	56.87
5	75.44	75.44	5	72.29	72.29
6	75.06	75.06	6	71.99	71.99
MEAN	*60.71*	*60.59*	*MEAN*	*65.96*	*63.03*
VAR	*300.96*	*305.19*	*VAR*	*43.73*	*118.61*
STD ERR	*7.76*	*7.81*	*STD ERR*	*2.96*	*4.87*
Shallow Stony Loamy Ecological Site			**Shallow Stony Loamy Ecological Site**		
Plot	Raw	With Quality Reduction	Plot	Raw	With Quality Reduction
7	30.00	30.00	7	25.00	25.00
8	30.00	30.00	8	25.00	25.00
15	20.87	20.87	15	25.00	25.00
16	79.83	79.83	16	43.09	39.79
17	80.51	80.38	17	69.83	56.41
18	93.42	93.16	18	65.74	49.49
MEAN	*55.77*	*55.71*	*MEAN*	*42.28*	*36.78*
VAR	*1030.92*	*1025.74*	*VAR*	*441.18*	*194.47*
STD ERR	*11.08*	*11.05*	*STD ERR*	*7.25*	*4.81*
Stony Loamy Ecological Site			**Stony Loamy Ecological Site**		
Plot	Raw	With Quality Reduction	Plot	Raw	With Quality Reduction
9	75.70	72.79	9	43.34	21.08
10	73.68	73.68	10	67.27	67.27
11	60.64	60.64	11	68.67	68.58
12	68.33	68.33	12	67.74	67.58
MEAN	69.59	68.86	MEAN	61.76	56.13
VAR	45.27	35.51	VAR	151.08	546.30
STD ERR	3.36	2.98	STD ERR	6.15	11.69

The similarity values for this site did not show the expected increases due to the juniper control. Several reasons are possible for this lack of noted change. First, the juniper on the site had a spotty distribution prior to treatment. This resulted in many of the pre-treatment plots (which were randomly distributed) falling in locations that did not have juniper present. These plots would not be expected to show a response to the juniper removal. A second reason is that the juniper removal did include some disruption in the existing plant community beyond the reduction in juniper. Mechanical equipment was used to cut and process the juniper, with some resulting impacts on vegetation. It was expected that these short-term impacts would be offset by the vegetation responses by the third year of the project, but responses by the plant communities may take longer than this to show positive results. A third reason for the lack of positive response was the presence of cheatgrass on areas of the treatment site. No control of the cheatgrass was included in the treatment, as California has not approved the use of Plateau herbicide, a treatment used effectively in other project locations to treat this invasive species. A final reason could be as mentioned above that the 2008 sampling was conducted very late in the year, when the vegetation was dried up and identification and accurate sampling was difficult. As these data formed the basis of comparison, any inaccuracies due to the timing of sampling are then reflected in the resulting similarity indices.

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 14. Habitat suitability and home range maps for the Ash Valley landscape are presented in Appendix B.

Table 14. 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.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Pronghorn antelope	0	0	1	0	0	3
Pygmy rabbit	46	29	20	48	28	20
Sage thrasher	1	30	5	0	32	5
Sagebrush lizard	1129	402	18	1095	415	16
Sage sparrow	138	18	1	128	22	4
Sagebrush vole	0	341	345	0	360	341
Sage grouse- nesting	1097	824	1347	1097	812	1360
Sage grouse brood-rearing	8	264	118	9	263	120
Sage grouse- wintering	127	46	72	126	46	75

*Pre-high refers to number of high quality home ranges identified in pre-treatment conditions, with medium and low similarly identifying these quality home ranges for both pre and post-treatment conditions.

Anthro Mountain Project, Utah

The Anthro Mountain study, in the Ashley National Forest in northeastern Utah ranged in elevation from 7000 - 8000 feet. The area had been used for many years for livestock grazing, and still supported grazing leases. The study area supported grass and sagebrush vegetation with 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.

Reference Plant Community Development

The Anthro Mountain site was primarily a shallow loamy site, although ecological site descriptions for this area were not available. Because of this lack of background information, development of state and transition models was not attempted. However, a reference plant community was developed for the area.

Recommended Reference Plant Community

Reference plant community for shallow loamy ecological sites in the Anthro Mountain area

- big sagebrush and silver sagebrush: 0-30%, with a minimum of 15% to achieve a score of 100%
- Idaho fescue, green needlegrass, and bluebunch wheatgrass: 0-50% with a minimum of 10% to achieve a score of 100%
- rhizomatous wheatgrasses, 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, pussytoes, sandwort, native milkvetches, sego lily, downy paintedcup, tiny trumpet, hawksbeards, miner's candle, fleabane, buckwheat, Indian paintbrush, painted cup, gilia, aster, desert parsley, lupine, buckwheat, scarlet beeblossom, desert biscuitroot, ragwort, penstemon, scurfpea, globemallow, beardtongue, phlox, American vetch, death camas), excluding Forb B species: 0-20%, with a minimum of 10% to achieve a score of 100%,
- prairie sagewort, spiny phlox, beaked skeletonweed, broom snakeweed, thistle, gumweed, and bastard toadflax: 0-5%
- Gardner's saltbrush, serviceberry, common snowberry, and rabbitbrush: 0-10%.

Treatments

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.

Plant Community Sampling

Site Level Results

Results of the vegetation sampling conducted at Anthro Mountain in 2009-2011 are presented in Table 15.

Table 15. Results of vegetation sampling conducted on shallow loamy ecological sites of the Anthro Mountain project area in Utah in 2009-2011.

	Shallow Loamy Ecological Site		
	2009	2010	2011
agoseris	**0**	0	**5.78** (3.94)
onion	**0**	0	**3.33** (1.57)
pussytoes	1.25 (0.94)	2.91 (1.31)	1.13 (0.63)
big sagebrush	10.71 (1.67)	7.95 (1.55)	12.74 (1.79)
milkvetch	1.86 (1.17)	3.79 (1.25)	6.32 (2.32)
Indian paintbrush	**0**	2.06 (1.25)	**2.47** (1.05)
fleabane	2.17 (1.17)	0	1.16 (0.76)
buckwheat	0	0	2.01 (0.9)
lily	0	2.08 (0.89)	0
desertparsley	0	3.84 (1.43)	0
juniper	**3.19** (1.16)		0
purple locoweed	0	0	2.63 (2.17)
mat penstemon	0	4.72 (2.33)	3.31 (1.41)
longleaf phlox	2.14 (0.88)	7.11 (1.99)	1.93 (0.82)
twoneedle pinyon	**27.06** (5.0)	0	**0**
longleaf phlox	0	4.01 (2.14)	0
muttongrass	**0**	0	**23.01** (5.13)
cinquefoil	3.56 (3.56)	0	0
Sandberg bluegrass	0	0	1.44 (1.02)
bluebunch wheatgrass	**40.12** (6.06)	42.92 (4.49)	**13.56** (3.45)
ragwort	**2.39** (1.01)	2.47 (1.49)	**6.8** (1.49)
tall tumblemustard	0	0	1.58 (1.35)

Similarity indices for Anthro Mountain were determined for 2009 and compared to 2011. Results are shown in Table 16.

Table 16. Comparison of pre- and post-treatment similarity index values for sample plots at the Anthro Mountain, UT site.

PRE-TREATMENT (2009) Shallow Loam Ecological Site			POST-TREATMENT (2010) Shallow Loam Ecological Site		
Plot	Raw	Quality Reduction	Plot	Raw	Quality Reduction
T1-1	87.4	87.4	T1-1	84.90	84.90
T1-2	15.8	15.8	T1-2	69.78	69.78
T1-3	68.9	68.9	T1-3	59.94	59.94
T2-1	71.2	71.2	T2-1	81.10	81.10
T2-2	57.2	57.2	T2-2	46.80	46.80
T2-3	50.8	50.8	T2-3	54.07	54.07
T5-1	51.8	51.8	T5-1	93.90	93.90
T5-2	80.0	80.0	T5-2	35.63	31.01
T5-3	73.0	73.0	T5-3	85.56	85.38
T7-1	56.3	56.3	T7-1	71.86	71.86
T7-2	65.9	65.9	T7-2	77.93	77.93
T7-3	65.9	65.9	T7-3	77.93	77.93
MEAN	*62.00*	*62.00*	*MEAN*	*69.95*	*69.55*
VAR	*333.54*	*333.54*	*VAR*	*305.67*	*335.76*
STD ERR	*5.27*	*5.27*	*STD ERR*	*5.05*	*5.29*

A few differences in vegetation were noted. Pine and juniper were removed by the treatment. Muttongrass was reported to significantly increase while bluebunch wheatgrass declined. Reasons for these changes are not known. Several forbs showed significant increases between pre and post-treatment. Similarity indices did not significantly differ between pre and post-treatment conditions, although an increasing trend was noted.

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 17.

Table 17. Results of wildlife species modeling for the Anthro Mountain project area in Utah.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Sage thrasher	0	42	6	0	42	9
Sagebrush lizard	45	1595	683	44	1582	39
Sage sparrow	0	18	44	0	15	48
Sage grouse- nesting	77	214	490	78	213	500
Sage grouse brood-rearing	0	2	354	0	3	352
Sage grouse- wintering	13	16	68	13	16	69

*Pre-high refers to number of high quality home ranges identified in pre-treatment conditions, with medium and low similarly identifying these quality home ranges for both pre and post-treatment conditions.

The landscape analyses showed little difference between pre and post-treatments. The reduction in juniper and pine apparently did not change the model values sufficiently to cause a change in habitat quality, at least for the limited treatment area within the overall landscape included in the analyses.

Deadman's Bench Project, Utah

This project was conducted cooperatively with Utah's Watershed Restoration Initiative, and was located in Uintah County in northeastern Utah. It is an area of relatively flat terrain supporting sagebrush. The sagebrush in the project area was considered to be in a state to adequately provide the desired wildlife habitat. The sagebrush was also experiencing an expansion in invasive species resulting in poor quality of understory vegetation. The greater sage grouse population in this area was small and poor habitat condition was identified as a significant contributor to the situation.

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

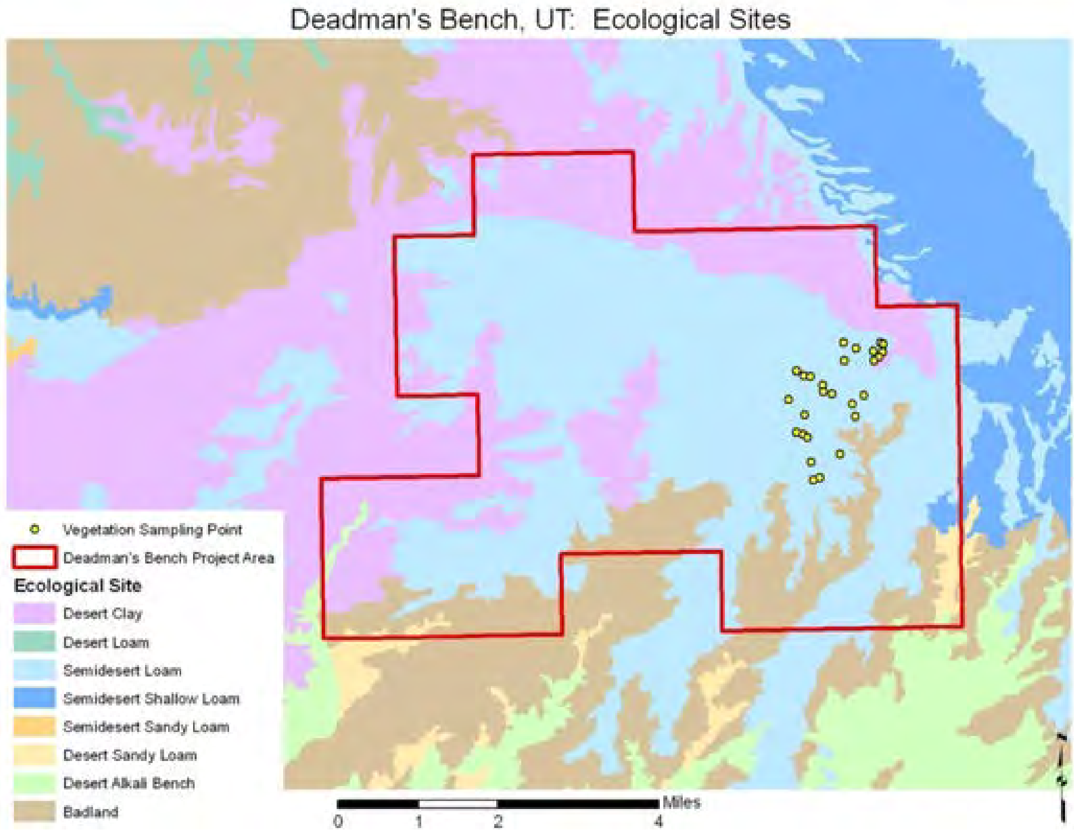

Figure 23. Ecological sites of the Deadman's Bench project area in Northeastern, UT.

Reference Plant Community Development

Semidesert Loam Ecological Site

As described in the ESD for this site, the semidesert loam site occurred 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 were 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.

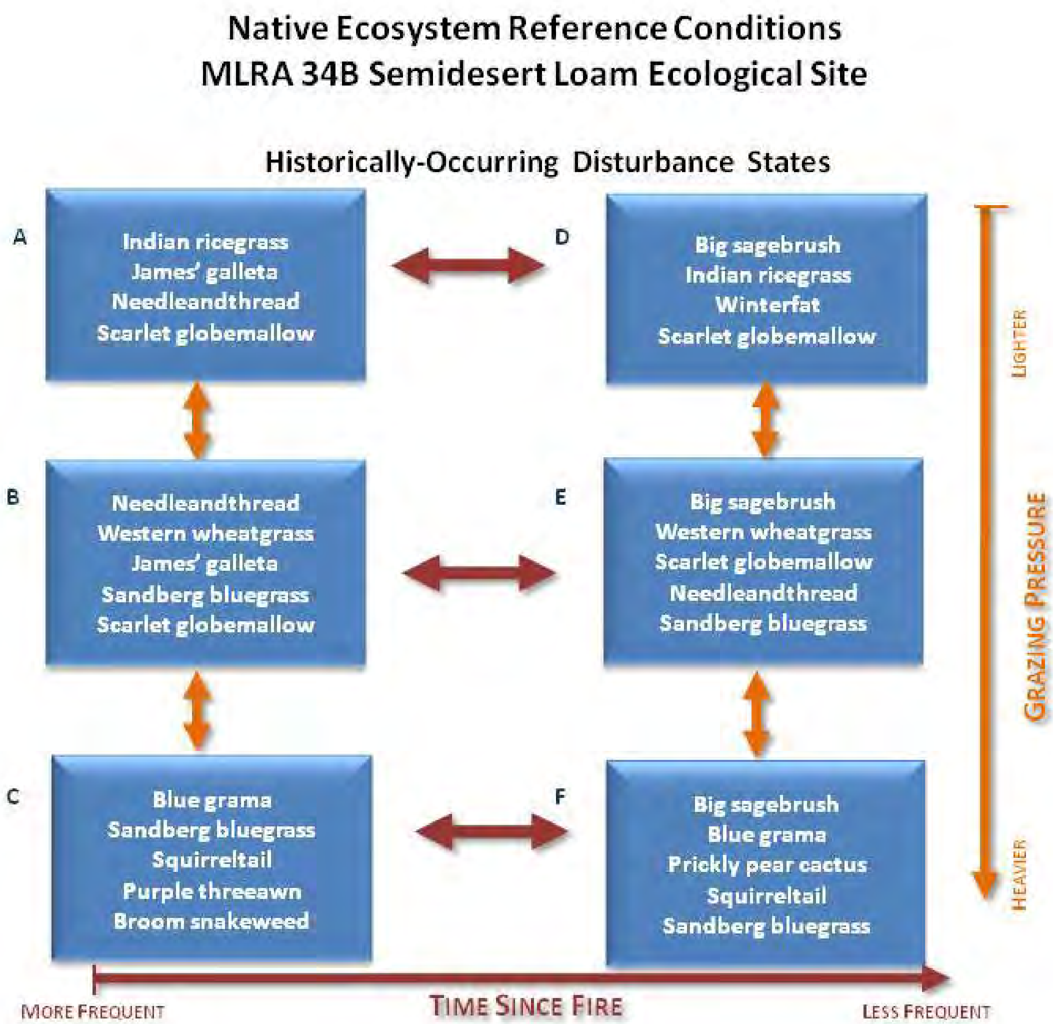

Figure 24. State and transition model for semidesert loam sites in MLRA 34B in the 8-12" precipitation zone.

Historical plant communities described for the semidesert loam ecological site are as follows.

- **A. Light herbivory - short fire return interval plant community**

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. Moderate herbivory - short fire return interval plant community**

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. Heavy herbivory - short fire return interval plant community**

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. Light herbivory - long fire return interval plant community**

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. Moderate herbivory - long fire return interval plant community**

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. Heavy herbivory - long fire return interval plant community

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.

Desert Clay Ecological Site

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.

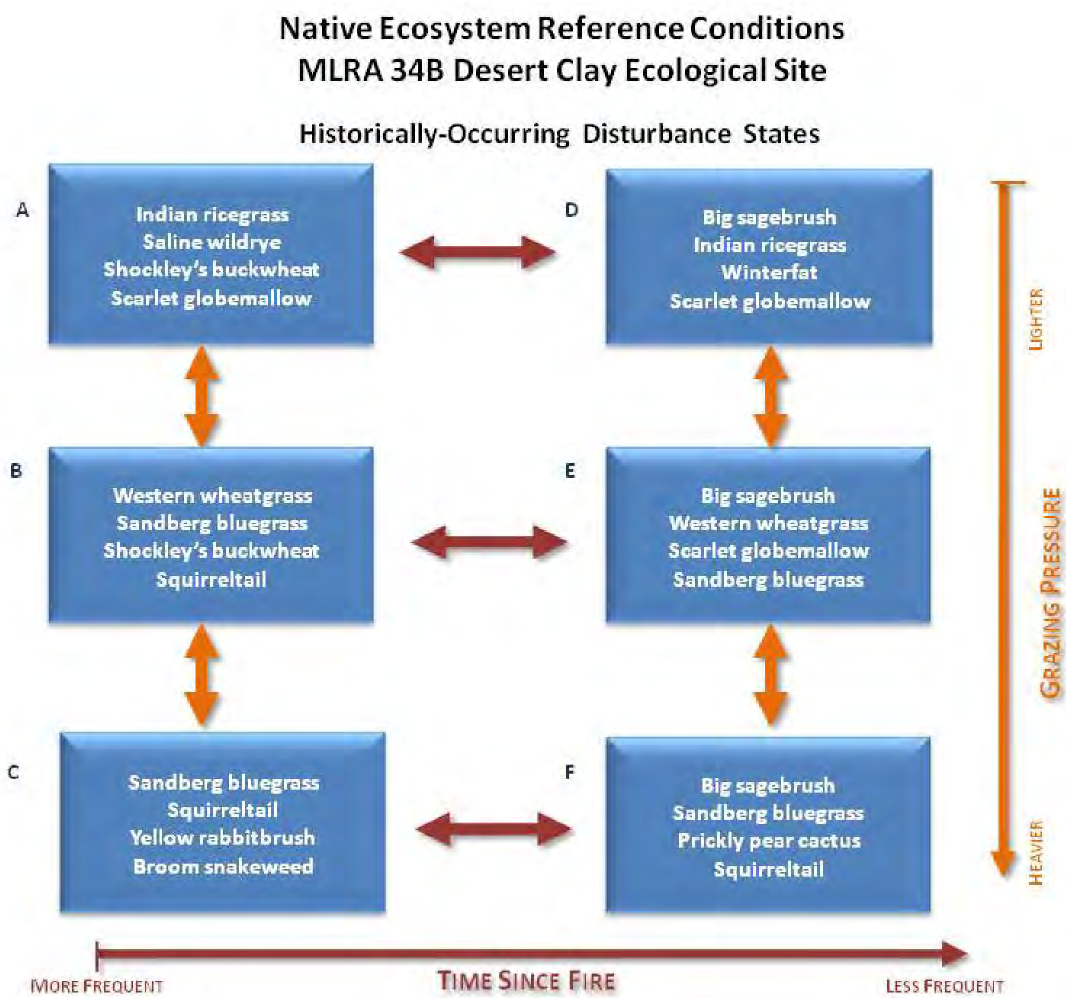

Figure 25. State and transition model for desert clay ecological sites in MLRA 34b, 8-12" precipitation zone.
Historical plant communities described for the loamy ecological site are as follows.

- **A. Light herbivory - short fire return interval plant community**

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. Moderate herbivory - short fire return interval plant community**

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. Heavy herbivory - short fire return interval plant community**

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. Light herbivory - long fire return interval plant community**

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. Moderate herbivory - long fire return interval plant community**

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. Heavy herbivory - long fire return interval plant community**

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.

Recommended Reference Plant Community

The reference plant communities 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%.

Treatments

Treatments applied included: 1) broadcast seeding and a double pass from a Dixie harrow, and 2) seed broadcast on plots that were strategically grazed by sheep to reduce canopy cover. A total of 560 acres in 10 plots were treated using the Dixie harrow. The size of the plots to be treated mechanically was no less than 40 acres each. Each treatment plot had a control plot to be used for comparison to determine treatment effects on vegetation and greater sage grouse use. A total of 64 acres was used to implement the grazing treatments. Of this acreage, 40 acres was used to conduct an actual grazing experiment. The remaining 24 acres were 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 was no smaller than 10 acres. Control plots were established for comparison to document treatment effects.

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

Plant Community Sampling

Site Level Results

Results for pre and post-treatment vegetation sampling in 2010 and 2011 for the semidesert loamy ecological site are listed in Table 18.

Table 18. Dominant plant species (with greater than 1% relative cover) sampled at the Deadman's Bench, Utah site in 2010 (pre-treatment) and 2011 (post-treatment) for the semidesert loam ecological site in the treatment area, presented as relative cover (standard error).

	Shallow Loamy Ecological Site	
	2010	**2011**
pale madwort	**3.82** (1.53)	**0**
big sagebrush	17.25 (1.54)	13.51 (1.56)
beggarticks	**8.8** (3.76)	**0**
cheatgrass	**20.13** (4.96)	**53.31** (4.61)
squirreltail	**30.66** (5.35)	**18.52** (4.73)
needle and thread	3.57 (1.95)	5.26 (2.31)
lupine	1.5 (1.34)	2.18 (0.9)
woolly plantain	**1.67** (1.08)	**0**
tall tumblemustard	**2.48** (0.84)	**0**
globemallow	**7.35 (2.5)**	**1.57 (0.51)**

The vegetation sampling revealed several differences between years. The greatest differences were in the increase in cheatgrass following treatment and the decline in squirreltail. The Plateau herbicide was applied to the site prior to the anchor chaining. It would appear that the desired response to the herbicide was not achieved, likely due to the site and soil disturbance that occurred after its application. The decline in squirreltail could be due to the combined effects of the site disturbance as well as the high levels of cheatgrass that were present to compete for moisture and nutrients. Declines were also noted in globemallow, woolly plantain, Beggerticks, and pale madwort. Sagebrush declined slightly (not surprising following anchor chaining) but this decline wasn't significant. With only one year of post-treatment monitoring due to the timing of the treatments, little more can be said about the site response to the treatments. With longer monitoring, the seeding should become established, and hopefully the amounts of cheatgrass will decline.

Similarity indices for Deadman's Bench were determined for pre-treatment plots and for the first year post-treatment. These results are presented in Table 19.

The similarity indices for Deadman's Bench displayed a significant decline in value following treatment. This was largely due to the substantial presence of cheatgrass occurring on the plots in 2011. As mentioned, the Plateau treatment, applied prior to the mechanical treatment of the site, had limited effectiveness in controlling the cheatgrass. As mentioned, the first year post-treatment is also very early for seeding to become established and display a significant contribution to the plant community. While the future status of cheatgrass on the site remains uncertain, it is certainly expected that the seeding will increase the amounts of desirable native species in the future, and generate an increase in similarity index values.

Table 19. Comparison of pre- and post-treatment similarity index values for sample plots at the Deadman's Bench, UT site.

Pre-treatment			**Post-treatment**		
Desert Loam Ecological Site			**Desert Loam Ecological Site**		
Plot	Raw	Quality Reduction	Plot	Raw	Quality Reduction
DH1-1	25.31	25.31	DH1-1	25.63	4.90
DH1-2	23.30	22.66	DH1-2	24.53	4.54
DH1-3	40.67	40.29	DH1-3	21.68	3.71
DH2-1	24.53	23.86	DH2-1	27.48	9.19
DH2-2	32.44	32.44	DH2-2	18.82	3.03
DH2-3	39.80	39.08	DH2-3	24.98	14.10
DH4-1	13.73	13.48	DH4-1	31.62	23.25
DH4-2	41.73	37.47	DH4-2	27.65	6.01
DH4-3	38.80	38.28	DH4-3	32.41	9.67
G1-1	41.74	39.55	G1-1	25.34	4.80
G1-2	52.72	47.19	G1-2	22.67	3.98
G1-3	42.24	40.03	G1-3	29.67	6.49
G2-1	23.73	23.51	G2-1	25.47	18.56
G2-2	26.81	26.81	G2-2	25.95	16.65
G2-3	31.37	31.37	G2-3	20.70	10.08
G3-1	40.23	40.23	G3-1	43.40	37.09
G3-2	35.78	35.78	G3-2	41.48	19.79
G3-3	20.90	20.90	G3-3	30.56	10.97
G4-1	75.33	74.08	G4-1	71.68	58.88
G4-2	62.93	62.07	G4-2	41.09	15.37
G4-3	33.21	33.21	G4-3	43.99	32.58
MEAN	*36.54*	***35.60***	*MEAN*	*31.28*	***14.94***
VAR	*206.01*	*189.54*	*VAR*	*141.07*	*189.66*
STD ERR	*3.13*	*3.00*	*STD ERR*	*2.59*	*3.01*

Landscape Level Analysis

Wildlife species modeling results for Deadman's Bench are presented in Table 20.

The landscape analysis found few changes in habitat quality as a result of the treatments. High quality habitat for sage sparrows decreased, but no other changes were noted.

Table 20. Results of landscape modeling analyses for pre and post-treatment conditions for the landscape including the Deadman's Bench treatment site.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Pronghorn	0	0	16	0	0	17
Sage thrasher	99	6	4	100	7	2
Sagebrush lizard	27	882	654	20	865	795
Sage sparrow	37	33	34	0	51	45
Sagebrush vole	419	854	140	416	765	132
Sage grouse- nesting	822	1344	2492	823	1381	2475
Sage grouse brood-rearing	25	508	189	28	510	182
Sage grouse- wintering	53	254	227	51	250	232

*High, medium, and low refer to the number of home ranges of the modeled species occurring in the landscape for both pre and post-treatment analyses.

Rock Springs Project, Utah

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

The Rock Springs project area was 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 was 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.

Reference Plant Community Development

Upland Loam Ecological Site

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.

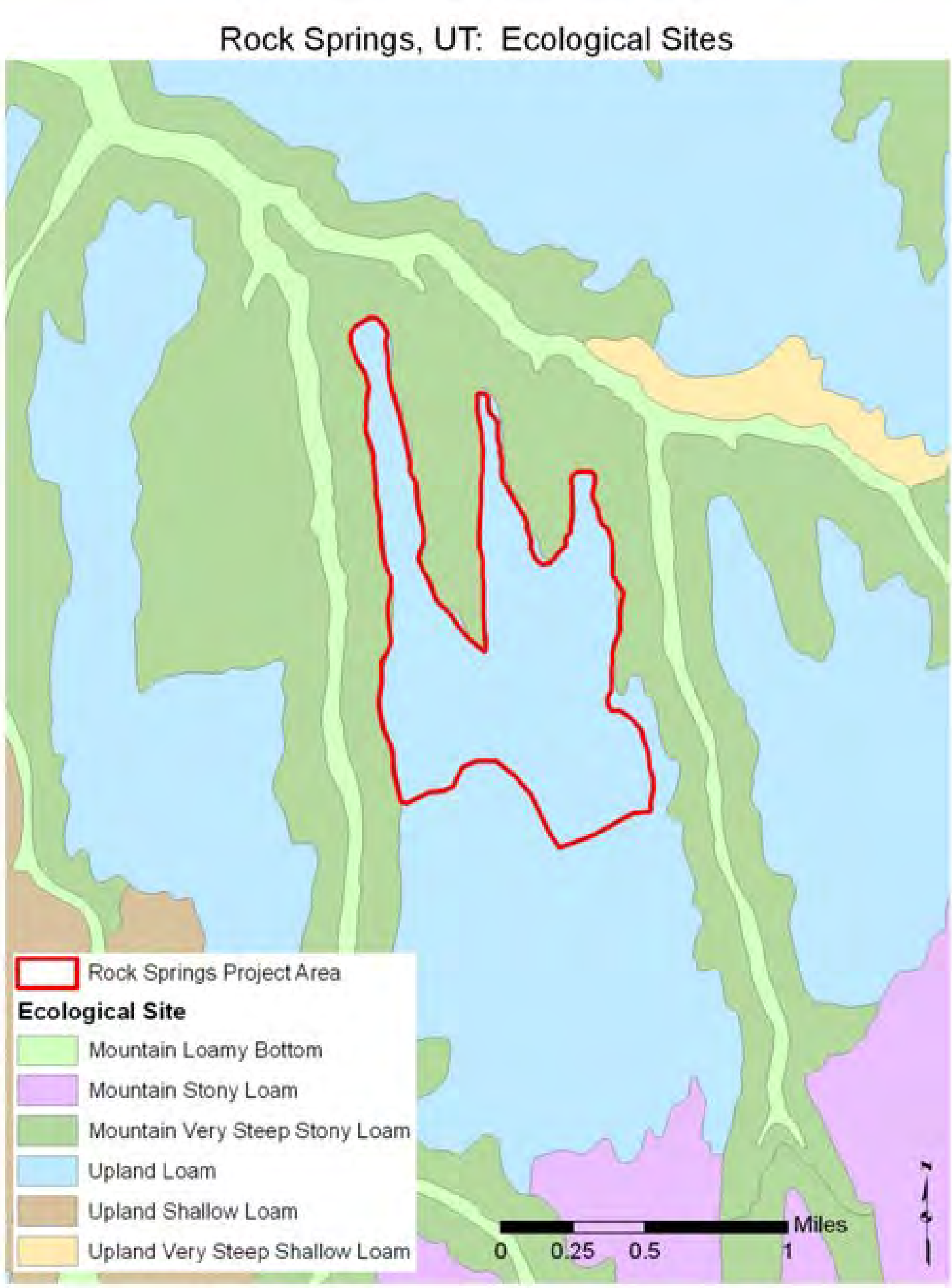

Figure 26. Map of ecological sites in the Rock Springs project area in Utah.

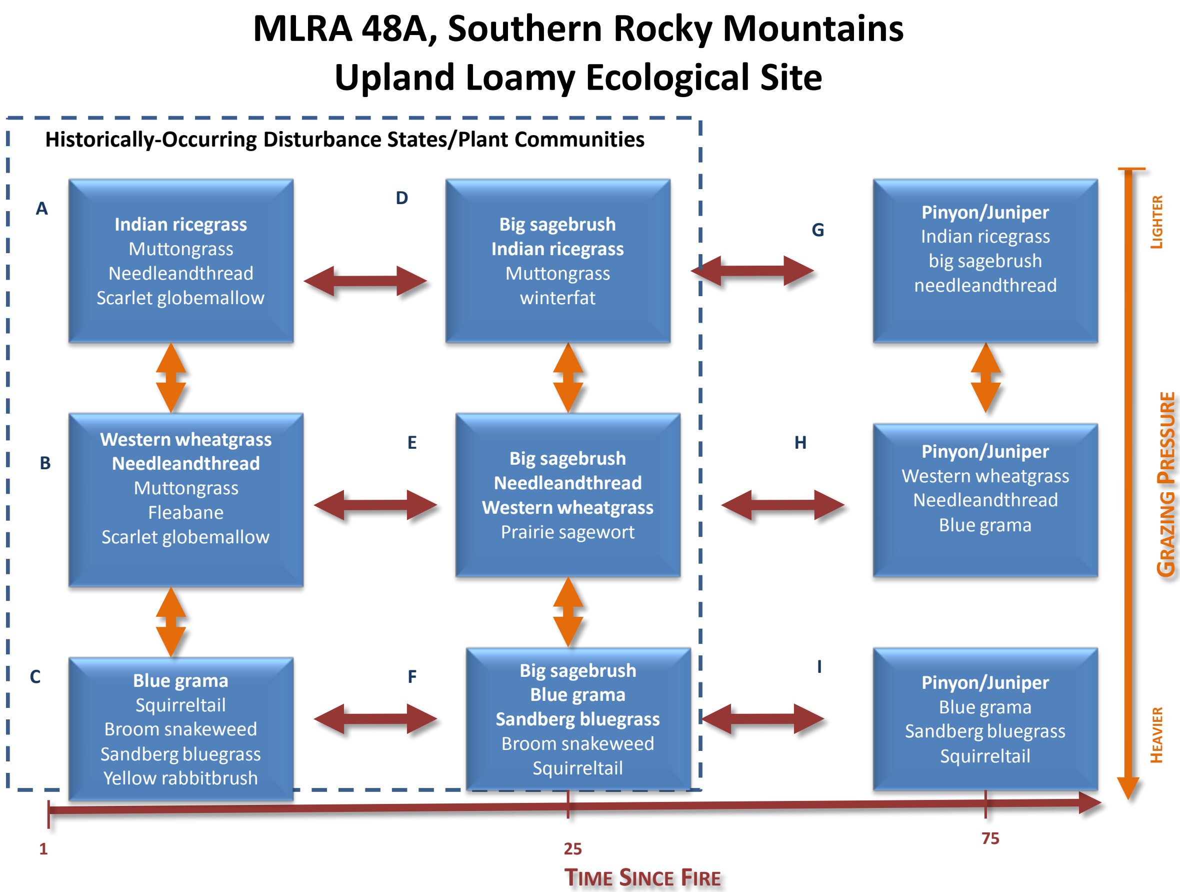

Figure 27. State and transition model for upland loamy ecological sites in MLRA 48A, 12-14" precipitation zone.

Historical plant communities described for the upland loam site are as follows.

- A. Light herbivory - short fire return interval 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. Moderate herbivory - short fire return interval plant community

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. Heavy herbivory - short fire return interval plant community**

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. Light herbivory - intermediate fire return interval plant community**

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. Moderate herbivory - intermediate fire return interval plant community**

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. Heavy herbivory - intermediate fire return interval plant community**

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. Light herbivory - long fire return interval plant community**

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. Moderate herbivory - long fire return interval**

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. Heavy herbivory - long fire return interval plant community**

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

Recommended 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%.

Treatments

This project, conducted in 2010, treated approximately 500 acres of pinyon-juniper. Pinyon and juniper trees were mechanically removed using a rubber-tired bullhog machine. Trees were shredded and material left on-site. Due to the amount of herbaceous understory present in the project area, no seeding was conducted. The site was used for grazing prior to treatment, and this use is planned to be continued after treatment.

Plant Community Sampling

Site Level Results

Vegetation was sampled on the site pre-treatment in 2010 and post-treatment in 2011. Table 21 lists the cover for each species measured in 2010 and 2011.

Vegetation sampling at the Rock Springs site revealed several differences between pre and post treatment. The amounts of pinyon pine and juniper, the targets of the treatment, declined significantly. Big sagebrush also declined significantly, likely due to the disturbances to this species of the bullhog treatment. Squirreltail increased dramatically following treatment, while Sandberg bluegrass declined. A number of forb species were noted post-treatment that had not been observed in the pre-treatment sampling.

Similarity index values were determined pre and post-treatment for the Rock Springs project area. These values and listed in Table 22.

Table 21. Dominant plant species (with greater than 1% relative cover in any year) sampled at the Rock Springs, Utah site in 2010 and 2011 for the upland loamy ecological site in the treatment area, presented as relative cover (standard error).

	Loamy Ecological Site	
	2010	**2011**
agoseris	**0**	**2.14** (0.91)
pussytoes	0	2.09 (1.18)
big sagebrush	**13.93** (2.83)	**4.24** (1.22)
milkvetch	6.54 (4.41)	4.64 (2.39)
Indian paintbrush	1.55 (1.11)	2.31 (1.04)
mountain mahogany	2.28 (1.88)	0
squirreltail	0	**35.35** (7.86)
fleabane	0	1.75 (0.89)
gilia	2.18 (1.16)	0
needle and thread	13.13 (4.39)	6.05 (3.9)
Utah juniper	**2.32** (0.9)	**0**
Junegrass	2.94 (1.56)	0
field locoweed	0	1.2 (0.91)
mat penstemon	0	4.73 (2.44)
western wheatgrass	3.25 (1.81)	0
phlox	12.31 (3.56)	9.18 (2.74)
twoneedle pinyon	**14.6** (4.32)	**0**
muttongrass	1.88 (1.88)	0
Sandberg bluegrass	**17.8** (5.15)	**3.87** (1.36)
tall tumblemustard	0	3.06 (2)

The similarity indices for Rock Springs showed a significant decline post-treatment compared to the pre-treatment values. As the mechanical treatment (bullhog) involved disturbance to the site and the scattering of mulched trees, it would be expected that one year post treatment, the vegetation would show some effects of this disturbance. Analysis of the plant cover values revealed the drop in sagebrush cover that would have caused some reduction in similarity values.

Table 22. Comparison of pre- and post-treatment similarity index values for sample plots at the Rock Springs, UT site.

Pre-treatment (2010)			Post-treatment (2011)		
Loamy Ecological Site			Loamy Ecological Site		
Plot	Raw	Quality Reduction	Plot	Raw	Quality Reduction
1	50.97	50.60	1	30.57	30.57
2	79.12	79.12	2	47.01	44.98
3	52.83	52.83	3	32.13	31.99
4	55.23	55.23	4	35.33	35.11
5	39.07	39.07	5	34.73	34.45
6	64.90	64.90	6	35.74	27.88
7	24.61	24.61	7	19.65	19.65
8	70.62	70.62	8	60.19	59.63
9	55.88	55.88	9	25.00	25.00
10	62.17	62.17	10	21.23	21.23
11	64.32	64.32	11	10.00	10.00
12	55.23	55.23	12	30.79	30.79
MEAN	***56.25***	***56.21***	*MEAN*	***31.86***	***30.94***
VAR	*203.90*	*204.27*	*VAR*	*168.9*	*159.6543*
STD ERR	*4.12*	*4.13*	*STD ERR*	*3.75*	*3.65*

Landscape Level Analyses

The analysis of wildlife species at the landscape scale was conducted for sage thrasher, sagebrush lizard, sage sparrow, sagebrush vole, and sage grouse. Results are presented in Table 23.

Table 23. Results of wildlife species modeling for the Anthro Mountain project area in Utah.

Species	Pre-High*	Pre-Medium	Pre-Low	Post-High	Post-Medium	Post-Low
Sage thrasher	2	20	16	1	11	17
Sagebrush lizard	0	0	620	0	0	465
Sage sparrow	1	55	12	24	34	13
Sagebrush vole	35	128	789	35	140	817
Sage grouse- nesting	482	1069	1278	461	1077	1383
Sage grouse brood-rearing	0	223	224	0	221	225
Sage grouse- wintering	104	36	139	103	36	138

*Pre-high refers to number of high quality home ranges identified in pre-treatment conditions, with medium and low similarly identifying these quality home ranges for both pre and post-treatment conditions.

Few differences were noted in species habitat conditions in comparisons of pre and post-treatment model results. Sage sparrow high quality home ranges increased despite the decline in sagebrush.

4.0 LOCAL STAKEHOLDER DISCUSSIONS

Meetings were held in each state where project sites were located as well as in Colorado and interested stakeholders invited to participate, including project cooperators, producers and producer groups, interested agencies (both state and Federal), and other interested stakeholders. Meetings were conducted in Denver CO, Sheridan WY, Salt Lake City Utah, Boise ID, and Susanville CA. In addition, a meeting was conducted with the Habitat Committee of the Western Association of Fish and Wildlife Agencies to review the metrics and solicit input on their application for mitigation. A presentation was also made at the CIG Showcase held at the Soil and Water Conservation Society Meeting in 2011, and input requested from attendees of that presentation. At each meeting, the mitigation metric and its determination along with preliminary results for nearby projects were presented. Input was solicited from each group on the specifics of the metrics, potential uses of the metrics, and various questions concerning how the metrics might be applied. Specifically, the following list of questions was posed to each audience, while any additional suggestions or input from the participants were also noted.

1. Were reference conditions used for similarity indices appropriate and correctly described?
2. Was the selected reference plant community appropriate, or should a different plant community have been used?
3. Was the similarity index used in the project appropriate?
4. Was the exotic species reduction curve used in the project appropriate?
5. Should all exotic species be included in the exotic species reduction calculation?
6. Were the wildlife species selected for the landscape analyses appropriate?
7. Were the landscape scales (1-5 miles) used in the species assessments appropriate?
8. Is a 1:1 ration of impacts to mitigation appropriate for mitigation trading, or should a different ration (e.g., 1:3) be used?
9. Should the existing condition of an impact site in comparison to reference conditions be used as the basis for quantifying impacts, or should a value of 1.0 be used or be added to the existing condition?
10. Should effects of human developments (roads, wells, etc.) be included in landscape models for species?
11. Should known species use/distributional information (e.g., sage grouse lek locations) be used in the landscape analyses, or should metrics rely only on the existing habitat potential of each area?
12. Should mitigation within an MLRA be credited if developed in a different ecological site than the impact ecological site, or can mitigation be switched among ecological sites? If switching is allowed, what parameters should be considered?
13. Can mitigation be credited across MLRA boundaries, and if so what parameters should apply?
14. Should direct production of mitigation metrics to off-set impacts be required, or can monetary compensation only be allowed?

At each meeting with stakeholders, excellent discussions followed an initial presentation on the metrics and the local project(s). In general, there was strong support for use of the selected reference plant community and the descriptions of the reference conditions. It was suggested that while this provided a good standard for the goal and general use of the metric system, that local modifications, where justified, should be allowed. For example, in Idaho and Utah, where selected exotic species were included in seeding mixes in order to establish a desired plant community and reduce competition from annual exotic forbs, it was suggested that the reference community should recognize as acceptable these exotic species. So, while in general the goal of maintaining and restoring native plant communities was recognized as appropriate, flexibility should be allowed where such a need can be justified by local managers. The use of a similarity index was supported as a basis for site level comparisons. No concerns were expressed over the modifications developed in this project to add greater flexibility to the calculation of a similarity index, although stakeholders did not conduct a thorough examination of these modifications. One stakeholder suggested adding a ground cover value as an index to soil stability that would reflect advantages of overall plant cover, regardless of the species present.

The exotic species curve was discussed. One suggestion was to keep the curve linear, as the curvilinear equation used didn't differ that greatly from linear, but added additional complexity to the calculations. Originally, all exotic species were included in the exotic species reduction equation. It was recommended that many exotic species, while not necessarily deserving of being included in the similarity score, do not sufficiently degrade a community to add in an additional reduction for their presence. It was recommended that exotic species reduction only include those species that are considered invasive or noxious. EMRI recalculated all similarity values and only included invasive or noxious species in the exotic species reduction.

The wildlife species included in the landscape assessment component of the metrics were generally thought to be appropriate. Brewer's sparrows were suggested as a possible additional species, as was the mule deer. However, it was acknowledged that mule deer occur in a much broader array of vegetation communities than sagebrush, so that its inclusion could make landscape analysis much more complicated. The scales of analysis were deemed appropriate, although the challenges of addressing needs of migratory populations of sage grouse were noted. Inclusion of effects of anthropogenic activities was thought by a number of stakeholders to be important. However, the challenge of identifying a model acceptable to a consensus of stakeholders that quantified these effects was recognized, especially for contentious species such as sage grouse.

Stakeholders generally agreed that mitigation should occur at a minimum of a 1:1 ratio with a number of people suggesting that a 1:3 ratio was probably more appropriate. In other words, a minimum of 1 acre or unit and for some stakeholders at least 3 acres or units should be improved through mitigation for each acre or unit impacted by development. Determination of the impact area was not as simple as might be thought. An impact area will have a certain footprint where activities will directly disturb the site and its plant and animal community. It will also have a larger area where particularly wildlife species may be impacted by the disturbance occurring nearby. However, defining the distance and extent of this disturbance on various wildlife species can prove challenging, and is further influenced by such additional factors as terrain, vegetation conditions, time of year, and other factors. There was a high degree of agreement on the direct effects of the development footprint at a site, but less agreement, particularly at increasingly larger distances on the disturbance impacts on various species. Our analysis of landscape impacts is designed to address these types of effects however we did not develop or use disturbance effects models in our analysis. Our analysis was restricted to the direct changes to habitat conditions, and how habitat conditions can be improved at a mitigation site to offset similar impacts to habitat at a development site. Haufler et al. (2009) (http://www.emri.org/PDF%20Docs/Adobe%20files/co%20cig%20report_reduced.pdf) did conduct a simulated analysis of disturbance effects of development at landscape scales to demonstrate how such an approach could be used, but did not propose that the landscape scale disturbance models that they used were more than an example of how such a system could be applied. This question of direct versus disturbance and even other indirect effects of developments on ecosystems and wildlife will need additional focus and details to be accepted by a wide diversity of stakeholders.

The question of units versus acres was discussed at each meeting of stakeholders. An impact or mitigation unit differs from the acres impacted or improved as a mitigation or impact unit quantifies the level of change that has occurred relative to the reference condition and multiplies this level of change times the acreage involved. Thus, if a site was improved so that its similarity index increased by 0.5, then if 100 acres were treated, 50 mitigation units would be generated. Generally an impact site, at least for the actual development footprint, will take a site to a 0 value. The additional disturbance effects, discussed above, would be quantified through the landscape analysis of the appropriate species. Two important questions on use of units were discussed. First, if an impact site under pre-development conditions has a site value substantially less than one, for example if the site is dominated by cheatgrass, should the existing value of that site be the basis for the required mitigation, or should the potential of that site or some other value be the basis for mitigation? If 100 acres are to be developed, and it had an existing similarity index of only 0.2 because it is essentially a site invaded by cheatgrass or noxious weeds, then should the developer only need to mitigate for 20 mitigation units? Many stakeholders expressed that at a minimum, the actual acreage being impacted (in this case 100 acres) should be the minimum required mitigation. Another possibility would be to have an impact site be quantified as the acreage being impacted plus its existing value. Thus, in the case suggested here, the impact site would need 120 mitigation units to offset the development impact, while a site with an existing similarity index of 0.8 would require 180 mitigation units. This combination of acres and quality seemed to capture the concerns for potential conditions at a site along with its existing condition, and possible desires for a mitigation ratio greater than 1:1.

The second discussion of mitigation units concerned whether many acres could be treated in a mitigation area to offset the impacts of a smaller number of acres of much higher quality of an impact area. In other words, if 100 acres of a high quality (0.8) area were being impacted (using the above discussion requiring 180 mitigation units), could this be offset by improving 1800 acres by a very small level of improvement (0.3 to 0.4 increase, for example). Most recognized that marginally improving a low quality area was unlikely to adequately offset a major disturbance to a high quality area. However, it was recognized that the best way to track such differences was through the landscape analysis and the effects expected to be seen by the wildlife species and the number of various quality home ranges determined by the habitat based species viability approach. In this case, a wildlife species might have 10 high quality home ranges in the impact area, and the mitigation treatments wouldn't increase the number of high quality home ranges in the mitigation area, so although the units may be equal, the offsetting mitigation treatments would not be deemed an acceptable credit because of the unequal effects on wildlife.

The discussion of use of known population distribution information for species included in the landscape analyses was discussed at several of the meetings. It was thought that this information may provide some useful insights on some species (primarily sage grouse), but its importance should not be over emphasized. There were concerns about relying too heavily on such information due to:

- Few species have such distributional information available for them,
- Not all important areas in use by even well studied species will be known,
- Focus on existing distributions undermines the potential for mitigation to help expand populations of species into new areas,
- Some long-lived species may have legacies of uses of an area that may not be sustainable under observed existing conditions.

Based on these considerations, it was suggested that other than such general designations as core areas for species such as sage grouse, that information such as lek locations be used only as supplemental information, and not as a specific component of a metric system. A concern was raised that we have not identified core areas for species other than sage grouse, so too much focus on these areas produces too much of a single species emphasis.

The metric system is designed to produce an equivalent measure of impacts to mitigation by ensuring that mitigation sites are equivalent to impact sites for both the types of ecosystems being considered as well as broader landscape effects. This means that to be completely equivalent, a mitigation site should match the ecological site being impacted and as such, occur within the same MLRA. This complicates mitigation as it would require finding equivalent ecological sites that also can play an equivalent landscape function to produce mitigation benefits exactly equal to impacts. The limited likelihood of producing such sites, even as desirable as it may be to do so, given all of the considerations of management constraints, means that some flexibility should be acceptable in the mitigation process. Various options were discussed.

In discussing the desirability of swapping among ecological site, several points were noted. First, it was recognized that mitigation might be more likely to succeed and produce greater benefits if applied on higher productivity (generally higher moisture or deeper soil) ecological sites than on lower productivity sites. For example, an impact occurring on a lower elevation saline site might be hard to mitigation on a similar site, as the harsh site conditions might make mitigation treatments risky and produce only slow response by a resulting treated plant community. If a nearby loamy site in a higher precipitation zone could be treated, higher quality sagebrush communities might be produced in a much quicker and assured response, and produce greater responses by various sagebrush-associated wildlife species. This was generally viewed as an acceptable trade-off. However, it was noted that if this were allowed, it is possible that no high quality saline sites might then be retained in the landscape, and the species reliant on these sites, while not currently recognized as of conservation concern, could become a new group of concern species. It was suggested that for such trade-offs in mitigation sites to be accepted, that first an assessment of the status and potential future risks to the lower productivity sites be conducted. If it can be shown that future risks to the lower productivity sites and associated species are likely to be low, then a trade-off to higher productivity sagebrush sites could be acceptable. It should be noted that concerns were expressed that accepting lower productivity sites for mitigation for impacts to higher productivity sites should not be allowed, except where a clearly documented conservation need has been identified to justify such a tradeoff. Wildlife have for decades been relegated lands that have no other identified economic use at the that time, so most higher productivity sites are rarely included in lands targeted for wildlife management. Thus, while the need for flexibility in trading off among ecological sites is recognized, such tradeoffs should be guided by careful analysis and justification, and should not allow for lower productivity sites to replace higher productivity sites without a clearly documented conservation need and benefit from such a tradeoff. A suggestion was offered that impacts and mitigation should only be allowed within the same type of sagebrush- thus an impact to a Wyoming big sagebrush community should be mitigation in a similar community, even if a mountain big sagebrush community might have higher productivity in a nearby location.

Trading across MLRA boundaries was also discussed. MLRA boundaries are loosely mapped and generally represent gradients of change. They should typically not form hard boundaries for management decisions, such that a mitigation area close to the edge of an MLRA may be quite acceptable to offset an impact area occurring in an adjacent MLRA. The question of having impact and mitigation areas in separated MLRA's raises different questions. For example, should impacts in southwest Wyoming be able to be mitigated in central Idaho. While a few stakeholders thought this could be desirable, considerable concerns from both an ecological and social acceptability standpoint were voiced. Much of these discussions quickly switched from an ecosystem-based approach to mitigation to a species-based approach focusing on sage grouse. Some suggestions included allowing mitigation to occur within the same sage grouse management zone instead of MLRA's. Some suggested that mitigation should occur within core areas for sage grouse, but were not specific on how far away acceptable core areas might be from impact areas. The crux of this discussion comes down to how much an ecosystem-based system is desired (one of the original objectives of this project), and how much can a species-based approach override the ecosystem-based framework. As a primary basis of the metrics was the use of an ecosystem-based approach, switching to a species-based approach is considered a major deviation of purpose. While a sage grouse metric system could be developed that would be more simply to apply, it would lack the conservation underpinnings desired of the ecosystem-based approach, and as such has not been viewed as an acceptable alternative to the objectives of this project.

One aspect that was agreed upon by stakeholders was that for a mitigation framework to work, it must produce documented results on the ground, and not simply be a financial arrangement for some potential benefits to be produced. While financial transactions will undoubtedly form the actual treatment agreements, the mitigation benefits produced must be quantified as on the ground mitigation units that have been documented to be equivalent replacements (even with considerations for ecological site tradeoffs or cross MLRA boundaries) for measured impacts.

While agreement existed that on-the-ground benefits should be the requirement rather than simply a financial commitment, there was concern that if best known management practices are applied to a site with an expected result, that this expected result should be the benefit credited, even if the treatments were unsuccessful. The thinking was that if actual changes on the ground are required, then developers would only want to conduct treatments on sites with a very high probability of success. Sites that are more difficult to improve or new treatments that hold promise but do not have a long track record might be avoided. Some review process that assures that good treatments based on best available science are being followed would need to be in place, but if this review process approved the application of a treatment with an expected response described, then the developer might reasonably expect to be credited with that expected response. One group suggested that perhaps a mitigation "insurance" fund could be created, whereby if an applied treatment was unsuccessful due to weather conditions or other factors, that this fund could step in to improve the site, taking the responsibility off of the developer who had funded a legitimate effort that was unsuccessful for reasons beyond their control.

Similarly, the question was raised about benefits being generated by simply maintaining a high quality area. On one hand, no improvements to the site were made, but if the site were maintained when it might have been degraded in quality, should this be a credit? How would credits be assigned, would they be based on the potential to degrade the site to a 0 value, or would some lesser benefit be assigned? Another group raised the question that if treatments were applied that were designed to keep areas from burning and losing habitat through these burns, how do you give credit for this?

The timing of producing mitigation benefits and development impacts was also discussed at some meetings. Impacts generally occur rapidly, with the onset of construction. They may be permanent, or have a shorter impact life, such as a 20 year expected life of many gas wells. Mitigation generally takes some time to produce optimal benefits, although some mitigation treatments such as control of invasive species may occur quite quickly. Incorporating these temporal aspects into a metric system was recognized as important. The short duration of this project did not allow suitable post-treatment time to incorporate good measurement of mitigation over a time span. The metric system as described by Haufler and Suring (2009) is designed to operate with impact and mitigation units determined on an annual basis. A challenge with this is that with annual weather events, would this mean that vegetation would need to be sampled annually to account for differences in plant community compositions and productivity? Some middle ground would seem to be needed between sampling vegetation annually and assigning site quality values without any data collected from the site. How the sampling results should be used relative to the discussion above about treatments that might not be successful but should still provide benefits to the developer would need further discussion and development.

Other suggestions were made for inclusion in the metric system or for its application in a mitigation trading framework. It was suggested that a key ecosystem service that should be included was the value of a site for livestock grazing. While the metric system did include estimates of herbaceous productivity in its descriptions of reference plant communities, productivity of herbaceous vegetation was not included in the plot sampling due to the challenges of accurately collecting this information and the increased intensity of sampling involved. Therefore, while this project did not collect the data to adequately address this ecosystem service, its inclusion in site evaluations would be quite feasible. How the supply of this ecosystem service would then be incorporated into a metric system is unclear. Certainly, changes to amounts of grass production could be determined and used as an index to grazing potential of a site. This might be applied as a multiplier of the conservation index produced from comparisons to the reference community. However, the appropriateness of increasing or decreasing the value of the conservation index through an index of grazing benefits would need further evaluation. Another stakeholder commented on the use of the term “light grazing” in identifying the reference plant community that would occur under many years of light grazing use, and cautioned that light grazing was a term that was likely to have many difference interpretations.

It was noted that climate change may make restoration of some reference conditions at some sites difficult or impossible. It was suggested that reference conditions be developed that reflect adjustments to make them sustainable under predicted climate change. EMRI was approved for a 2011 CIG award to conduct such a project for the sagebrush biome, so such climate-adjusted reference conditions will be available for all locations that have ESD’s available.

One of the biggest observations about many of the group discussions on the sagebrush metric system was the challenge of keeping the group focused on the tool as an ecosystem-based approach for sagebrush and sagebrush-associated species and not simply a sage grouse metric system. While sage grouse currently dominate the attention of managers in sagebrush ecosystems, this project has always emphasized the need and importance of an ecosystem-based system, and this emphasis has been repeatedly supported by groups. Many potential users of the tool are not that knowledgeable about the differences between ecosystem-based approaches and species-based approaches, and why these differences are significant. As long as the regulatory environment maintains such a high focus on species rather than ecosystems, it will remain a complex challenge to implement an ecosystem-based metric system while one or more species are the focus of a potential regulatory process. Various suggestions were made to use sage grouse as a direct focus, but these were not accepted as appropriate, as the objective of this project was the development of an ecosystem-based mitigation metric system for sagebrush ecosystems.

5.0 EVALUATION OF THE MITIGATION METRIC SYSTEM

The metric system worked well for quantifying changes to sagebrush plant communities at the site level and evaluating changes in species habitat conditions at the landscape level. In this project, reference plant communities were developed using the information contained in ecological site descriptions to describe the sagebrush-dominated plant community that would have occurred historically under a light grazing regime. A consistent system of providing this description of a preferred reference community is needed to easily apply the metric system to all locations in the sagebrush biome. As mentioned, EMRI was recently awarded a new CIG project that will develop this description further adjusted to provide for a sustainable plant community under predicted future climate conditions for all areas within the sagebrush biome that have existing ecological site descriptions. This information will be available in a user-friendly web-based system. The combination of the metric system evaluated in this project with access to reference plant communities for any specific location within the sagebrush biome should provide a powerful tool for mitigation planning and evaluation.

The metric system should allow for local adjustments to the reference community, where suitable justification for such adjustments can be provided. In addition, it would be good to document changes produced by treatments to other ecosystem services, such as grazing productivity and soil stability. Herbaceous vegetation cover was sampled in this project, and could be used as an index to grazing opportunity however productivity was not included in our sampling. Productivity of grasses and forbs could be added as an additional sampling component if a better determination of grazing as an ecosystem service was desired. An index to soil stability could be developed from the bare ground estimates included in the vegetation sampling.

Typically, vegetation sampling took a 1-2 person crew one day to complete 4 plots. The vegetation data collected provided a detailed description of the plant community at the site level. On many sites, the vegetation was patchy, for example where stands of juniper or patches of invasive species occurred prior to treatment. In these areas, considerable variation among sampling plots was noted. Larger sample sizes would be required in some of the project areas if greater statistical accuracy in documenting responses to treatments was desired. However, if the metrics were to be used as a mitigation monitoring and crediting tool, the required level of sampling would not be that great, generally requiring less than 1-2 weeks of field time for a sampling crew. This seems to be a reasonable time commitment for documenting existing conditions for mitigation credits.

The similarity index and its modifications seemed to work well in the variety of treatment areas included in this project. While significant differences were not produced for several of the sites, this can be explained by several reasons. For some sites, such as Thunder Basin, the Plateau treatment was not successful in keeping cheatgrass out the third year of post-treatment sampling, coupled with only one year of post-treatment response time for the seeding of additional forbs. For Rock Springs and Deadman's Bench, only one year of post-treatment monitoring was possible due to the timing of the treatments. The Deadman's Bench treatment was not successful in controlling cheatgrass, and insufficient time was available for the seeding to become established. The Rock Springs bullhog treatment reduced the cover of sagebrush as well as the targeted pinyon pine and juniper trees. Additional time post-treatment should produce measurable responses by the plant community at this site. We did expect to see positive response by the plant community at the Ash Valley site, but the timing of the pre-treatment sampling, presence of cheatgrass, and variability in the plant community all complicated the measurement of treatment effects at this site. Both the Fidelity and Idaho sites showed how positive improvements in the plant community could be effectively monitored with the vegetation sampling conducted and the calculation of the similarity index values for these areas.

At the landscape level, species models worked to document the differences produced by the treatments. While the accuracy of the models for the surrounding areas where values were assigned to remotely-sensed maps of vegetation could not be evaluated, we were able to document the changes to potential habitat quality produced by the treatments. However, the scale used for sage grouse and pronghorn (5 mile radius from the treatment area) made the changes in habitat quality produced by the relatively small treatment areas fairly minor when assessed at the large landscape scale. For species assessed at the smaller sized landscape (1 mile radius), changes to habitat quality produced by the treatments was more apparent. While we do not advocate changing the assessment scales, we note that major changes in landscape scale analyses for wide-ranging species should not be expected when treating project-sized areas of 1-2000 acres or less. This does not mean that these aren't significant contributions in terms of habitat for all of the sagebrush associated species, but simply that additional areas will need to be treated to show sizable changes at these larger landscape scales.

Development of a Credit Trading System

Groups were asked how a credit trading system could be implemented. Various levels of application are possible. The currently proposed metrics have been shown to have the potential for immediate application to specific sites; in other words, to quantify impacts and off-site mitigation and provide a framework that will consistently produce repeatable and defensible results. The metric system can be used to document equivalency of impacts and mitigation between a specific development site and a treated mitigation area. The metric systems allows for an assessment of the costs associated with producing equivalent improvements to mitigation areas, and as such, can provide for an equitable determination of a developers responsibilities. Thus, the metric system should provide a valuable tool that can be put to immediate use by developers, landowners, or agencies to evaluate mitigation needs for any development project occurring in sagebrush ecosystems.

How the metric system could be used in a more general credit trading environment is less clear. Numerous application and policy questions discussed by the stakeholder groups would need to be answered before such a trading system could be initiated. Further, how such a trading system could assure that on-the-ground equivalent benefits were being produced by mitigation to off-set specific impacts is not clear. The metric system does provide the scientific under-pinning for such a trading system, but its actual application through some type of sagebrush exchange will require additional thought and analysis.

6.0 PRODUCER SUPPORT FOR MITIGATION AND METRICS

This project applied mitigation treatments to 7 sites used by producers. These producers were all very supportive of the mitigation treatments, perceiving them to be improvements to the quality of each of these sites. The producer in Thunder Basin was part of the Thunder Basin Grasslands Prairie Ecosystem Association and supported the improvements to the site that were likely to increase productivity as well as the benefits produced to sage-grouse and other sagebrush associated wildlife. Similarly, the producer in Ash Valley, California was interested in the improvements to the productivity of the site, the quality of wildlife habitat, and the overall health of the ecosystem. The Fidelity/Wyoming site producer was very interested in seeing the site maintain its good productivity as well as reducing the invasive species. The Idaho site producer supported the project to restore the site to a more productive and natural state.

The producers associated with the Thunder Basin Grassland Prairie Ecosystem Association supported the metrics as an important tool to quantify benefits being produced at a mitigation site. Similarly, the producer associated with the Fidelity site supported the metric system. Other stakeholders that work with and represent producers, as discussed above, generally supported the metric system. One suggestion was to include a grazing/grass productivity component in the metrics, while others commented on being able to include what they thought were desirable exotic species as positive components in a metric system. There was support for a metric system such as the one used in this project to assure that impacts and benefits could be effectively measured and balanced.

7.0 PROJECT TREATMENT ACCOMPLISHMENTS

This project involved 7 different sets of cooperators and partners, as shown in Figure 2. Project areas involved various different types of treatments all designed to demonstrate how mitigation can be accomplished in sagebrush ecosystems. In total, this project treated over 7000 acres across the 7 project sites and involved 7 different producers, two being actual landowners of the site and 5 holding grazing leases to the site.

8.0 ACKNOWLEDGEMENTS

This project was funded by a grant from the National Fish and Wildlife Foundation (Grant #2008-0116-003), as administrator for the NRCS Conservation Innovative Grant program, to the Cooperative Sagebrush Initiative. Matching funding was provided by a large number of sources including the Sand County Foundation, Utah Department of Natural Resources, Fidelity Exploration and Production

Company, Idaho Fish and Game, The Nature Conservancy, Pheasants Forever, the Wild Turkey Federation, Peabody Energy Company, Cooperative Sagebrush Steppe Restoration Initiative, Thunder Basin Grasslands Prairie Ecosystem Association, and Wyoming Wildlife and Natural Resources Trust Fund, Lassen County Fire Safe Council, Lassen County Resource Advisory Committee, California Department of Forestry and Fire Protection, US Fish and Wildlife Service, Ash Valley Ranch. Funding for this project has also been provided by the Sierra Nevada Conservancy, an agency of the State of California. Numerous individuals assisted with implementing the various treatments and with conducting the field sampling at the various project sites. A large number of stakeholders from various agencies, organizations, and individual landowners participated in the discussions on the metrics. We appreciate the assistance that was provided by all of the above that made this project possible.

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10.0 APPENDIX A. SPECIES HABITAT SUITABILITY MODELS

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.

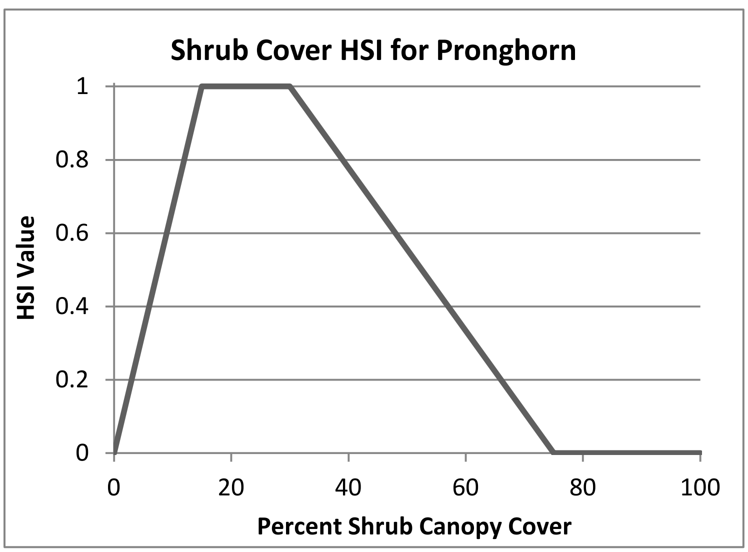


Figure A-1. Shrub cover HSI for pronghorn. The equation between 0 and 15 is y=0.0667x and the equation between 30 and 75 is y=-0.0222x + 1.6667.

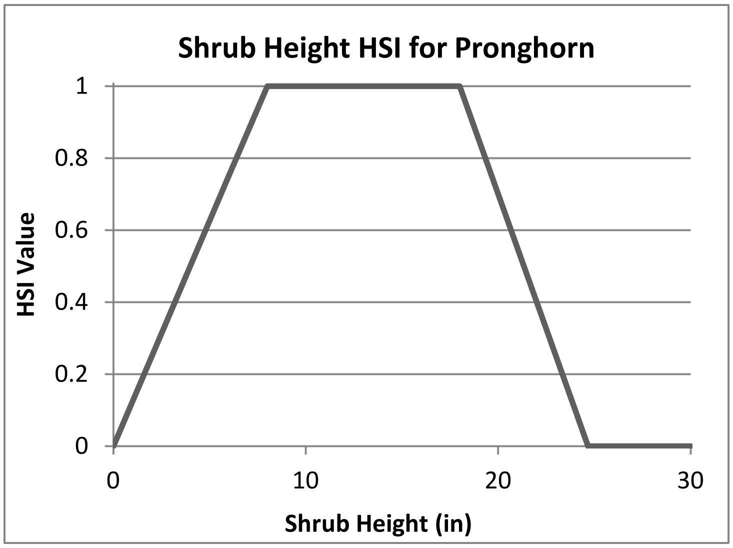


Figure A-2. Shrub height HSI for pronghorn. The equation between 0 and 8 is y=0.125x and the equation between 18 and 25 is y=-0.15x + 3.7.

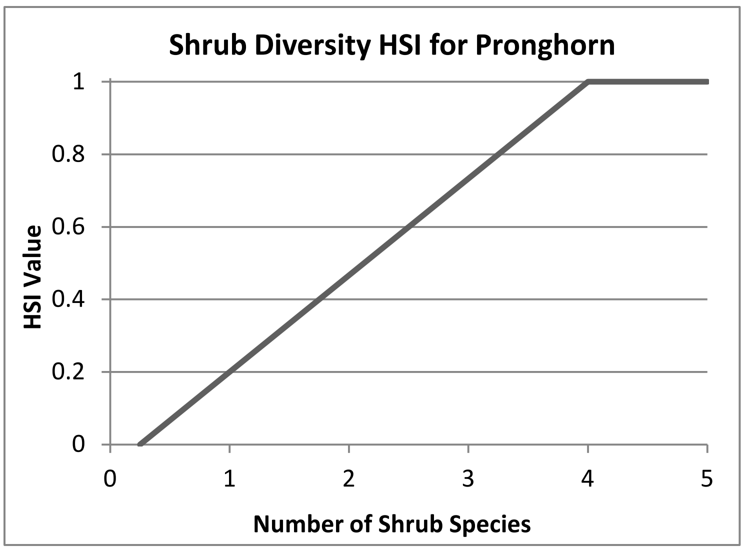


Figure A-3. Shrub diversity HSI for pronghorn. The equation between 0.25 and 4 is y=0.2667x - 0.0667.

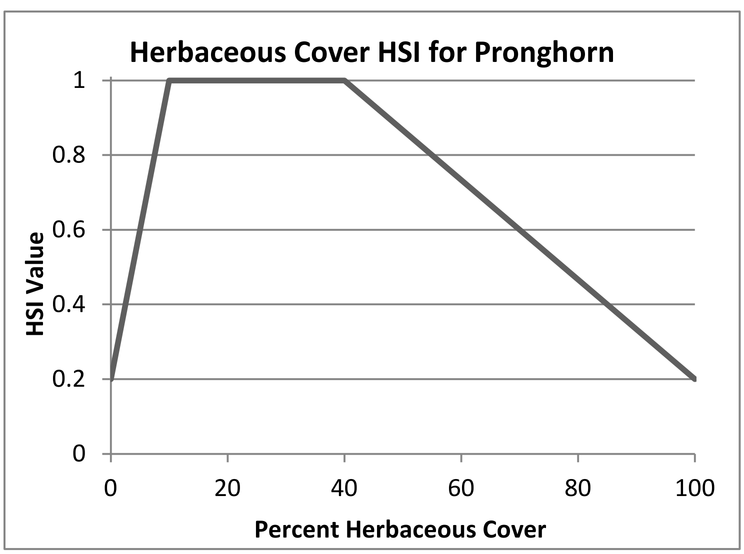


Figure A-4. Herbaceous cover HSI for pronghorn. The equation between 0 and 10 is y=0.08x +0.2 and the equation between 40 and 100 is y=-0.0133x + 1.5333.

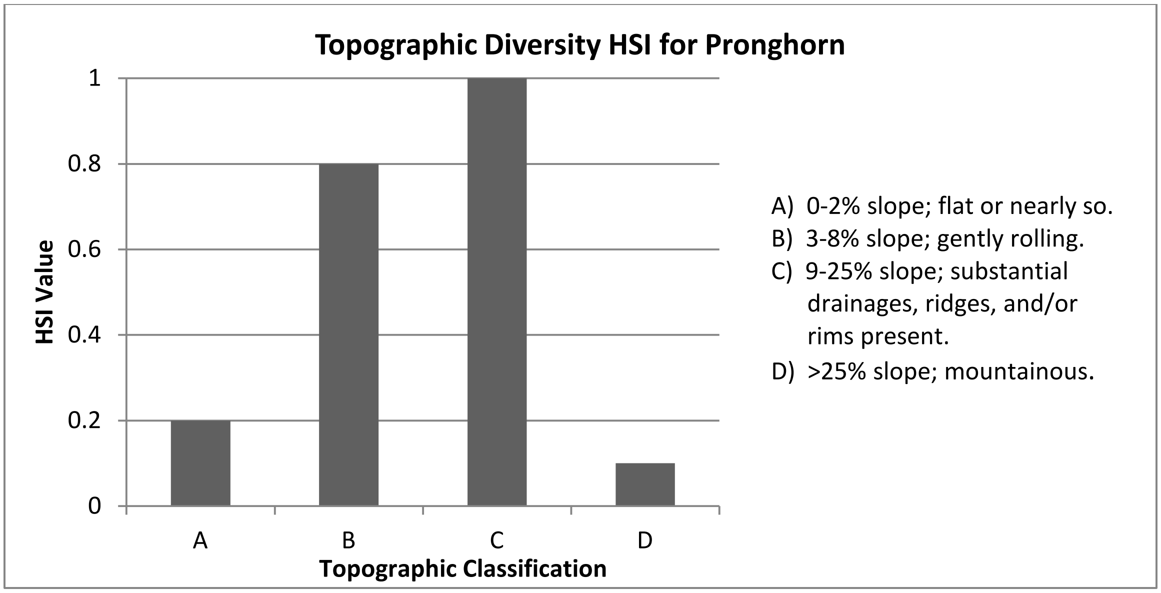


Figure A- 5. Topographic diversity HSI for pronghorn.

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: $(\text{Bare Ground} * \text{Shrub Cover} * \text{Herbaceous Cover} * \text{Cheatgrass Cover})^{1/4} * \text{Soil Type}$. 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.

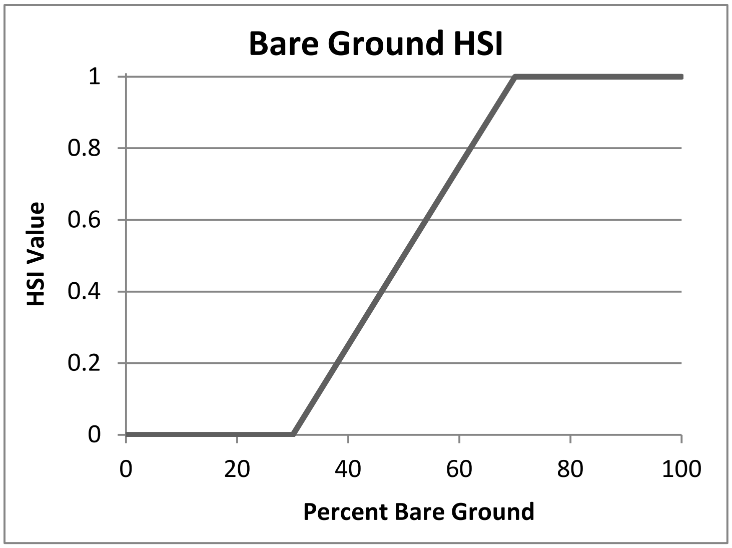


Figure A-6. Bare ground HSI for sagebrush lizard. The equation between 30 and 70 is y=0.025x -0.75.

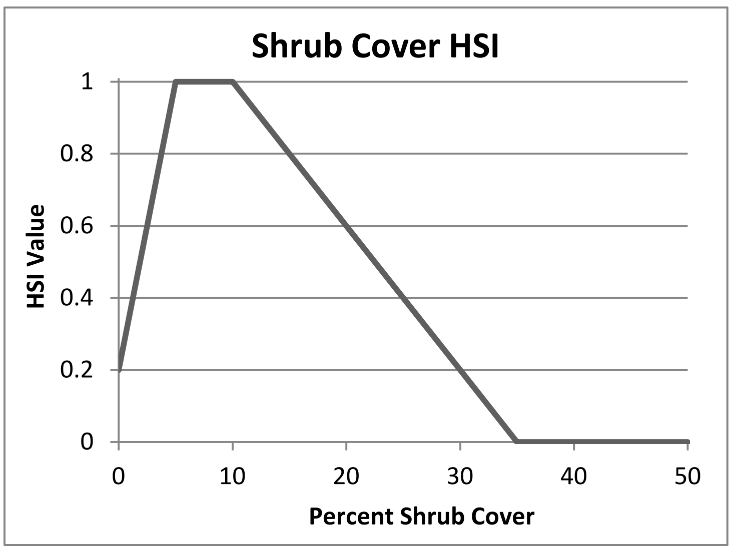


Figure A-7. Shrub cover HSI for sagebrush lizard. The equation between 0 and 5 is y=0.16X+0.2 and the equation between 10 and 35 is y=-0.04x+1.4.

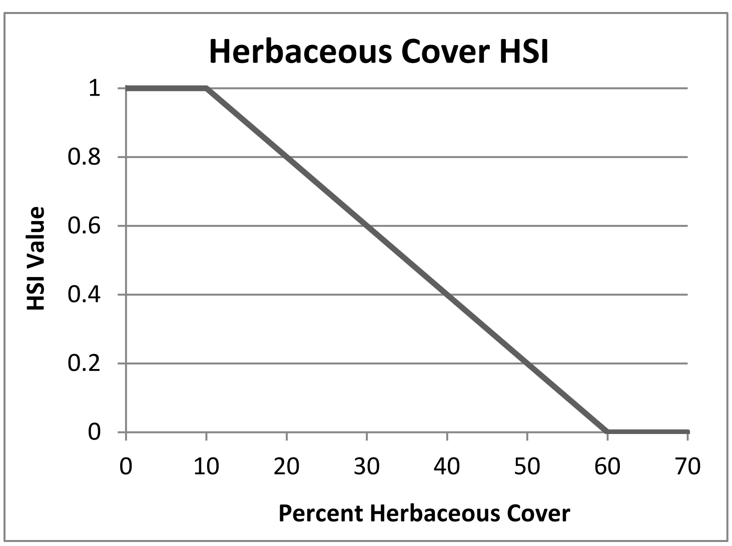


Figure A-8. Herbaceous cover HSI for sagebrush lizard. The equation between 10 and 60 is y=-0.02x+1.2.

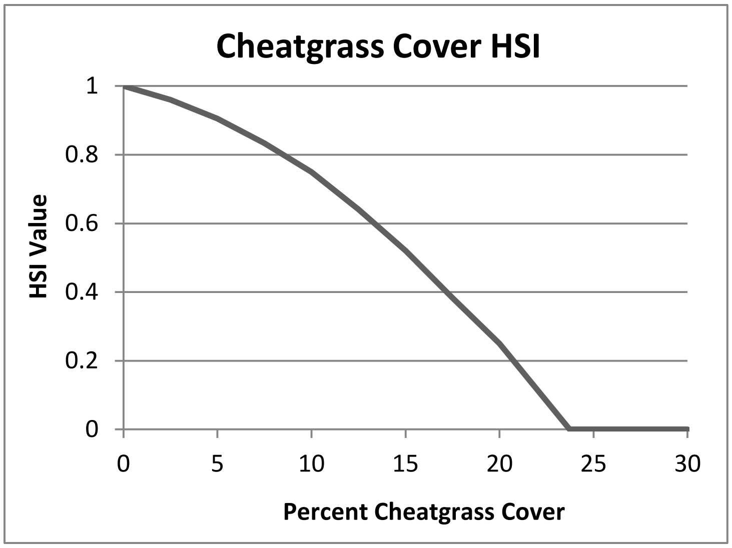


Figure A-9. Cheatgrass cover HSI for sagebrush lizard. The equation between 0 and 23.725 is $y=-0.0013x^2-0.0125x+1$.

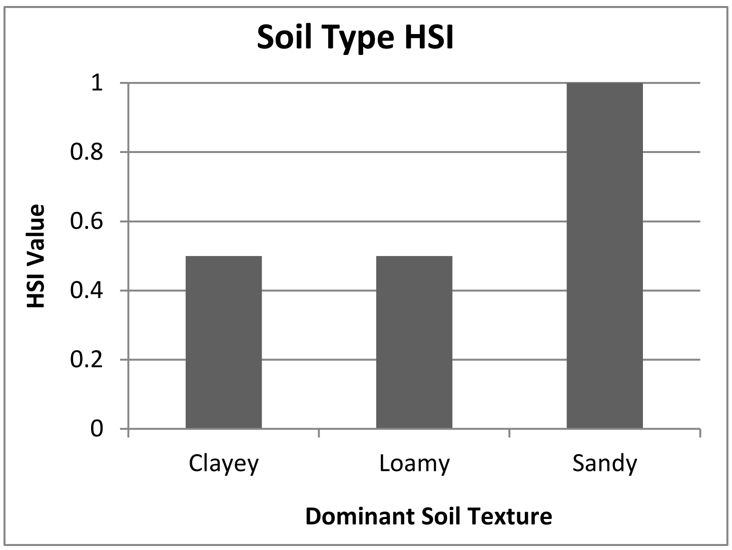


Figure A-10. Soil type HSI for sagebrush lizard.

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.

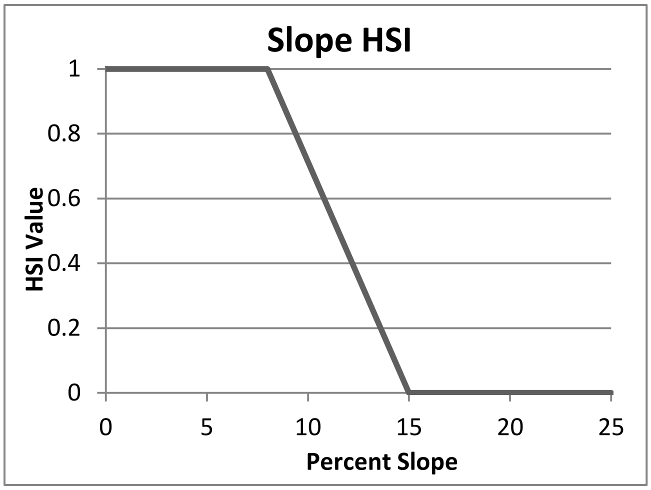


Figure A-11. Percent slope HSI for pygmy rabbit. The equation between 8 and 15 is y=-0.1429x+ 2.1429.

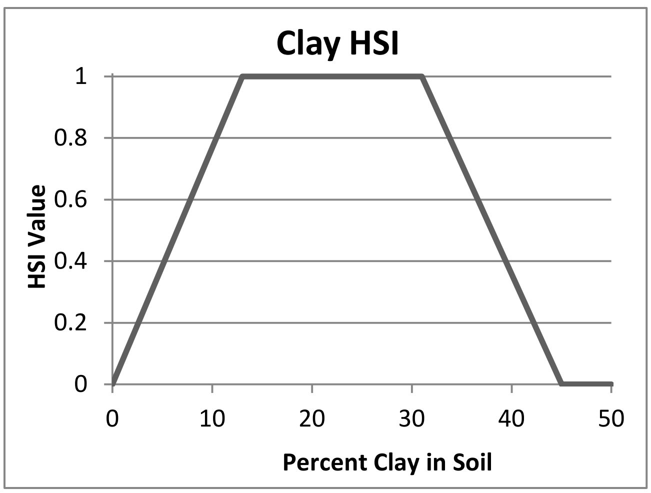


Figure A-12. Soil composition HSI for pygmy rabbit. The equation between 0 and 13 is y=0.0769x and the equation between 31 and 45 is y=-0.0714x+3.2143.

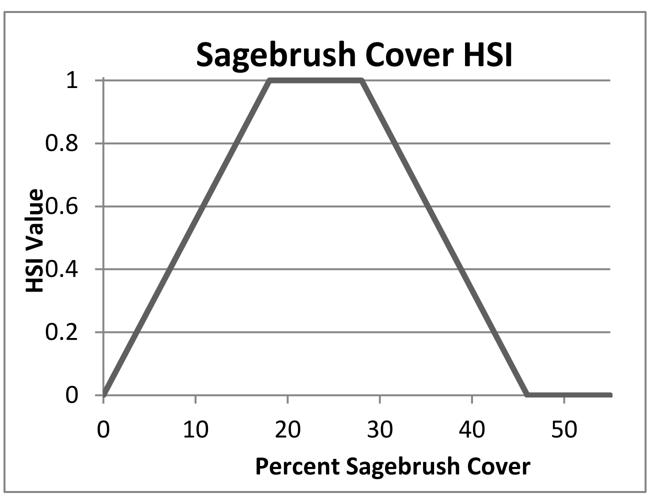


Figure A-13. Sagebrush cover HSI for pygmy rabbit. The equation between 0 and 18 is y=-0.0556x and the equation between 28 and 46 is y=-0.0556x+2.5556.

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.

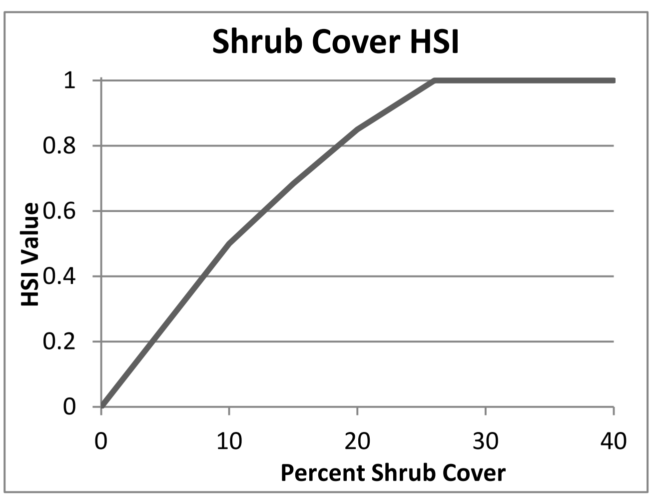


Figure A-14. Shrub cover HSI for sage sparrow. The equation between 0 and 26 is $y=-0.0007x^2+0.0564x-0.0041$.

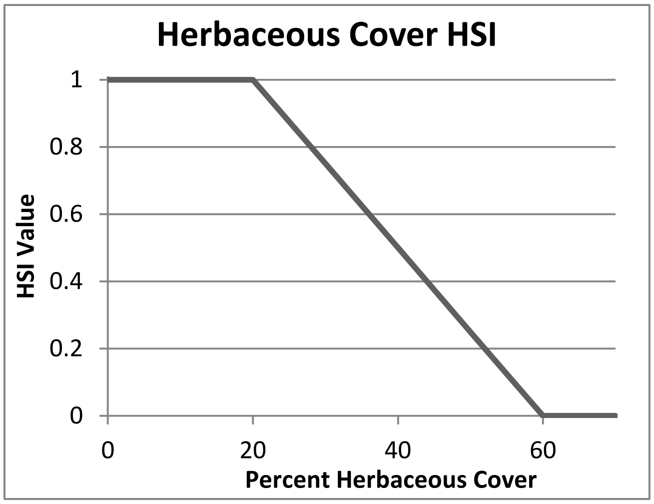


Figure A-15. Herbaceous cover HSI for sage sparrow. The equation between 20 and 60 is y=-0.025x +1.5.

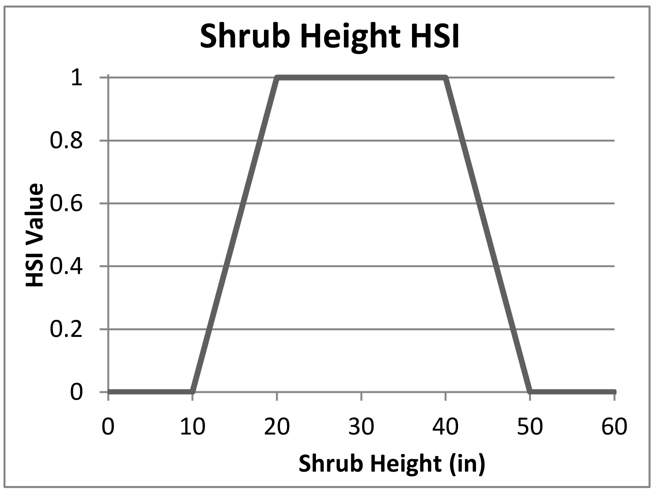


Figure A-16. Shrub height HSI for sage sparrow. The equation between 10 and 20 is y=0.1x-1 and the equation between 40 and 50 is y=-0.1x+5.

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.

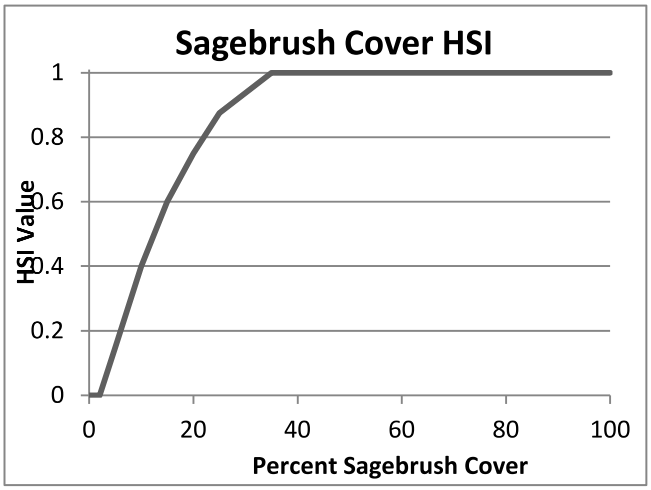


Figure A-17. Sagebrush cover HSI for sage thrasher. The equation between 2 and 35 is $y=-0.0008x^2 +0.0593x-0.1191$.

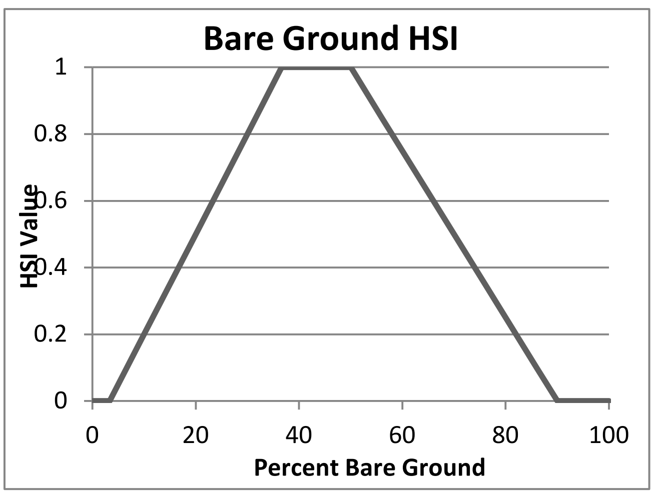


Figure A-18. Bare ground HSI for sage thrasher. The equation between 3.33 and 36.67 is $y=0.03x-0.1$ and the equation between 50 and 90 is $y=-0.025x+2.25$.

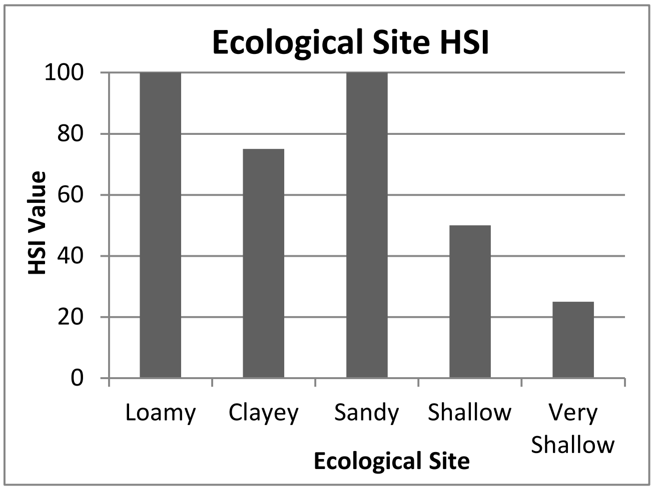


Figure A-19. Ecological site HSI for sage thrasher.

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.

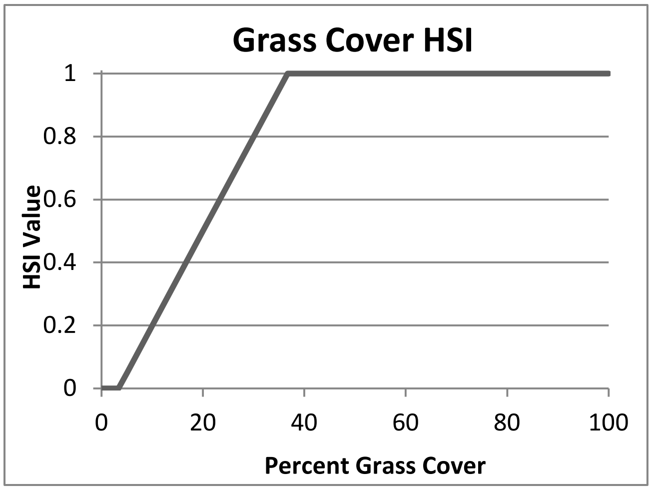


Figure A-20. Grass cover HSI for sagebrush vole. The equation between 3.33 and 36.67 is y=0.03x-0.1.

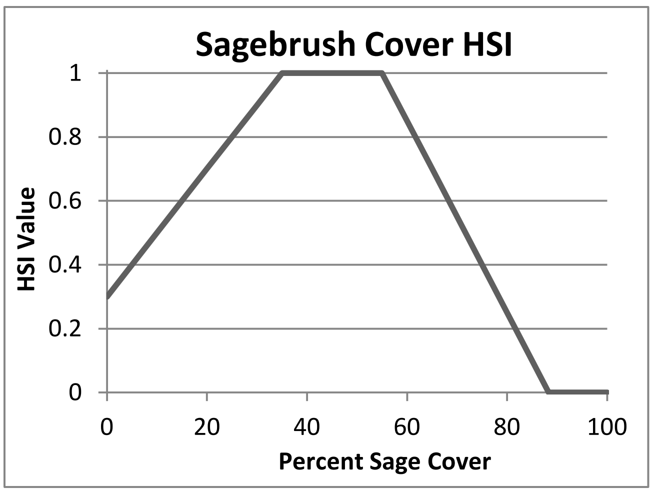


Figure A-21. Sagebrush cover HSI for sagebrush vole. The equation between 0 and 35 is y=0.02x+0.3 and the equation between 55 and 83.3 is y=-0.03x+2.65.

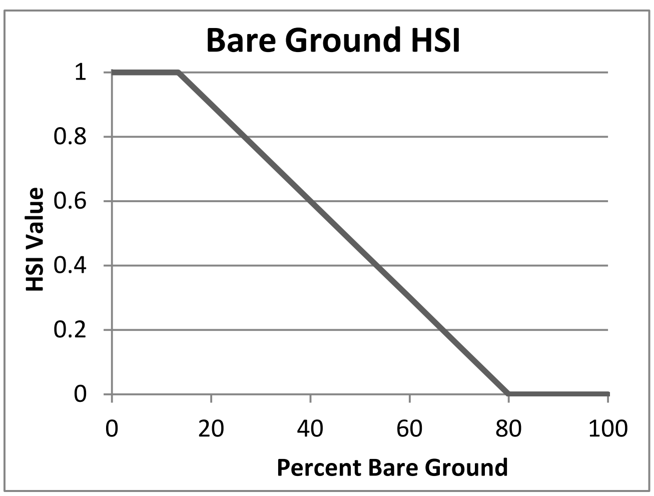


Figure A-22. Bare ground HSI for sagebrush vole. The equation between 13.3 and 80 is y=-0.015x +1.2.

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.

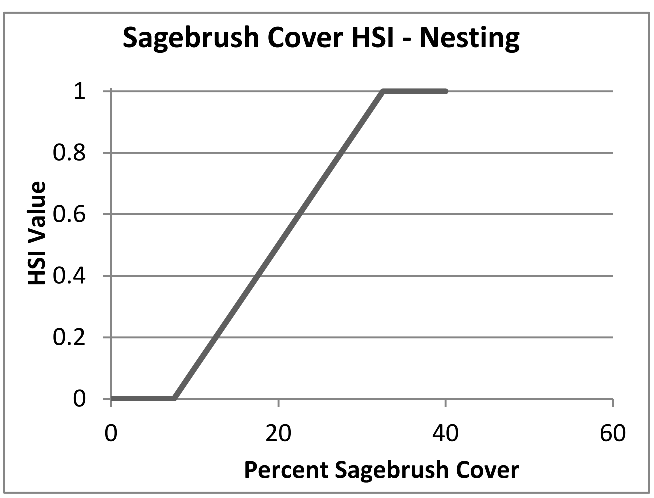


Figure A-23. Sagebrush cover HSI for sage grouse nesting. The equation between 7.5 and 32.5 is y=0.04x-0.3.

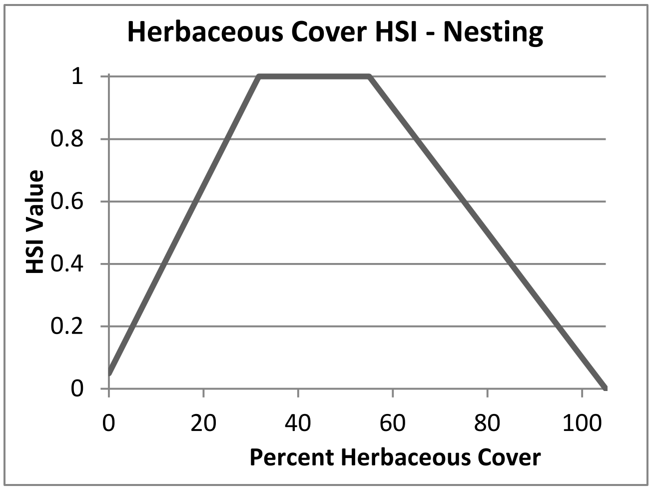


Figure A-24. Herbaceous cover HSI for sage grouse nesting. The equation between 0 and 31.67 is y=0.03x+0.05 and the equation between 55 and 105 is y=-0.02x +2.1.

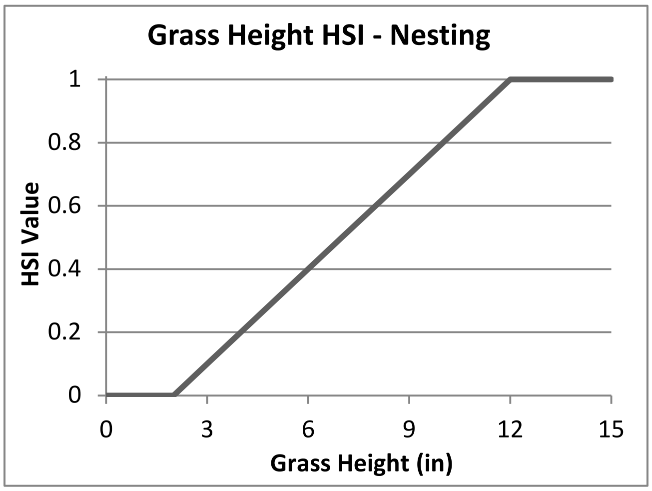


Figure A-25. Grass height HSI for sage grouse nesting. The equation between 2 and 12 is y=0.1x-0.2.

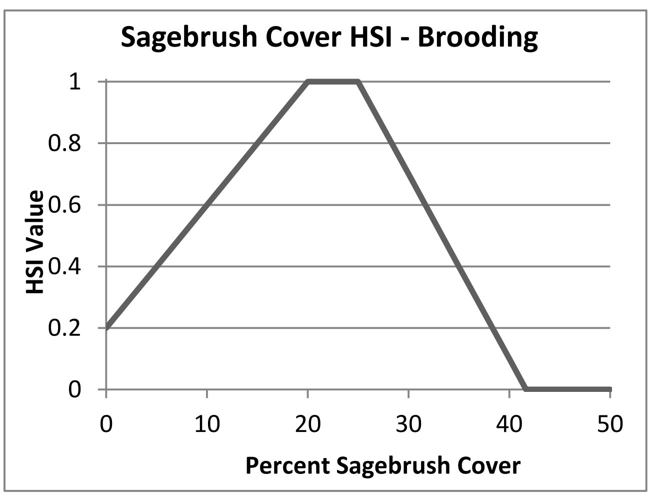


Figure A-26. Sagebrush cover HSI for sage grouse brood rearing. The equation between 0 and 20 is y=0.04x+0.2 and the equation between 25 and 41.67 is y=-0.06x+2.5.

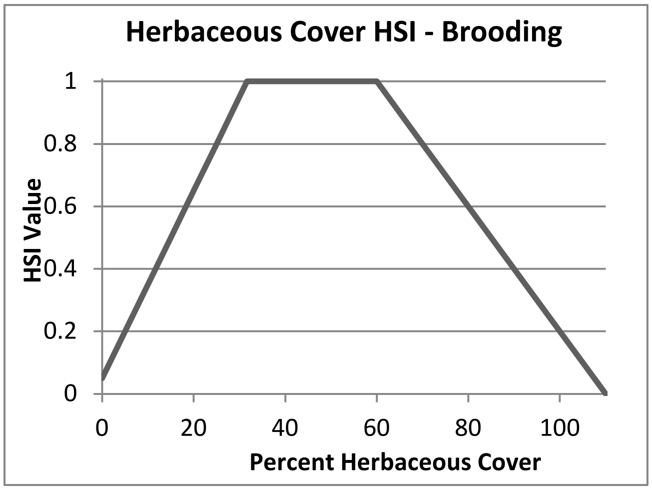


Figure A-27. Herbaceous cover HSI for sage grouse brood rearing. The equation between 0 and 31.67 is y=0.03x+0.05 and the equation between 60 and 110 is y=-0.02x+2.2.

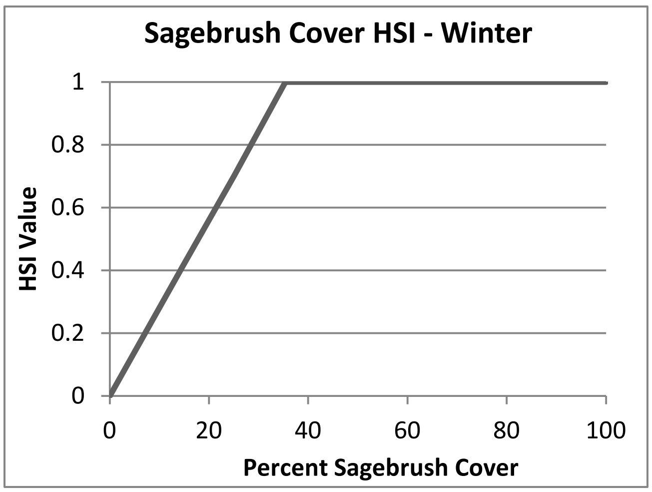


Figure A-28. Sagebrush cover HSI for sage grouse wintering. The equation between 0 and 35.4 is y=0.0282x-0.0018.

11.0 APPENDIX B. HABITAT SUITABILITY AND HOME RANGE MAPS

Fidelity Project, Wyoming

Pronghorn Antelope

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.

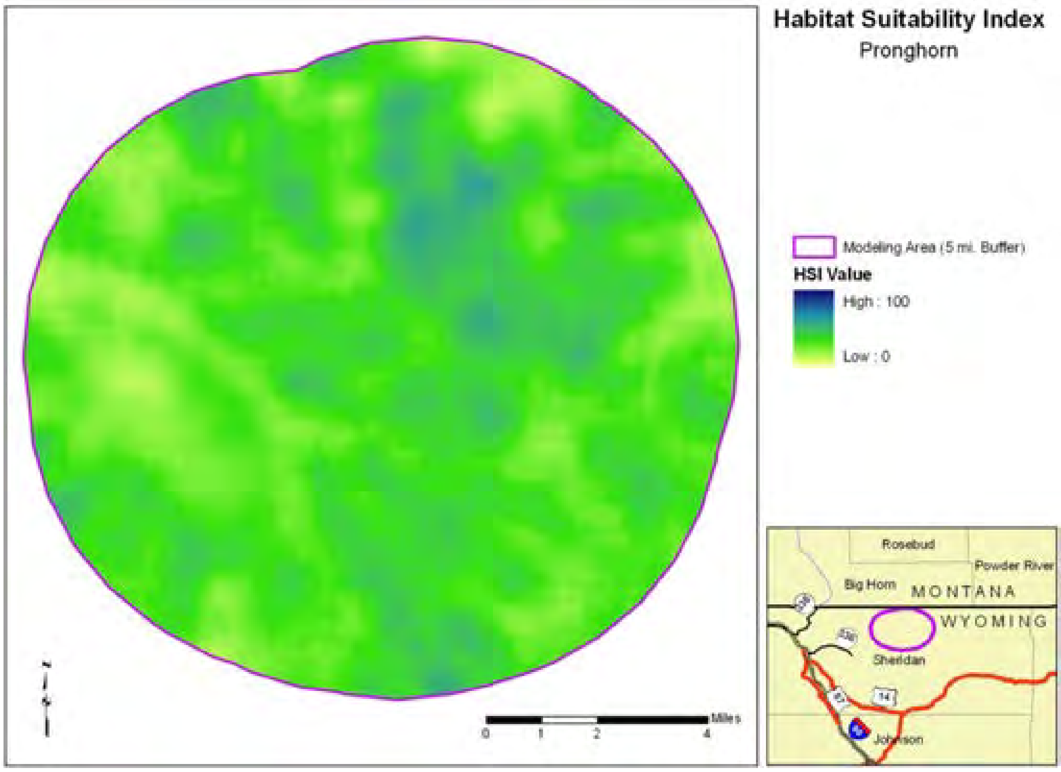


Figure B-1. Pre-treatment habitat suitability index for pronghorn in the Fidelity project area.

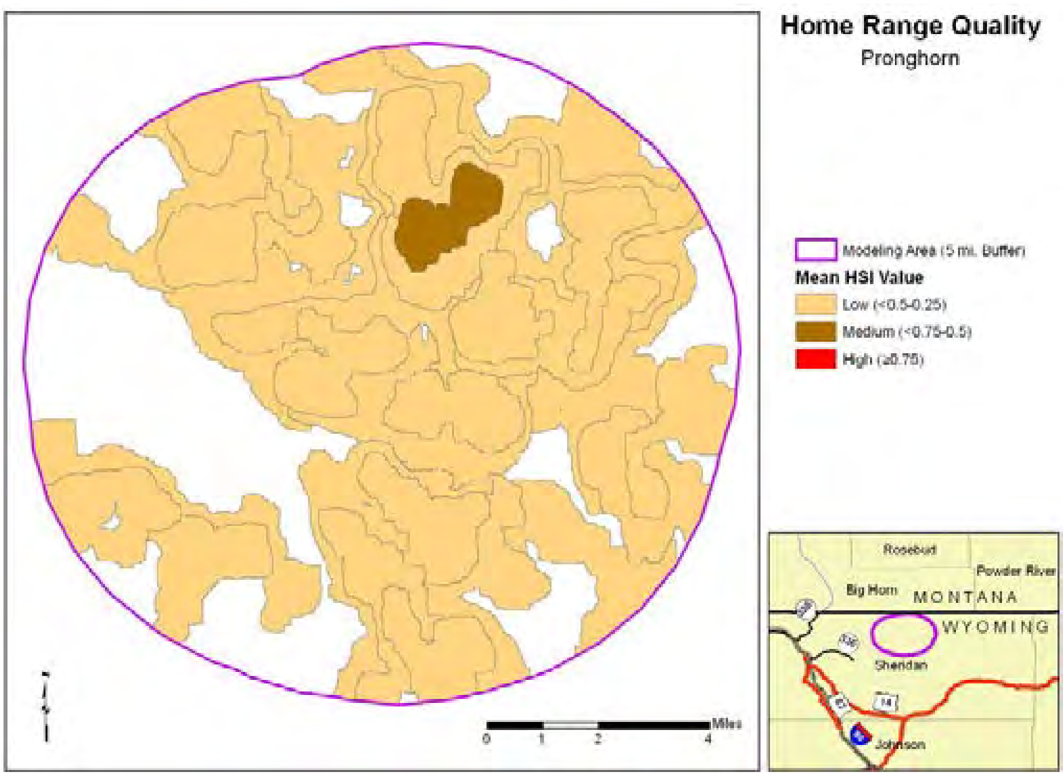


Figure B-2. Pre-treatment home range quality for pronghorn in the Fidelity project area. Home ranges are used as an index of relative resource availability and proximity of quality habitat.

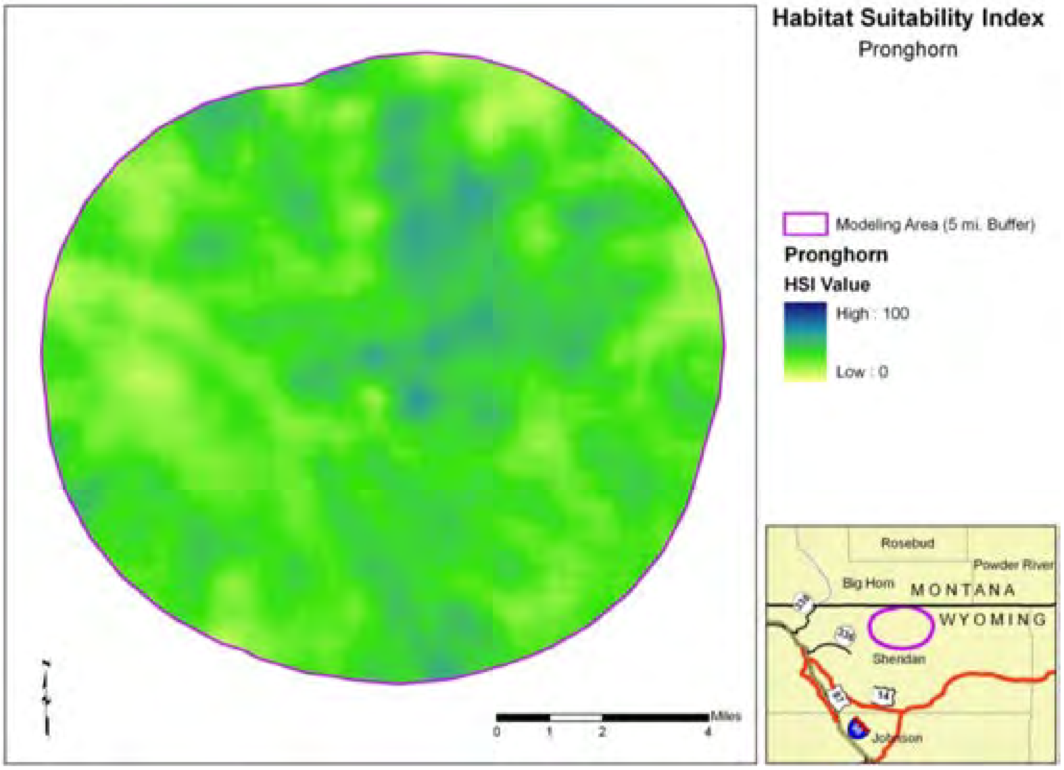


Figure B-3. Post-treatment habitat quality for pronghorn in the Fidelity project area.

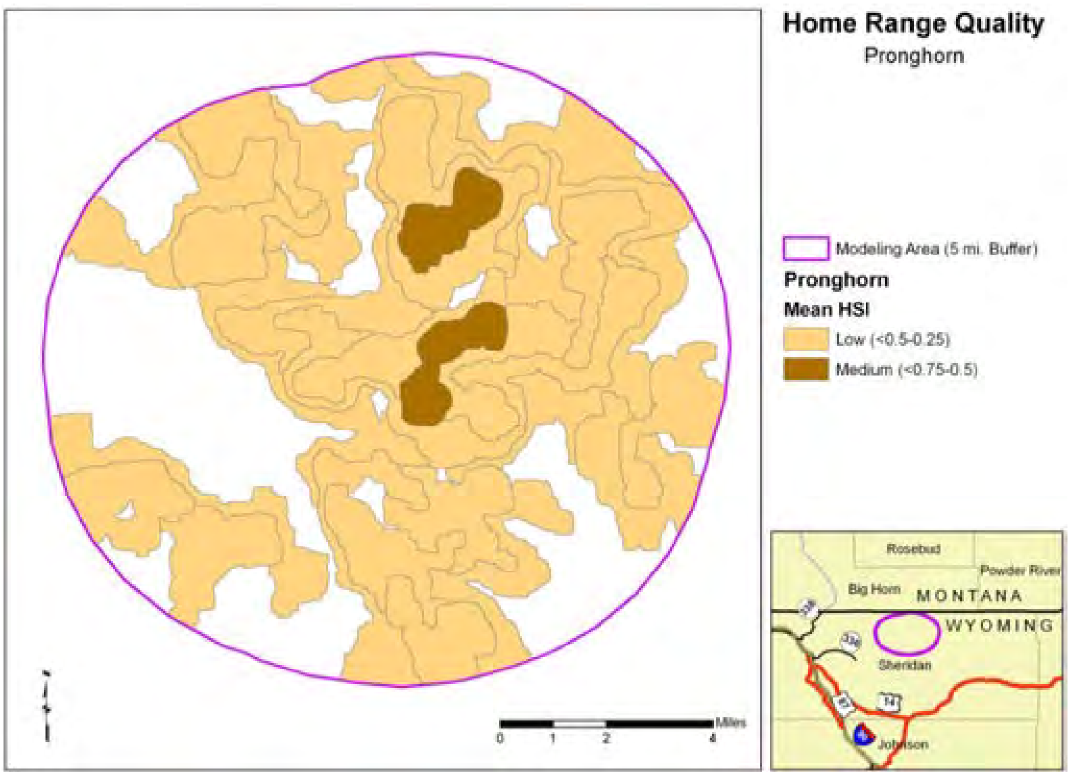


Figure B-4. Post-treatment home range qualities for pronghorn in the Fidelity site. Home ranges are used as an index of relative resource availability and proximity of quality habitat.

Sagebrush Lizard

The final HSI grid for sagebrush lizard 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 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-6 depicts the results for home range quality under existing, pre-treatment conditions. There were no high or medium quality home ranges. Figures B-7 and B-8 present the post-treatment modeling results.

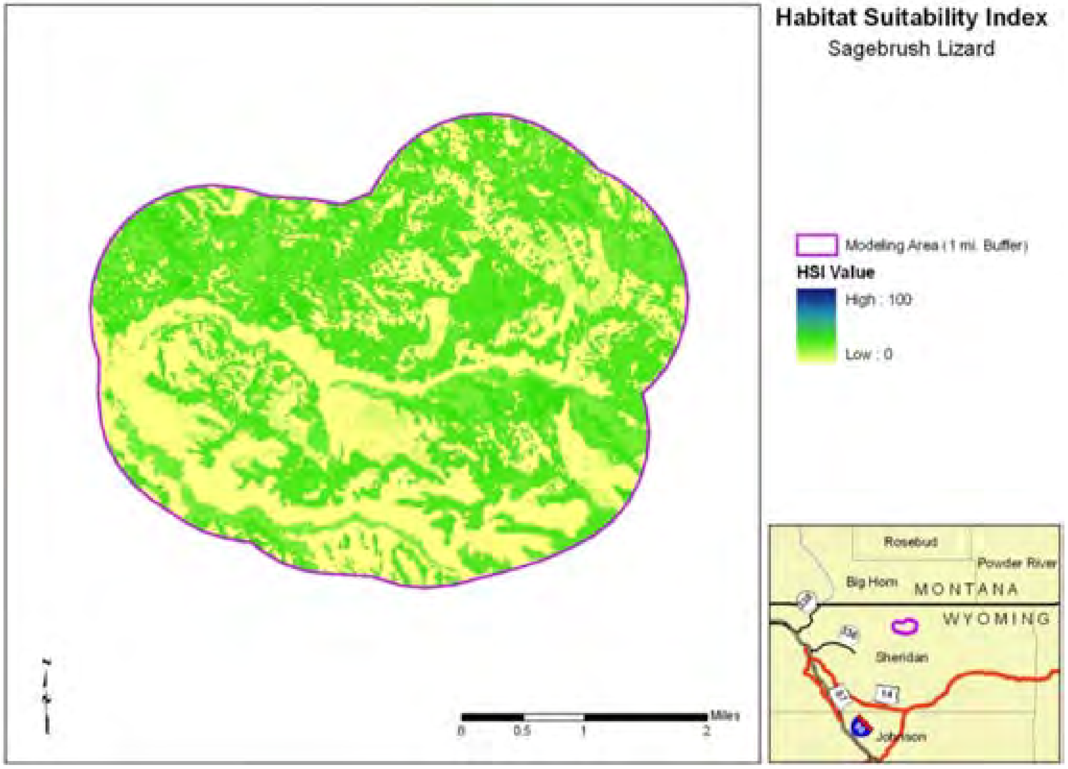


Figure B-5. Pre-treatment habitat suitability for sagebrush lizard in the Fidelity project area.

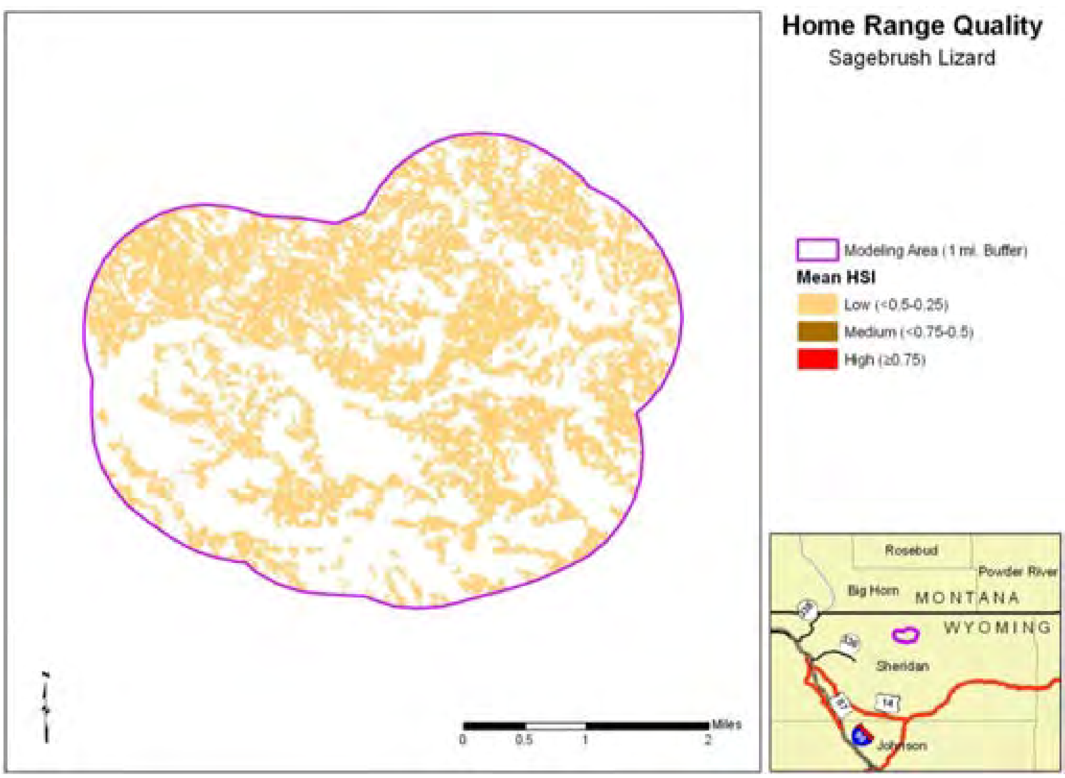


Figure B-6. Pre-treatment home range quality for sagebrush lizard in the Fidelity project area.

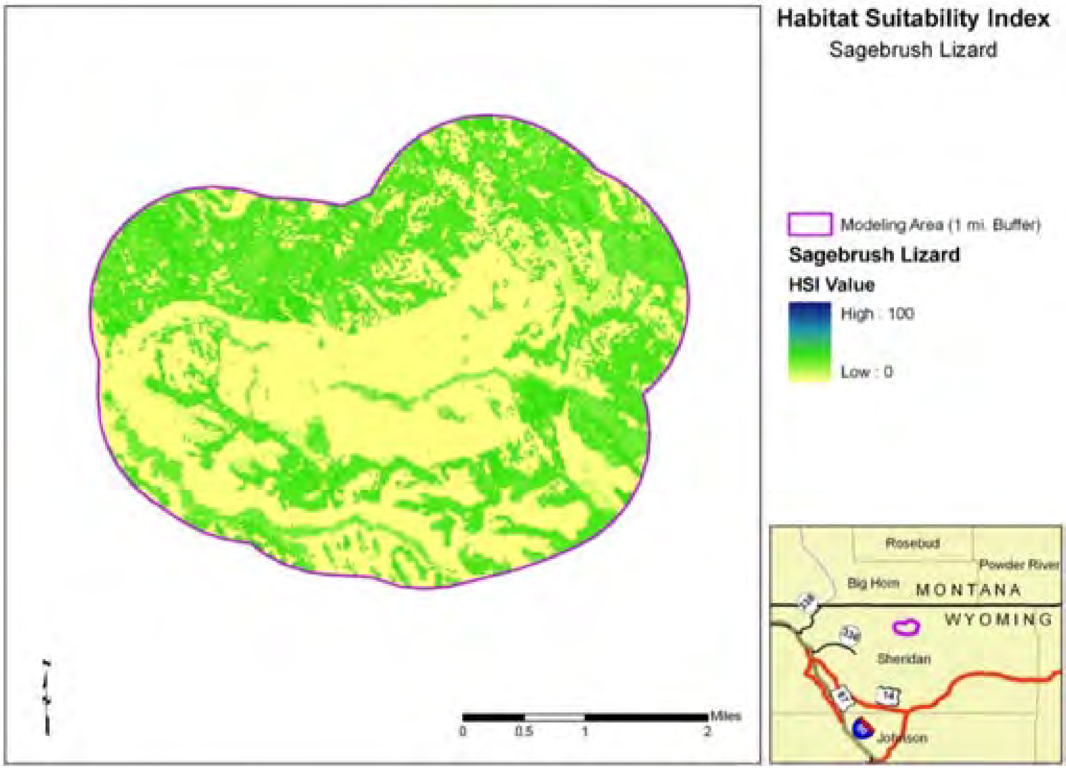


Figure B-7. Post-treatment habitat suitability for sagebrush lizard in the Fidelity project area.

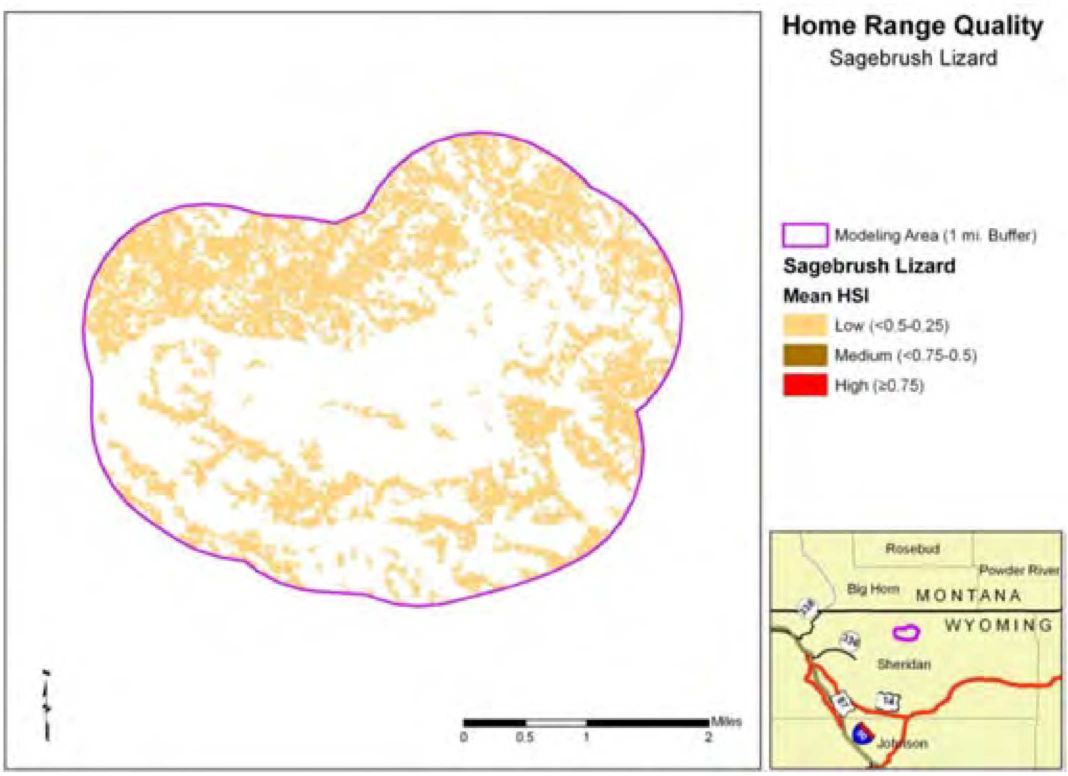


Figure B-8. Post-treatment home range quality for sagebrush lizard in the Fidelity project area.

Sage Sparrow

The final HSI grid for sage sparrow used for HOMEGROWER is shown in Figure B-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 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-10 depicts the results for home range quality under existing, pre-treatment conditions while figures B-11 and B-12 display the post-treatment results.

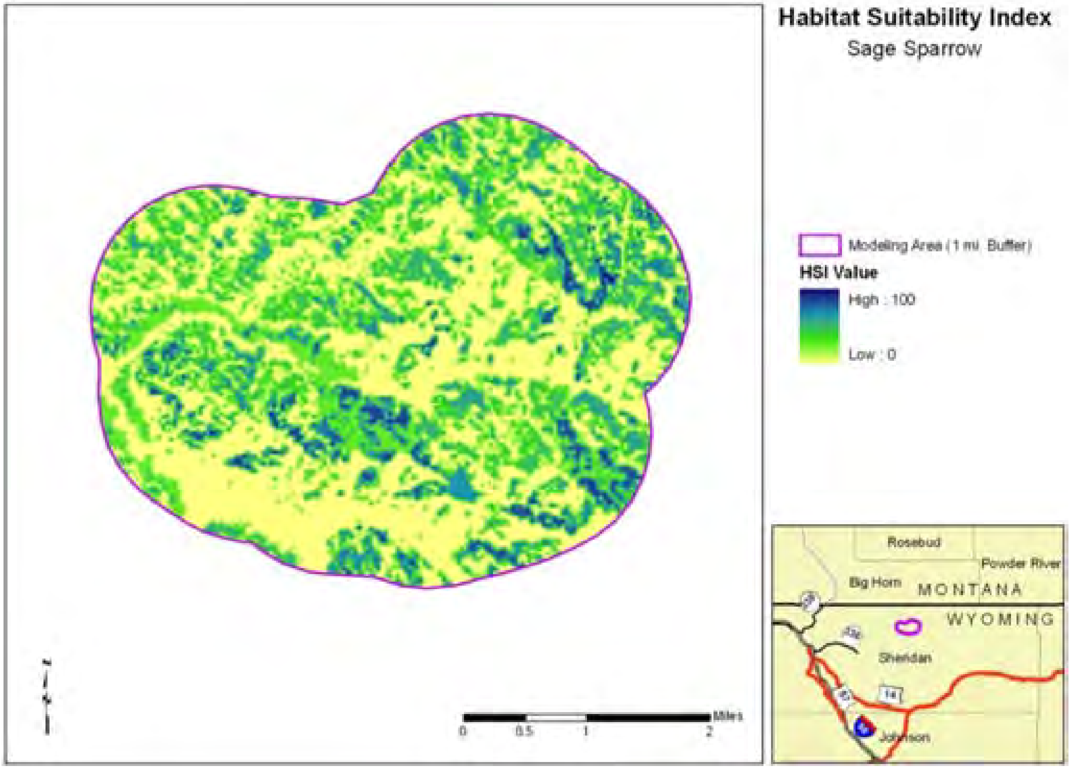


Figure B-9. Pre-treatment habitat suitability index for sage sparrow in the Fidelity project area.

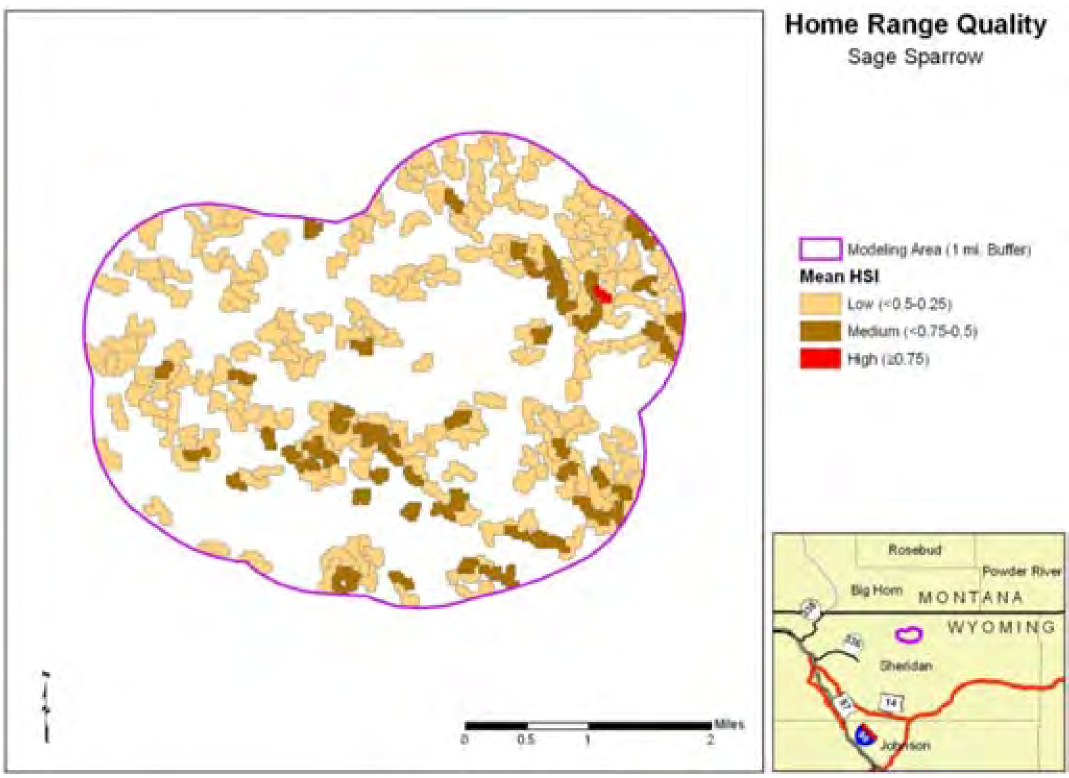


Figure B-10. Pre-treatment home range quality for sage sparrow in the Fidelity project area.

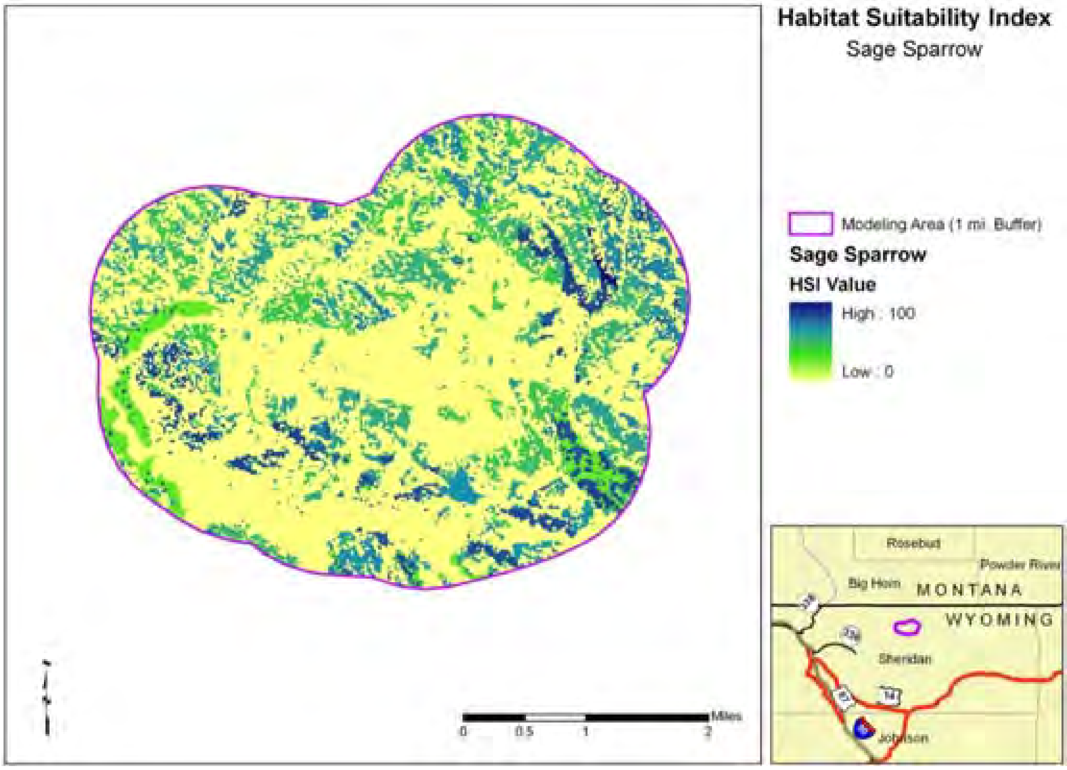


Figure B-11. Post-treatment habitat suitability index for sage sparrow in the Fidelity project area.

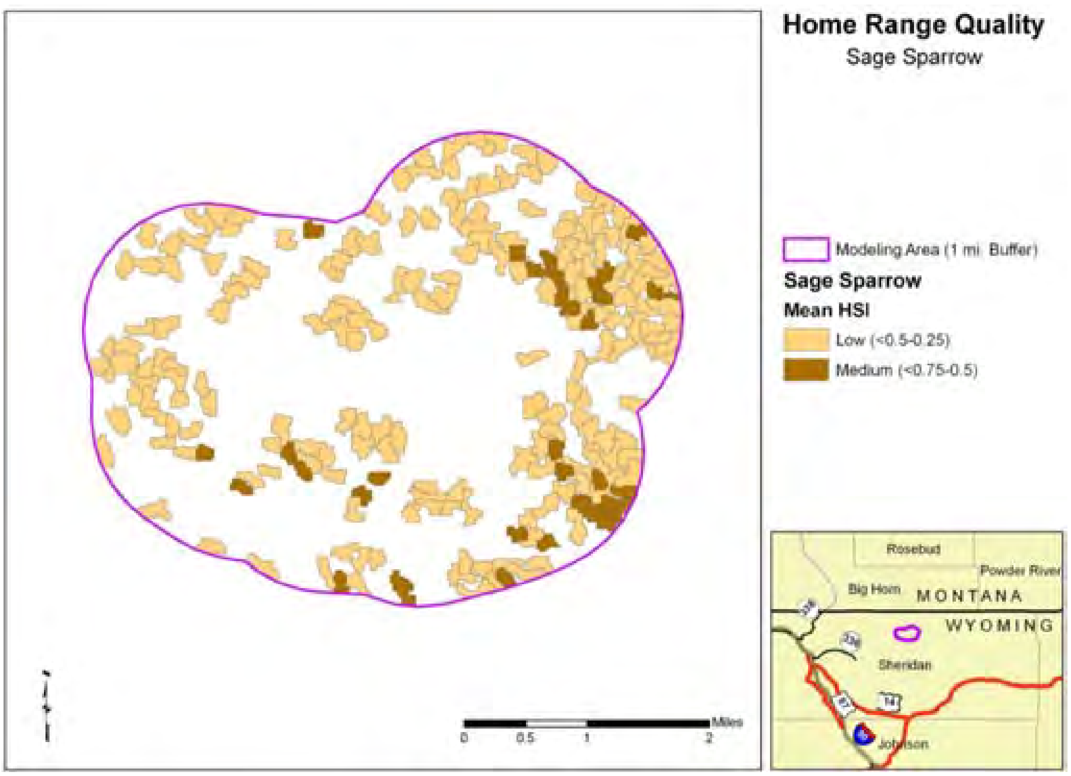


Figure B-12. Post-treatment home range quality for sage sparrow in the Fidelity project area.

Sage Thrasher

The final HSI grid for sage thrasher used for HOMEGROWER is shown in Figure B-13. 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-14 depicts the results for home range quality under existing, pre-treatment conditions, while B-15 and B-16 present the post-treatment maps.

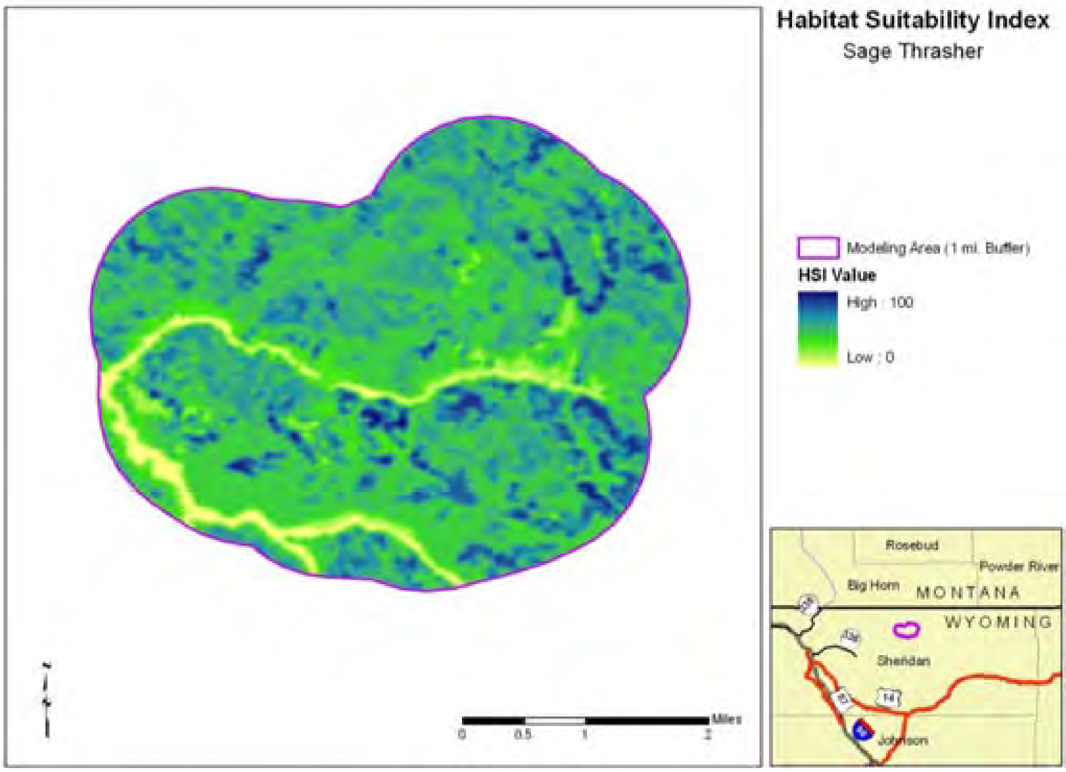


Figure B-13. Pre-treatment habitat suitability index for sage thrasher in the Fidelity project area.

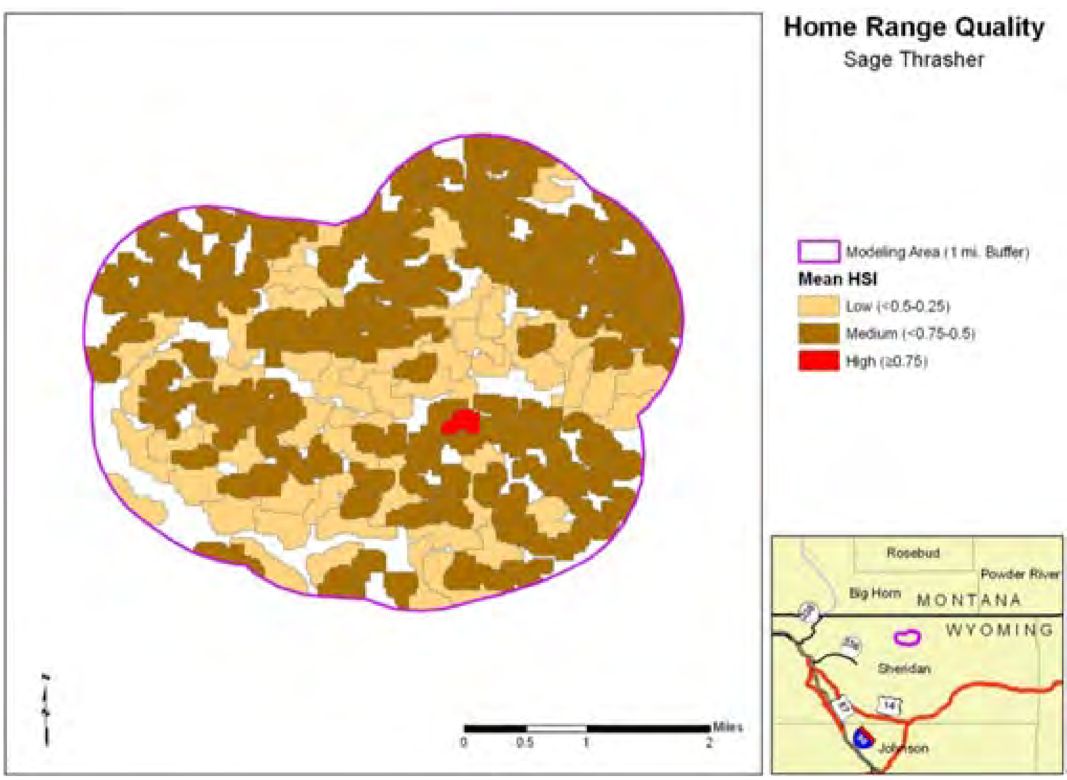


Figure B-14. Pre-treatment potential home range quality for sage thrasher in the Fidelity project area.

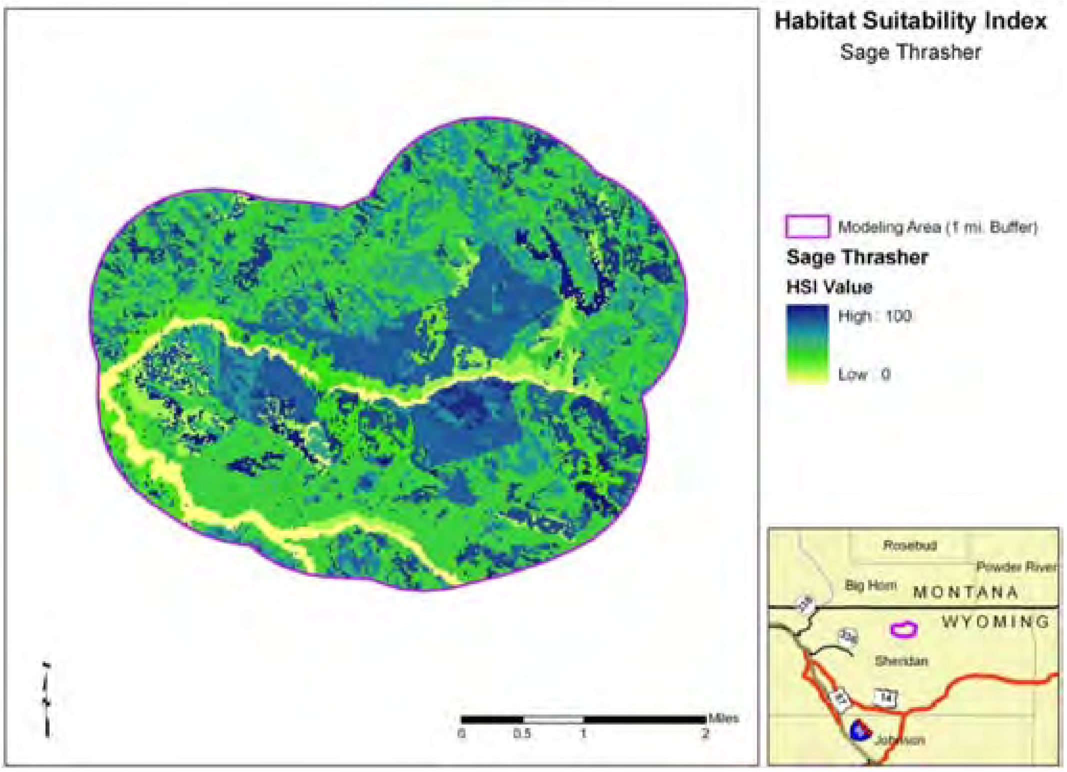


Figure B-15. Post-treatment habitat suitability index for sage thrasher in the Fidelity project area.

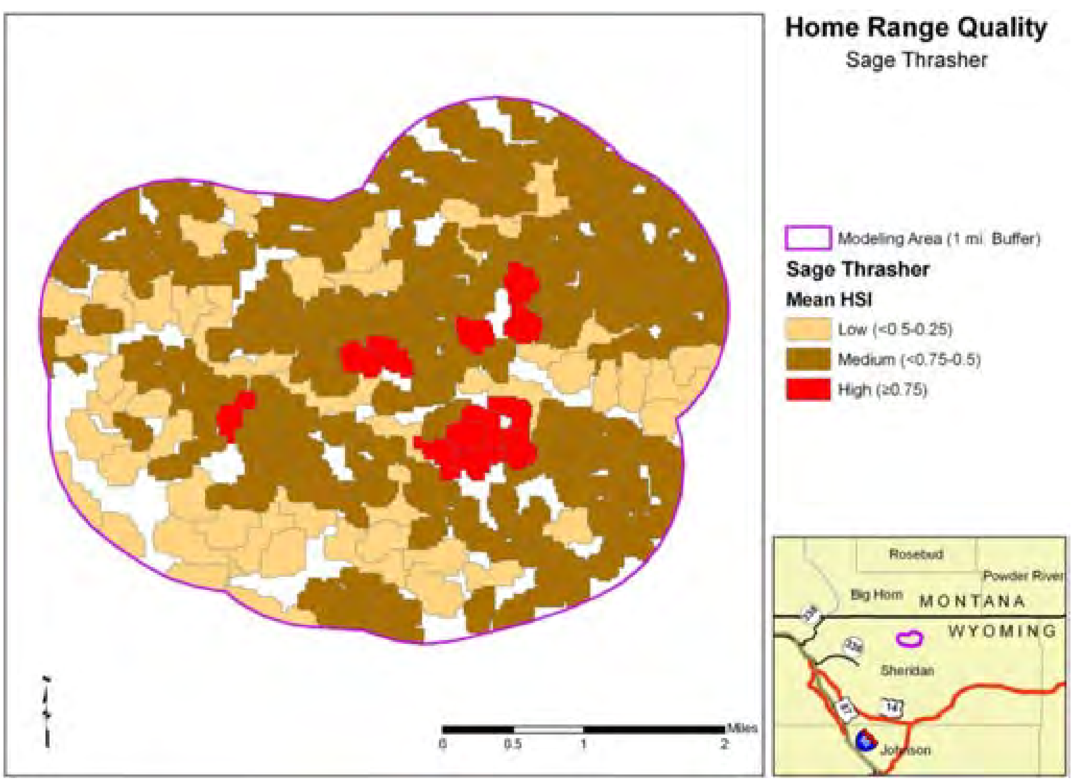


Figure B-16. Post-treatment potential home range quality for sage thrasher in the Fidelity project area.

Sagebrush Vole

The final HSI grid for sagebrush vole used for HOMEGROWER is shown in Figure B-17. 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-18 depicts the results for home range quality under existing, pre-treatment conditions, while figures B-19 and B-20 depict the post-treatment maps.

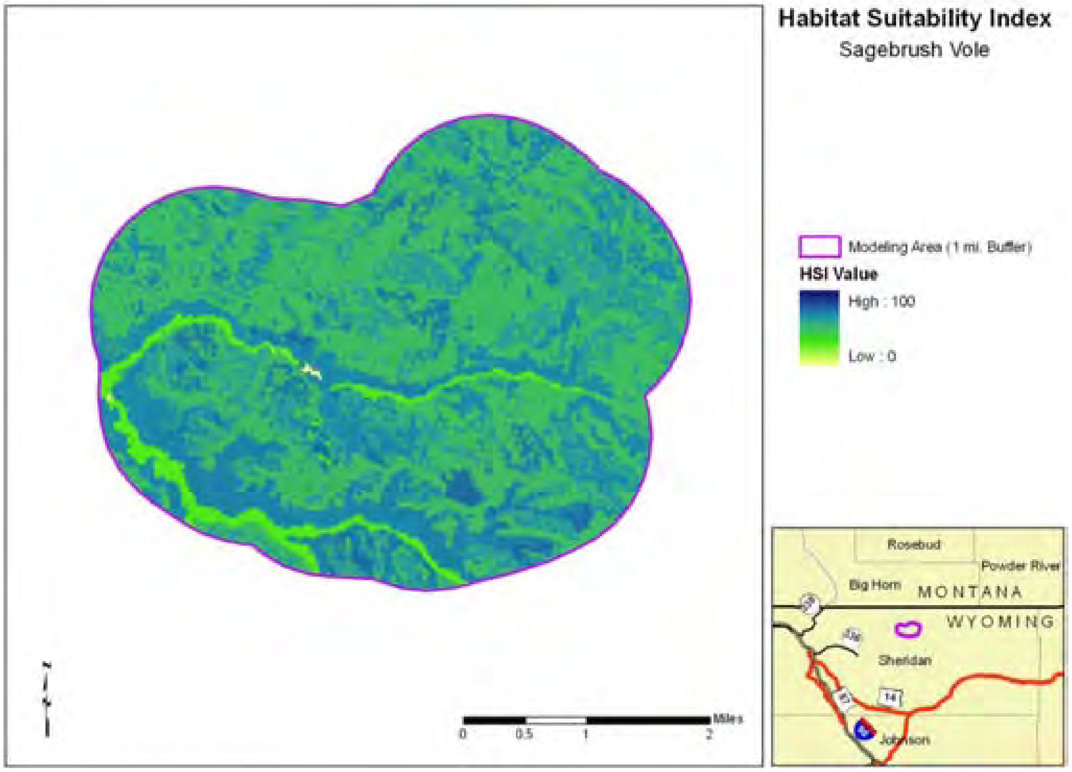


Figure B-17. Pre-treatment habitat suitability index for sagebrush vole in the Fidelity project area.

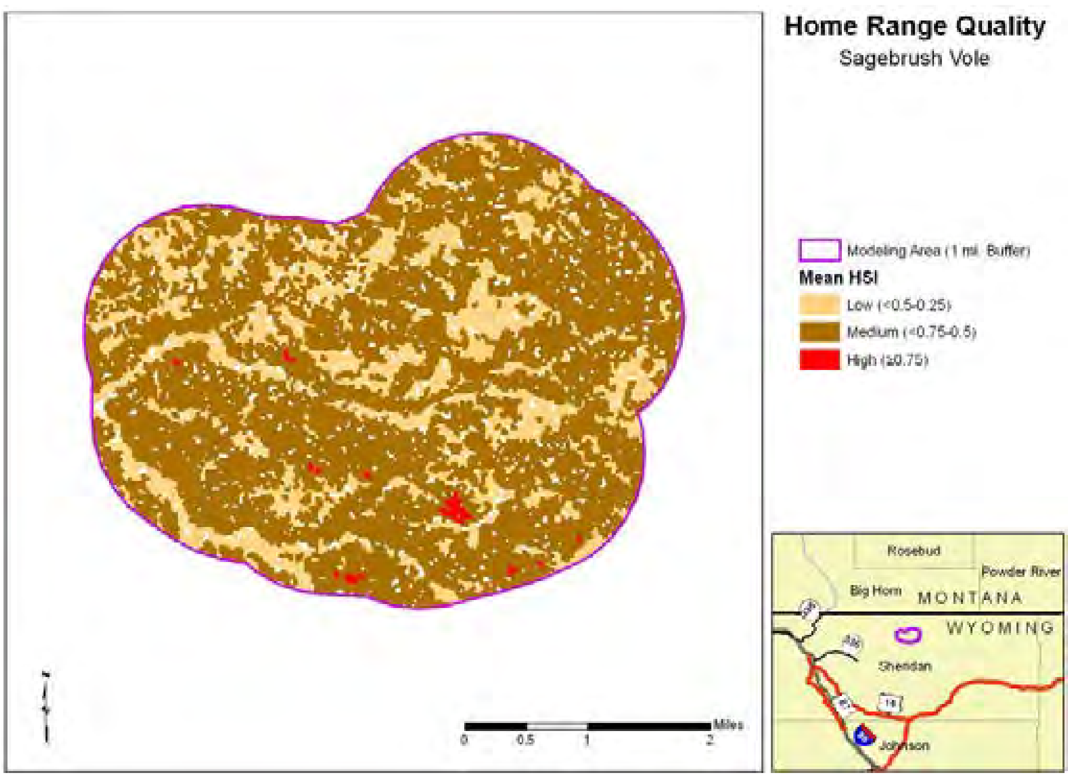


Figure B-18. Pre-treatment home range quality for sagebrush vole in the Fidelity project area.

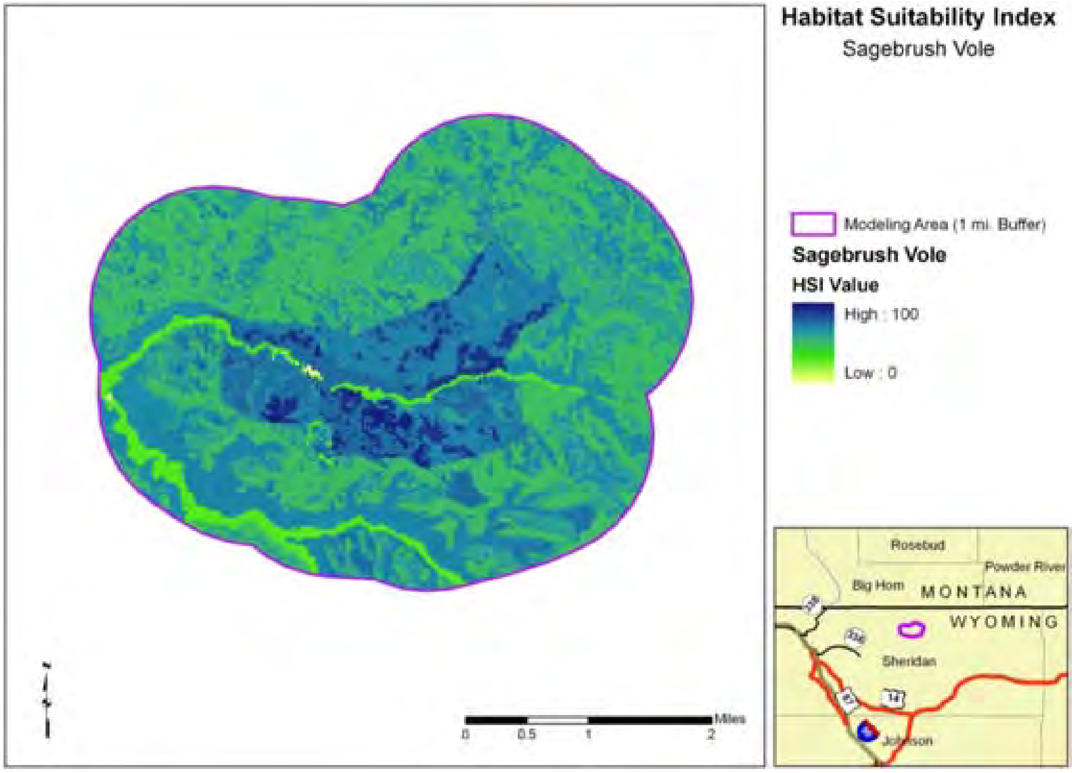


Figure B-19. Post-treatment habitat suitability index for sagebrush vole in the Fidelity project area.

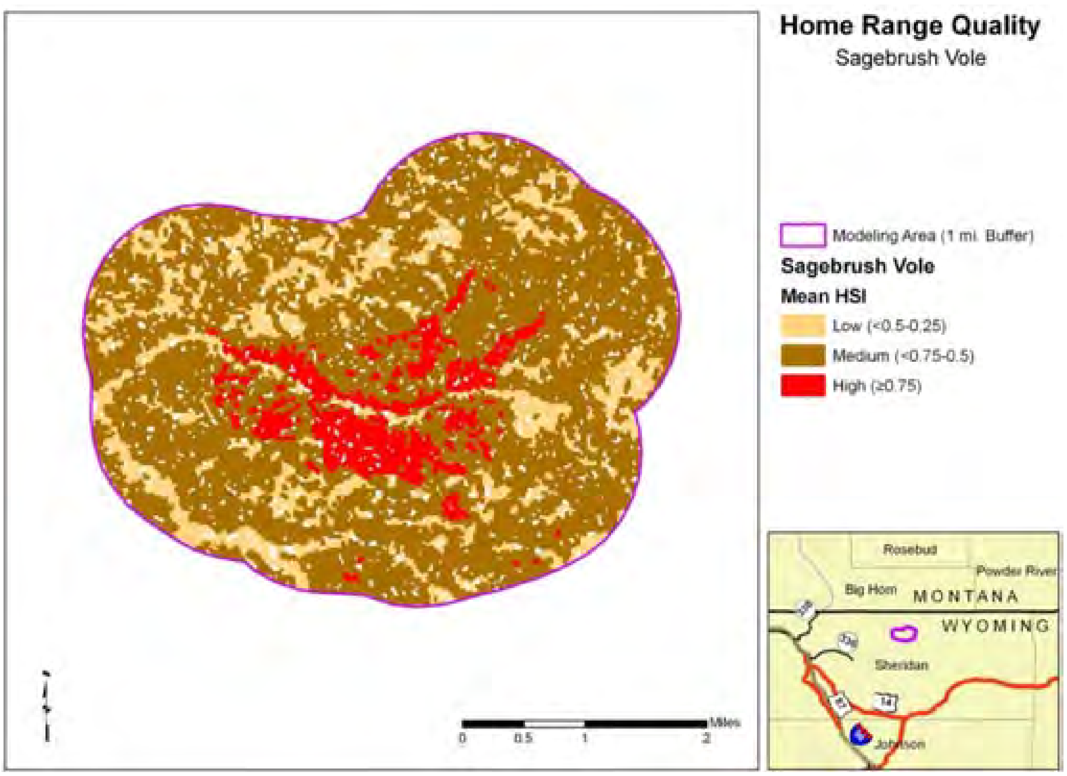


Figure B-20. Post-treatment home range quality for sagebrush vole in the Fidelity project area.

Sage grouse

The final HSI grid for sage grouse nesting habitat used for HOMEGROWER is shown in Figure B-21. 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-22 depicts the results for home range quality under existing, pre-treatment conditions while figures B-23 and B-24 present post-treatment maps.

The final HSI grid for sage grouse brood rearing habitat used for HOMEGROWER is shown in Figure B-25. 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 26 depicts the results for home range quality under existing, pre-treatment conditions, while figures B-27 and B-28 present post-treatment maps.

The final HSI grid for sage grouse wintering used for HOMEGROWER is shown in Figure 29. 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 B-30 depicts the results for home range quality under existing, pre-treatment conditions, while figures B-31 and B-32 present post-treatment results.

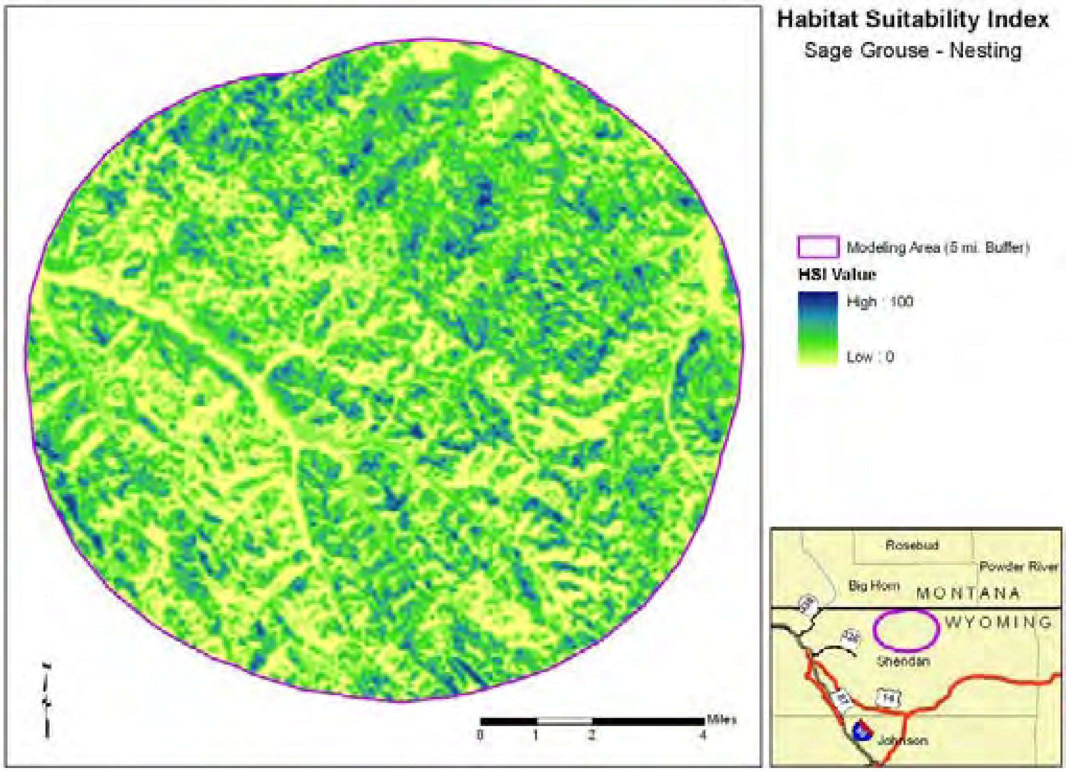


Figure B-21. Pre-treatment habitat suitability index for sage grouse -nesting in the Fidelity project area.

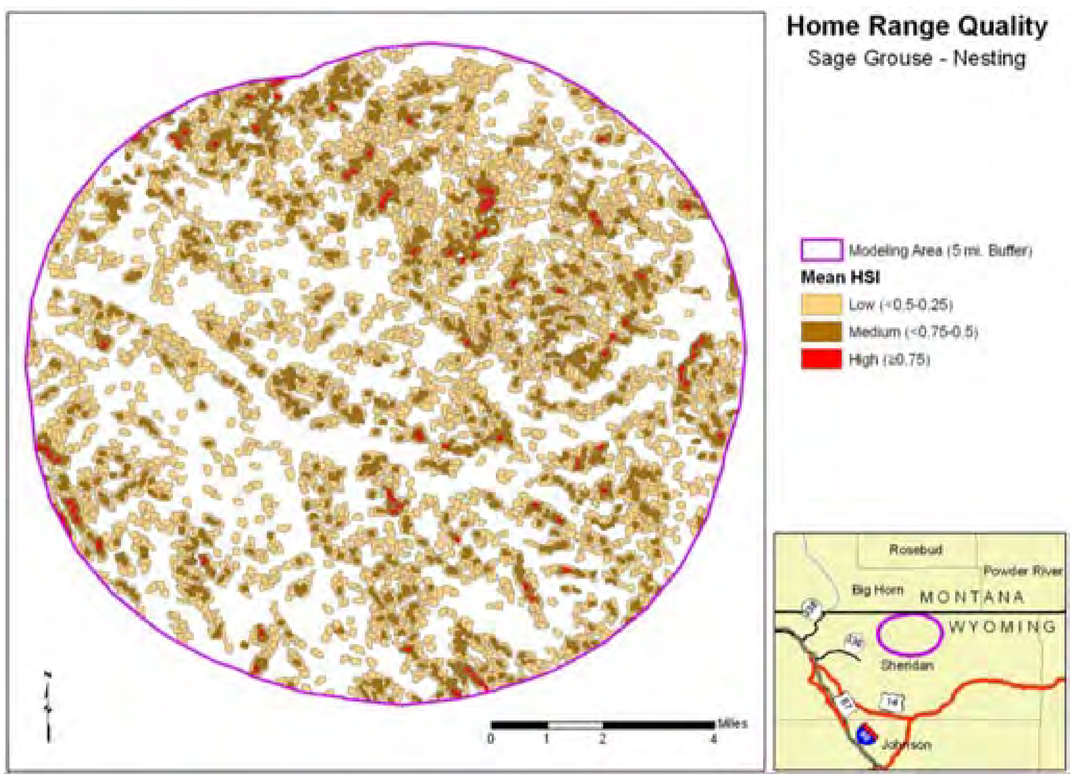


Figure B-22. Pre-treatment home range quality for sage grouse nesting in the Fidelity project area.

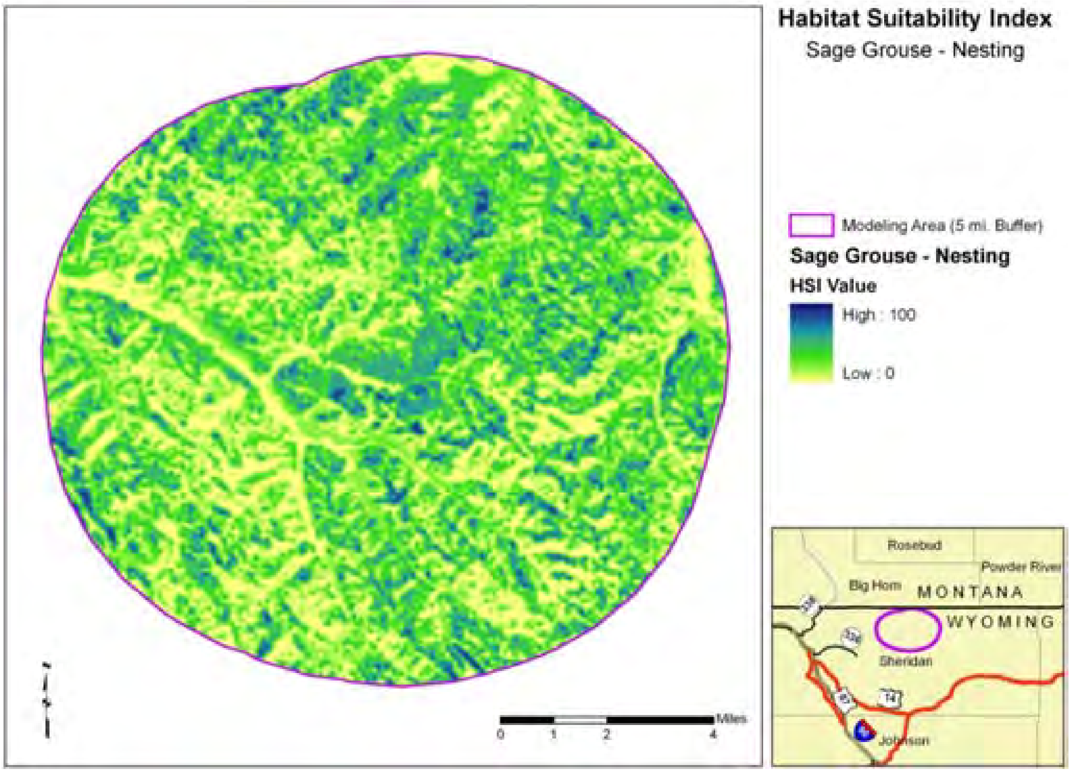


Figure B-23. Post-treatment habitat suitability index for sage grouse nesting in the Fidelity project area.

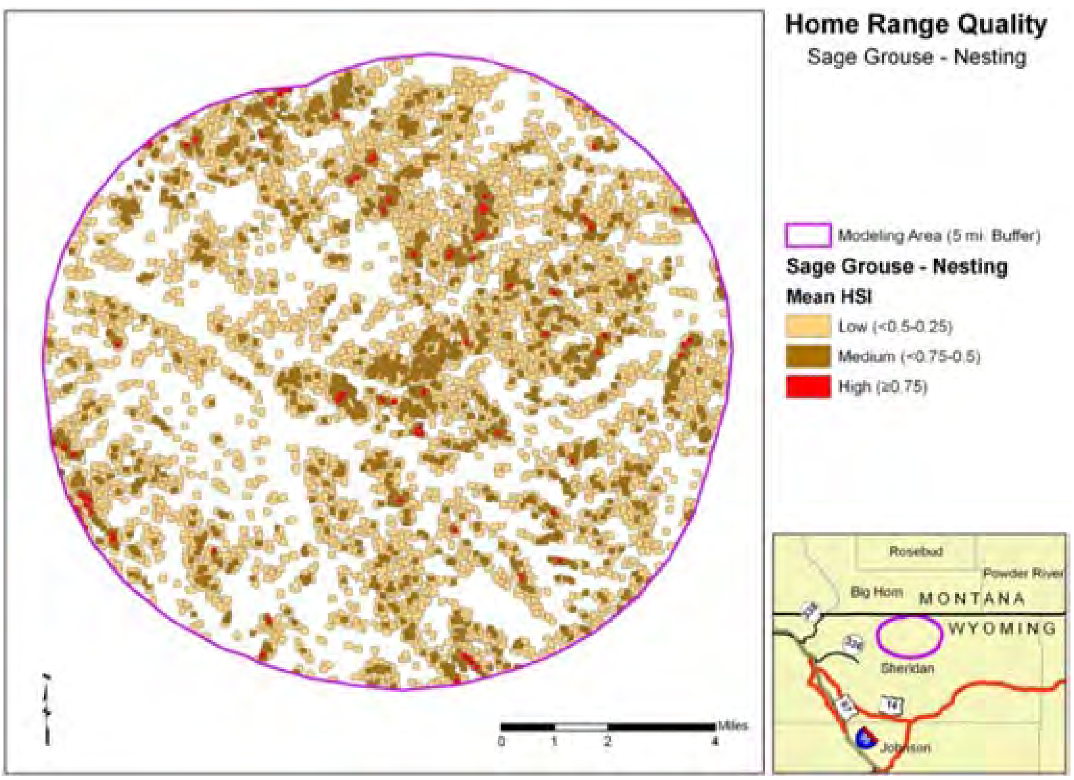


Figure B-24. Post-treatment home range quality for sage grouse nesting in the Fidelity project area.

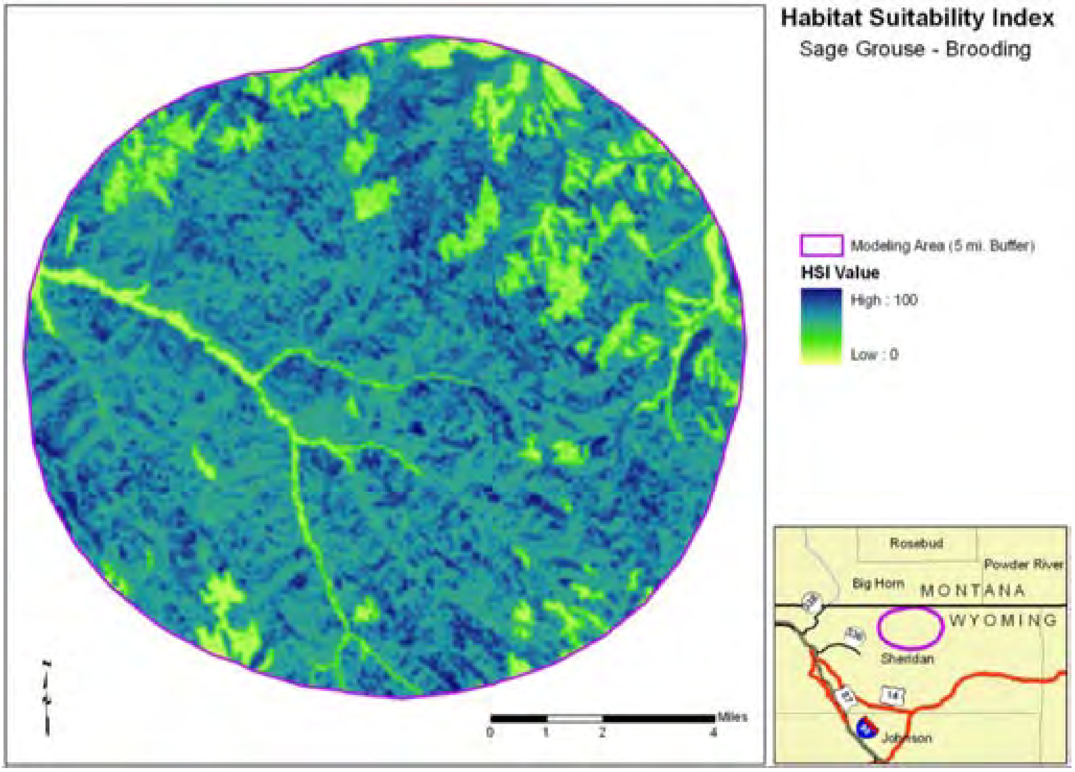


Figure B-25. Pre-treatment habitat suitability index for sage grouse brood rearing in the Fidelity project area.

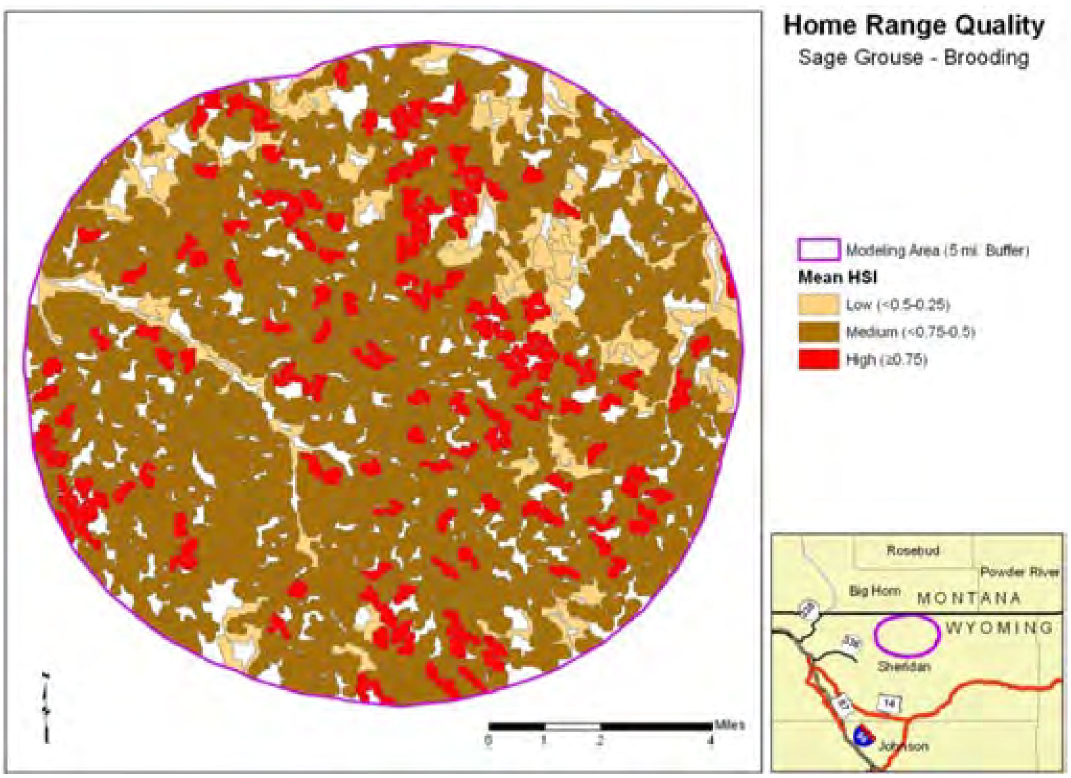


Figure B-26. Pre-treatment home range quality for sage grouse brood rearing in the Fidelity project area.

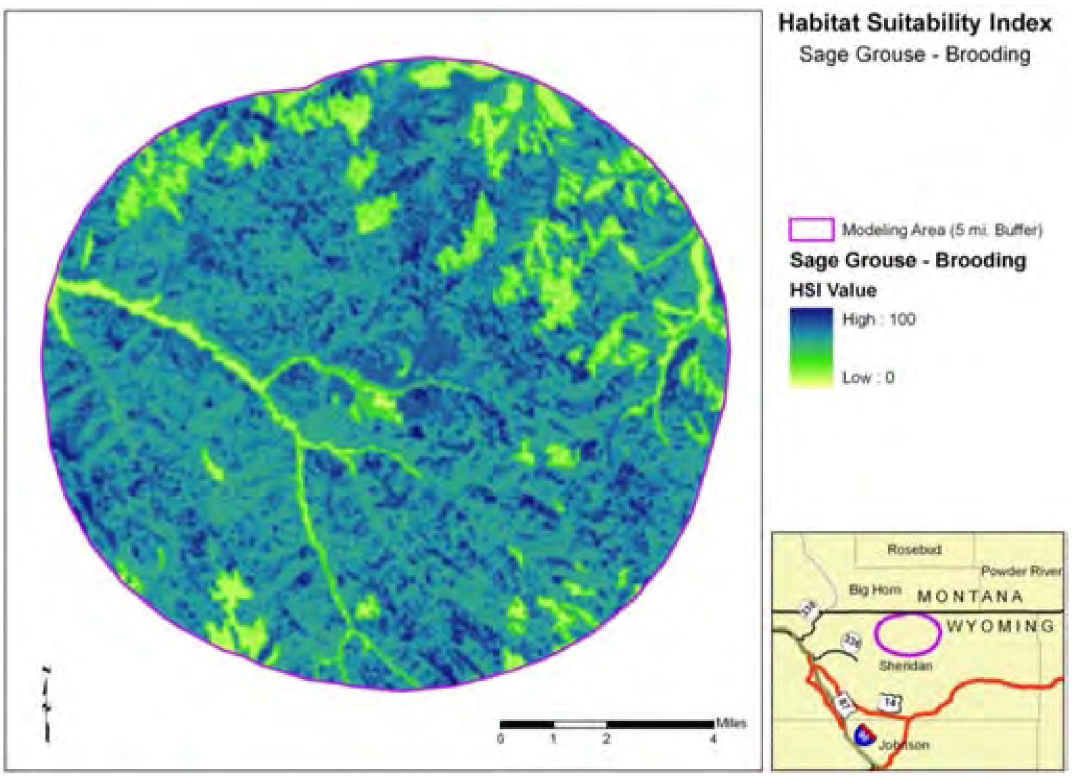


Figure B-27. Post-treatment habitat suitability index for sage grouse brood rearing habitat in the Fidelity project area.

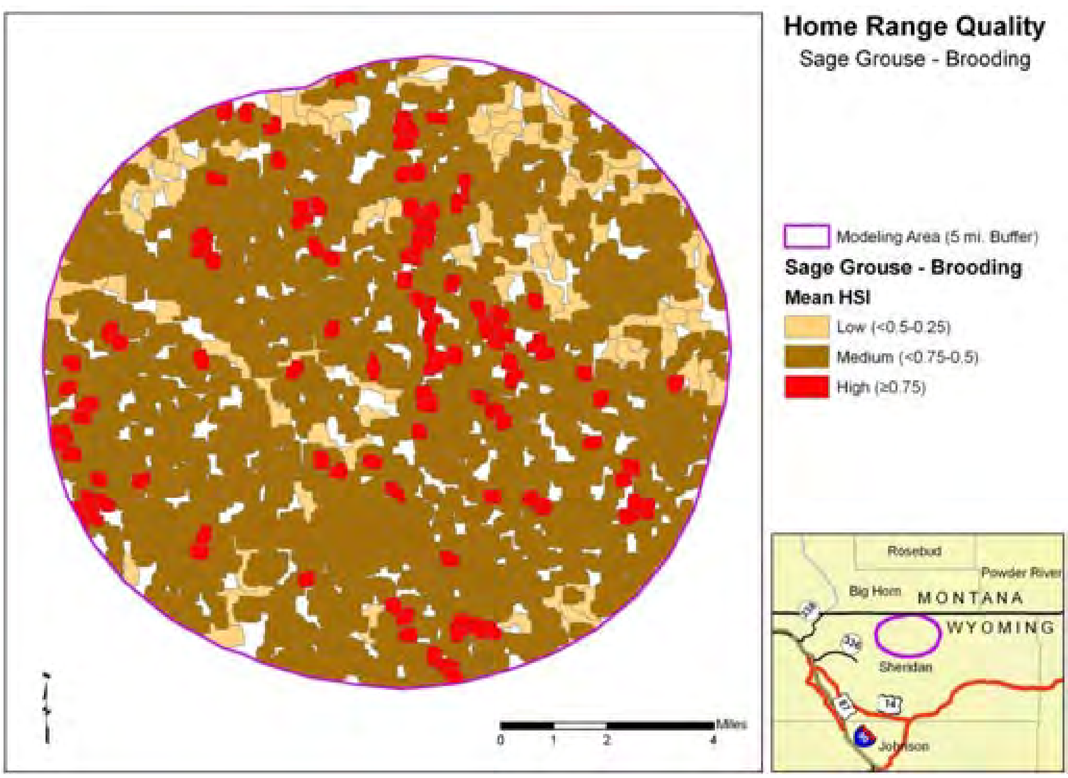


Figure B-28. Post-treatment home range quality for sage grouse brood rearing habitat in the Fidelity project area.

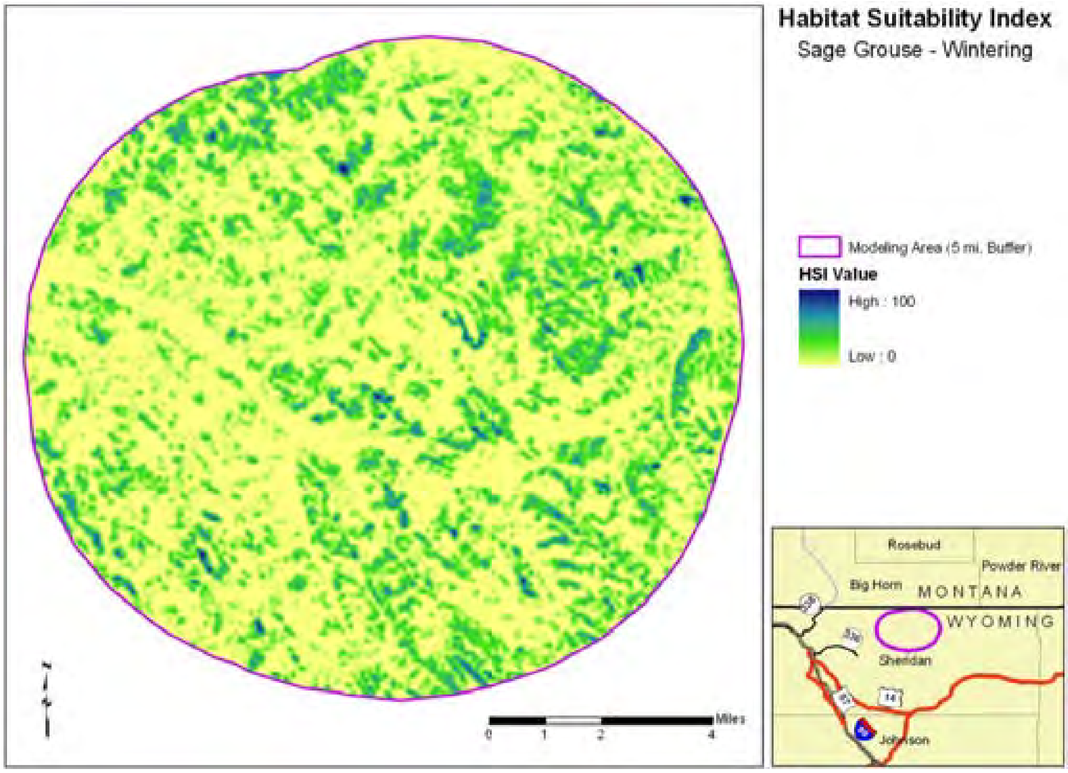


Figure B-29. Pre-treatment habitat suitability index for sage grouse wintering habitat in the Fidelity project area.

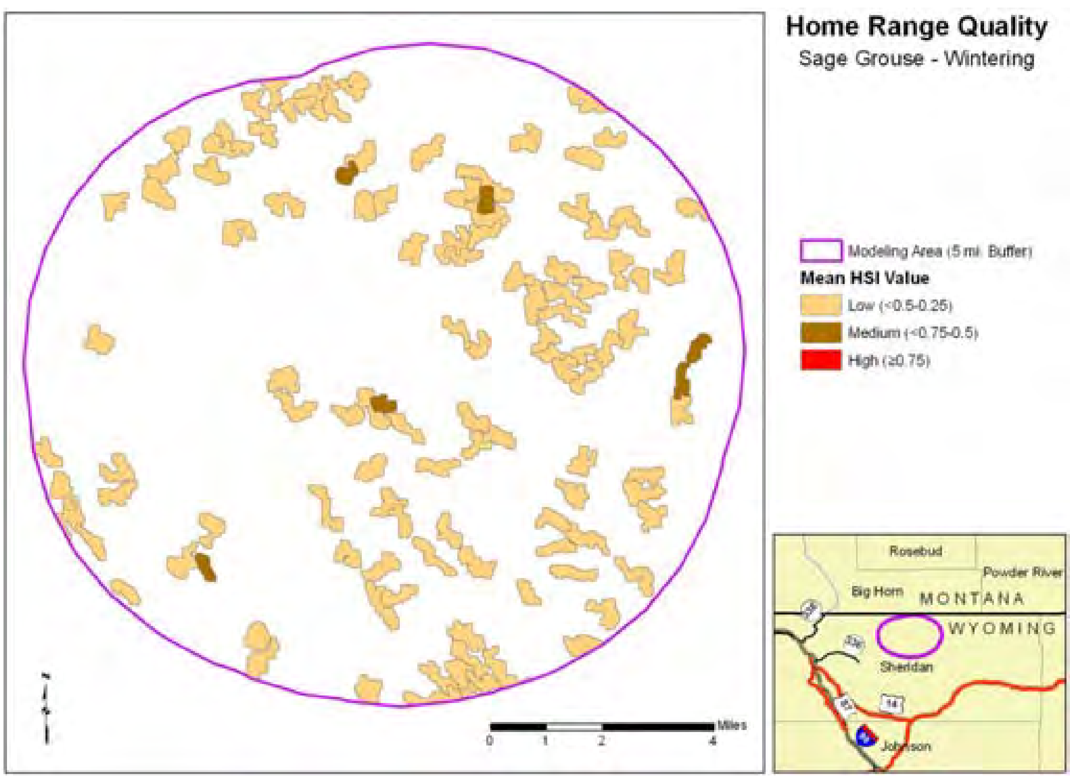


Figure B-30. Pre-treatment home range quality for sage grouse wintering habitat in the Fidelity project area.

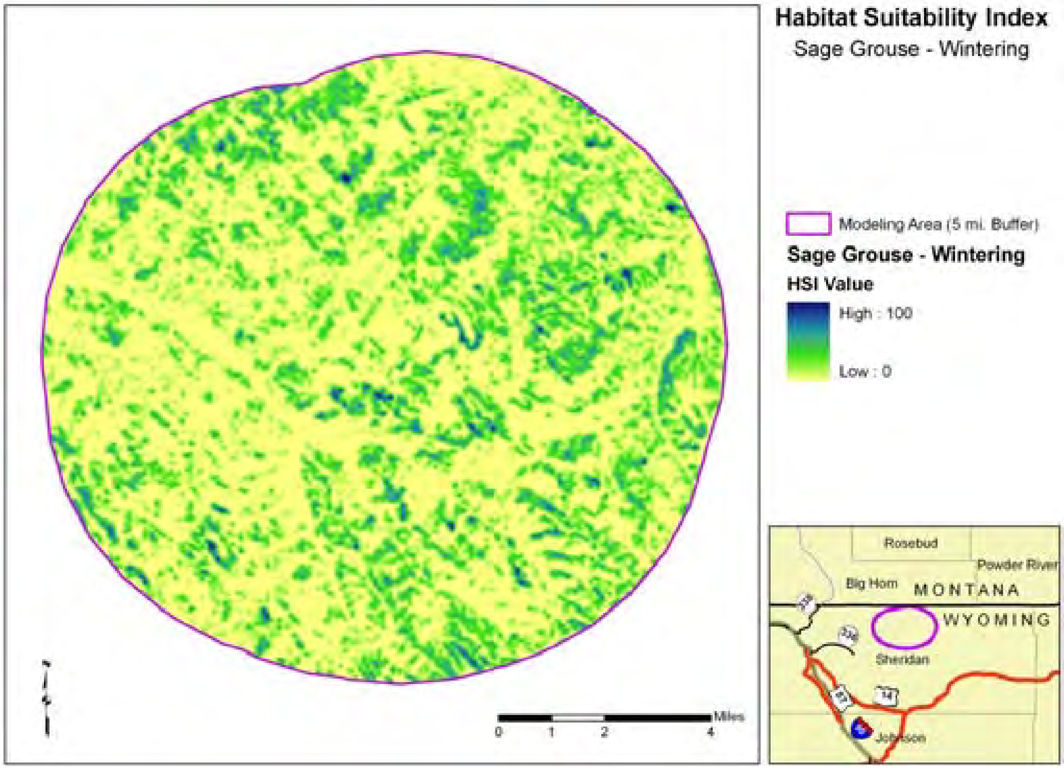


Figure B-31. Post-treatment habitat suitability index for sage grouse wintering habitat in the Fidelity project area.

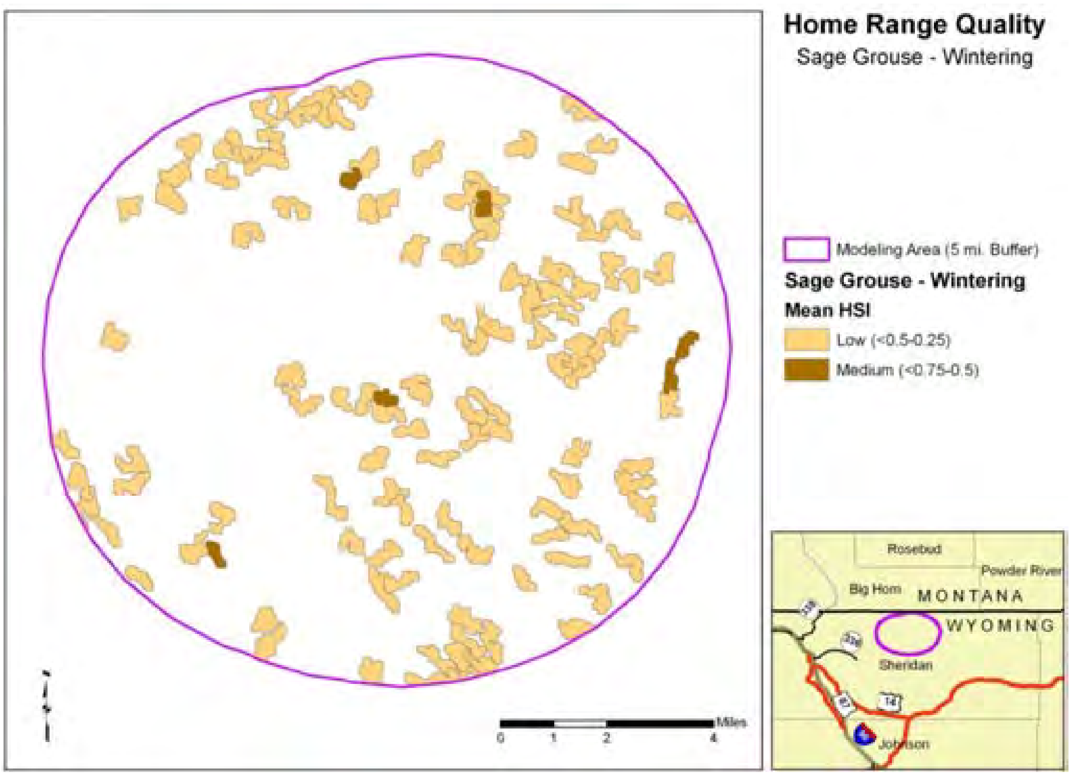


Figure B-32. Post-treatment home range quality for sage grouse wintering habitat in the Fidelity project area.

Ash Valley Project, California

Sage Grouse

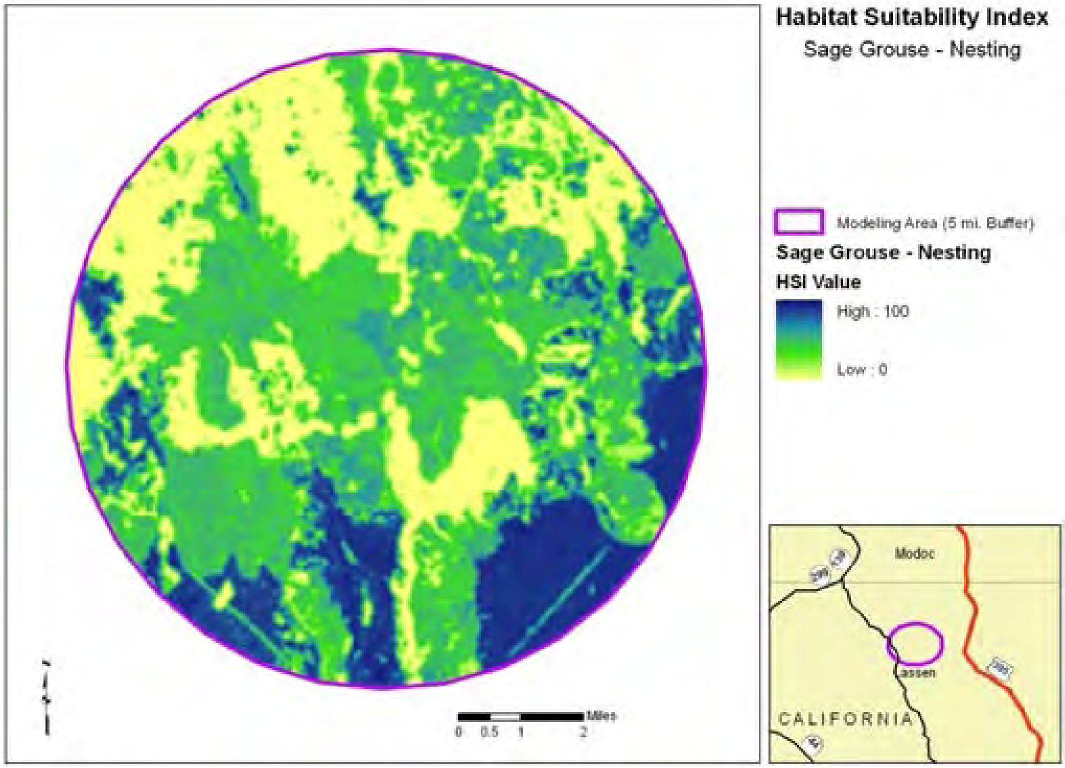


Figure B-33. Pre-treatment habitat suitability map for nesting sage grouse in Ash Valley Ranch, California.

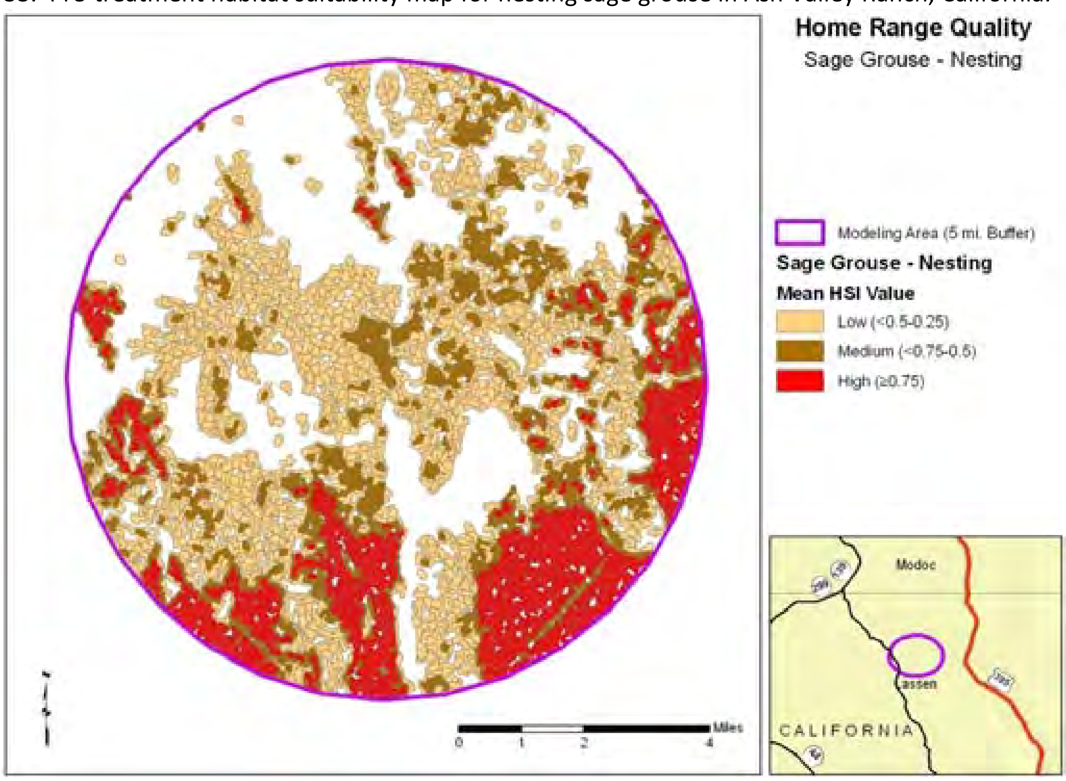


Figure B-34. Pre-treatment home range analysis of sage grouse nesting habitat in Ash Valley Ranch, California.

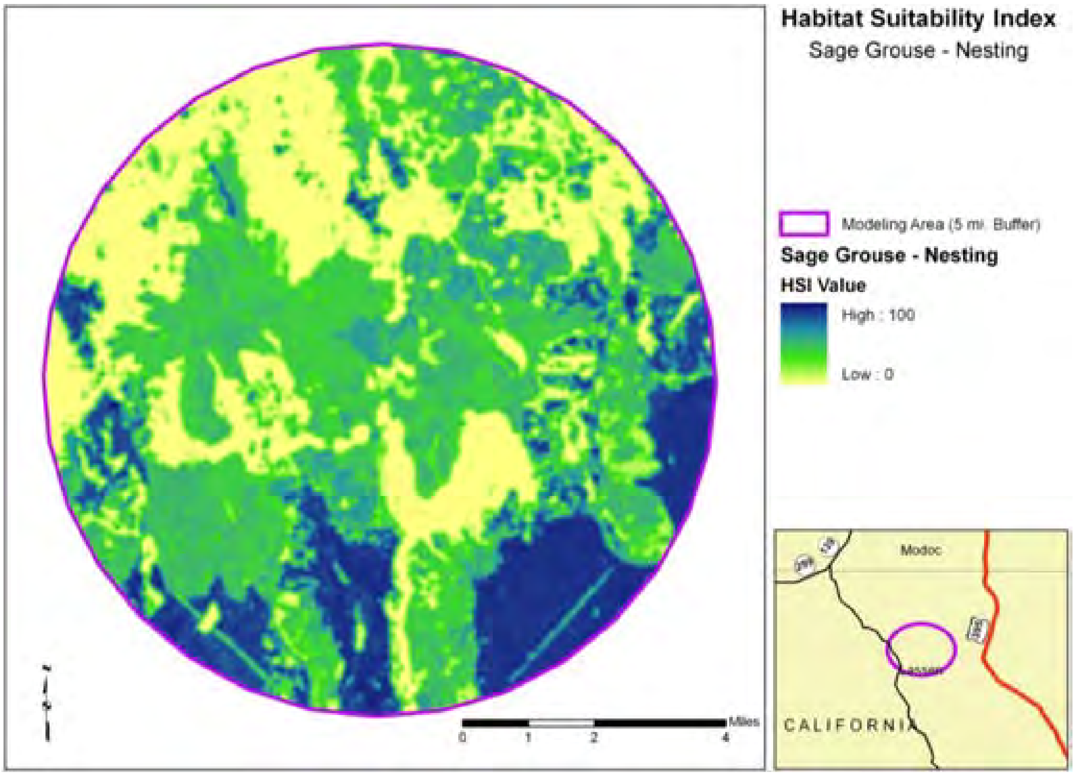


Figure B-35. Post-treatment habitat suitability map for nesting sage grouse in Ash Valley Ranch, California.

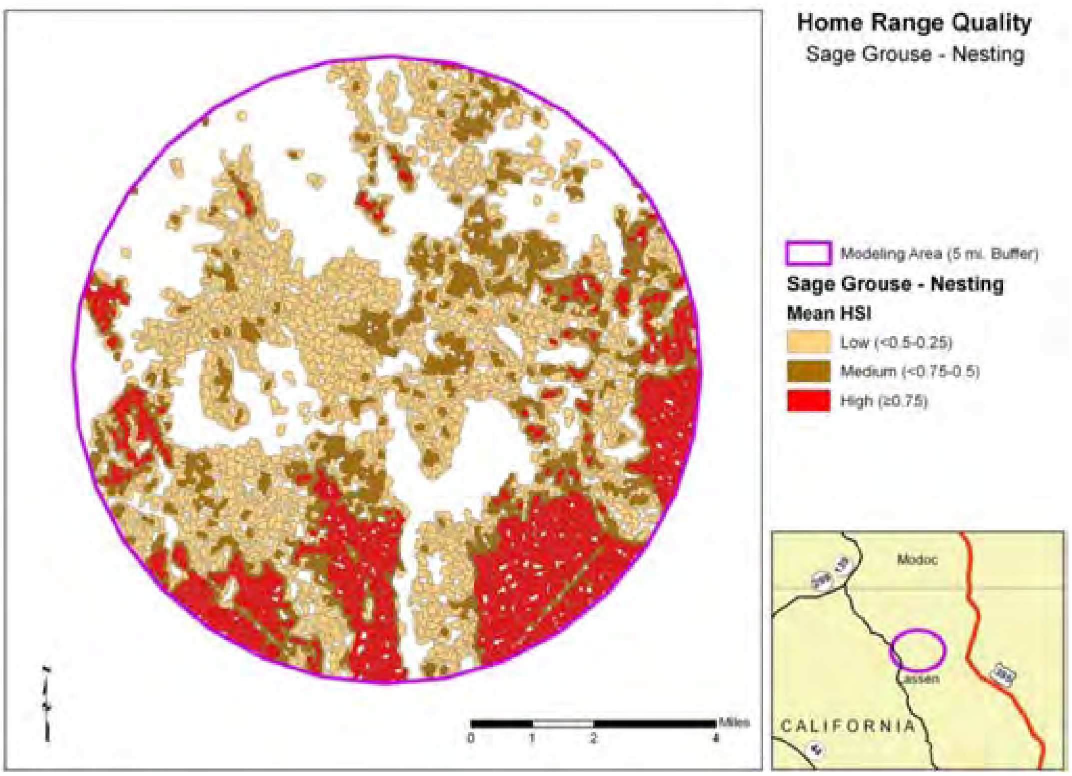


Figure B-36. Pre-treatment home range analysis of sage grouse nesting habitat in Ash Valley Ranch, California.

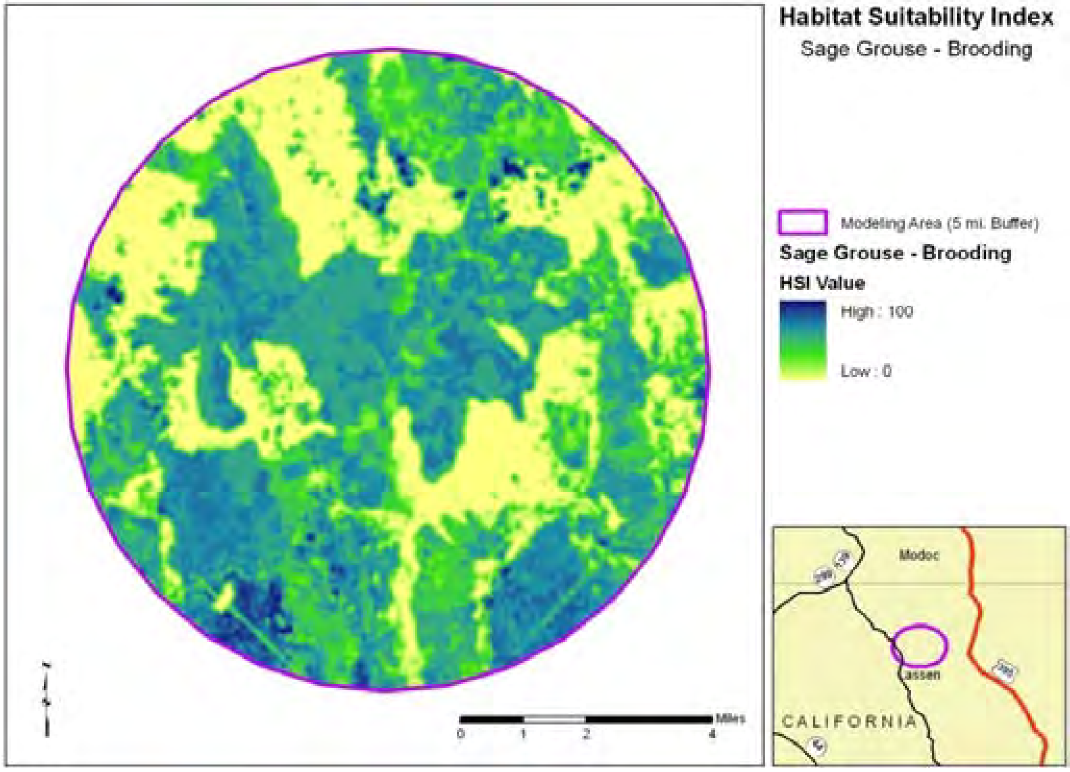


Figure B-37. Pre-treatment habitat suitability map for sage grouse brood rearing habitat in Ash Valley Ranch, California.

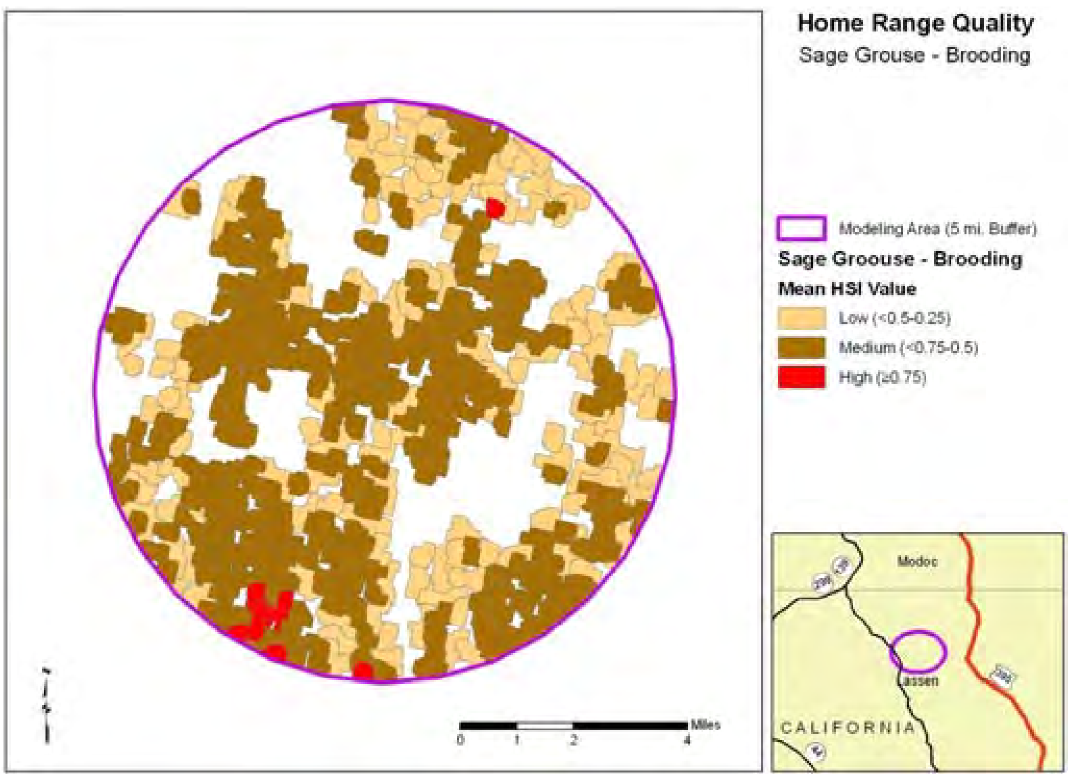


Figure B-38. Pre-treatment home range analysis of brood-rearing habitat for sage grouse in the Ash Valley Ranch, California.

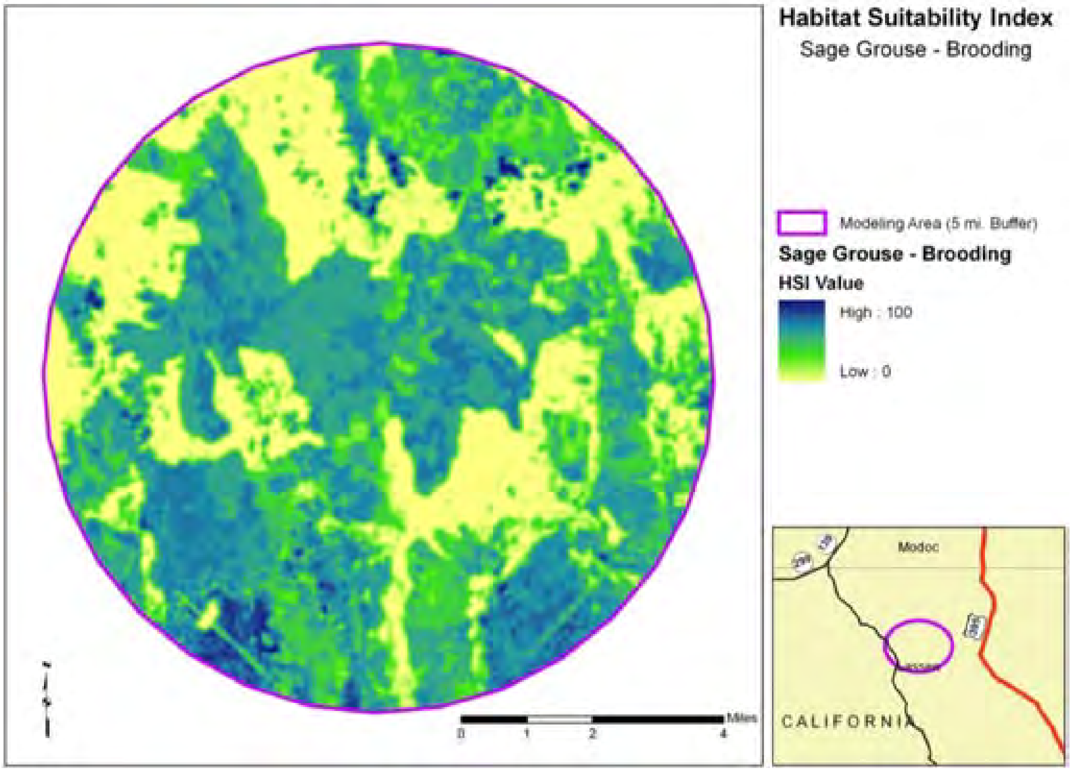
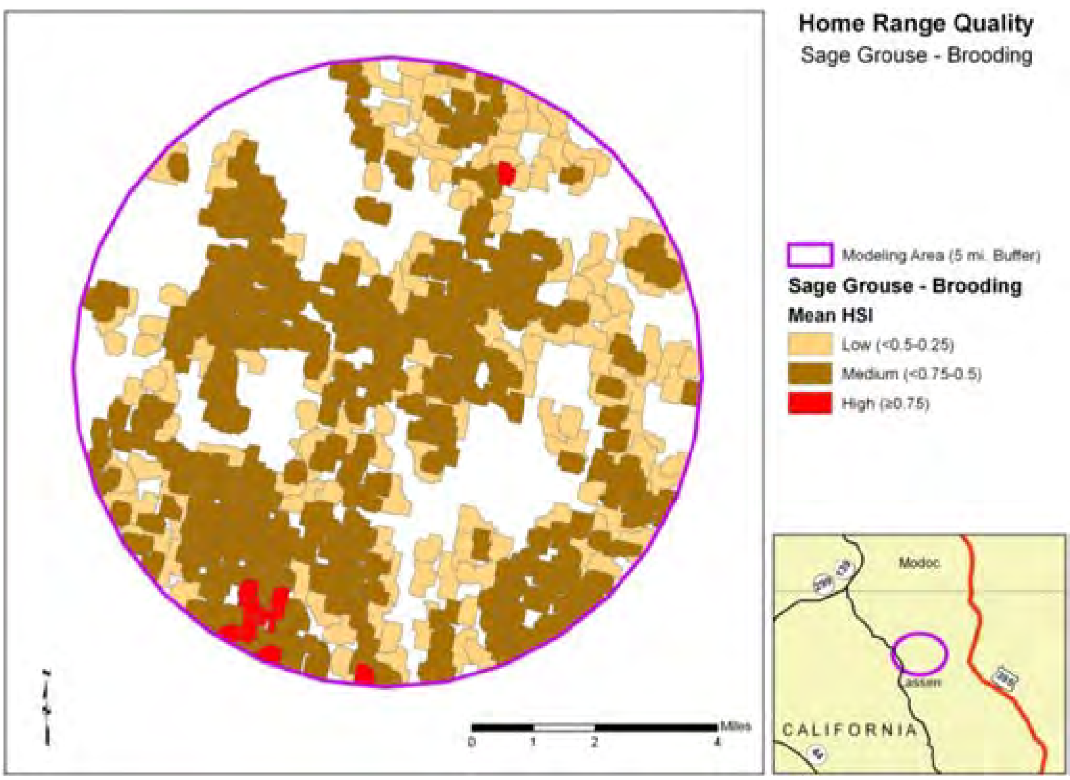


Figure B-39. Post-treatment habitat suitability map for sage grouse brood rearing habitat in Ash Valley Ranch, California.



igure B-40. Post-treatment home range analysis of brood-rearing habitat for sage grouse in the Ash Valley Ranch, California.

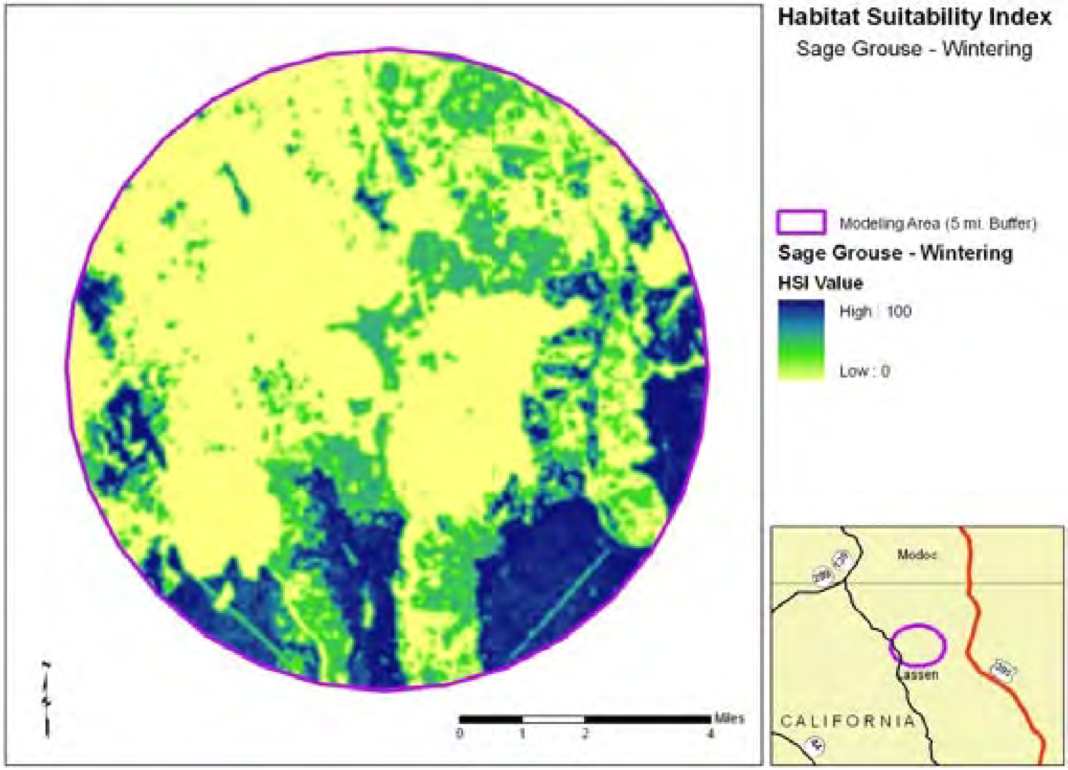


Figure B-41. Pre-treatment habitat suitability map for wintering sage grouse habitat in the Ash Valley Ranch, California.

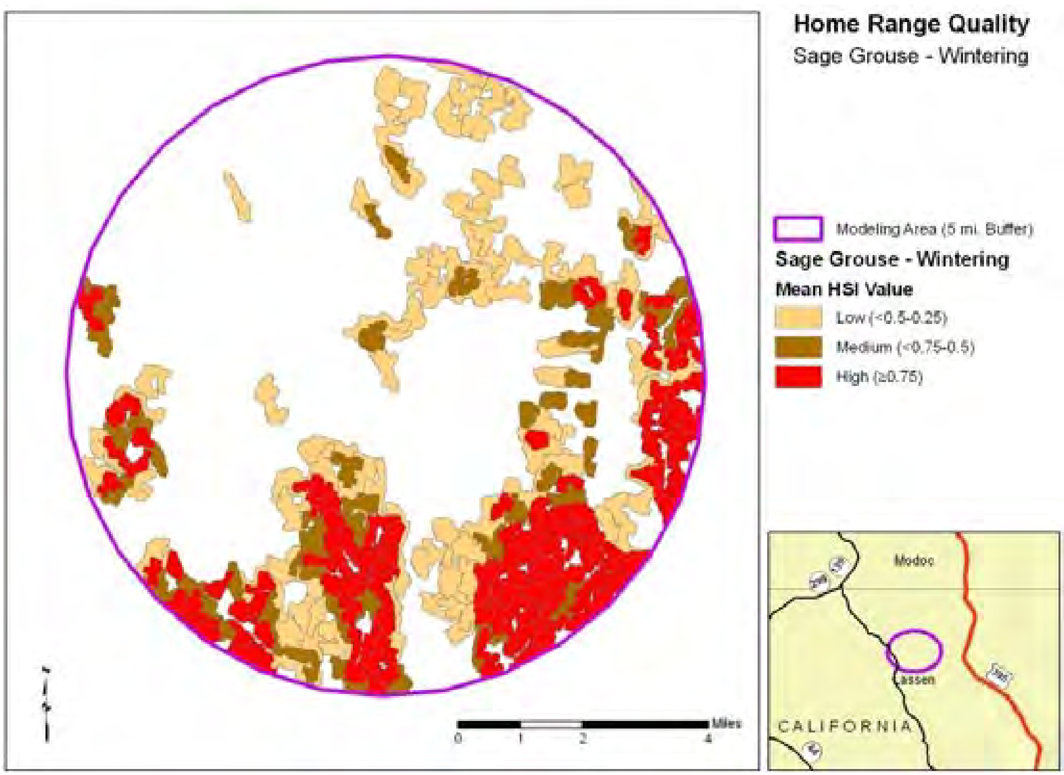


Figure B-42. Pre-treatment home range analysis of sage grouse wintering habitat in Ash Valley Ranch, California.

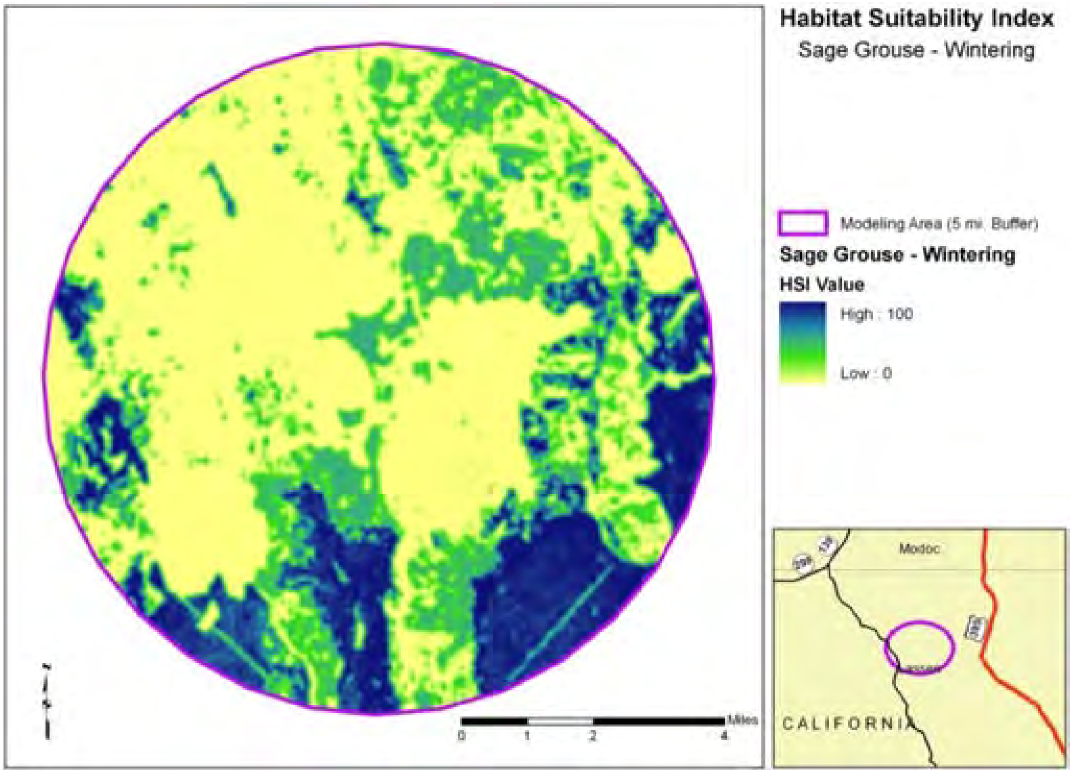


Figure B-43. Post-treatment habitat suitability map for wintering sage grouse habitat in the Ash Valley Ranch, California.

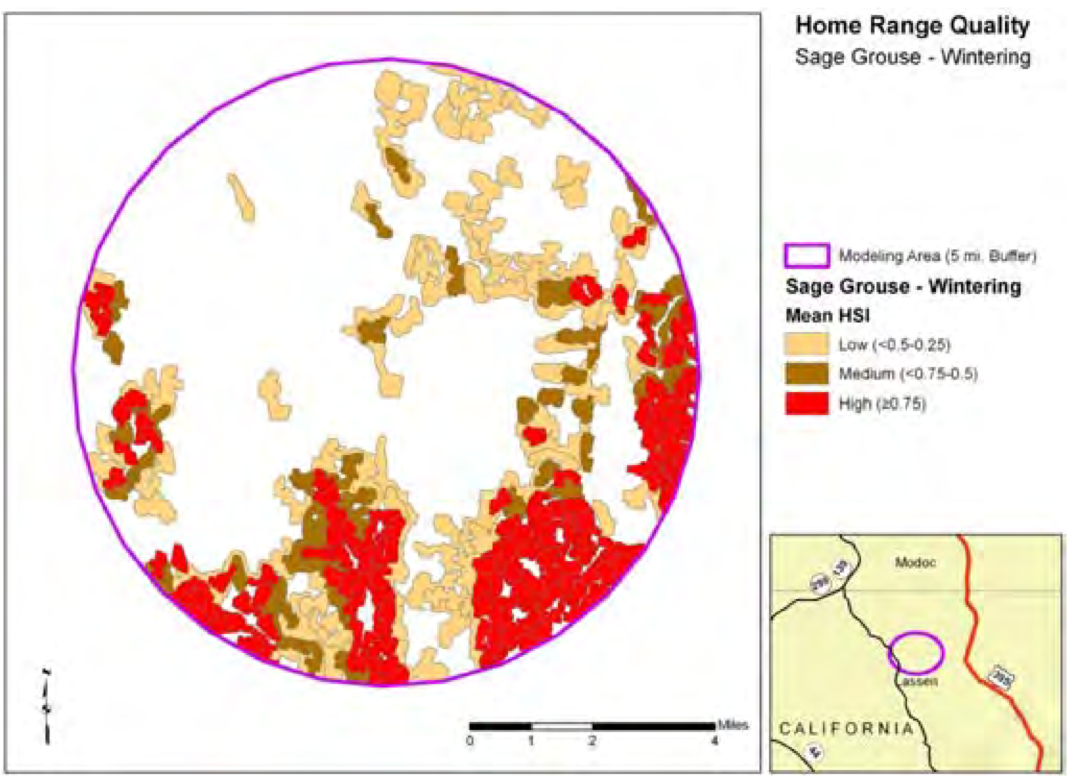


Figure B-44. Post-treatment home range analysis of sage grouse wintering habitat in Ash Valley Ranch, California.

Sage Thrasher

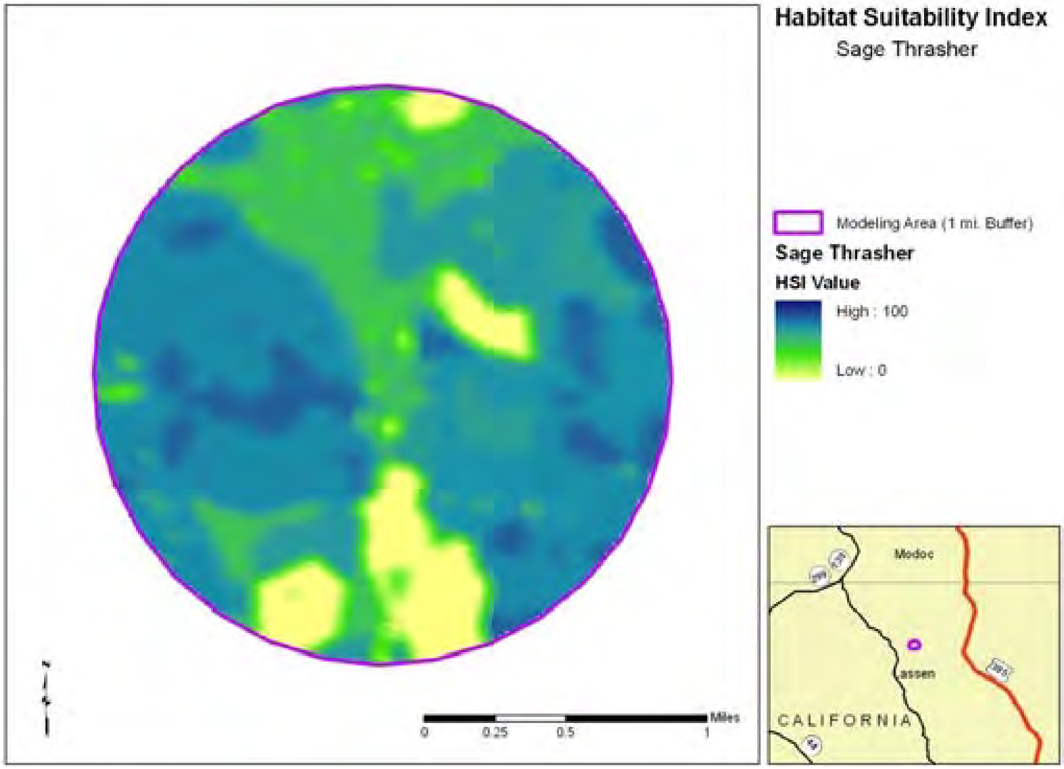


Figure B-45. Pre-treatment habitat suitability map of sage thrasher habitat in Ash Valley Ranch, California.

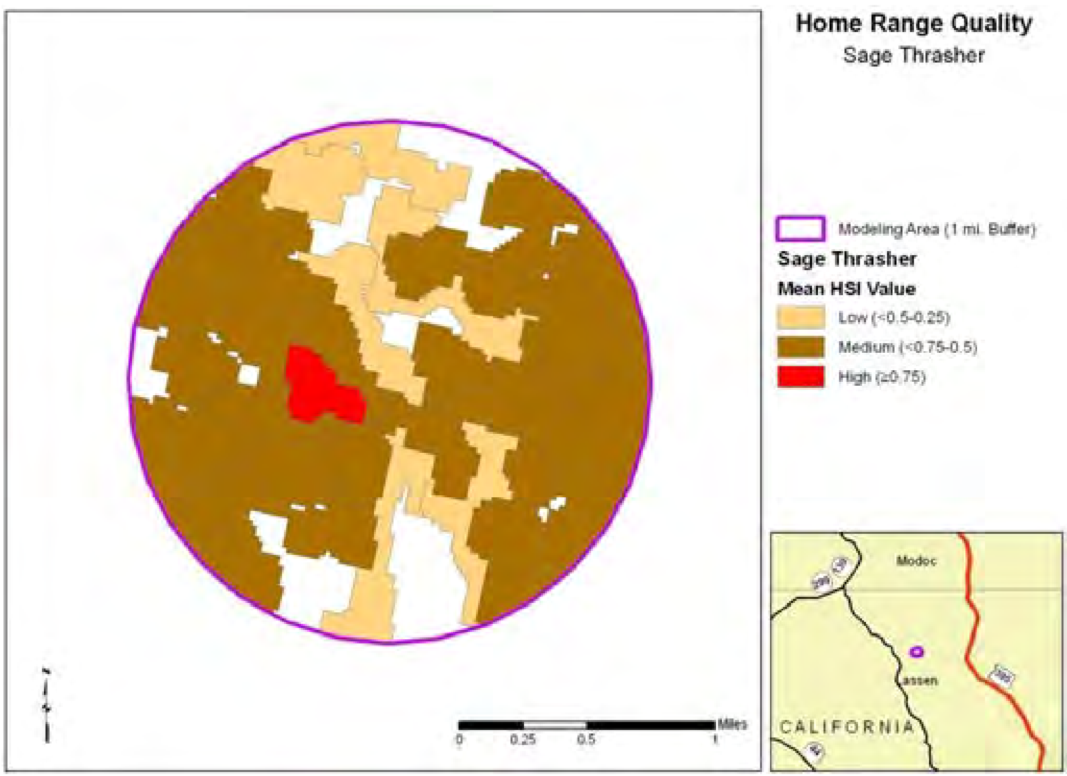


Figure B-46. Pre-treatment home range analysis of sage thrasher habitat in Ash Valley Ranch, California.

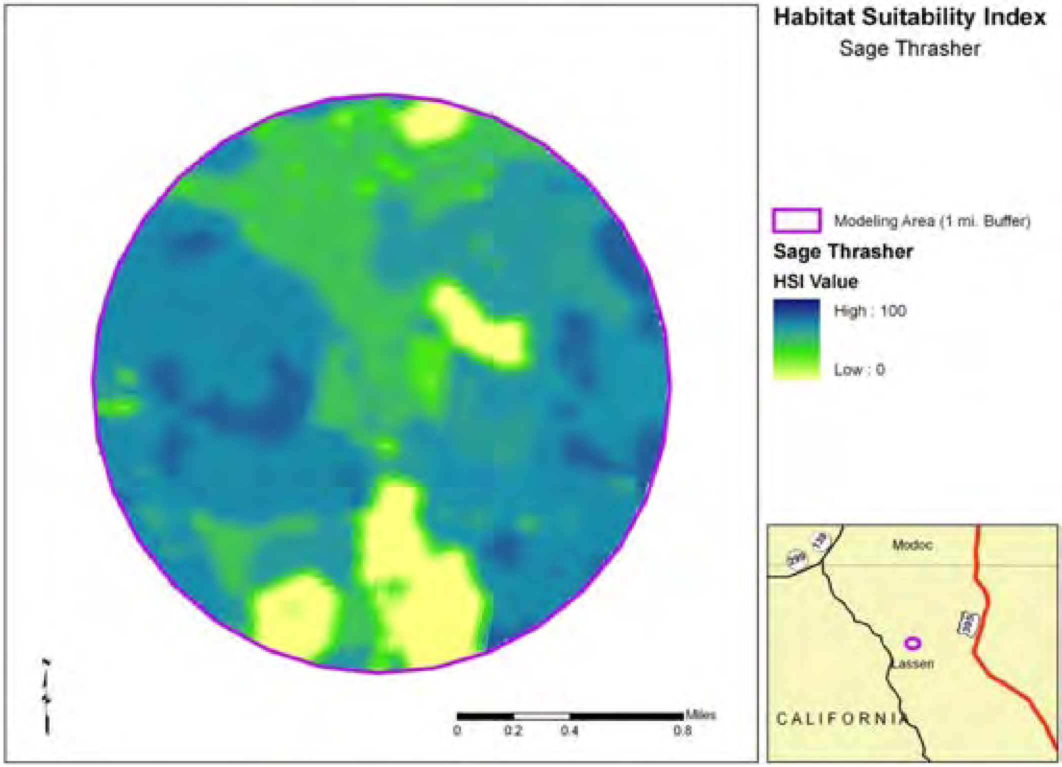


Figure B-47. Post-treatment habitat suitability map of sage thrasher habitat in Ash Valley Ranch, California.

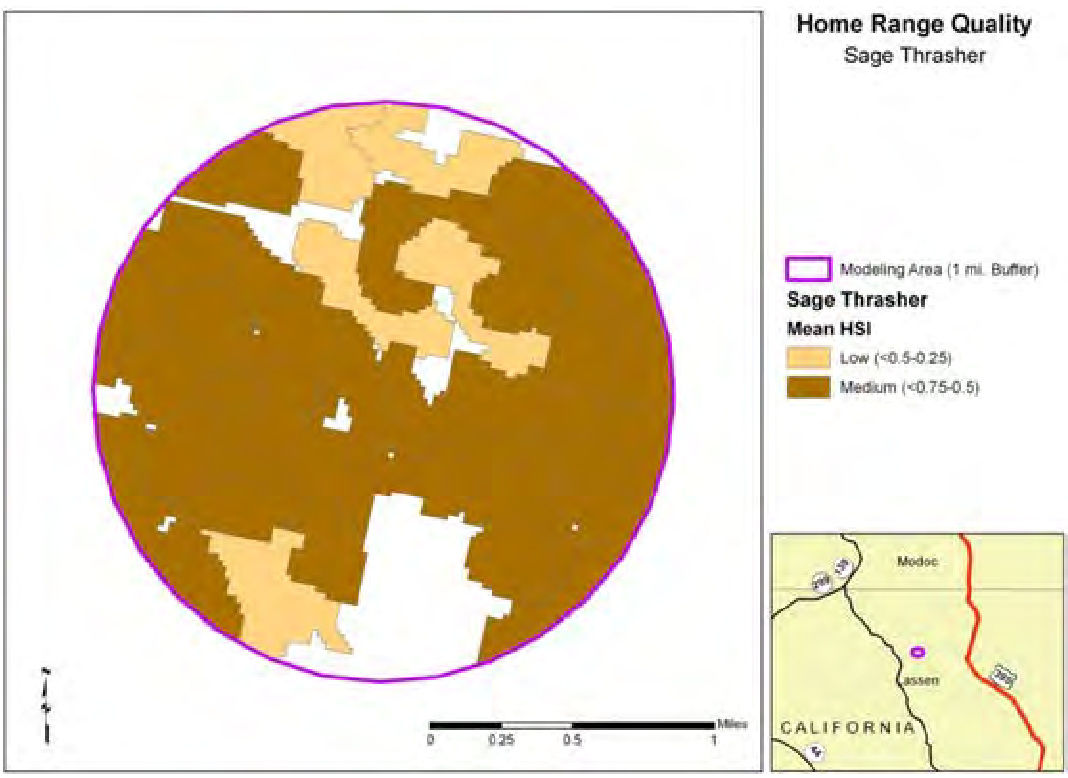


Figure B-48. Post-treatment home range analysis of sage thrasher habitat in Ash Valley Ranch, California.

Sage Sparrow

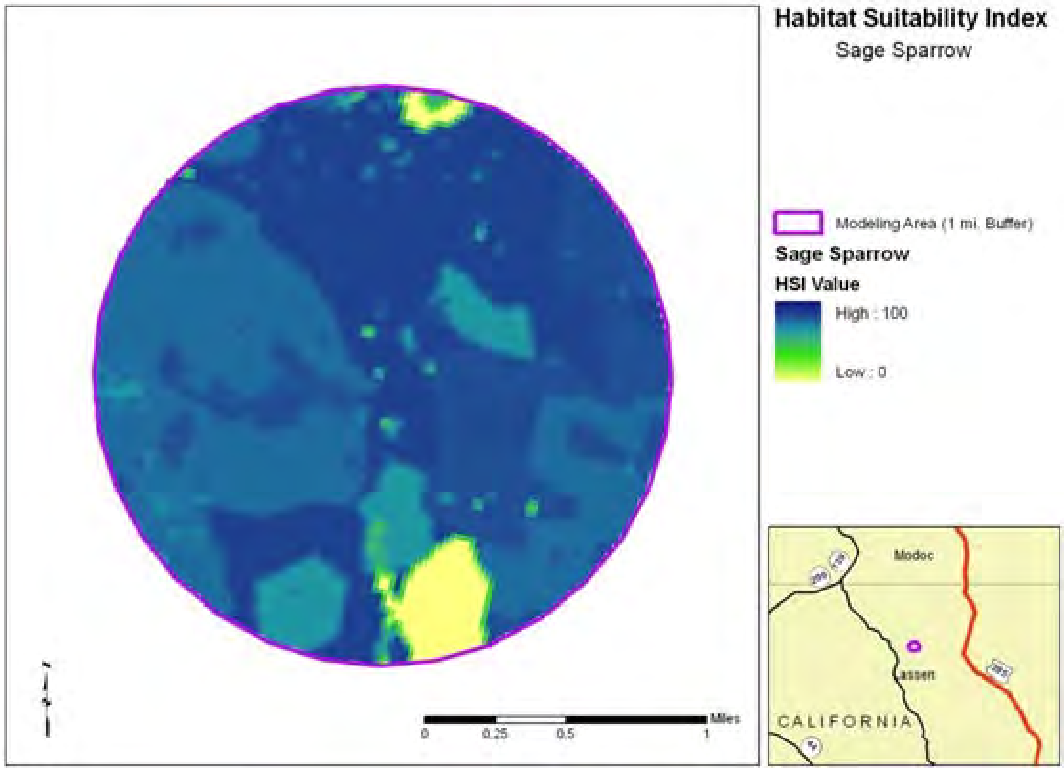


Figure B-49. Pre-treatment habitat suitability map for sage sparrows in Ash Valley Ranch, California.

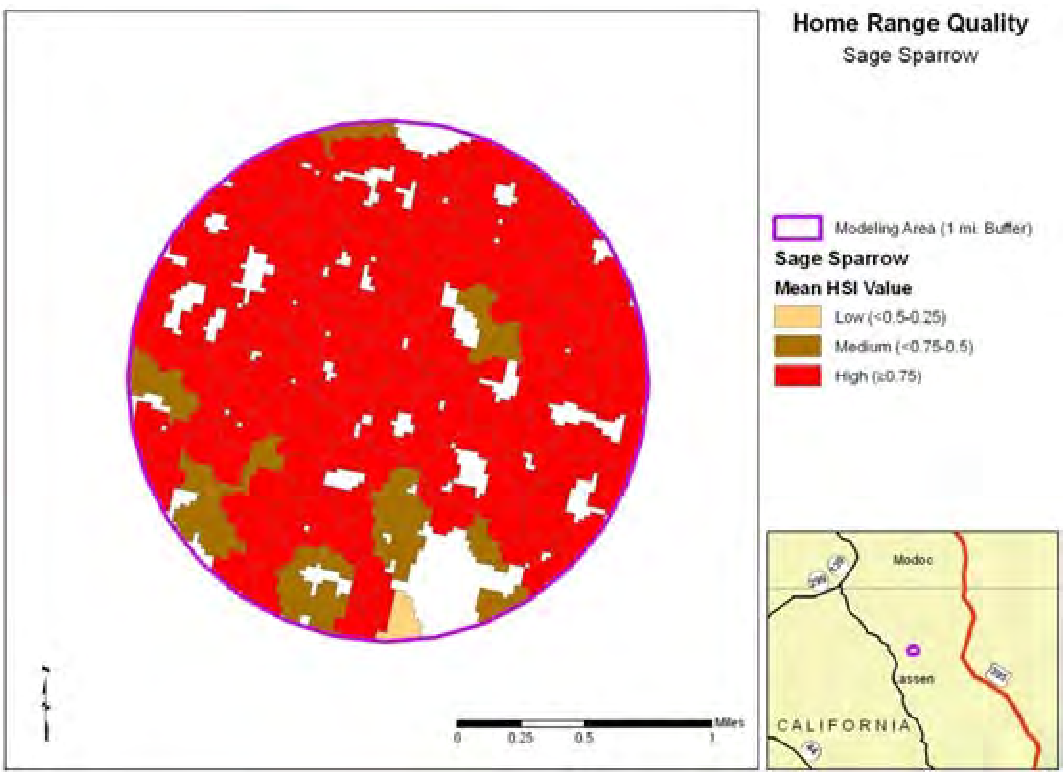


Figure B-50. Pre-treatment home range analysis of sage sparrow habitat in Ash Valley Ranch, California.

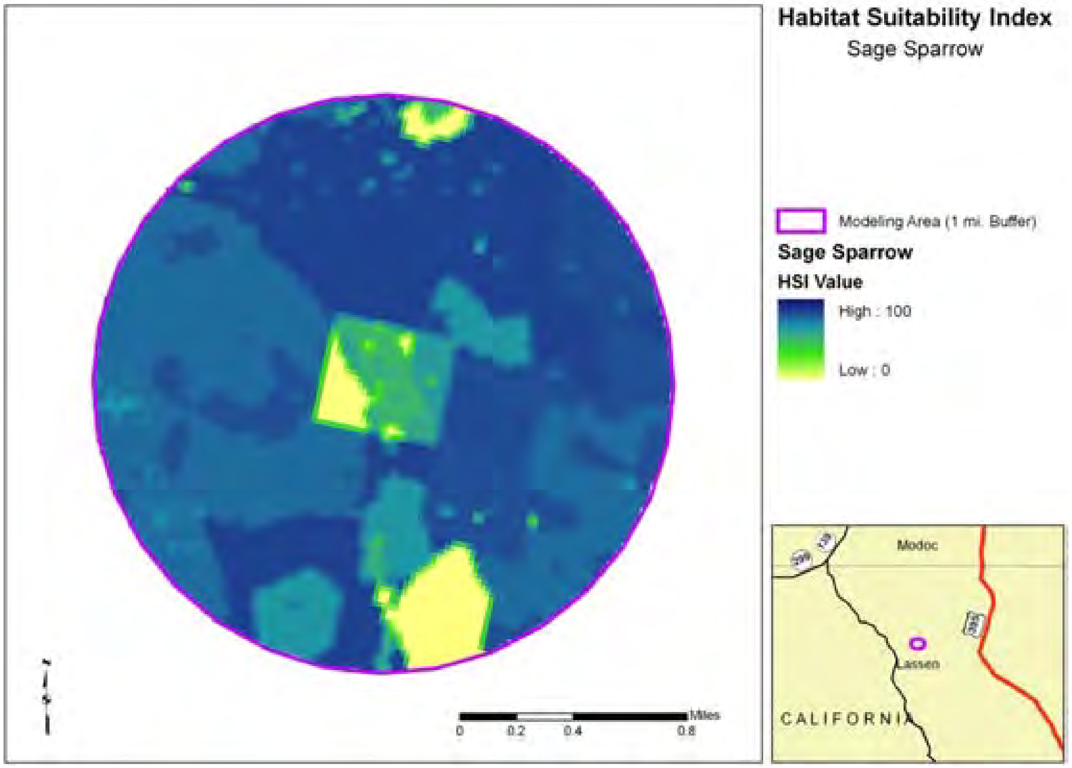


Figure B-51. Post-treatment habitat suitability map for sage sparrows in Ash Valley Ranch, California.

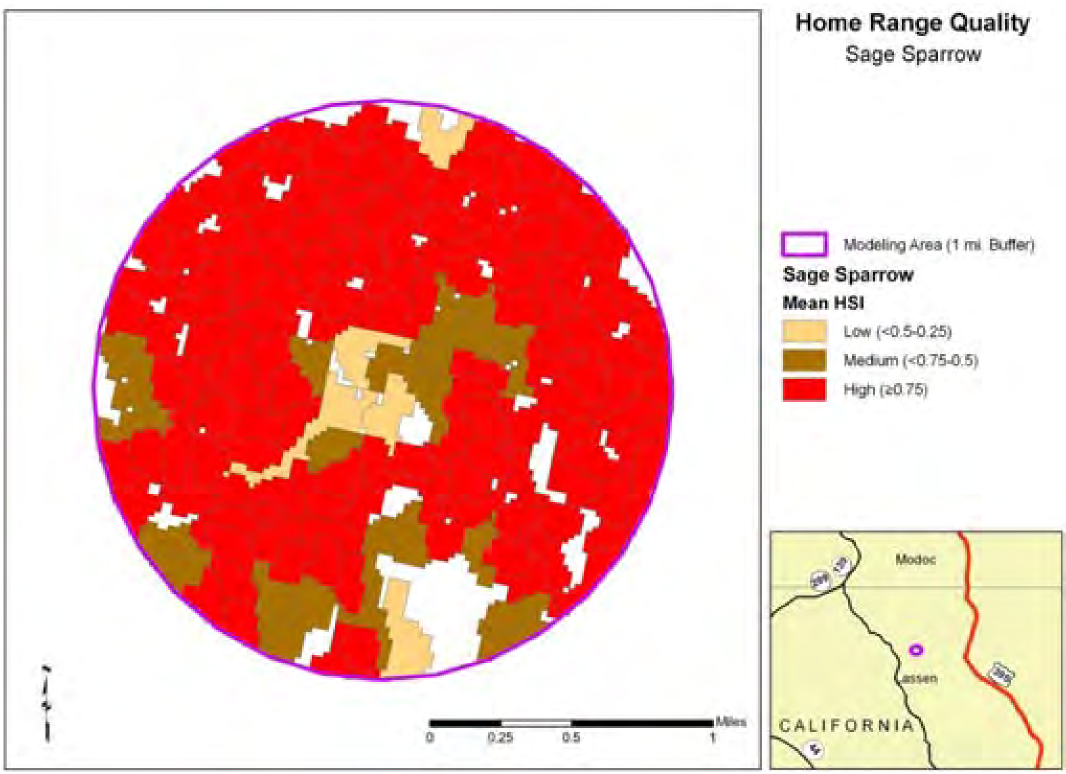


Figure B-52. Post-treatment home range analysis of sage sparrow habitat in Ash Valley Ranch, California.

Sagebrush Vole

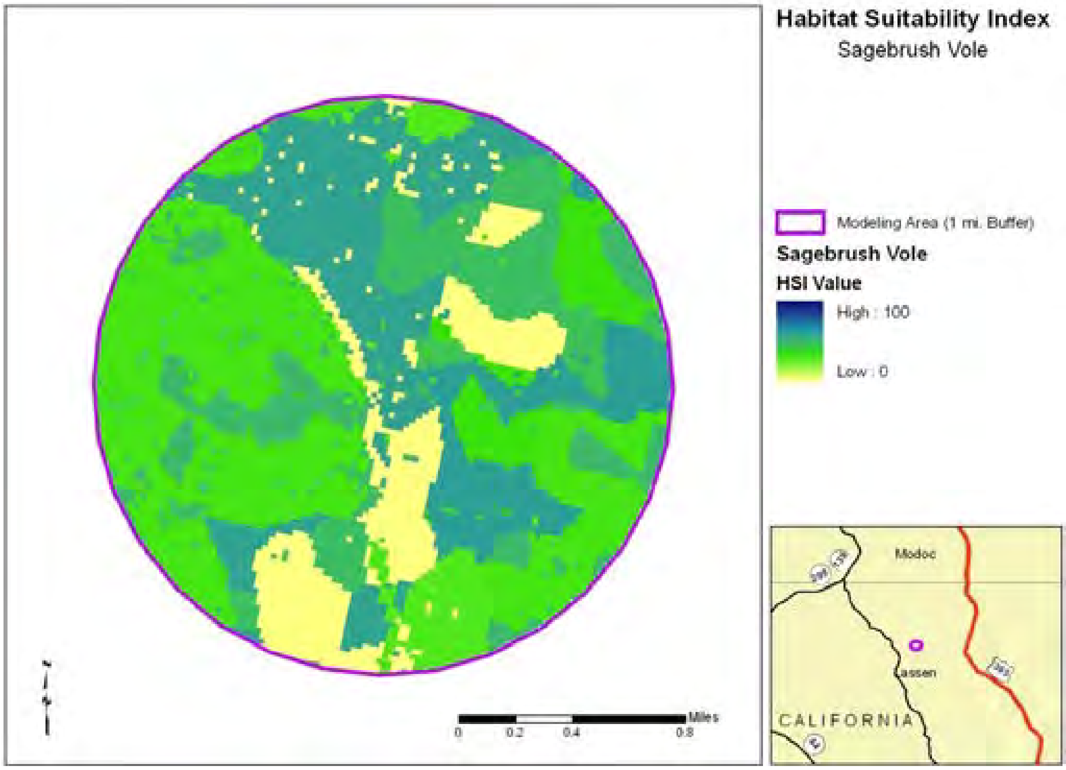


Figure B-53. Pre-treatment habitat suitability map for sagebrush voles in Ash Valley Ranch, California.

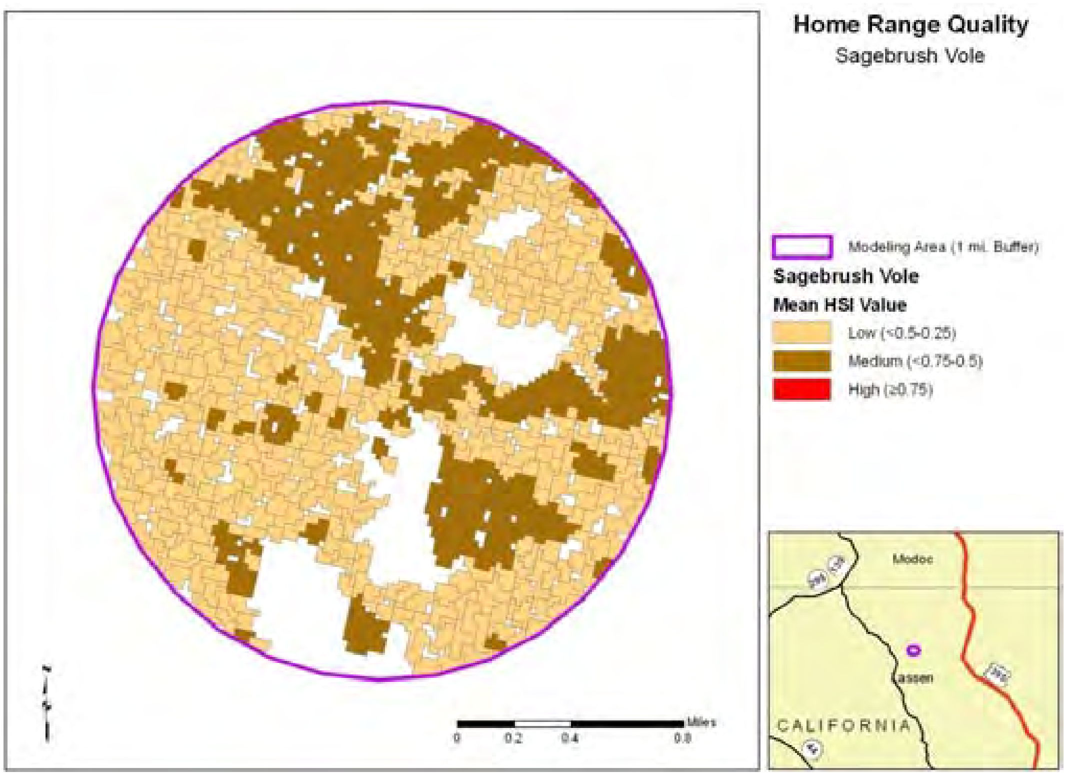


Figure B-54. Pre-treatment home range analysis of sagebrush vole habitat in Ash Valley Ranch, California.

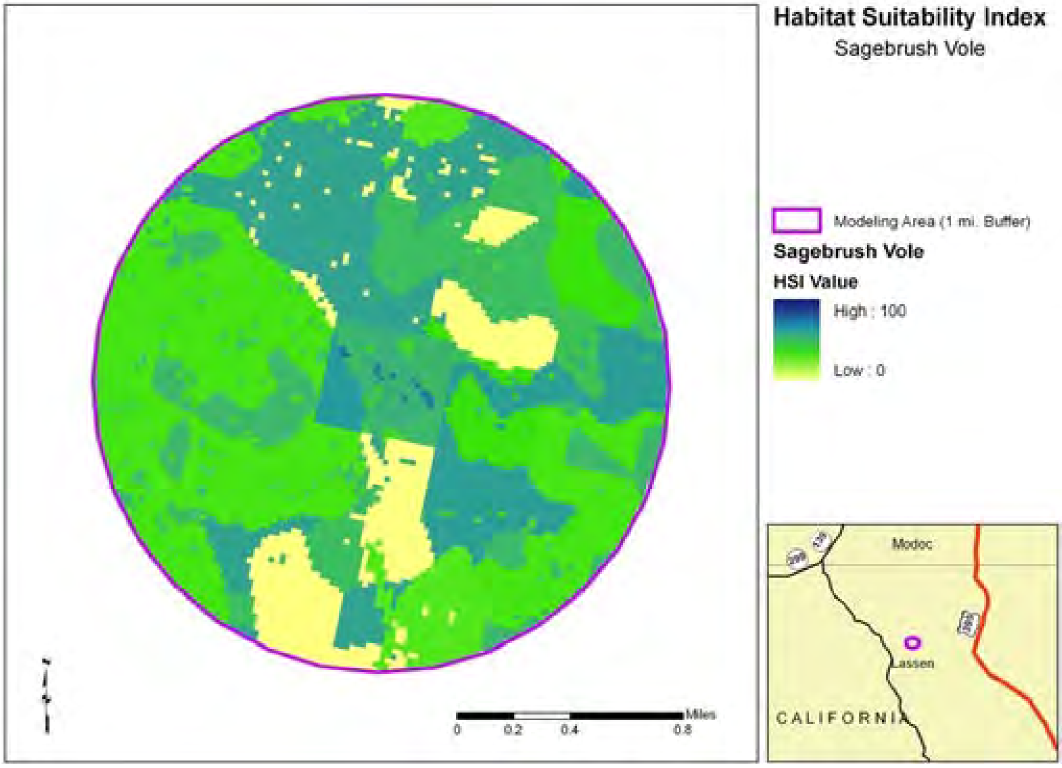


Figure B-55. Post-treatment habitat suitability map for sagebrush voles in Ash Valley Ranch, California.

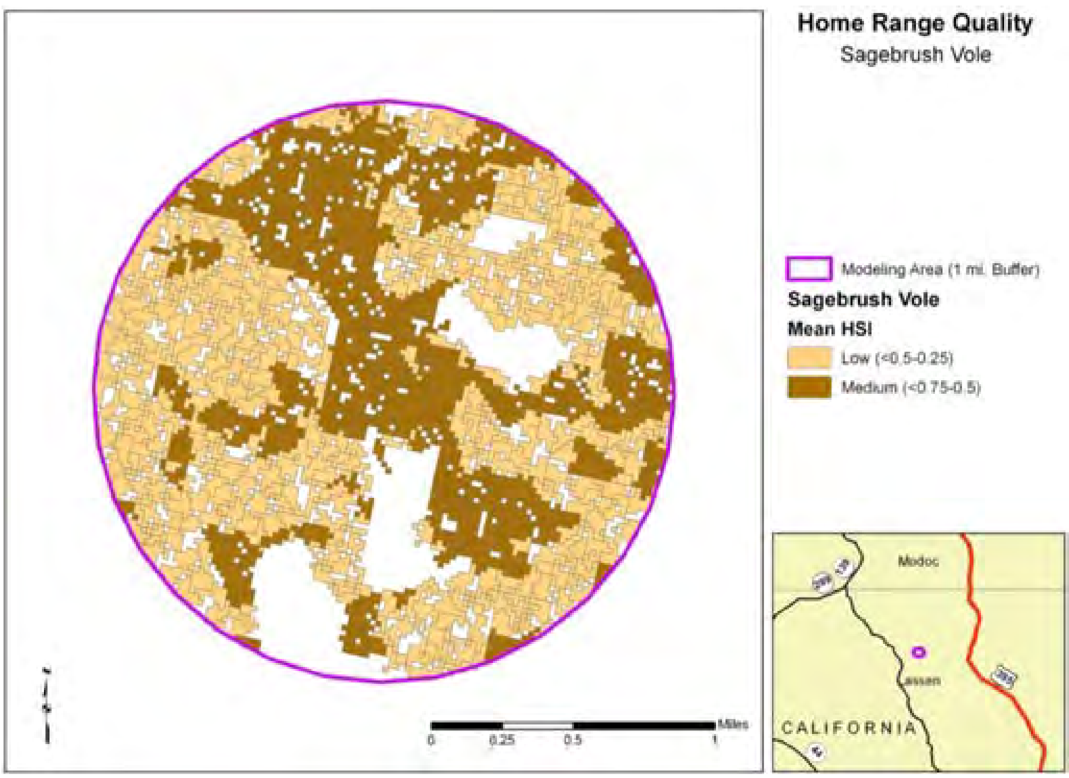


Figure B-56. Pre-treatment home range analysis of sagebrush vole habitat in Ash Valley Ranch, California.

Pygmy Rabbit

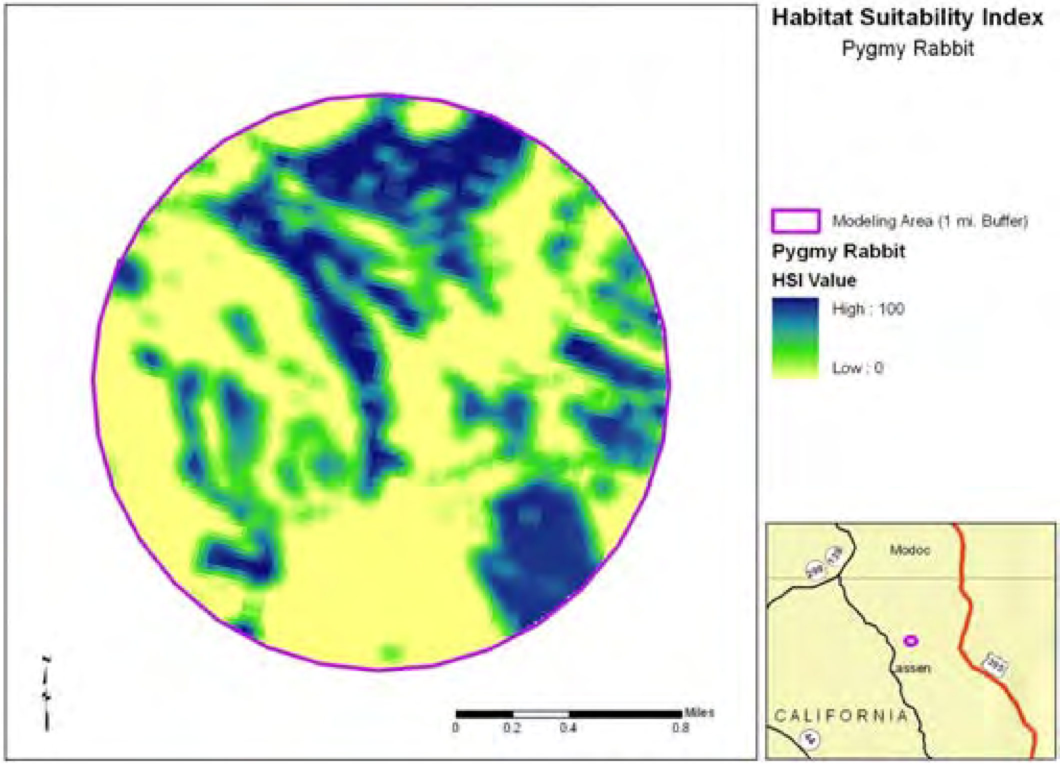


Figure B-57. Pre-treatment habitat suitability map for pygmy rabbits in Ash Valley Ranch, California.

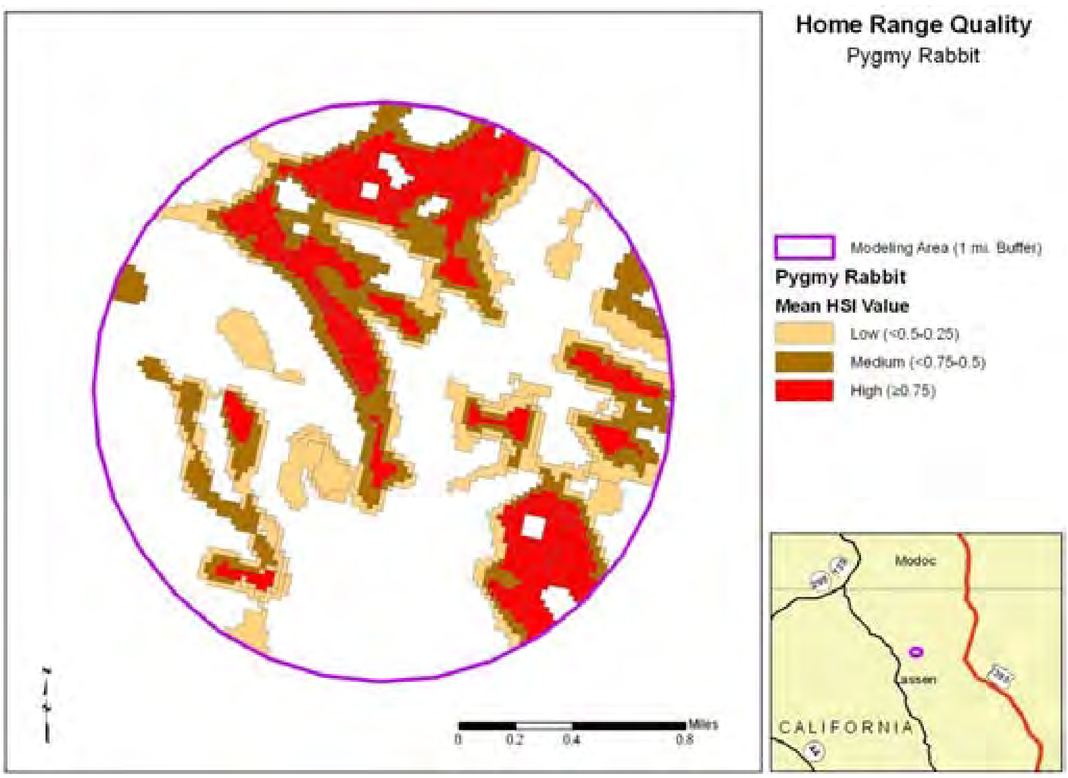


Figure B-58. Pre-treatment home range analysis of pygmy rabbit habitat in Ash Valley Ranch, California.

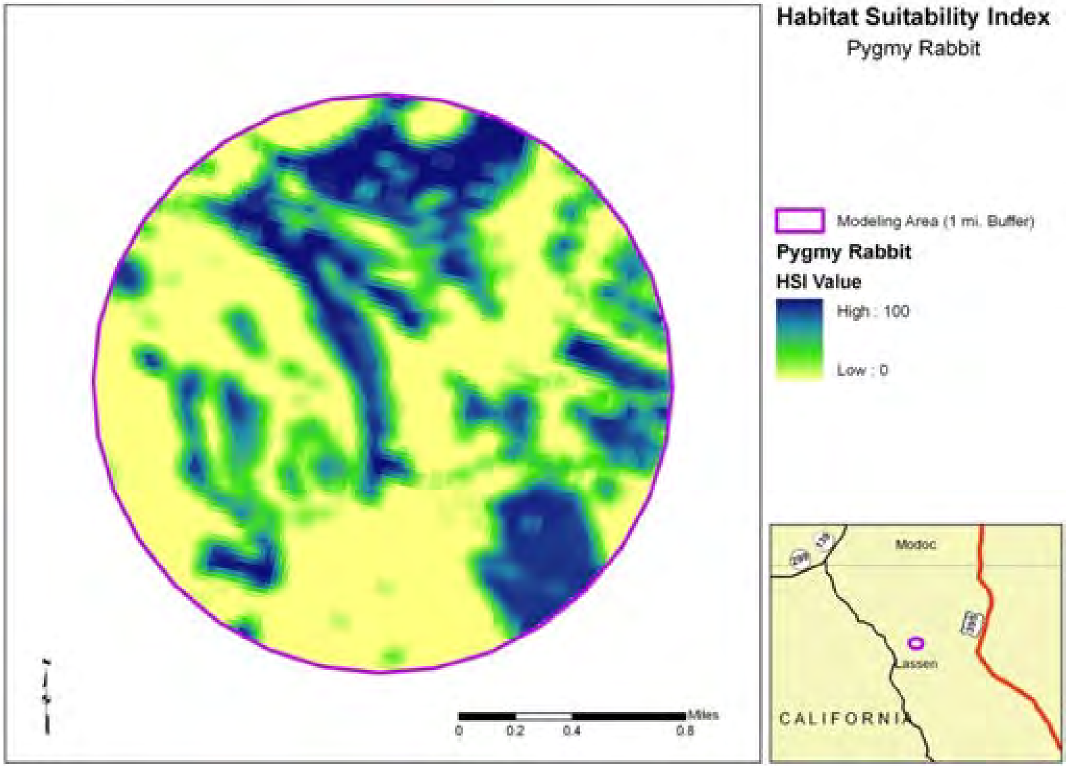


Figure B-59. Post-treatment habitat suitability map for pygmy rabbits in Ash Valley Ranch, California.

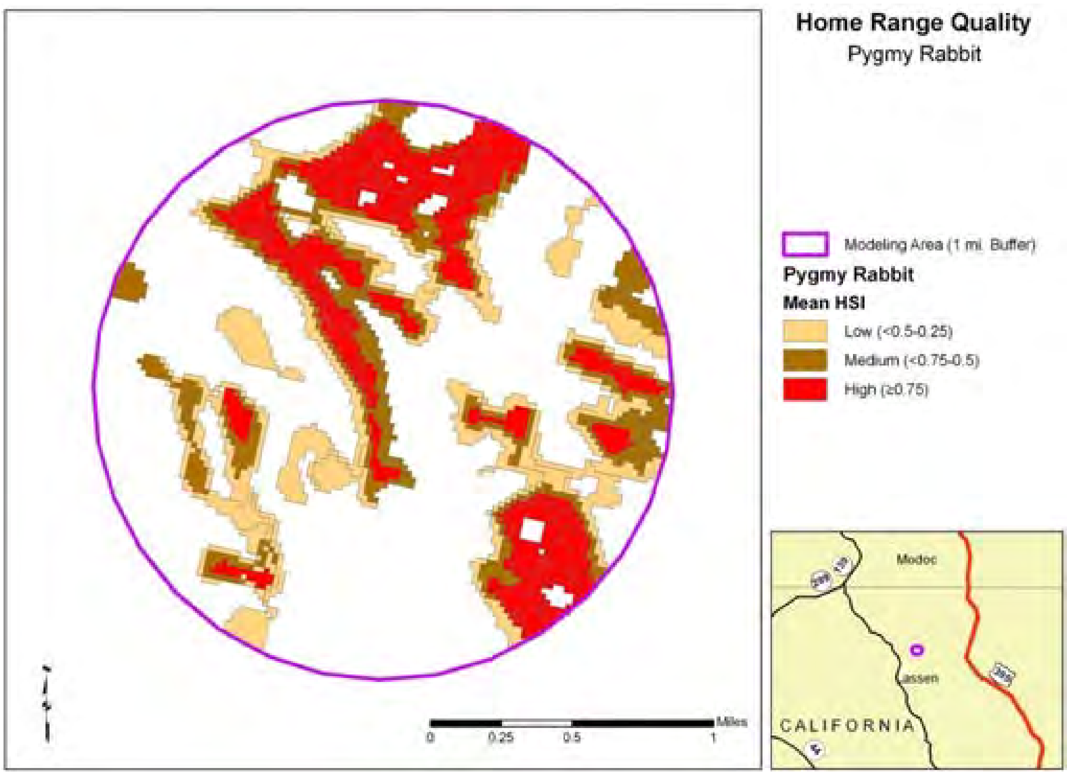


Figure B-60. Post-treatment home range analysis of pygmy rabbit habitat in Ash Valley Ranch, California.

Pronghorn Antelope

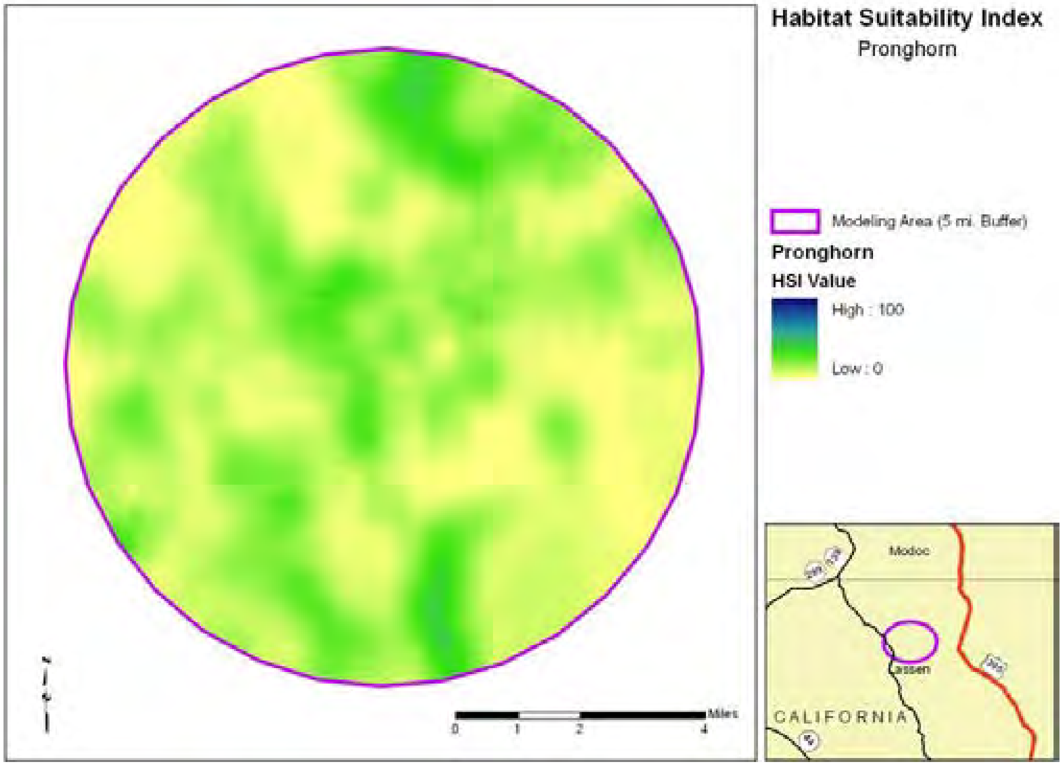


Figure B-61. Pre-treatment habitat suitability map for pronghorn antelope in Ash Valley Ranch, California.

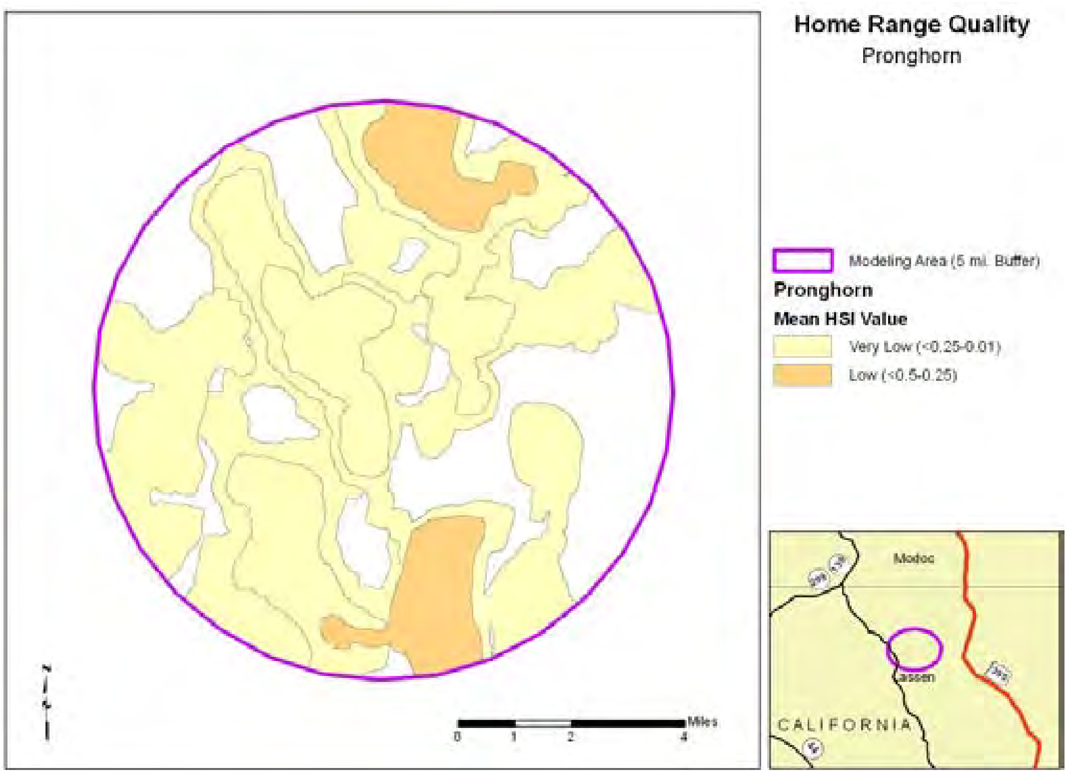


Figure B-62. Pre-treatment home range analysis of pronghorn antelope habitat in Ash Valley Ranch, California.

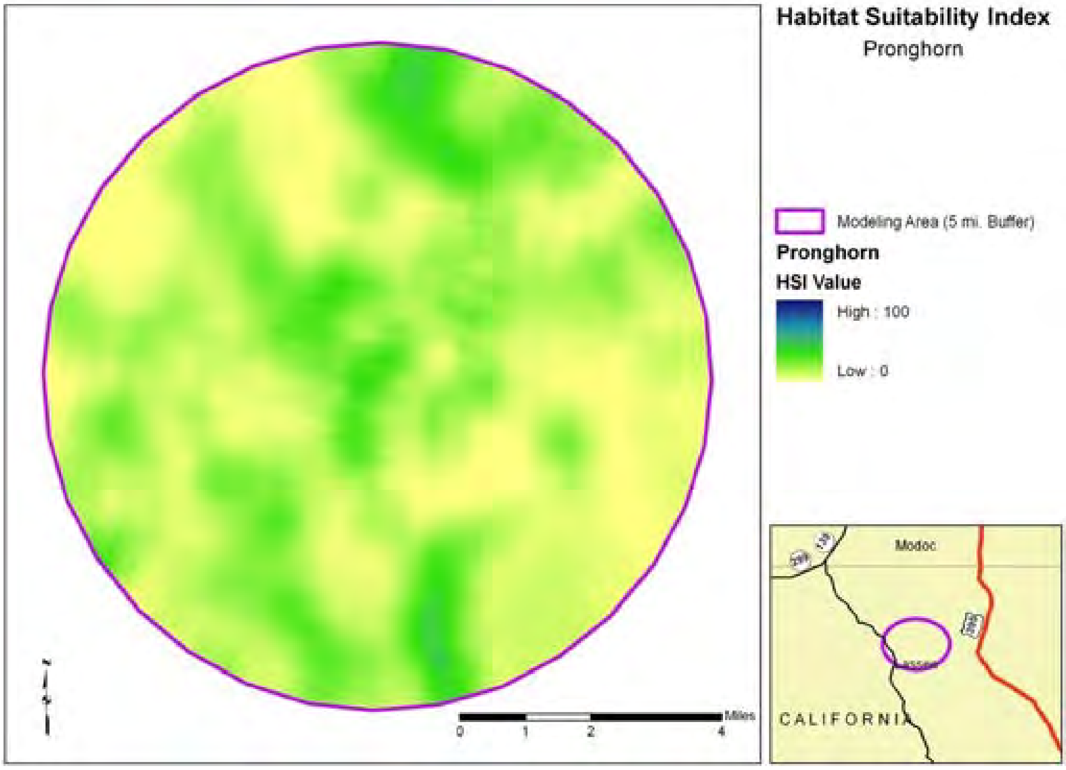


Figure B-63. Post-treatment habitat suitability map for pronghorn antelope in Ash Valley Ranch, California.

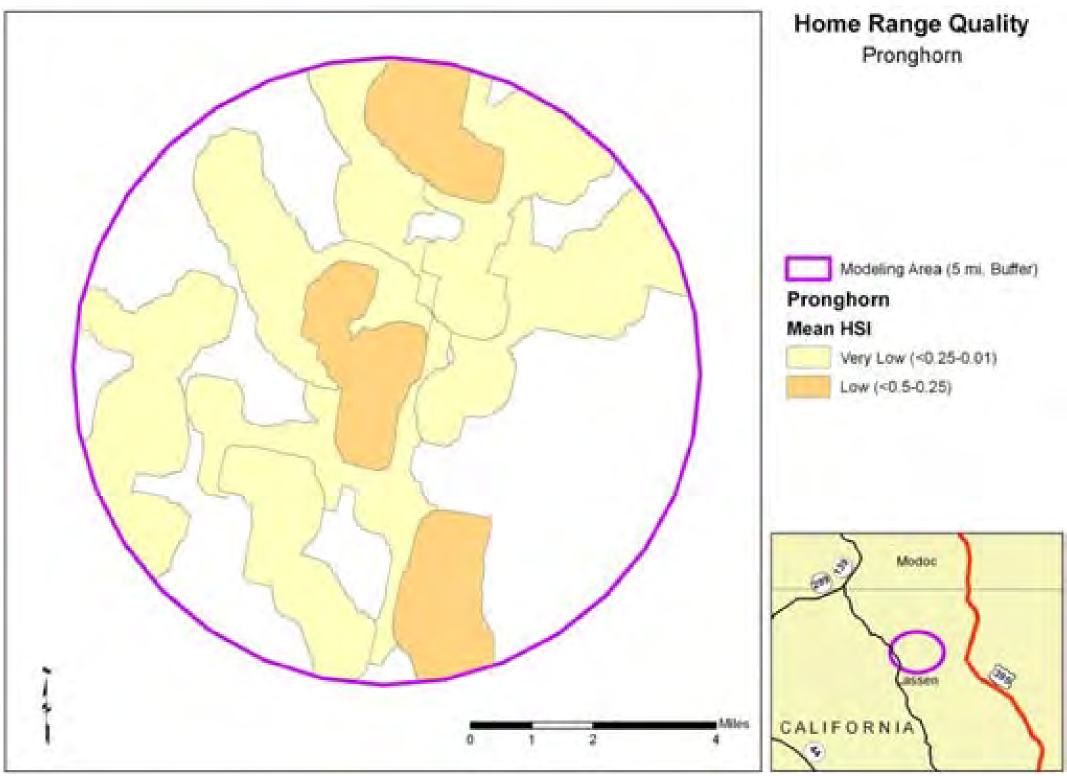


Figure B-64. Post-treatment home range analysis of pronghorn antelope habitat in Ash Valley Ranch, California.

Sagebrush Lizard

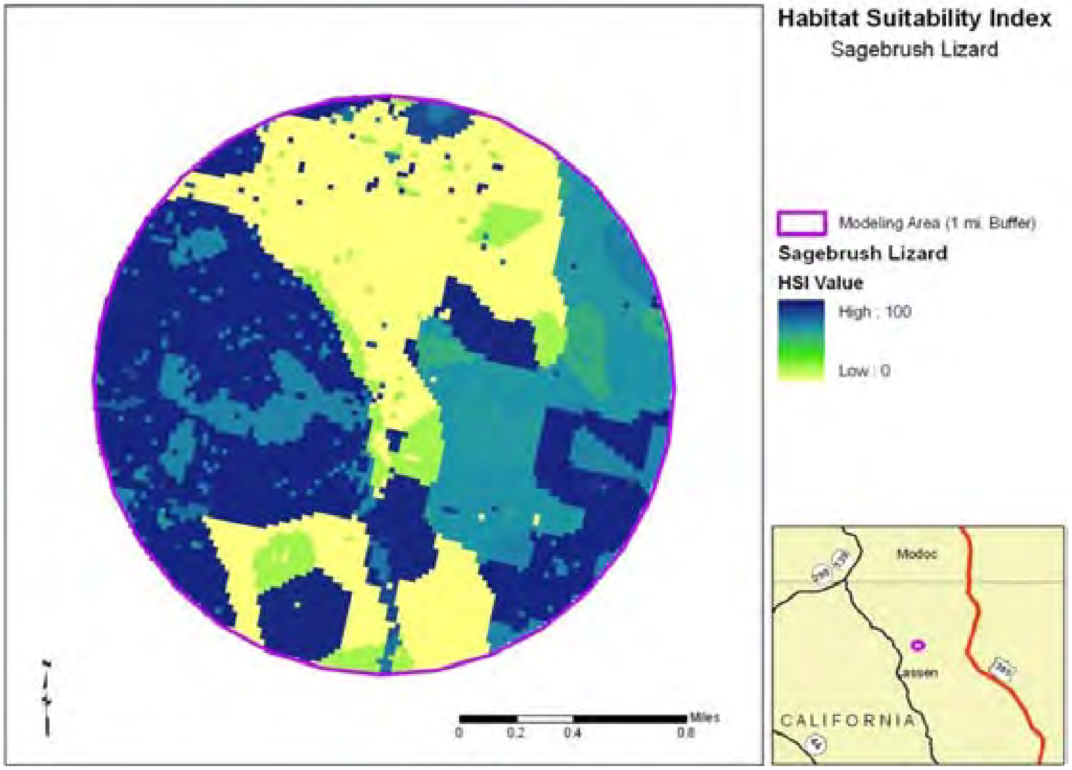


Figure B-65. Pre-treatment habitat suitability map for sagebrush lizards in Ash Valley Ranch, California.

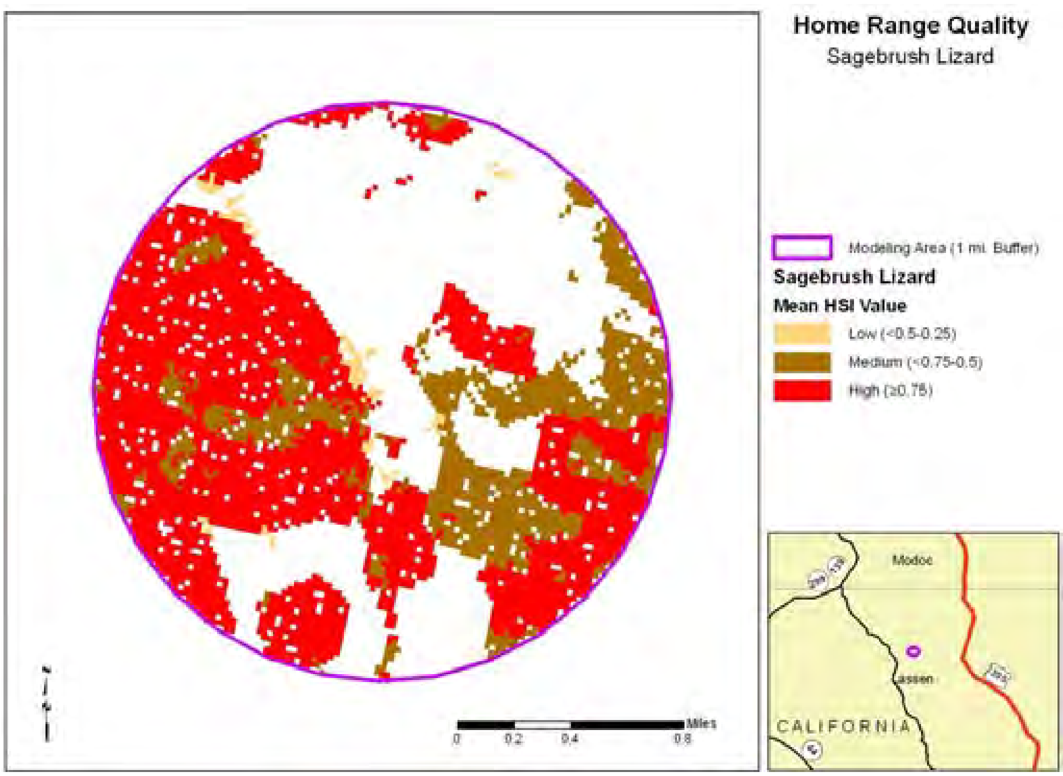


Figure B-66. Pre-treatment home range analysis of sagebrush lizard habitat in Ash Valley Ranch, California.

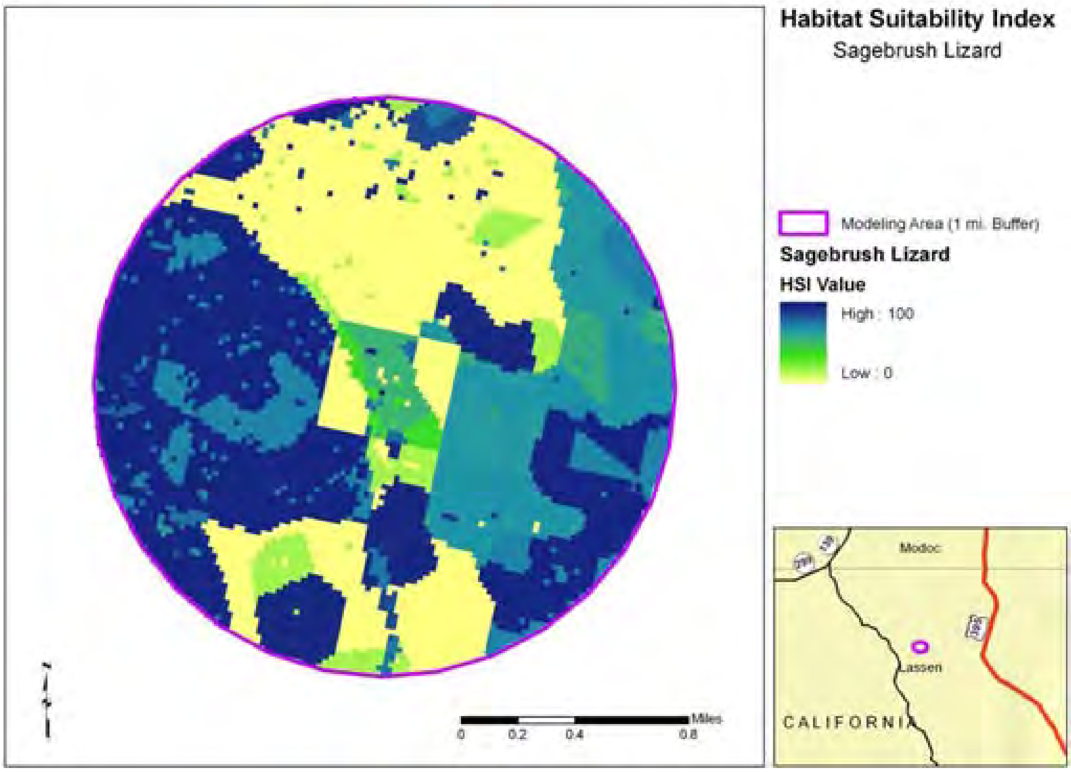


Figure B-67. Post-treatment habitat suitability map for sagebrush lizards in Ash Valley Ranch, California.

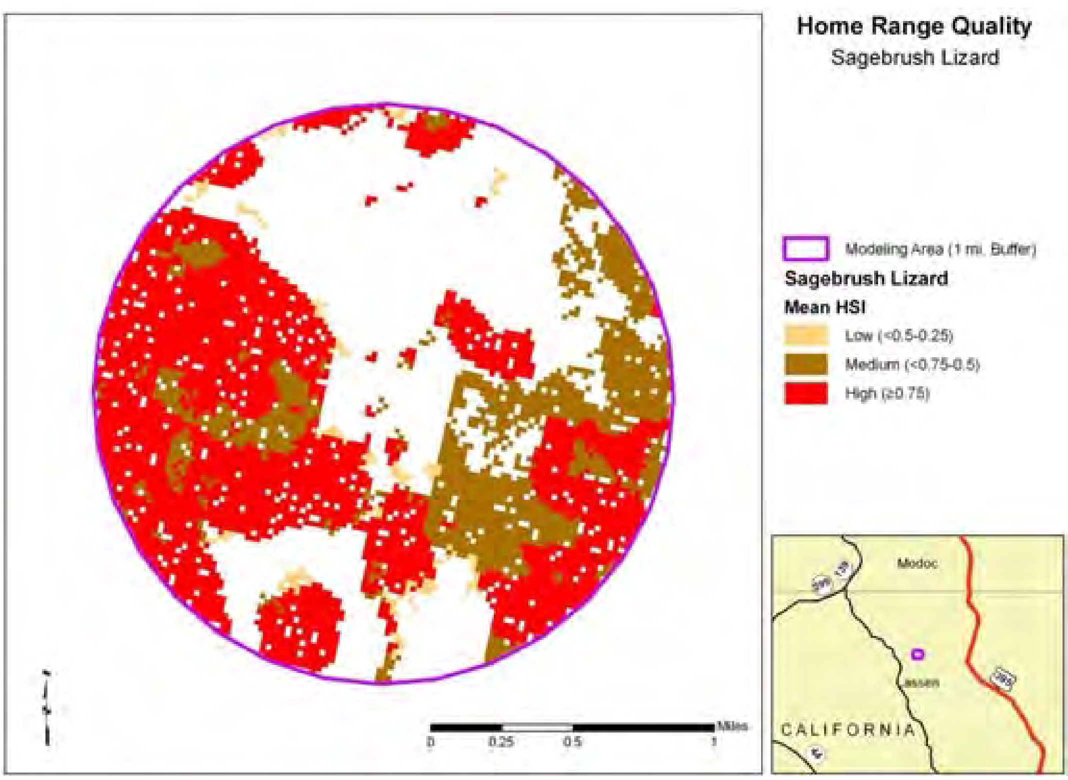


Figure B-68. Post-treatment home range analysis of sagebrush lizard habitat in Ash Valley Ranch, California.

Thunder Basin Project (TBGPEA), Wyoming

Sage Thrasher

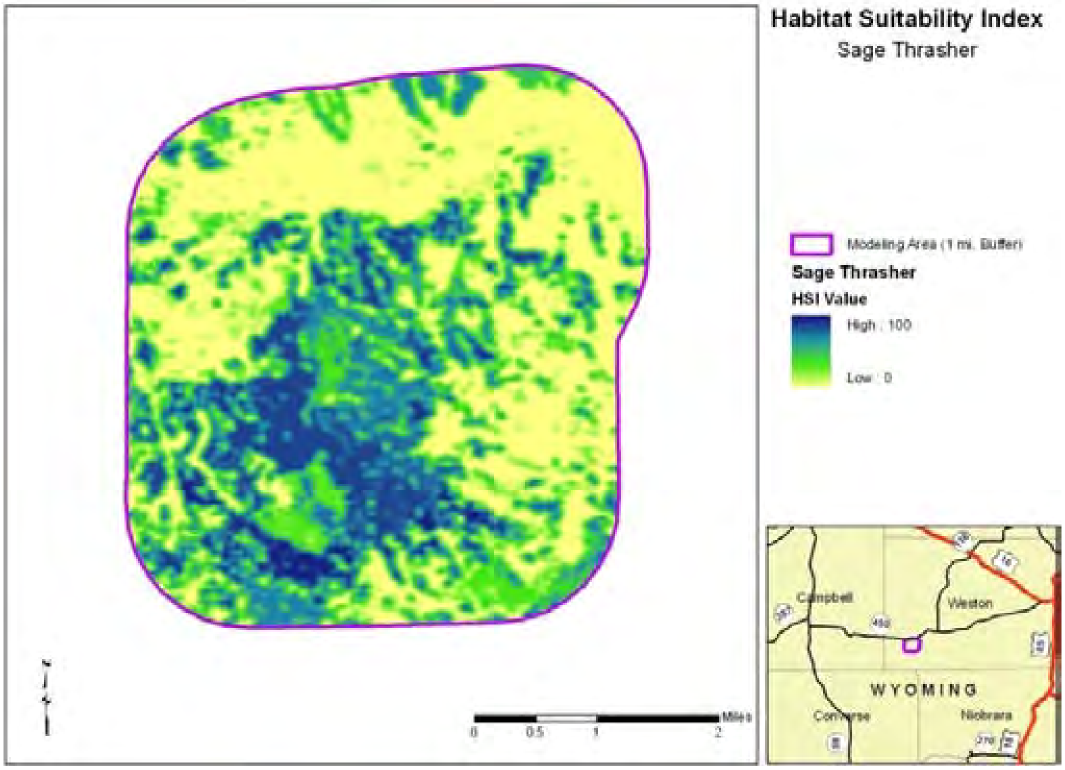


Figure B-69. Pre-treatment habitat suitability map for sage thrashers for the Thunder Basin project in Wyoming.

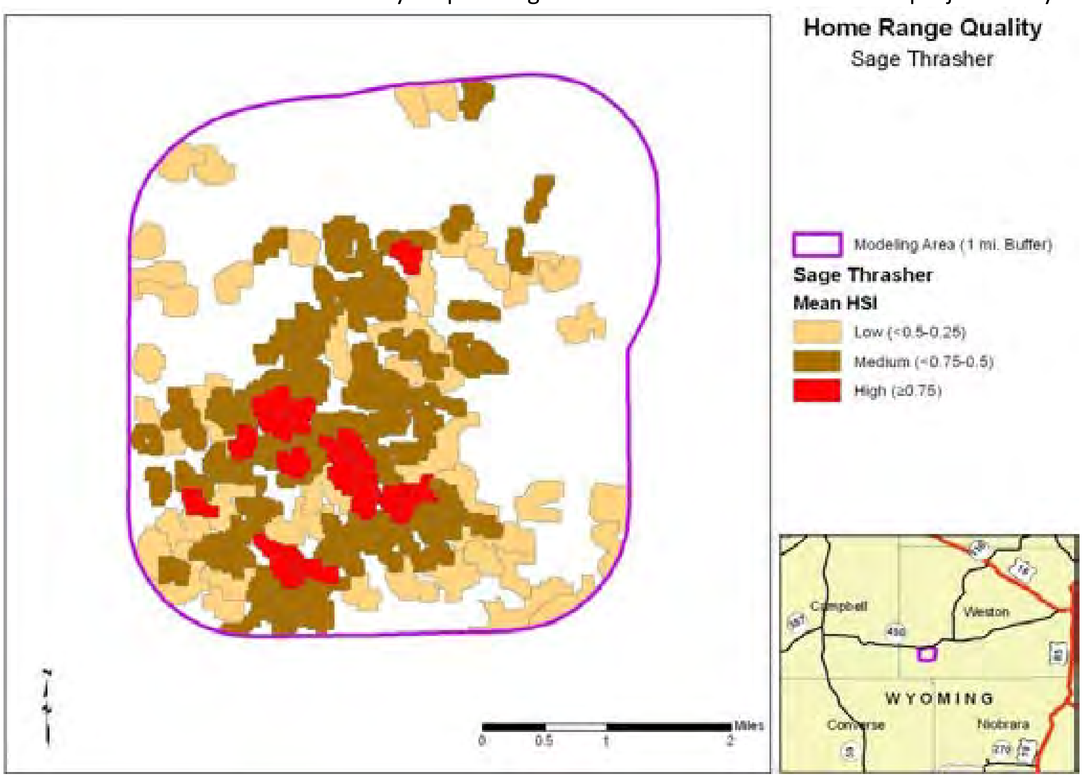


Figure B-70. Pre-treatment potential home range map for sage thrashers for the Thunder Basin project, Wyoming.

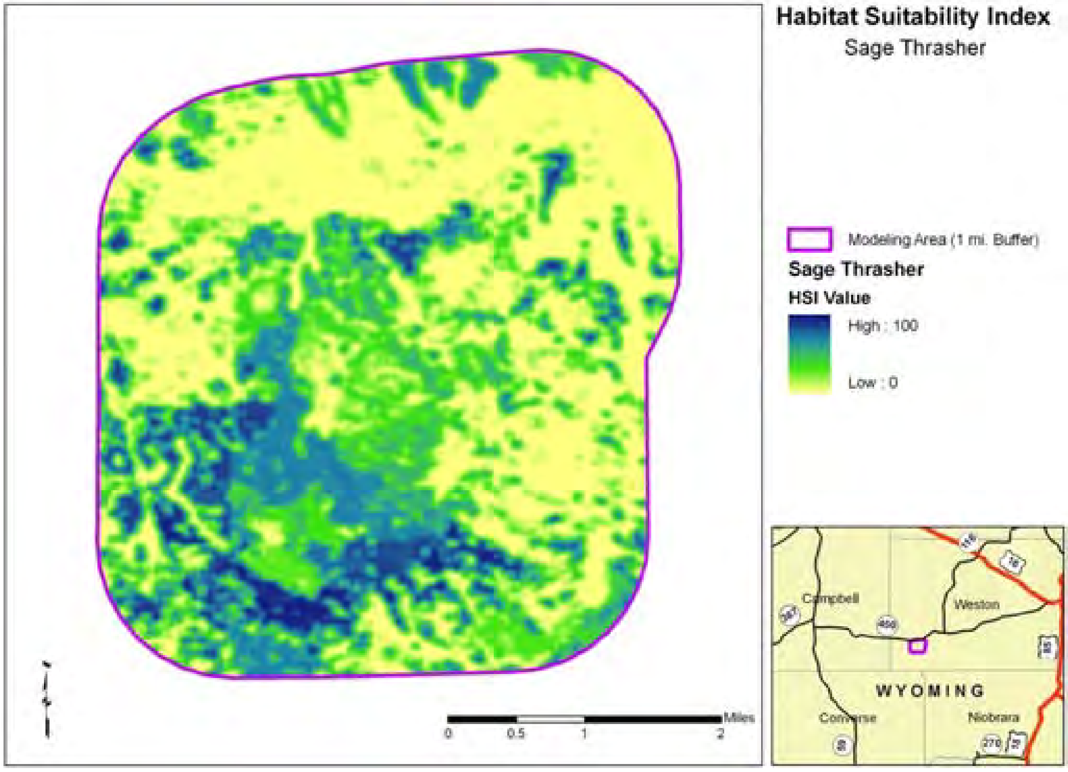


Figure B-71. Post-treatment habitat suitability map for sage thrashers for the Thunder Basin project, Wyoming.

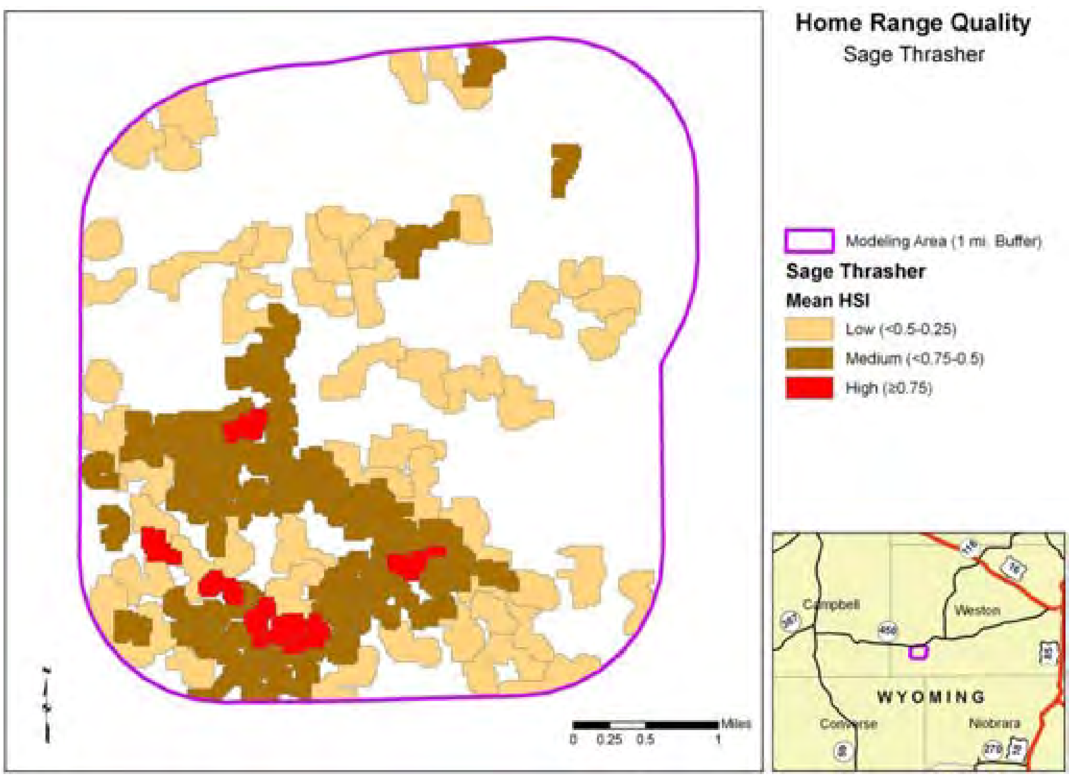


Figure B-72. Post-treatment potential home range map for sage thrashers for the Thunder Basin project, Wyoming.

Sage Sparrow

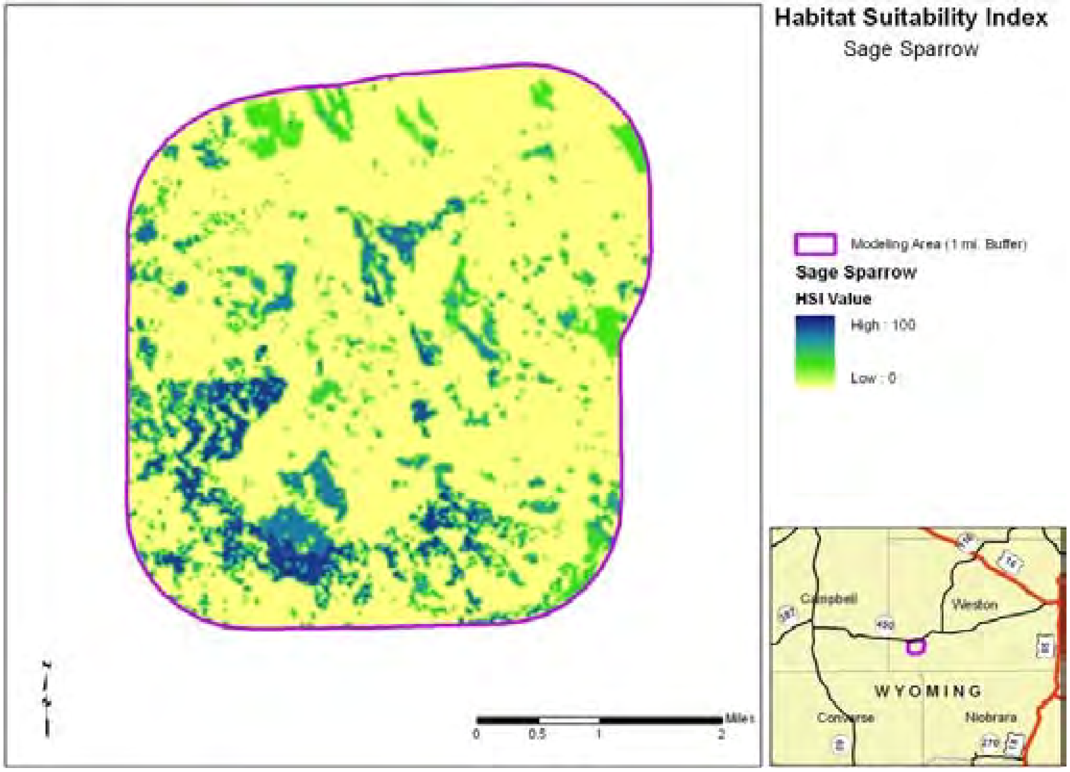


Figure B-73. Pre-treatment habitat suitability map for sage sparrows for the Thunder Basin project, Wyoming.

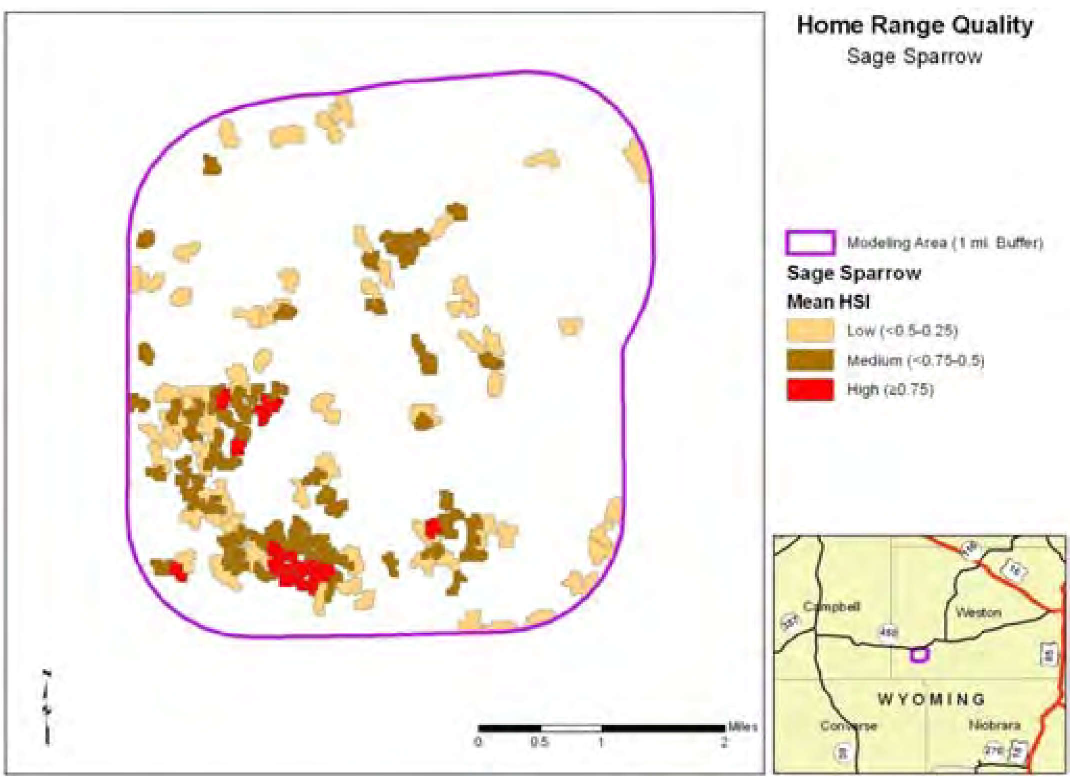


Figure B-74. Pre-treatment potential home range map for sage sparrows for the Thunder Basin project, Wyoming.

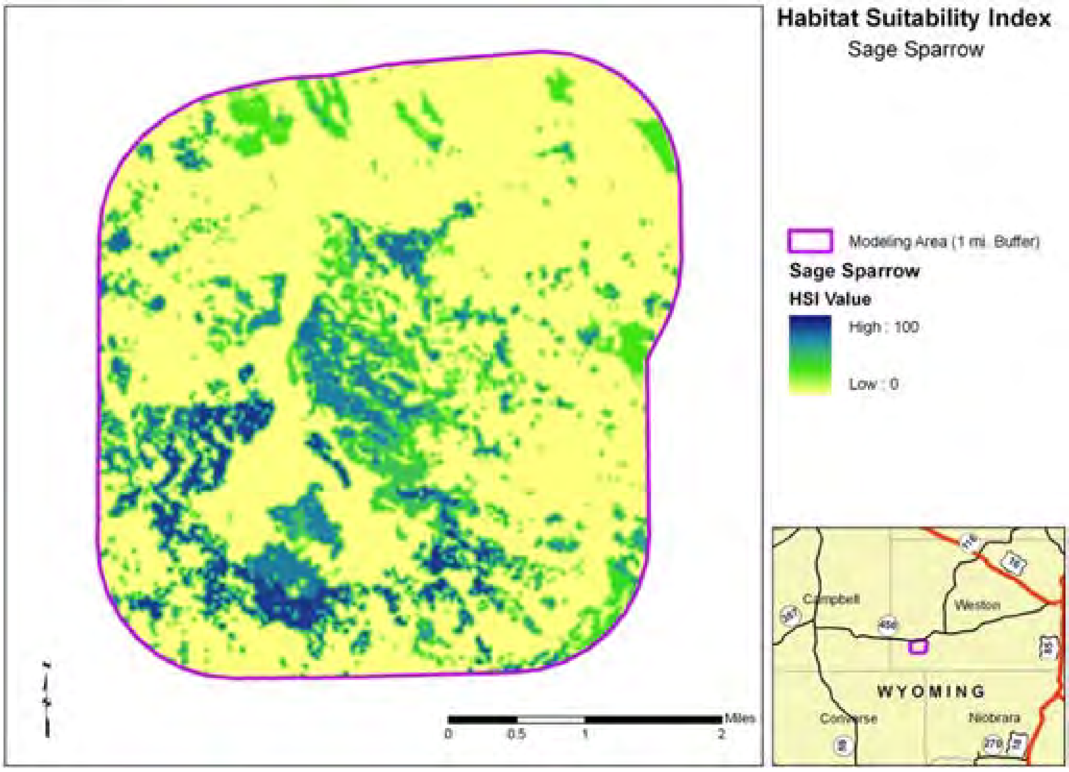


Figure B-75. Post-treatment habitat suitability map for sage sparrows for the Thunder Basin project, Wyoming.

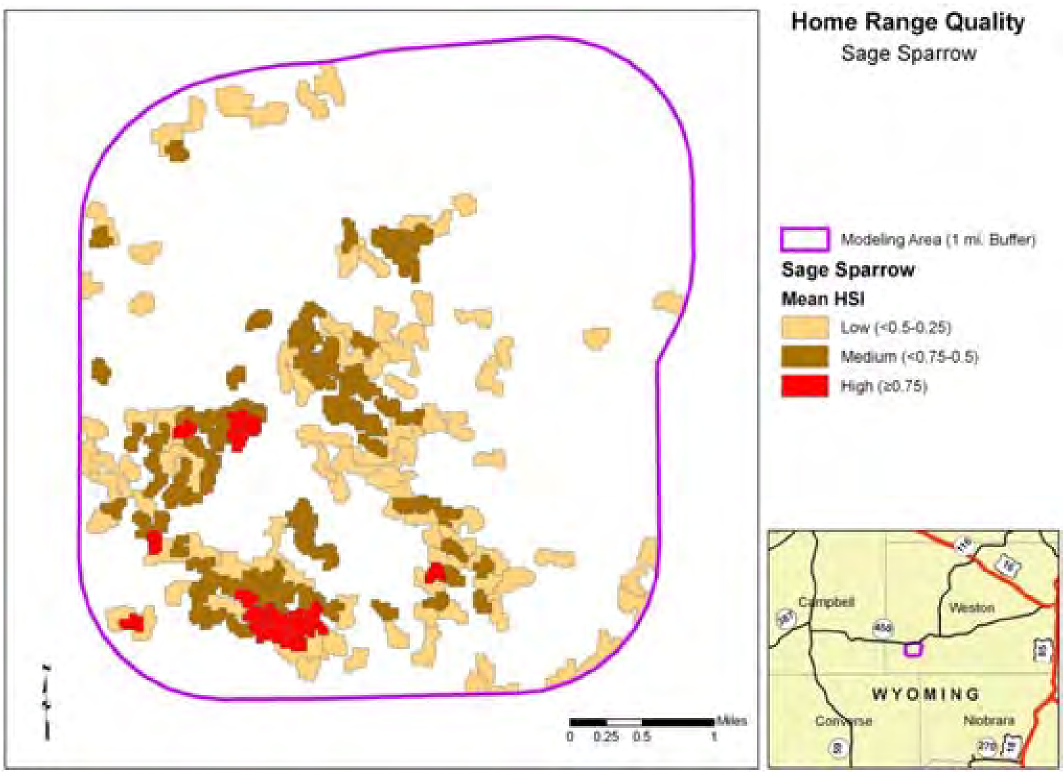


Figure B-76. Post-treatment potential home range map for sage sparrows for the Thunder Basin project, Wyoming.

Pronghorn Antelope

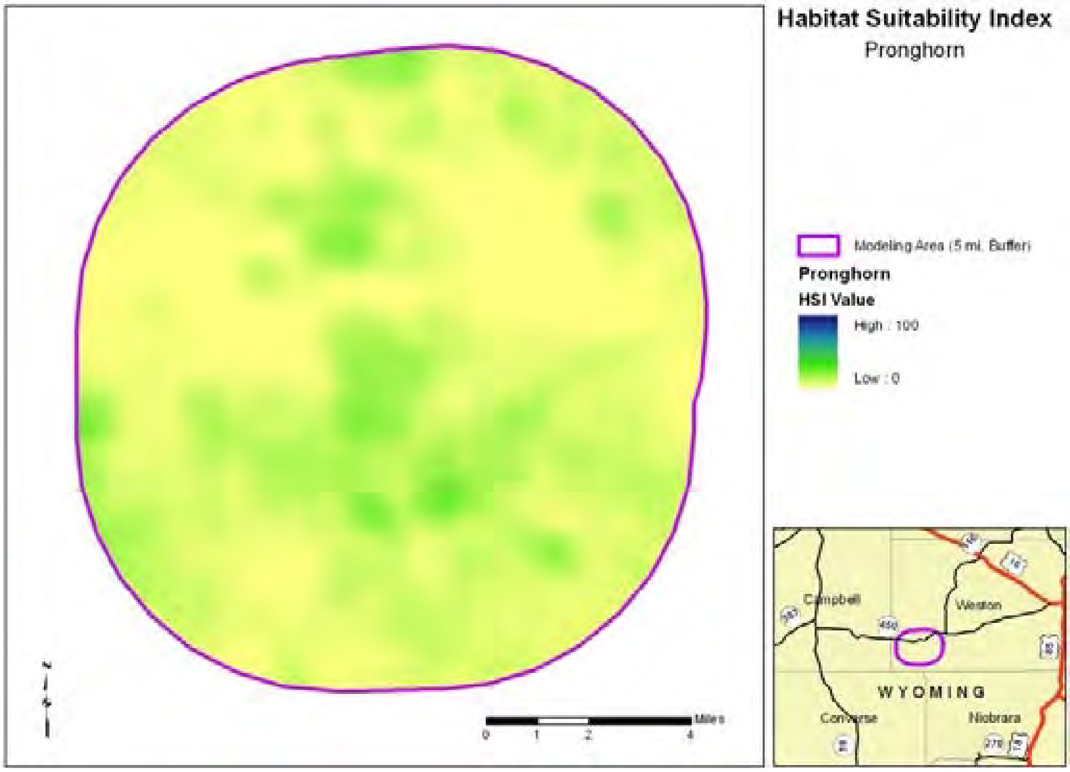


Figure B-77. Pre-treatment habitat suitability map for pronghorn antelope for Thunder Basin project, Wyoming.

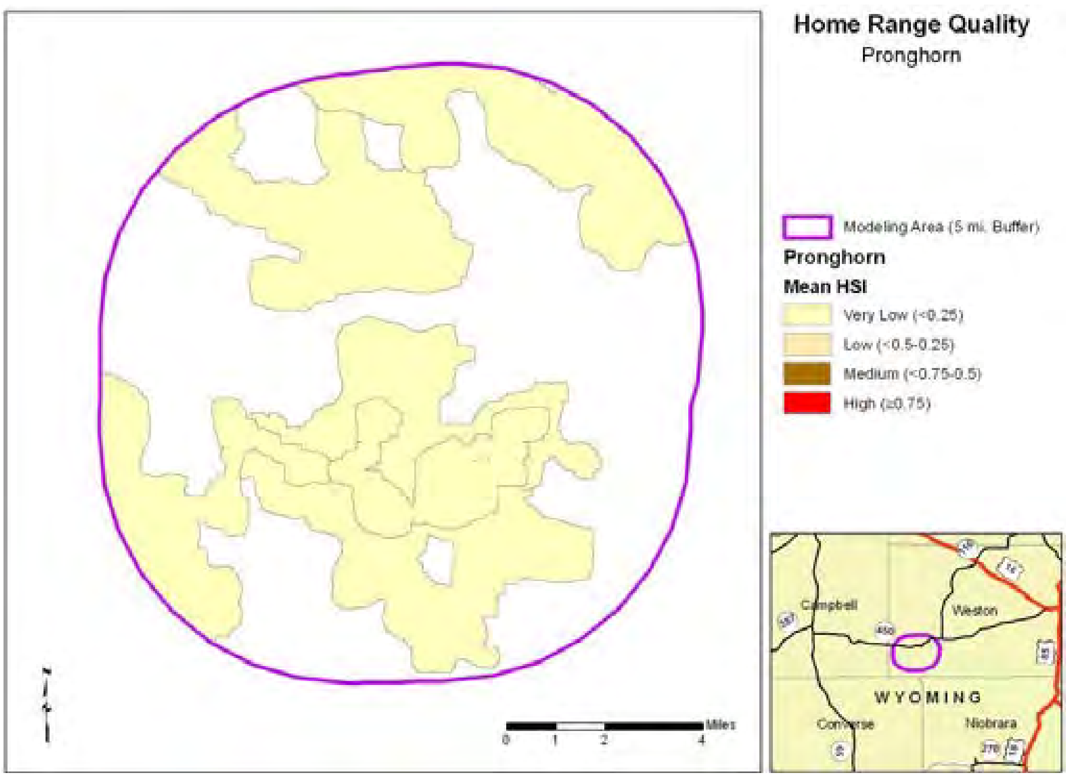


Figure B-78. Pre-treatment potential home range map for pronghorn antelope for Thunder Basin project, Wyoming.

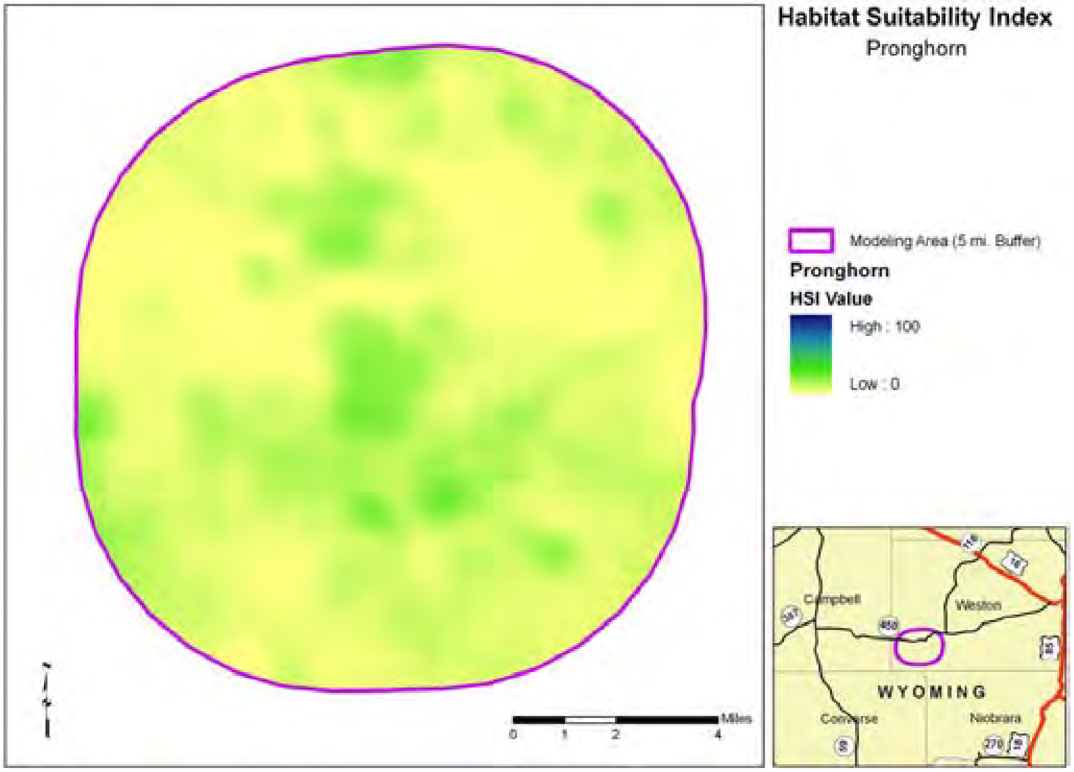


Figure B-79. Post-treatment habitat suitability map for pronghorn antelope for the Thunder Basin project, Wyoming.

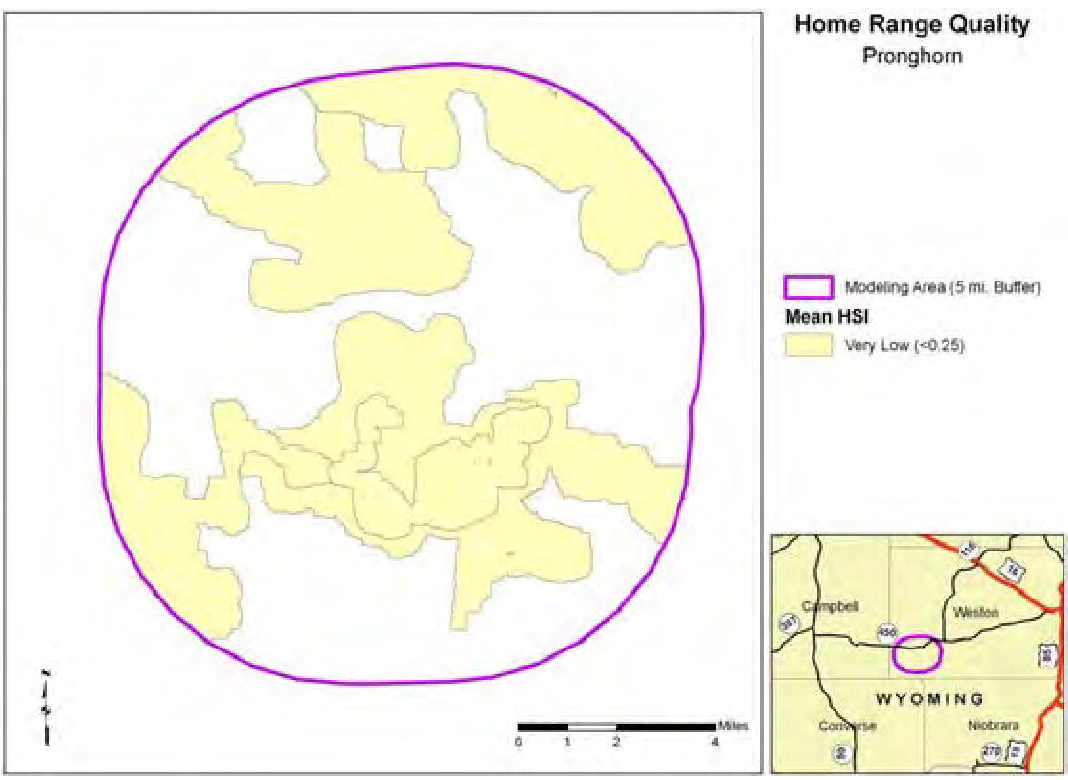


Figure B-80. Post-treatment potential home range map for pronghorn antelope for the Thunder Basin project, WY.

Sagebrush Lizard

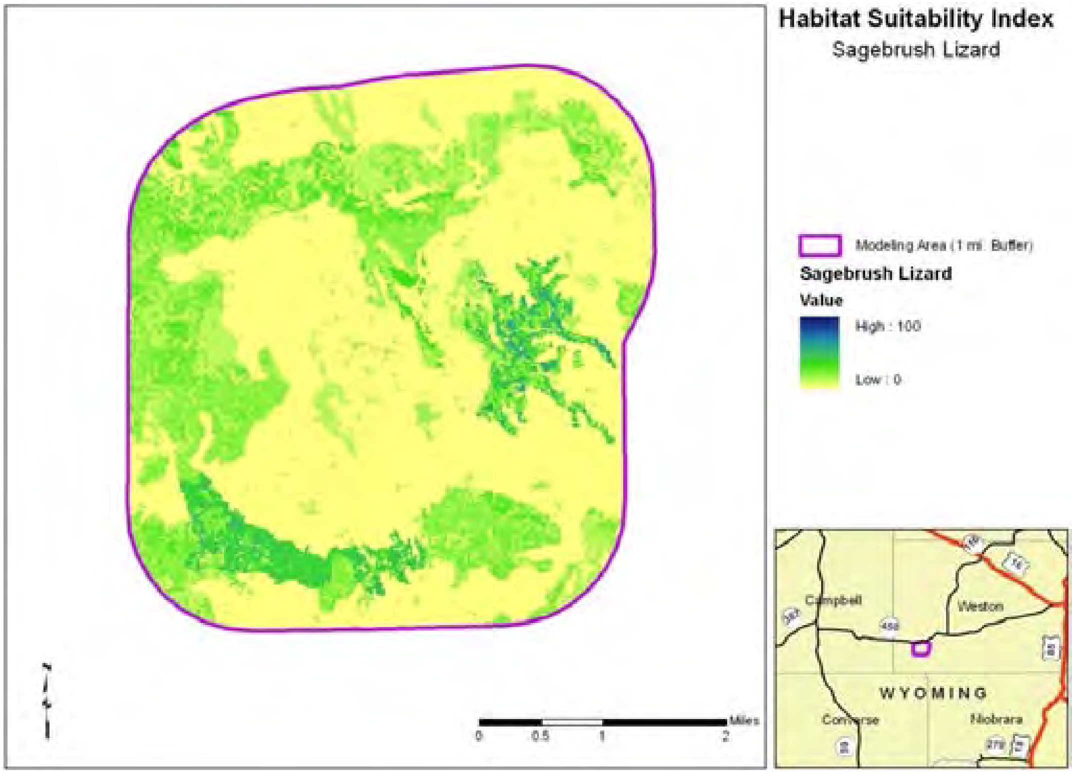


Figure B-81. Pre-treatment habitat suitability map for sagebrush lizard for Thunder Basin project site, Wyoming.

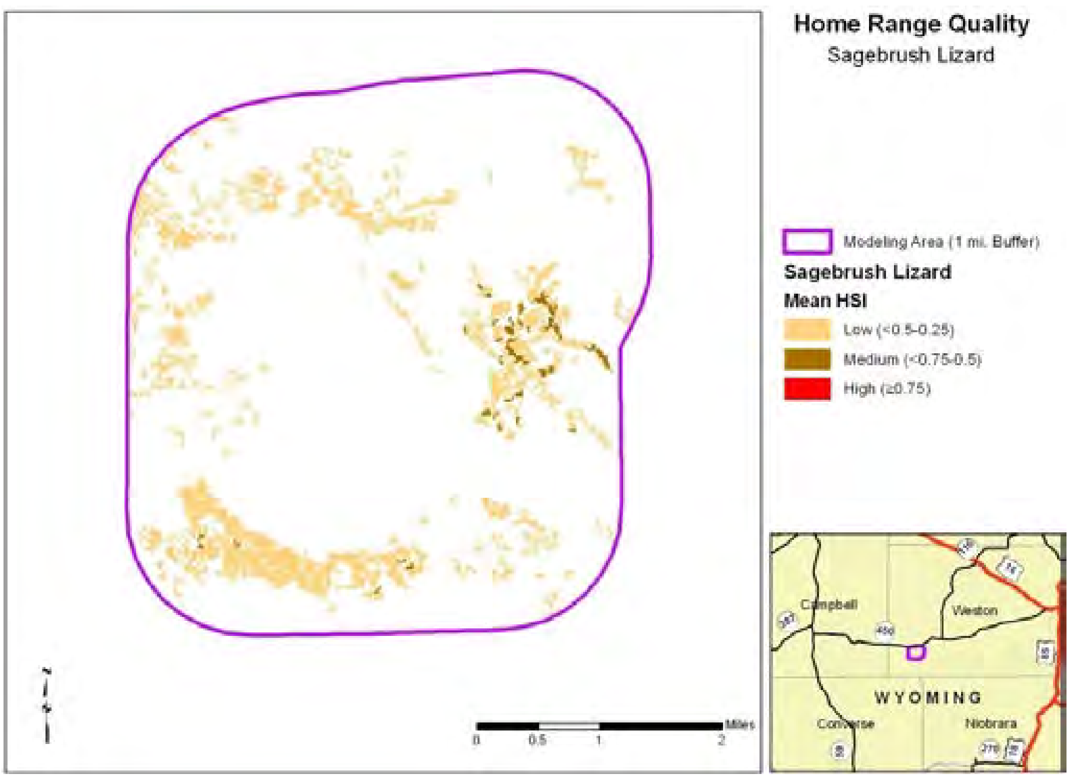


Figure B-82. Pre-treatment potential home range map for sagebrush lizards for Thunder Basin project, Wyoming.

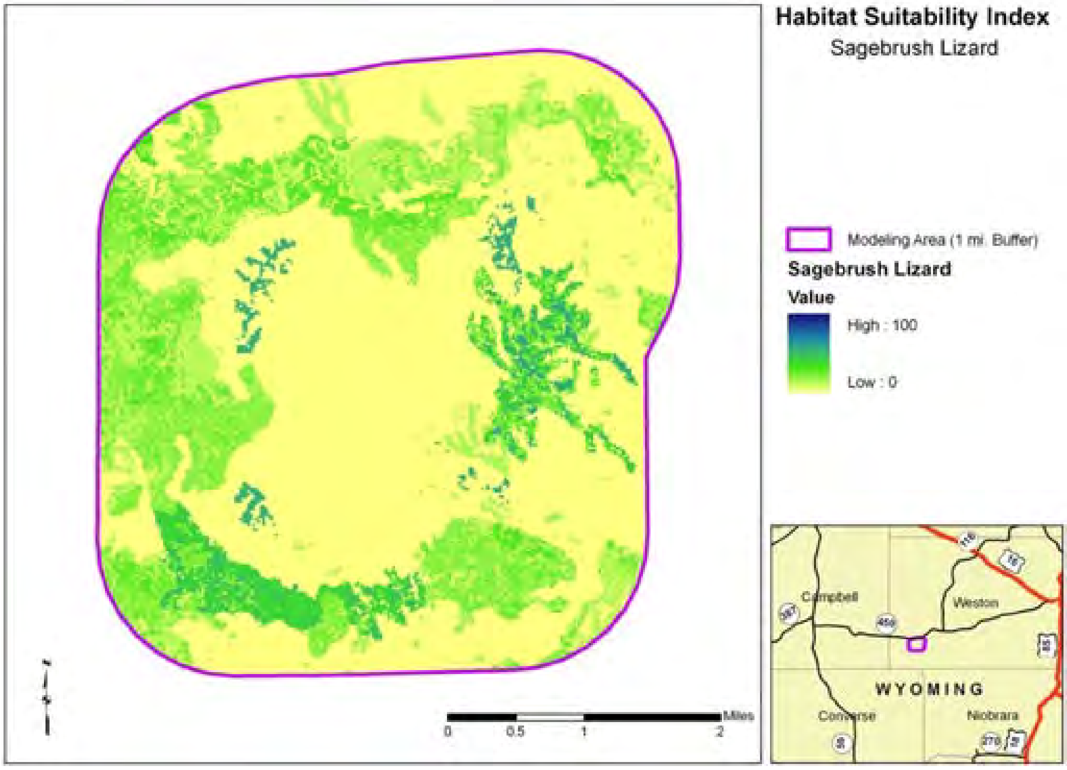


Figure B-83. Post-treatment habitat suitability map for sagebrush lizard for the Thunder Basin project, Wyoming.

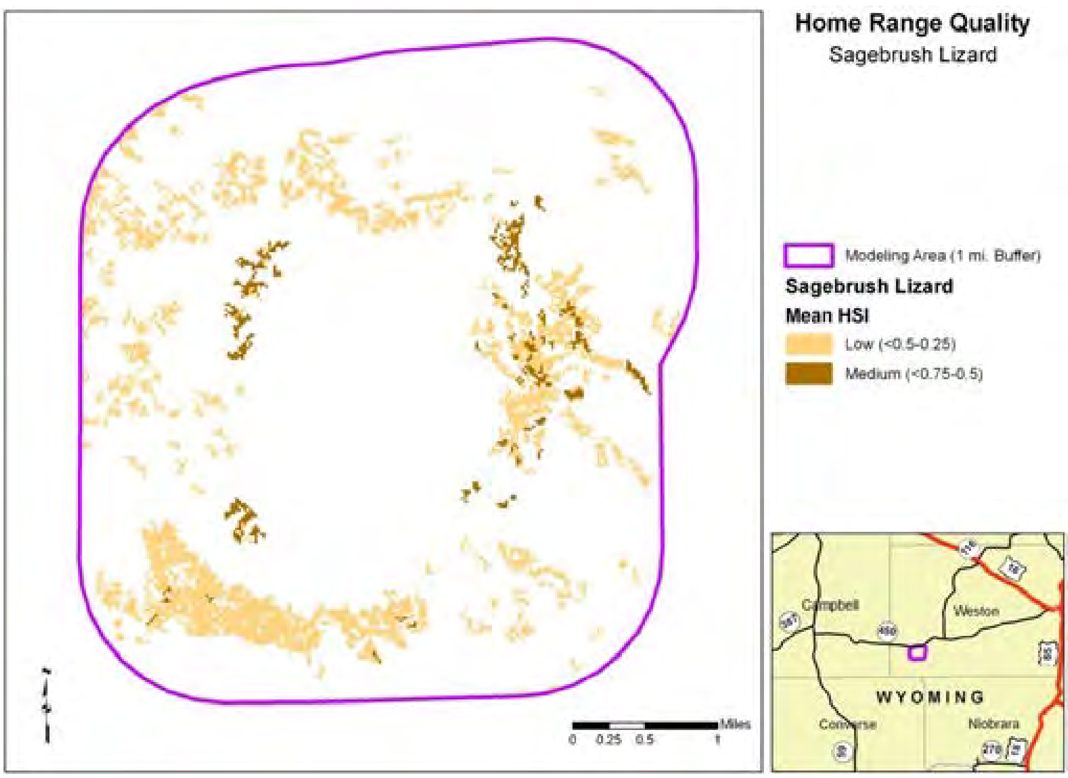


Figure B-84. Post-treatment potential home range map for sagebrush lizards for Thunder Basin project, Wyoming.

Sagebrush Vole

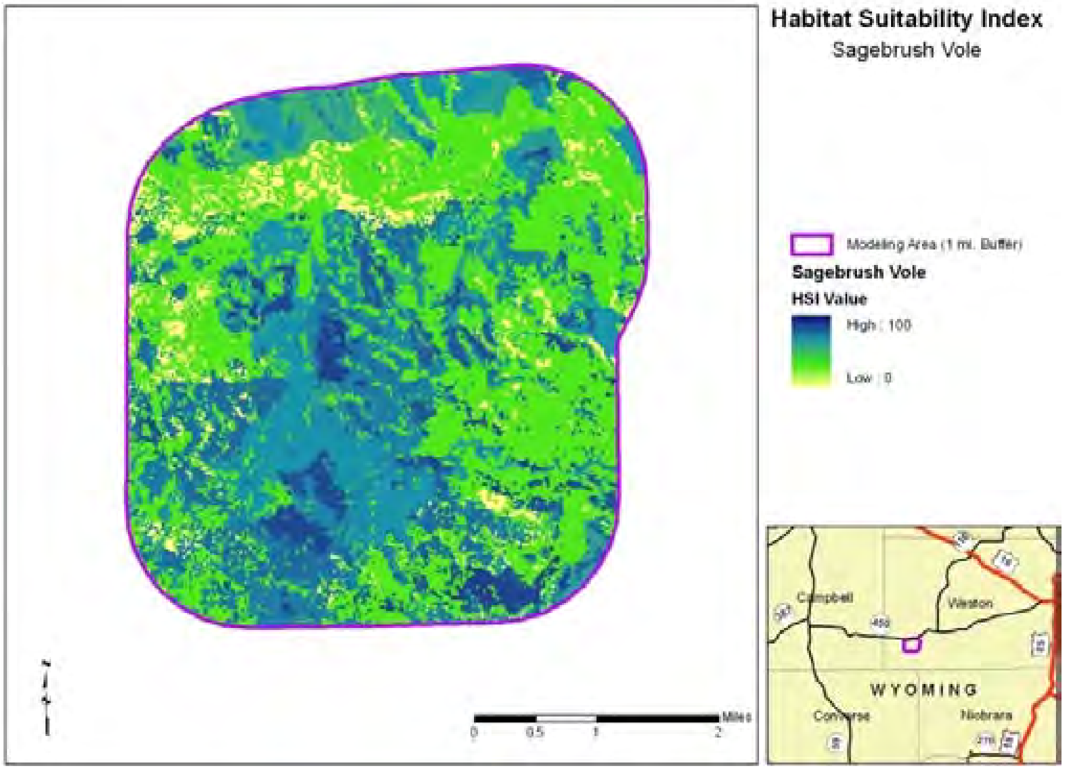


Figure B-85. Pre-treatment habitat suitability map for sagebrush voles for the Thunder Basin project, Wyoming.

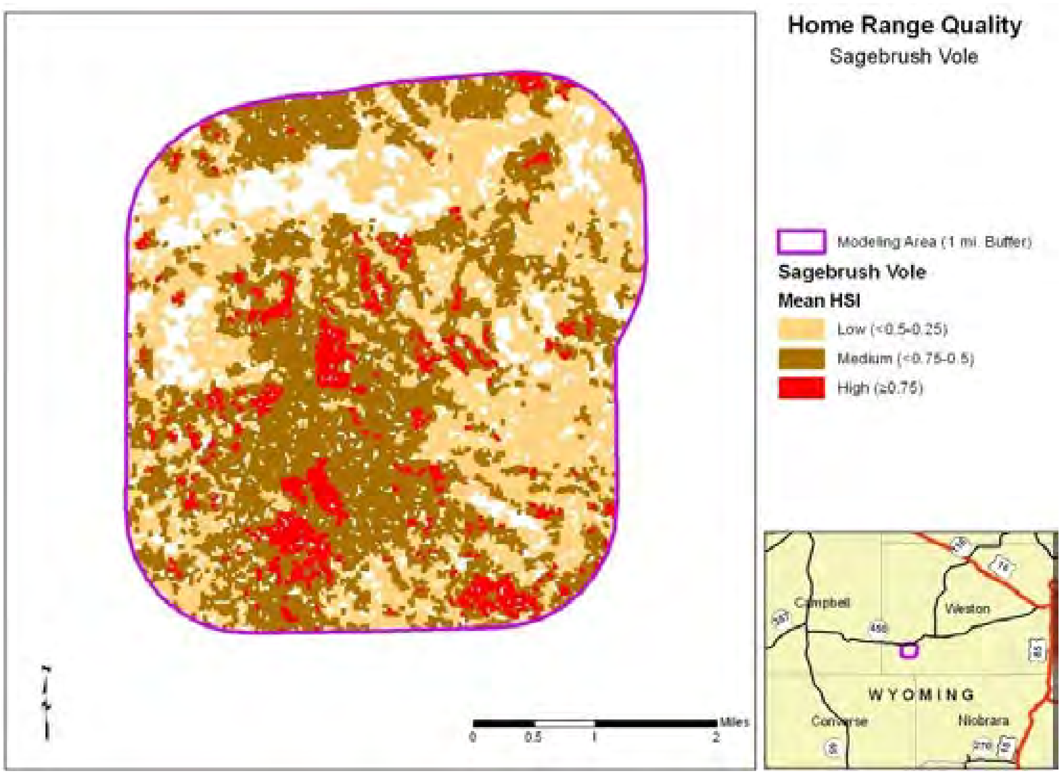


Figure B-86. Pre-treatment potential home range map for sagebrush voles for Thunder Basin project, Wyoming.

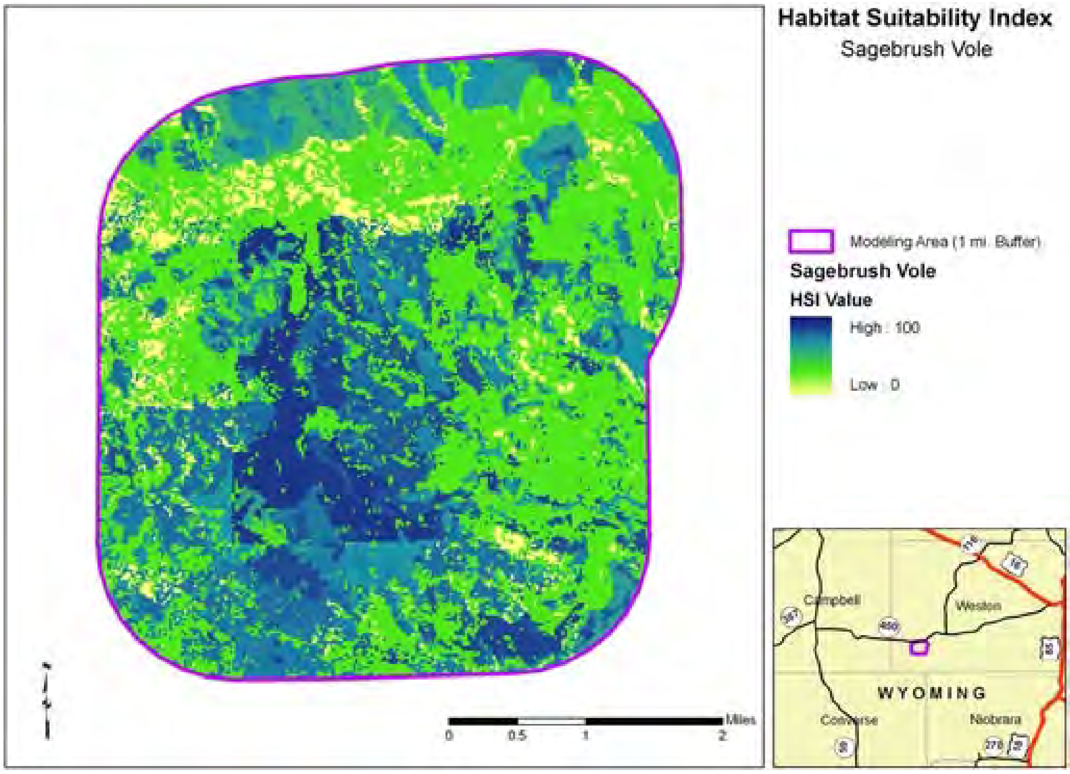


Figure B-87. Post-treatment habitat suitability map for sagebrush voles for the Thunder Basin project, Wyoming.

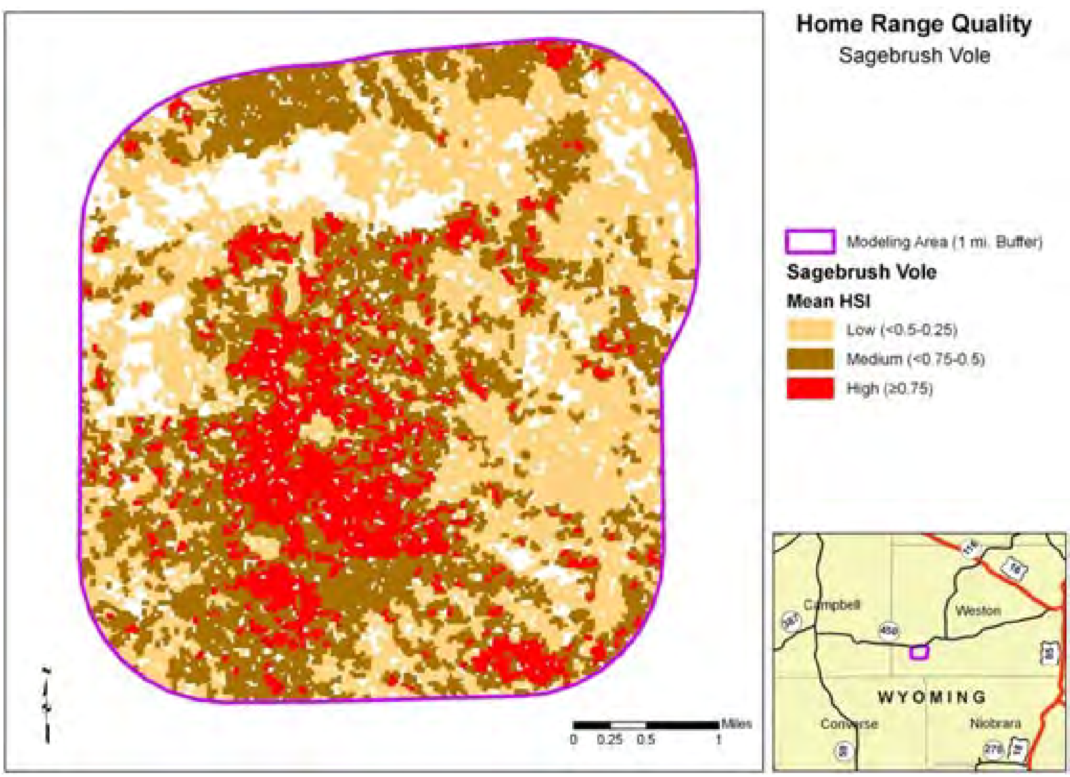


Figure B-88. Post-treatment potential home range map for sagebrush voles for Thunder Basin project, Wyoming.

Sage Grouse

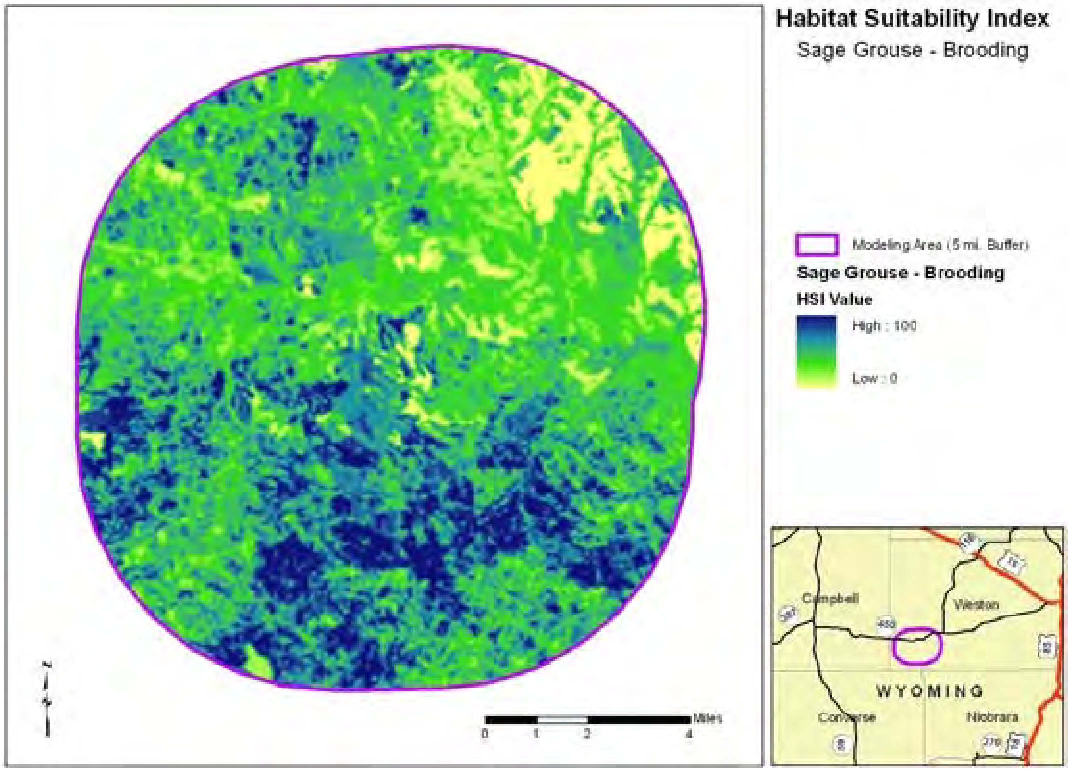


Figure B-89. Pre-treatment habitat suitability map for sage grouse brood habitat, Thunder Basin project, WY.

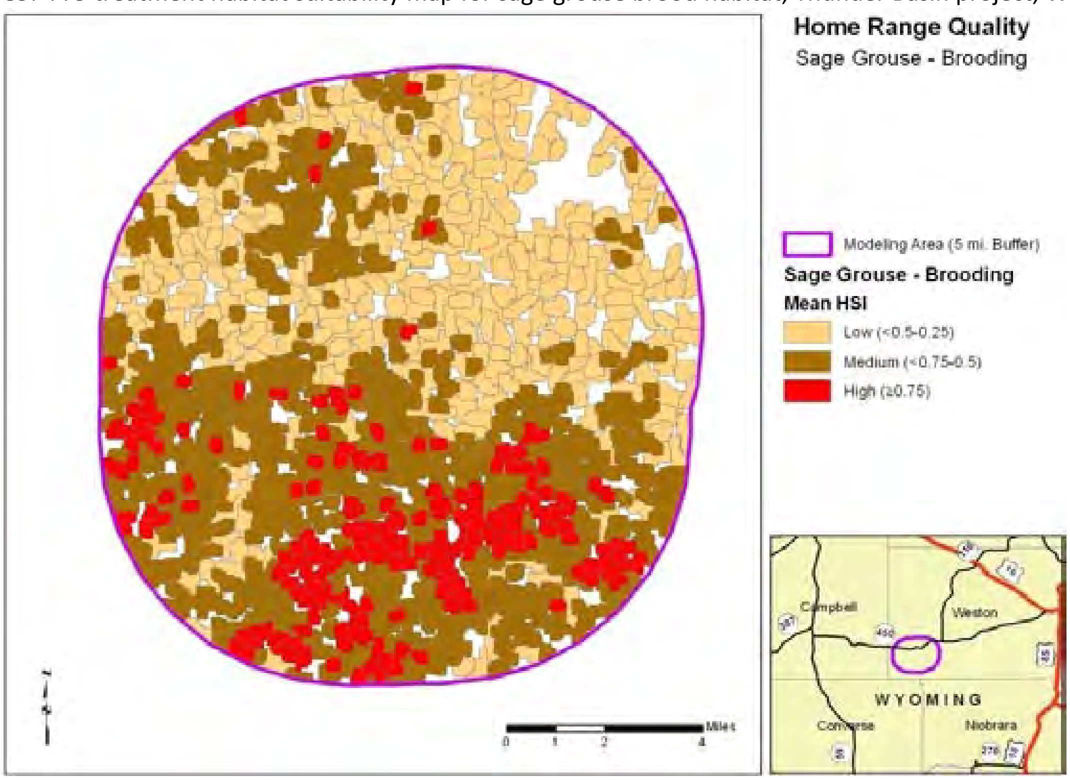


Figure B-90. Pre-treatment potential home range map for sage grouse brood habitat for the Thunder Basin project, Wyoming.

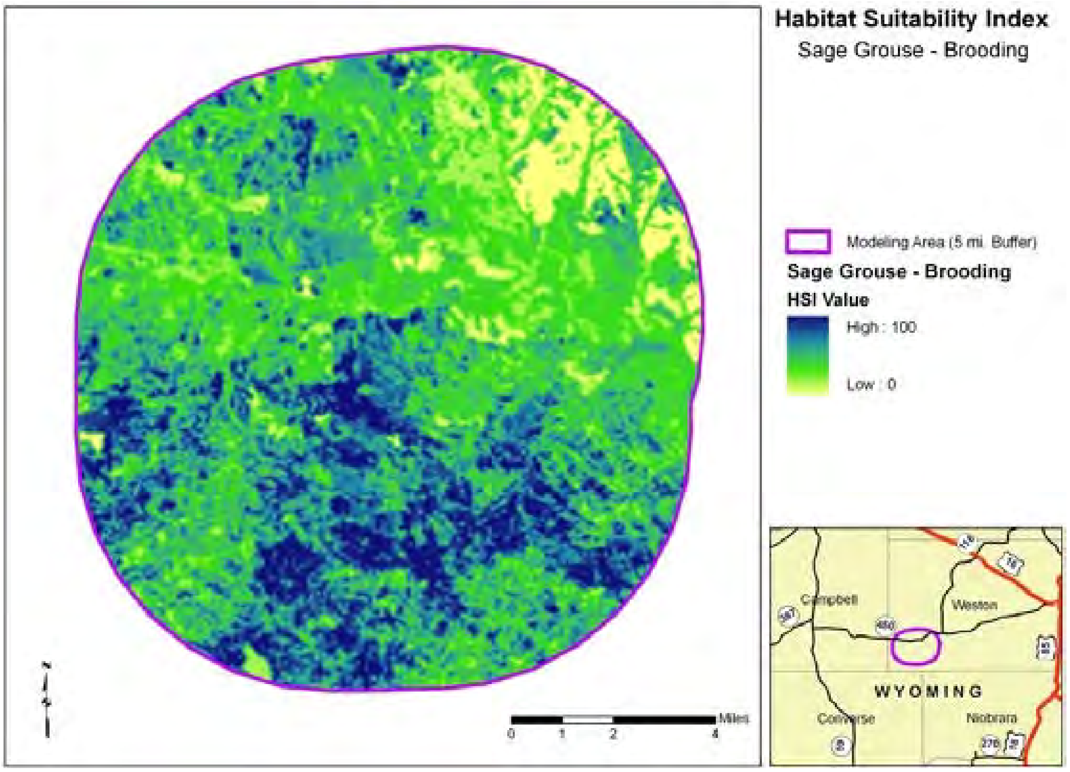


Figure B-91. Post-treatment habitat suitability map for sage grouse brood habitat for Thunder Basin project, Wyoming.

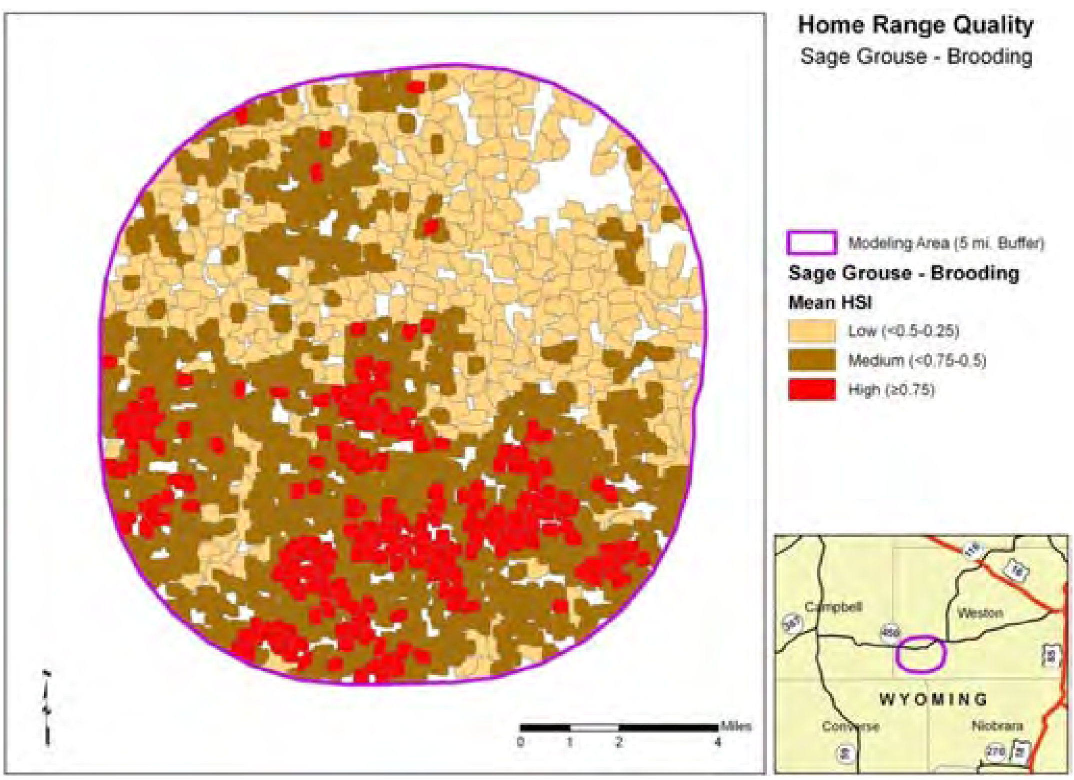


Figure B-92. Post-treatment potential home range map for sage grouse brood habitat for the Thunder Basin project, Wyoming.

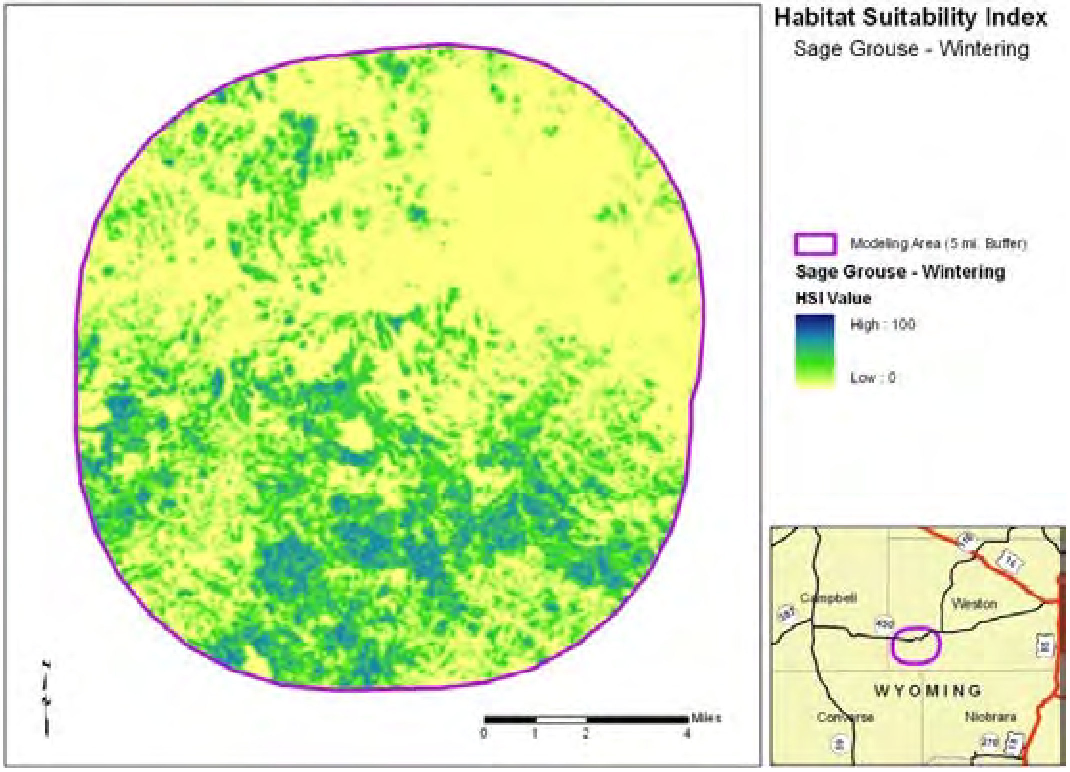


Figure B-93. Pre-treatment habitat suitability map for sage grouse wintering habitat for the Thunder Basin project, Wyoming.

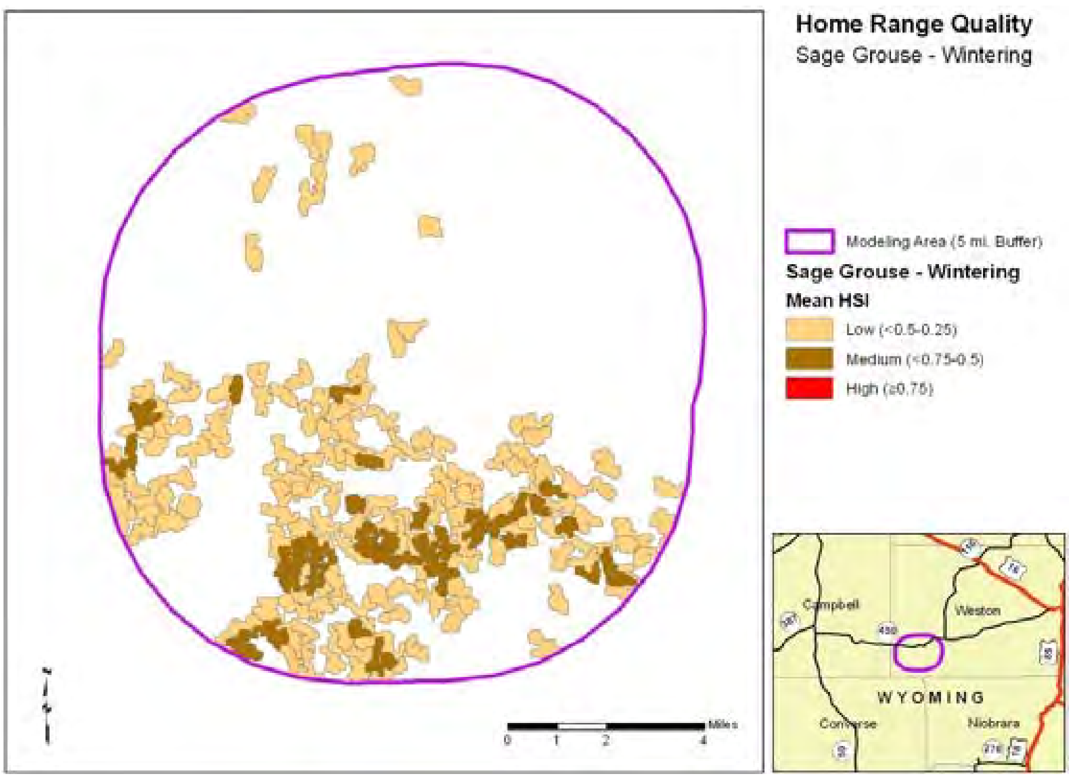


Figure B-94. Pre-treatment potential “home range” map for wintering sage grouse for the Thunder Basin project, Wyoming.

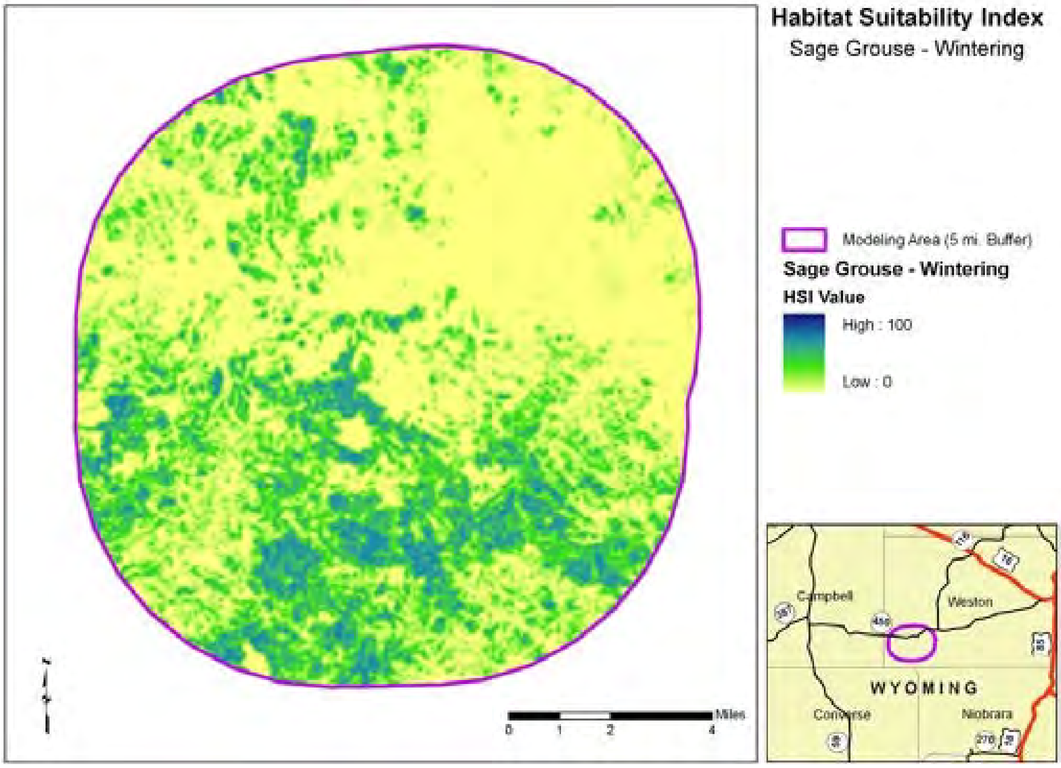


Figure B-95. Post-treatment habitat suitability map for sage grouse wintering habitat for the Thunder Basin project, Wyoming.

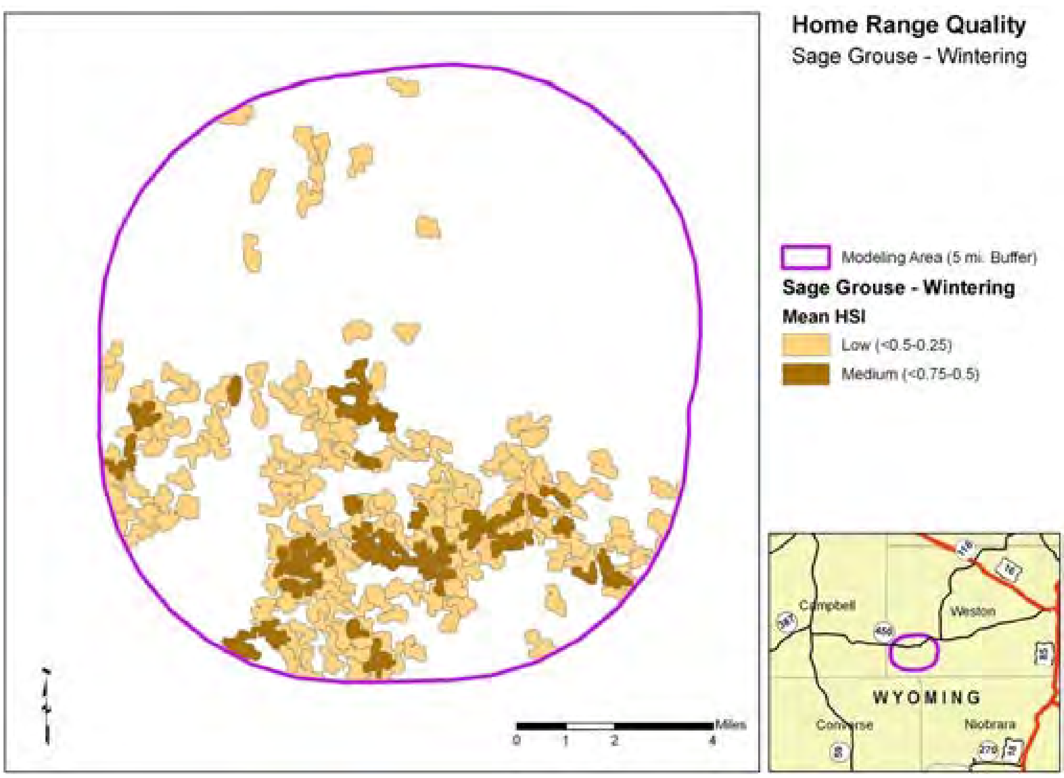


Figure B-96. Post-treatment potential home range map for wintering sage grouse for the Thunder Basin project, Wyoming.

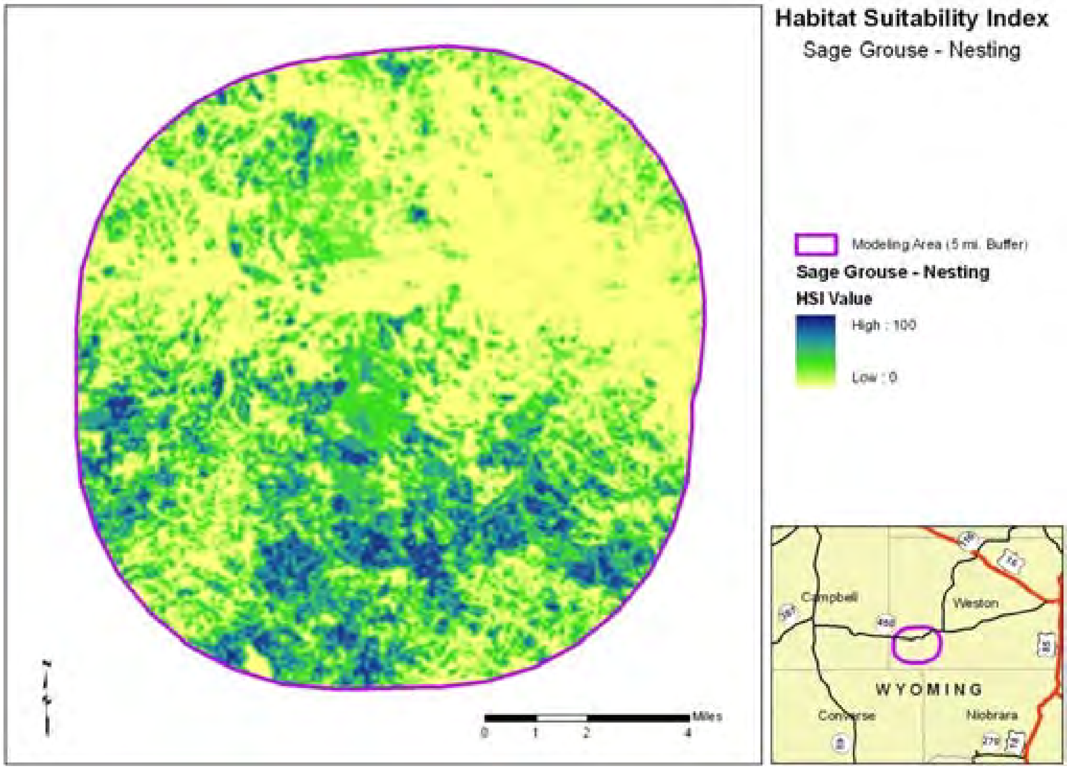


Figure B-97. Pre-treatment habitat suitability map for sage grouse nesting habitat for the Thunder Basin project, Wyoming.

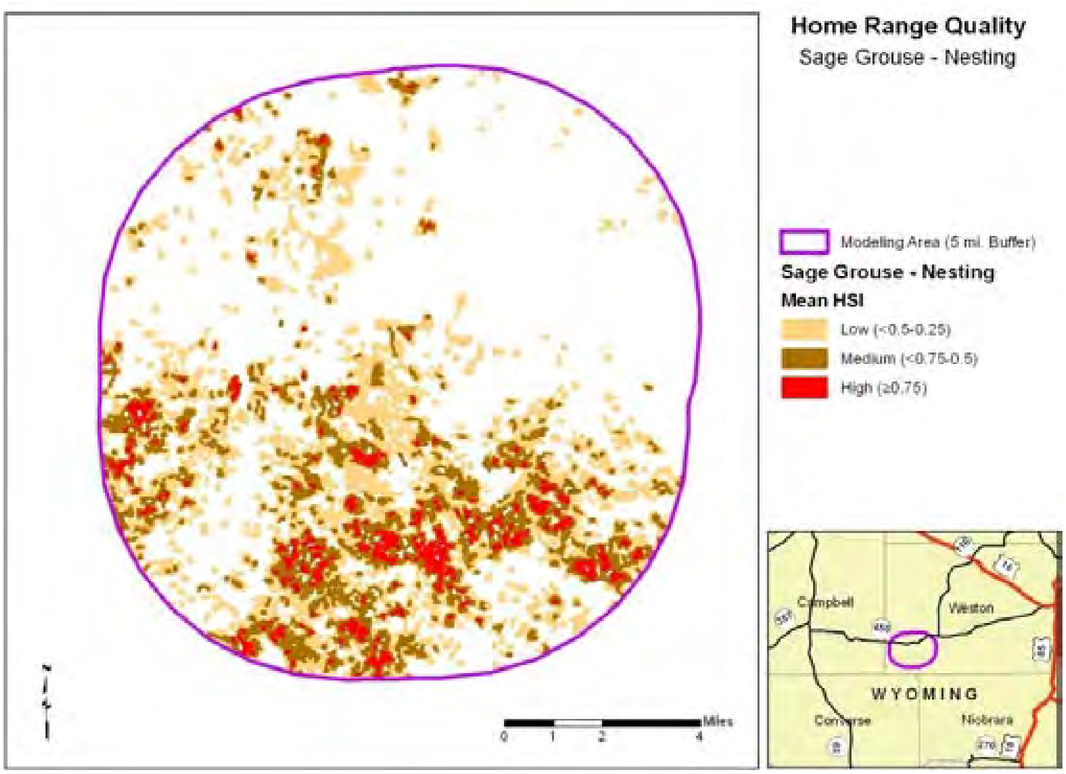


Figure B-98. Pre-treatment potential home range map for nesting sage grouse for the Thunder Basin project, Wyoming.

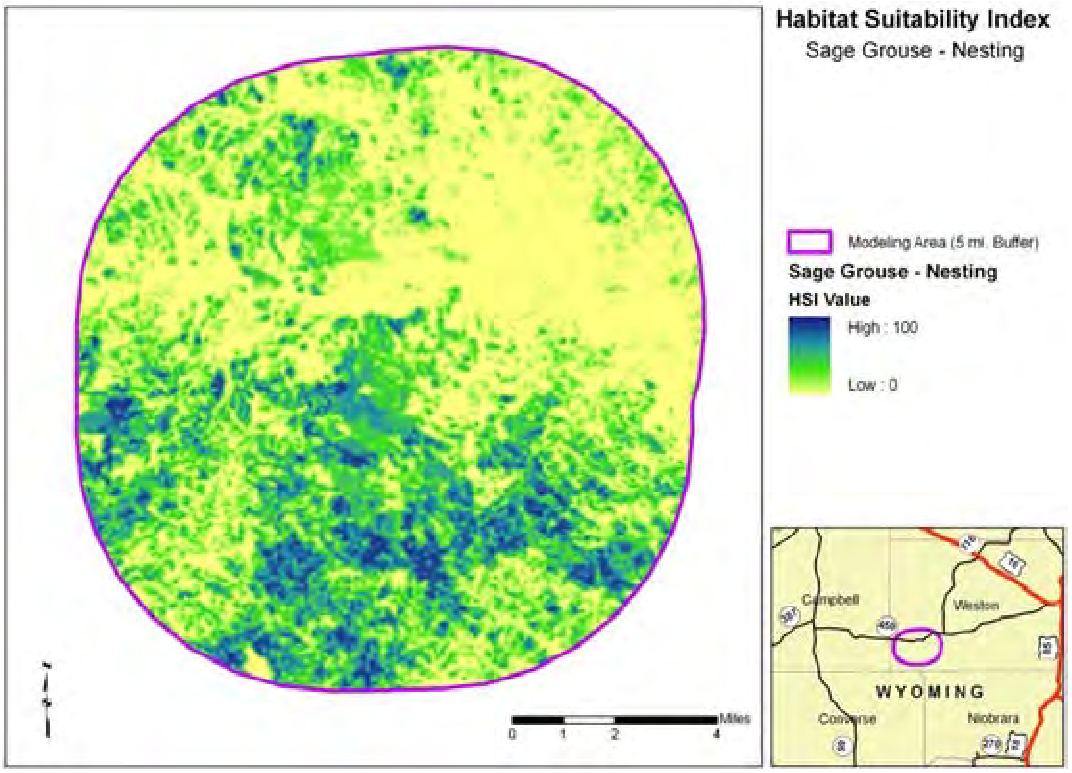


Figure B-99. Post-treatment habitat suitability map for sage grouse nesting habitat for the Thunder Basin project, Wyoming.

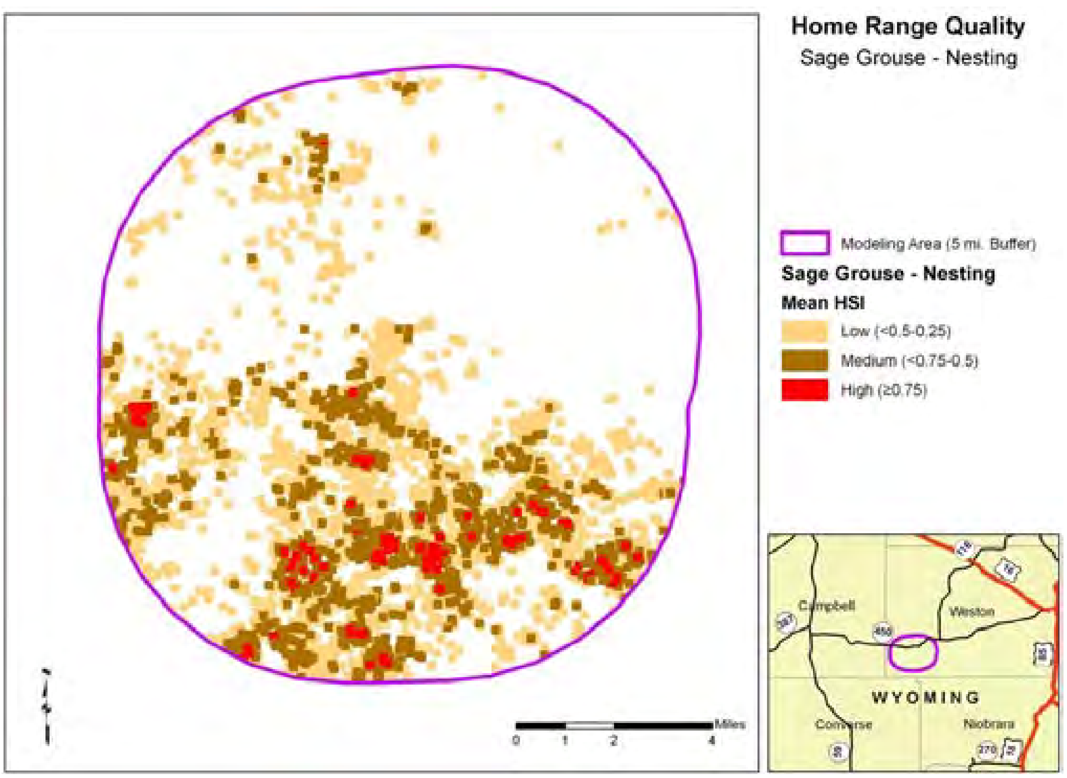


Figure B-100. Post-treatment potential home range map for nesting sage grouse for the Thunder Basin project site, Wyoming.

Laidlaw Park Project, Idaho

Sage Sparrow

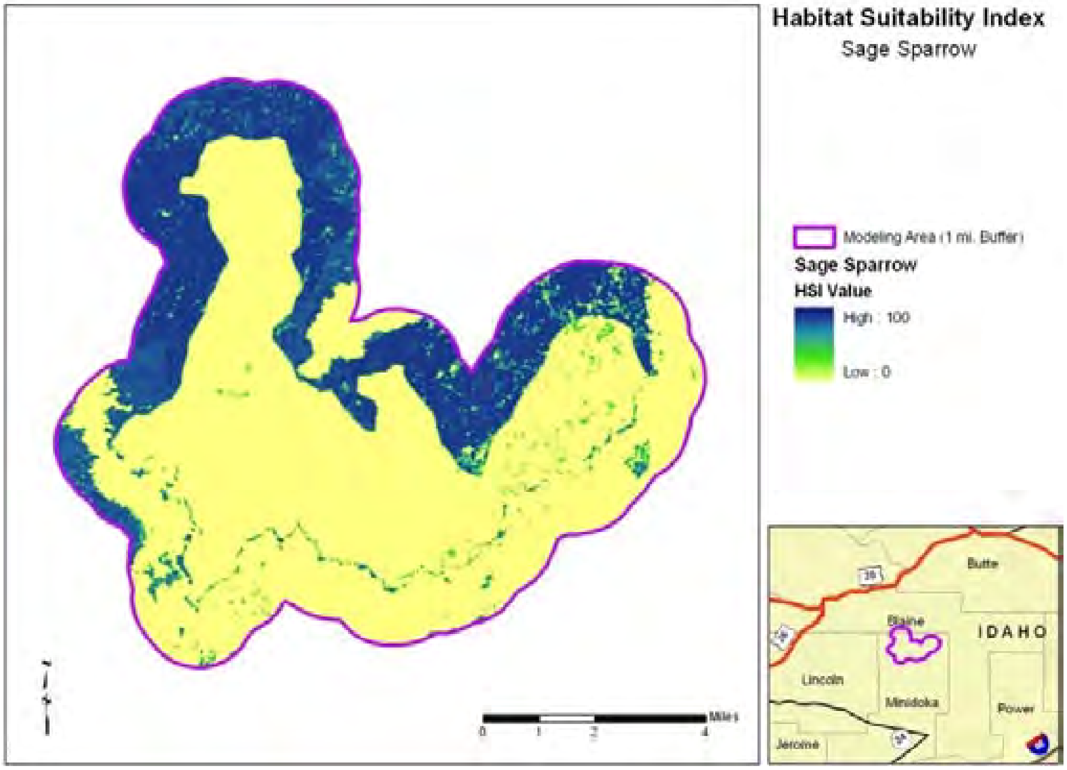


Figure B-101. Pre-treatment habitat suitability map for sage sparrow habitat for the Laidlaw Park, ID.

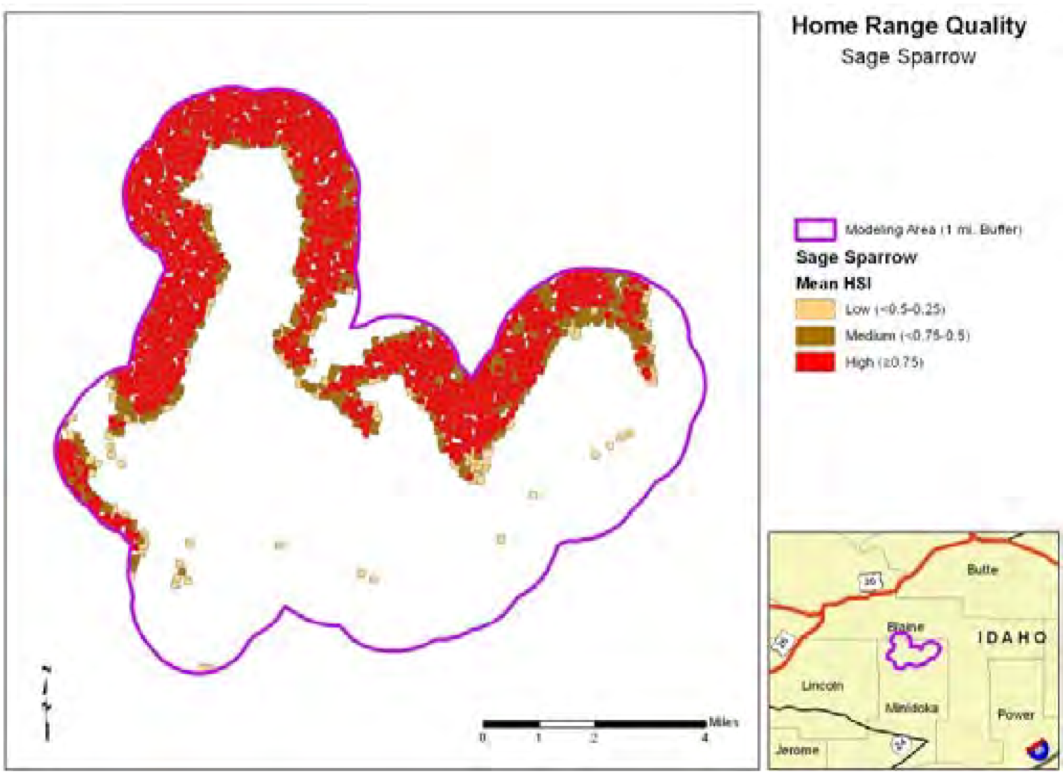


Figure B-102. Pre-treatment potential home range map for sage sparrows for the Laidlaw Park, ID.

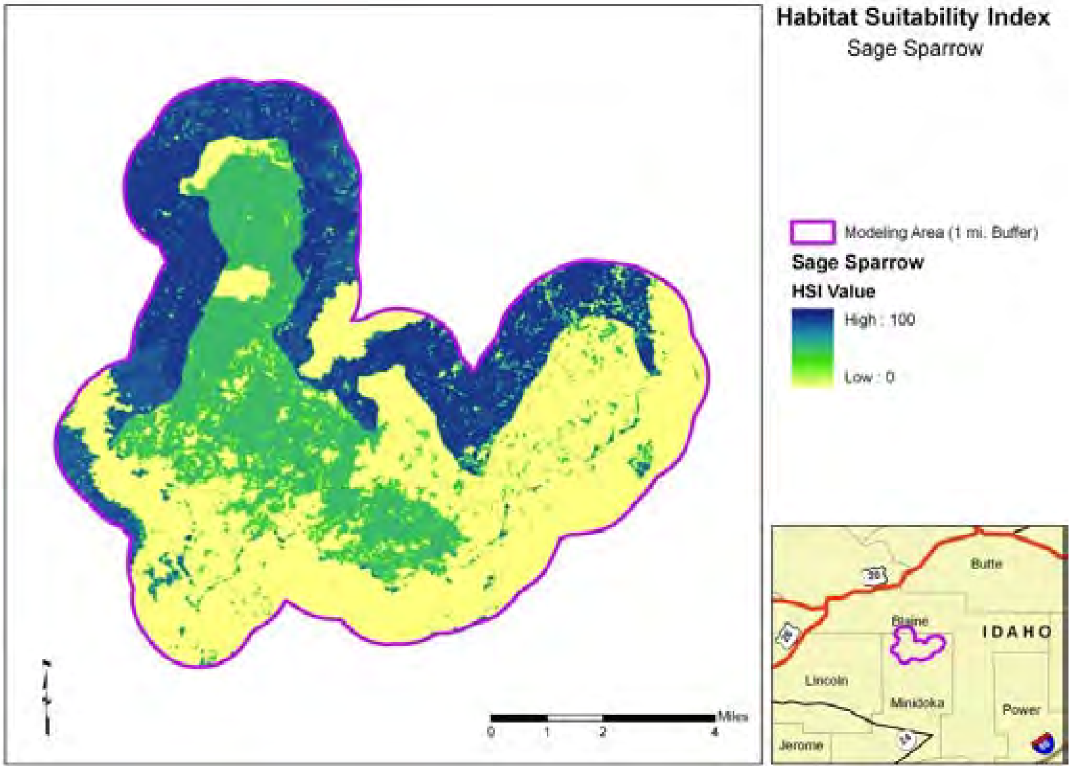


Figure B-103. Post-treatment habitat suitability map for sage sparrow habitat for the Laidlaw Park project, Idaho.

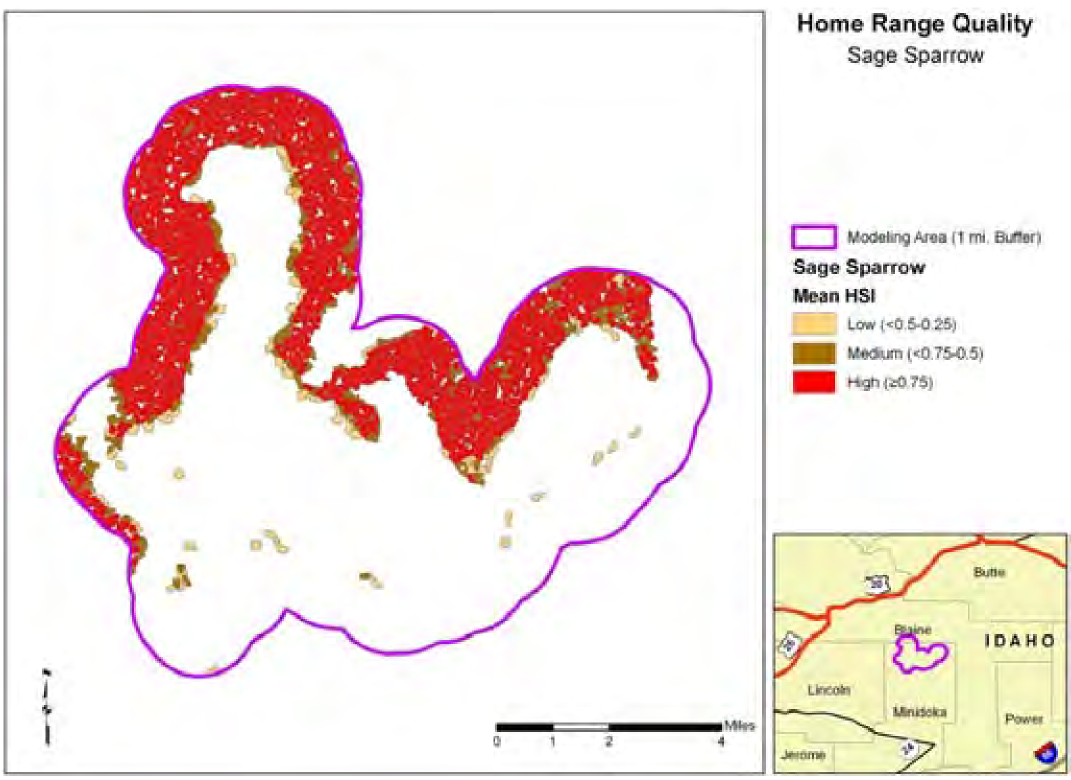


Figure B-104. Post-treatment potential home range map for sage sparrows for Laidlaw Park project, ID.

Pygmy Rabbit

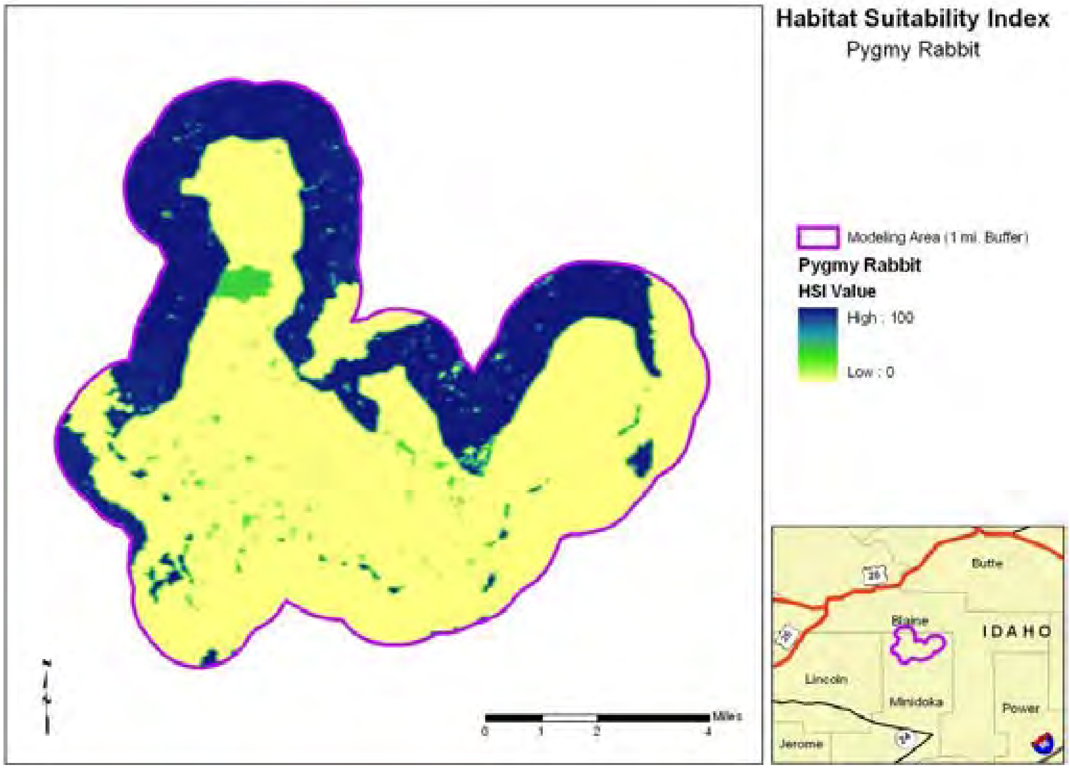


Figure B-105. Pre-treatment habitat suitability map for pygmy rabbit habitat for Laidlaw Park project, ID.

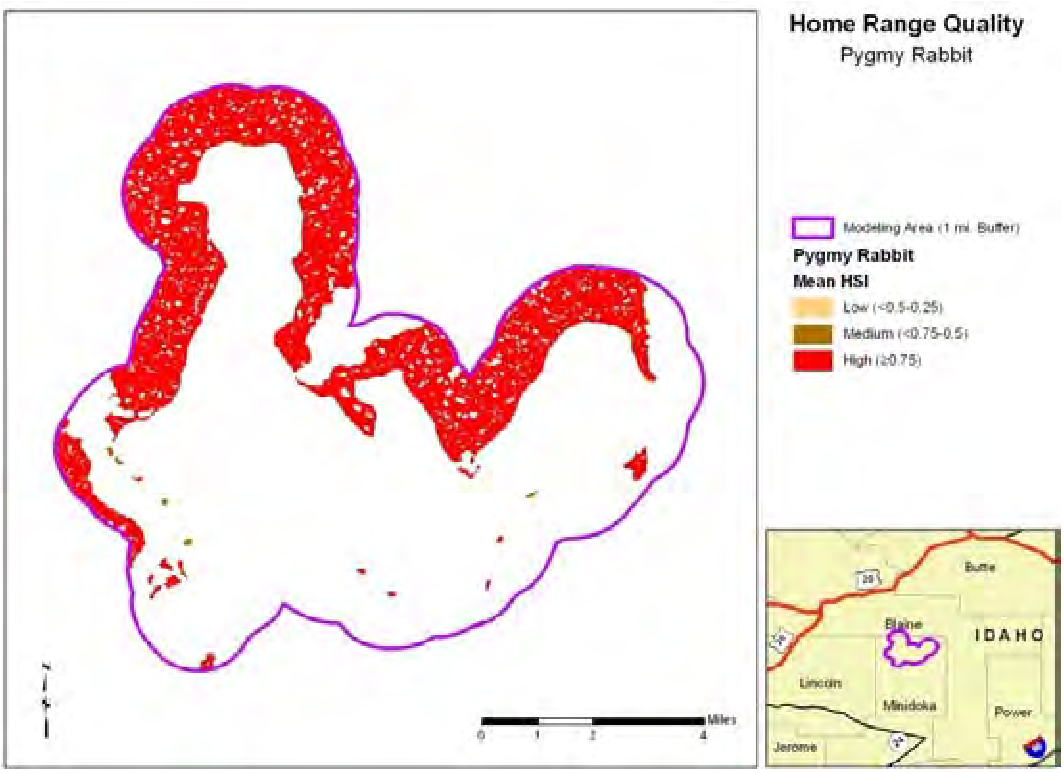


Figure B-106. Pre-treatment potential home range map for pygmy rabbits for the Laidlaw Park project, Idaho.

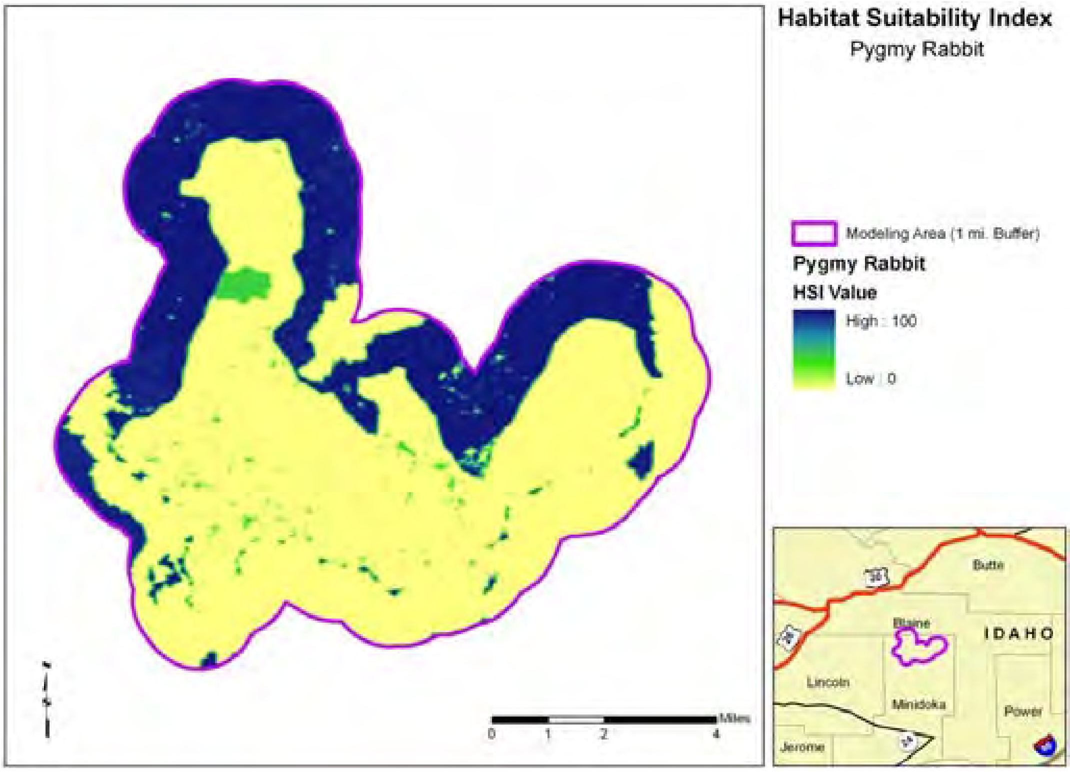


Figure B-107. Post-treatment habitat suitability map for pygmy rabbit habitat for the Laidlaw Park project, Idaho.

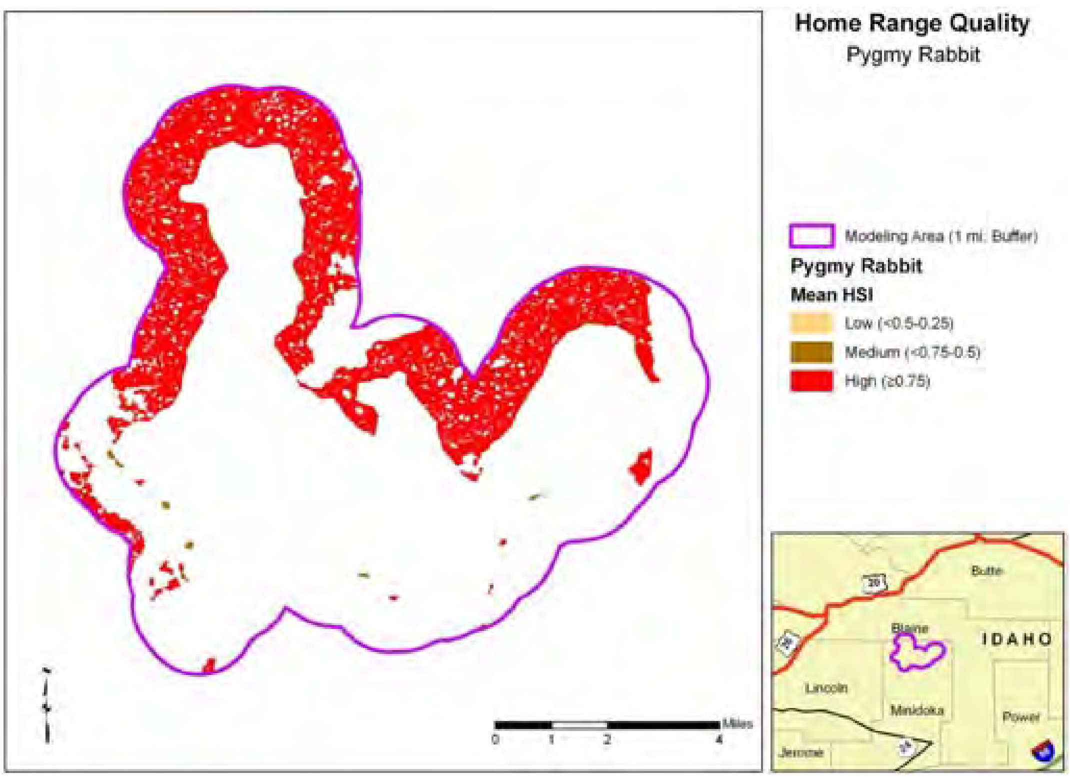


Figure B-108. Post-treatment potential home range map for pygmy rabbits for Laidlaw Park project, ID.

Sagebrush Lizard

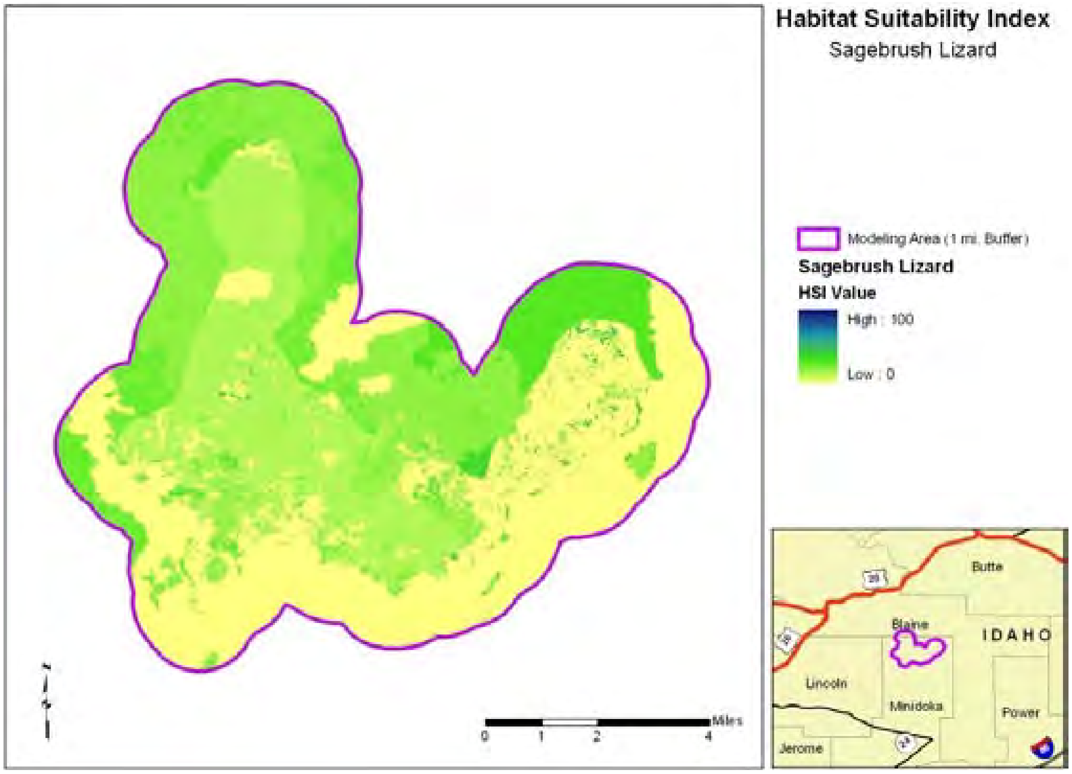


Figure B-109. Pre-treatment habitat suitability map for sagebrush lizard habitat, Laidlaw Park project, ID.

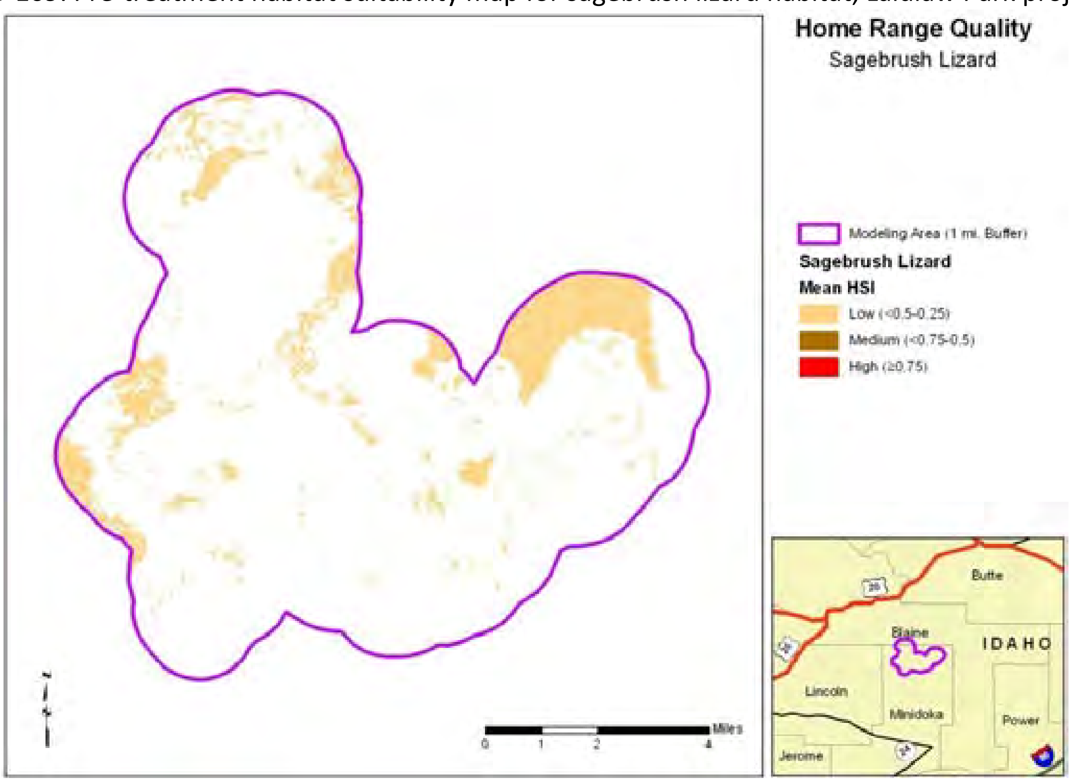


Figure B-110. Pre-treatment potential home range map for sagebrush lizards for the Laidlaw Park project, Idaho.

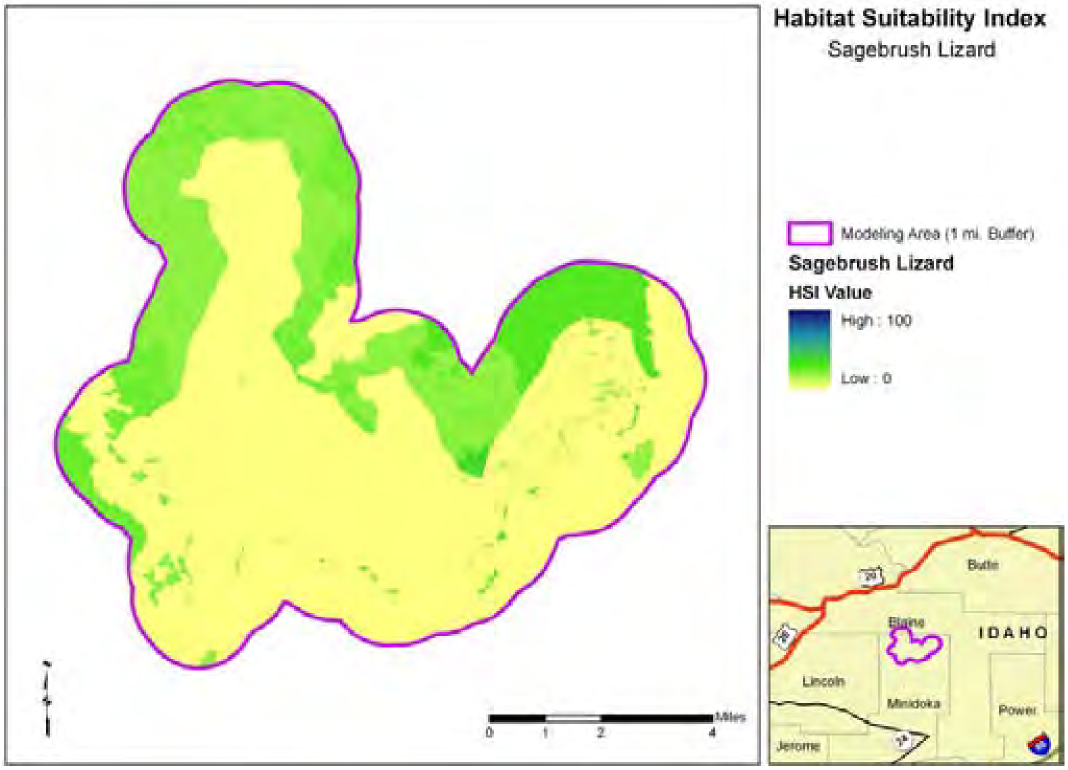


Figure B-111. Post-treatment habitat suitability map for sagebrush lizard habitat for the Laidlaw Park project, Idaho.

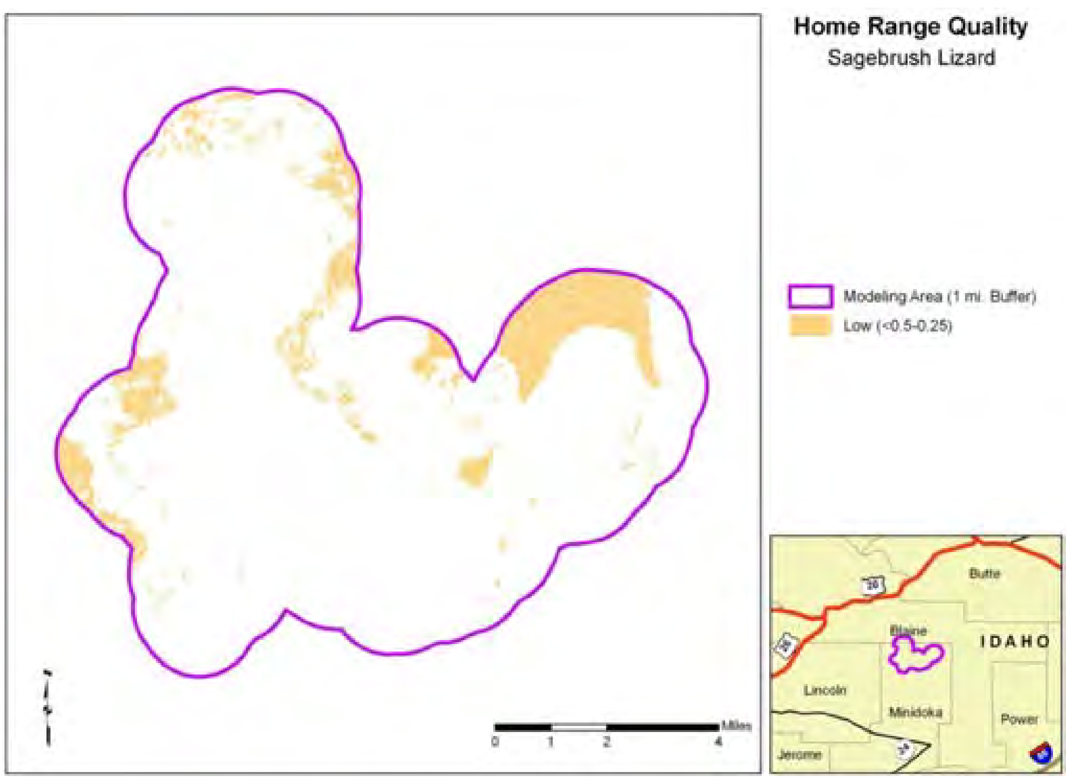


Figure B-112. Post-treatment potential home range map for sagebrush lizard, Laidlaw Park project, ID.

Pronghorn Antelope

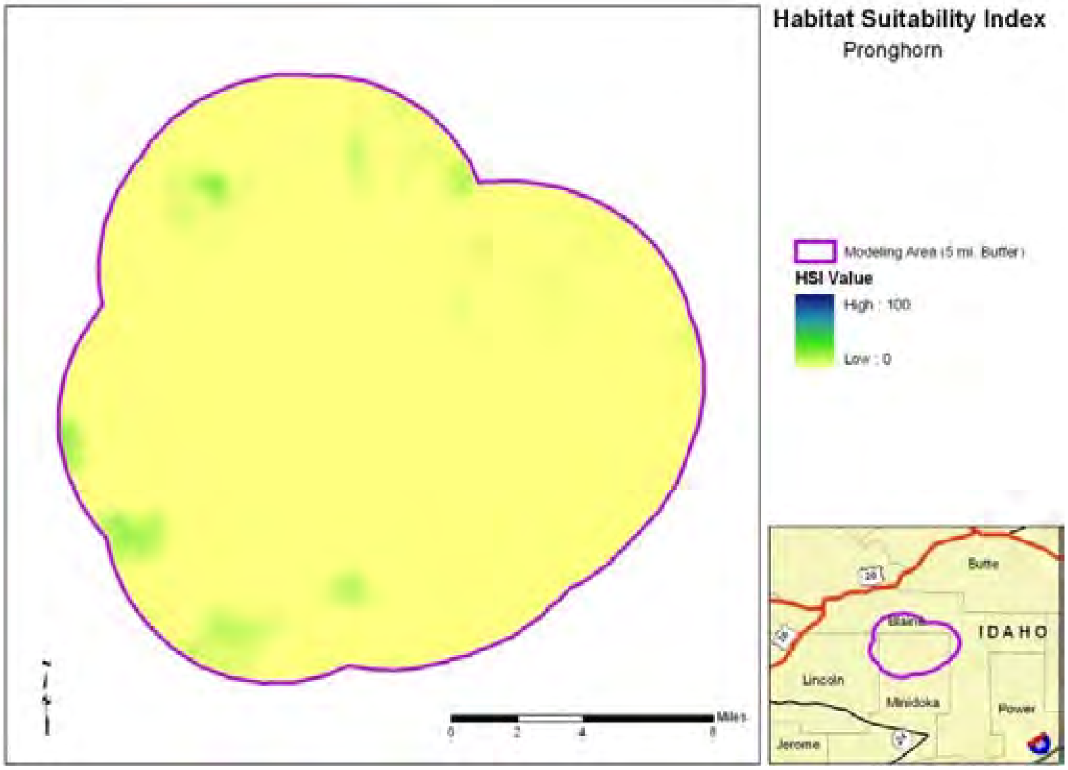


Figure B-113. Pre-treatment habitat suitability map for pronghorn antelope, Laidlaw Park project, ID.

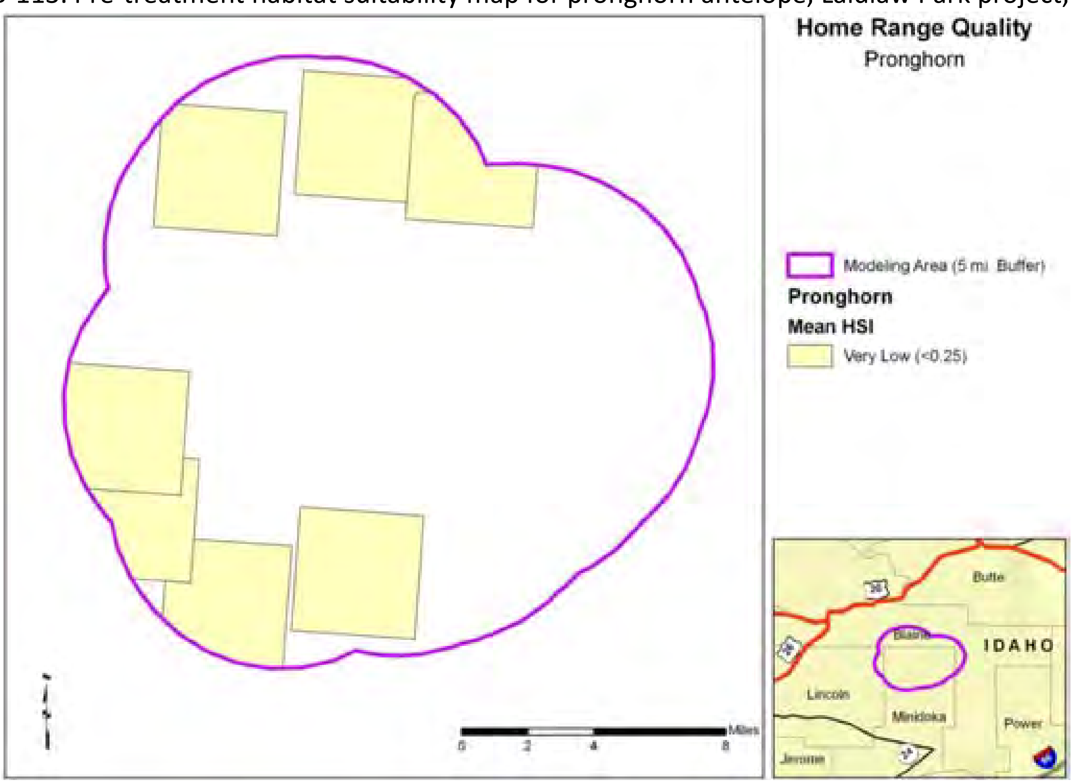


Figure B-114. Pre-treatment potential home ranges for pronghorn antelope for the Laidlaw Park project, Idaho. .

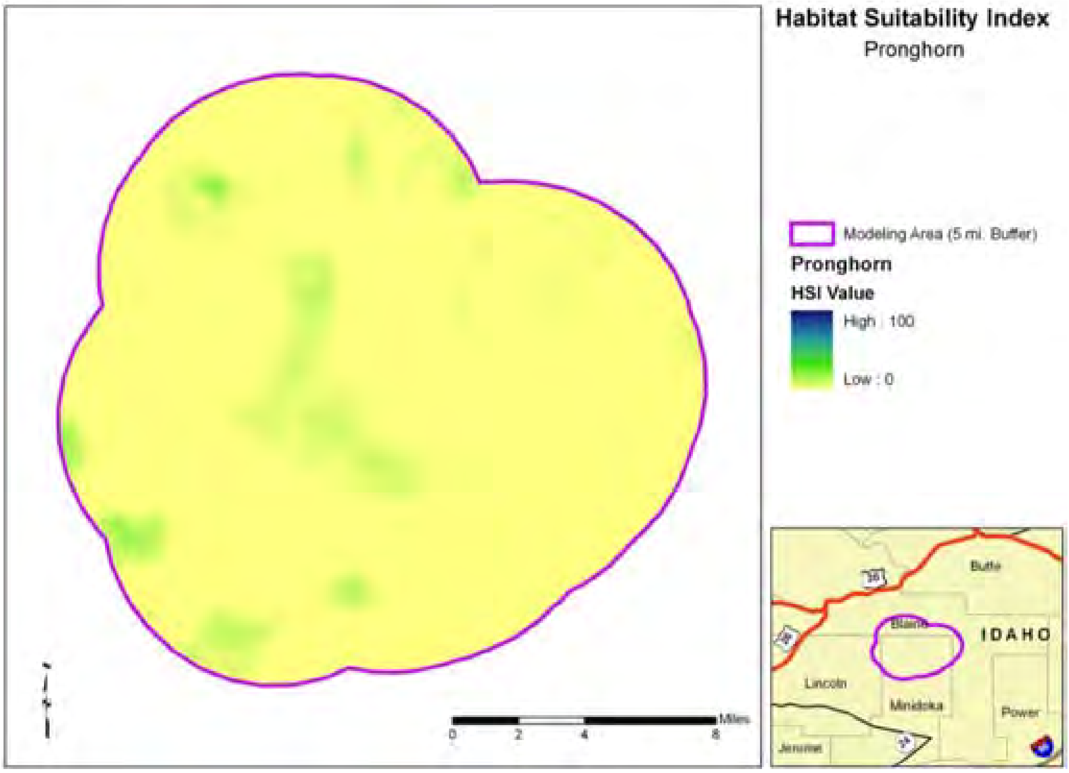


Figure B-115. Post-treatment habitat suitability map for pronghorn antelope habitat for the Laidlaw Park project, Idaho.

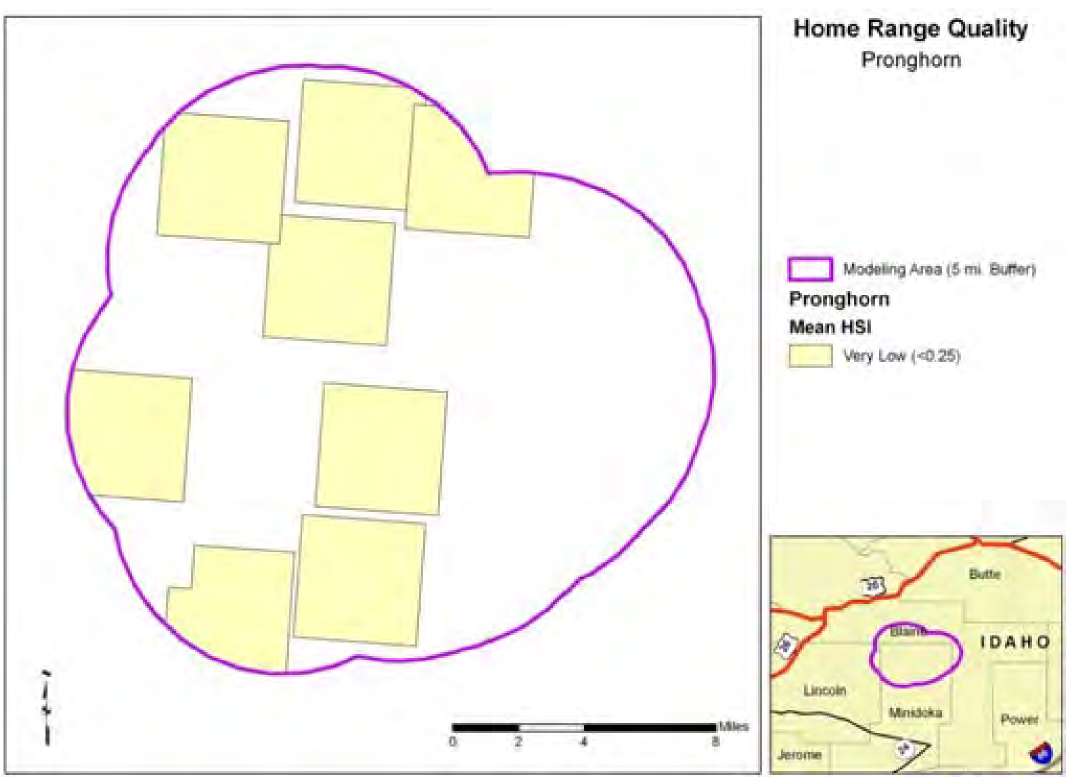


Figure B-116. Post-treatment potential home ranges for pronghorn antelope, Laidlaw Park project, ID.

Sage Grouse

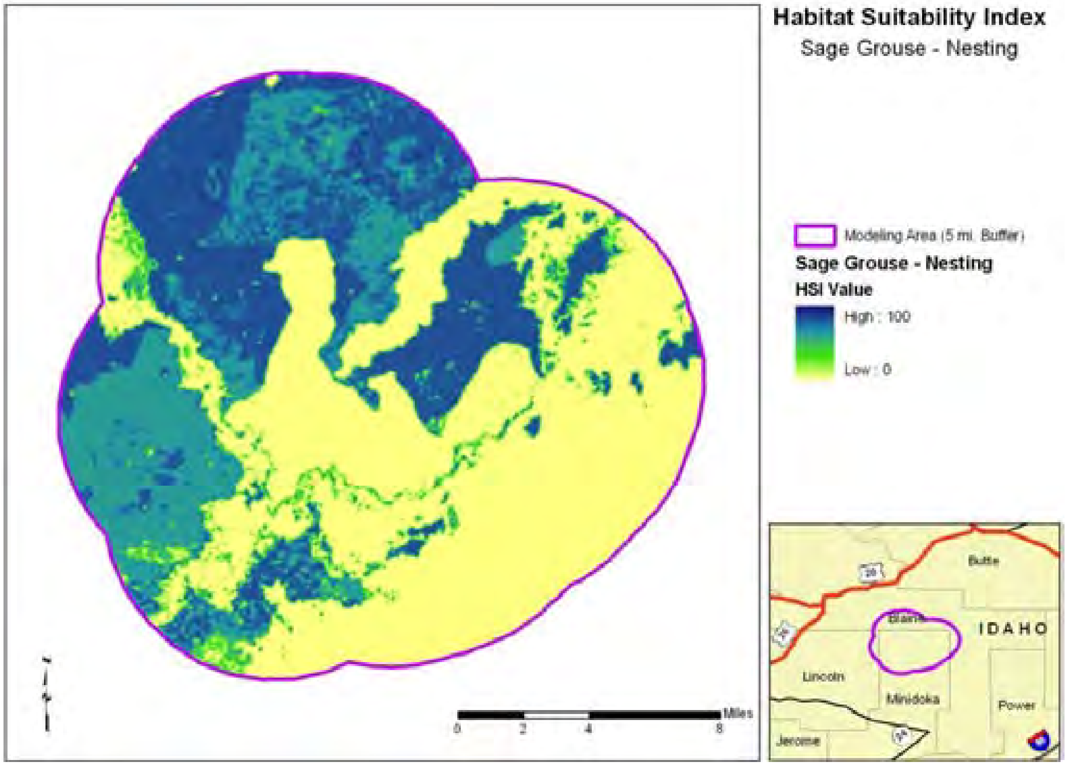


Figure B-117. Pre-treatment habitat suitability map for sage grouse nesting habitat, Laidlaw Park, Idaho.

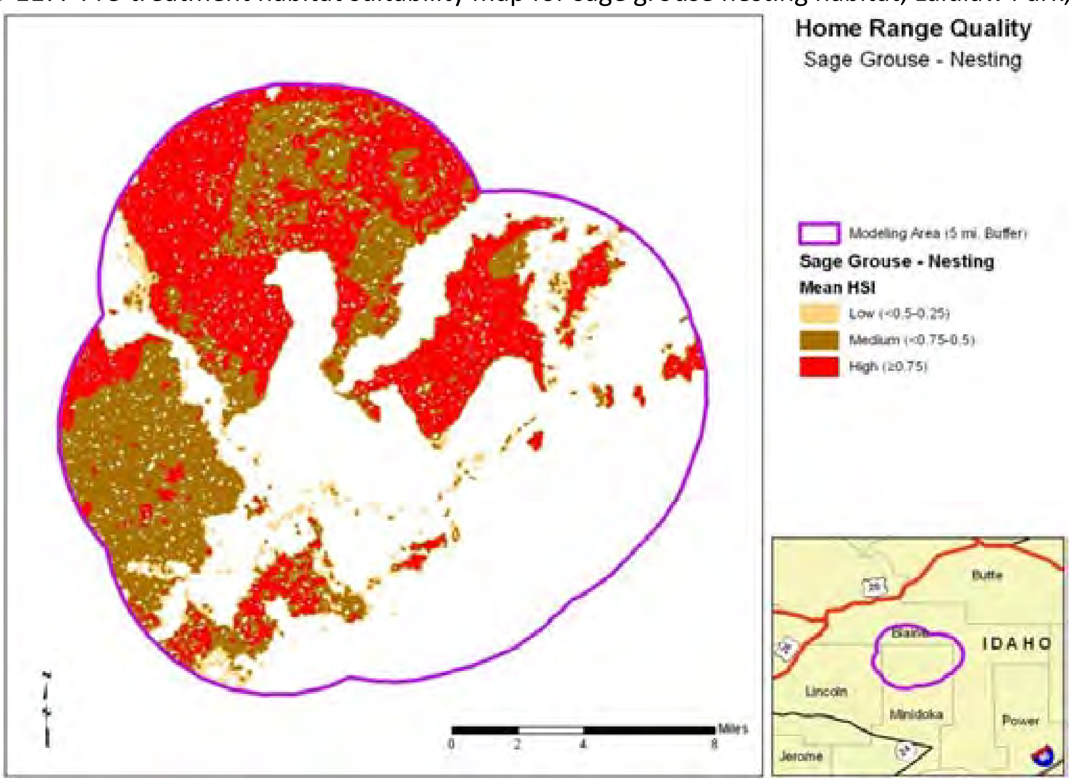


Figure B-118. Pre-treatment potential home range map for nesting sage grouse for the Laidlaw Park project, Idaho.

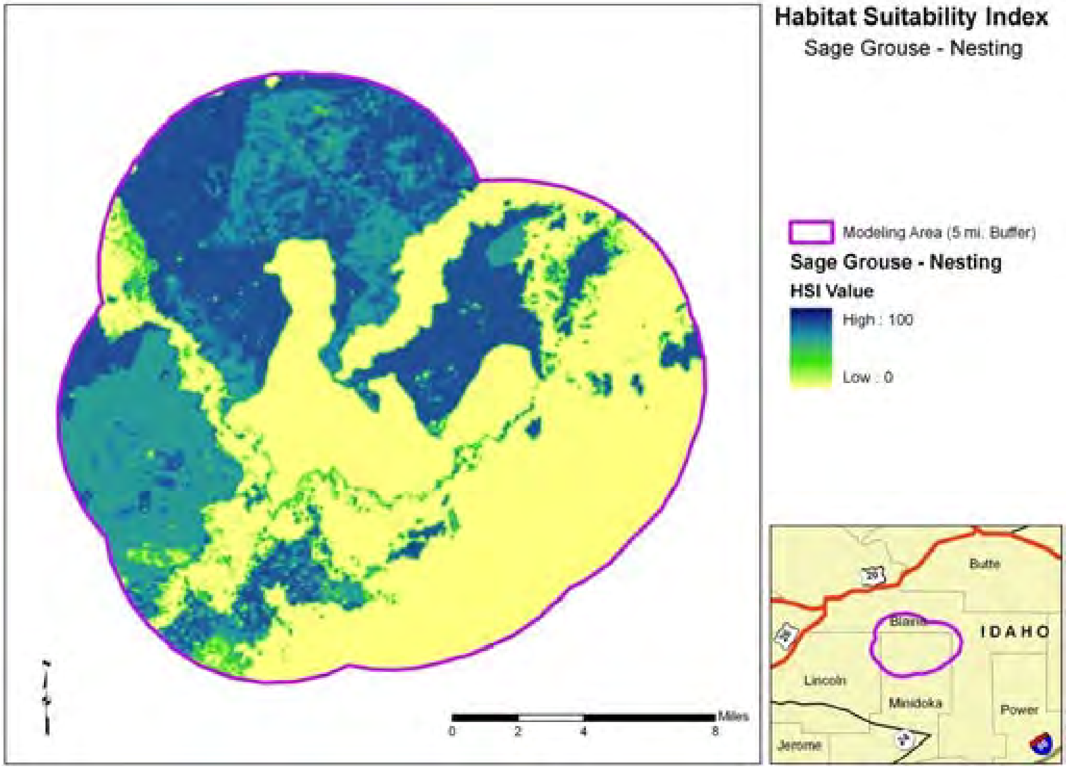


Figure B-119. Post-treatment habitat suitability map for sage grouse nesting habitat for the Laidlaw Park project, Idaho.

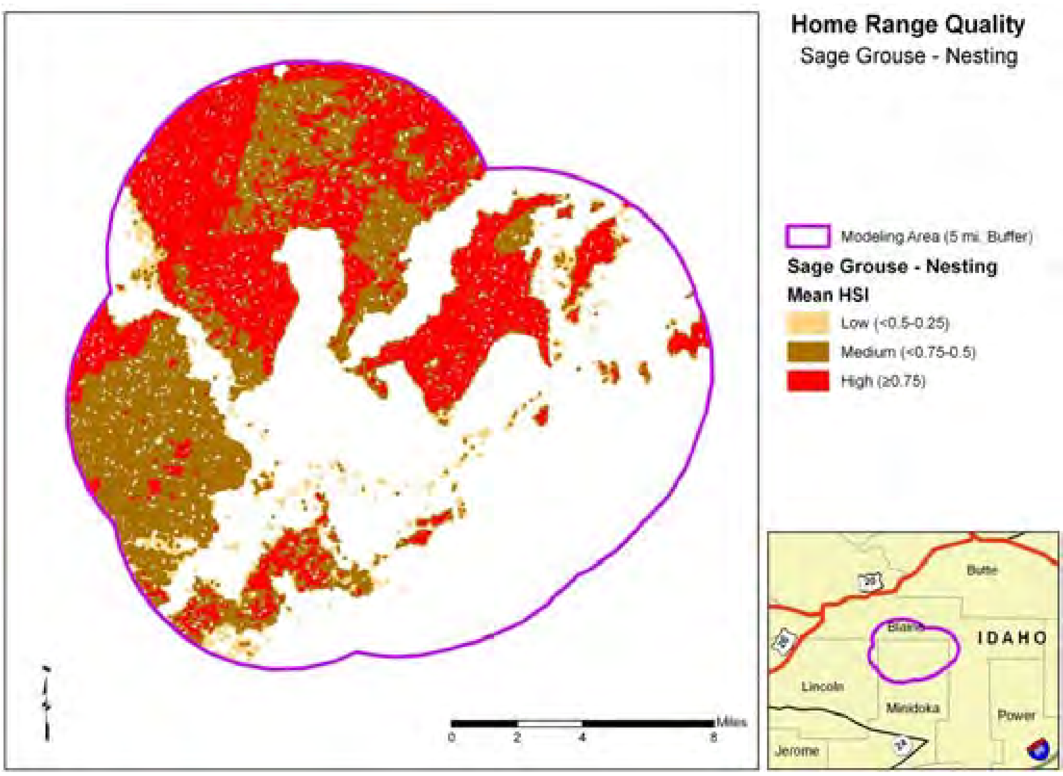


Figure B-120. Post-treatment potential home range map for nesting sage grouse for the Laidlaw Park project, Idaho.

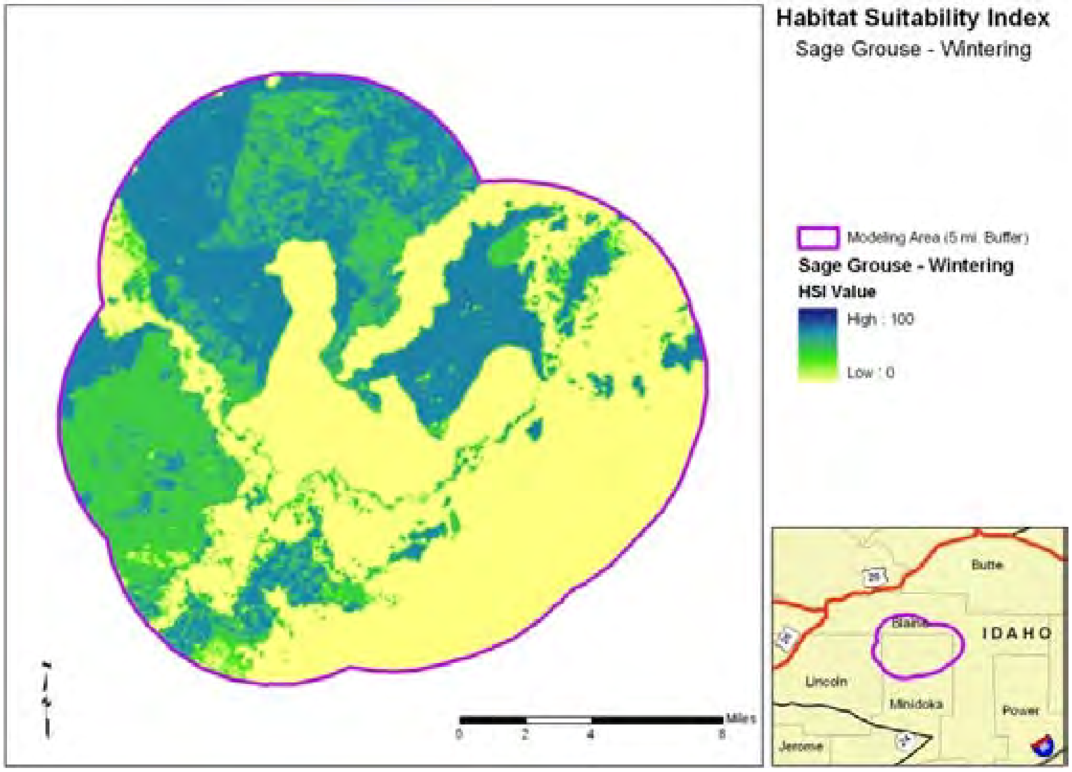


Figure B-121. Pre-treatment habitat suitability map for sage grouse wintering habitat for the Laidlaw Park project, Idaho.

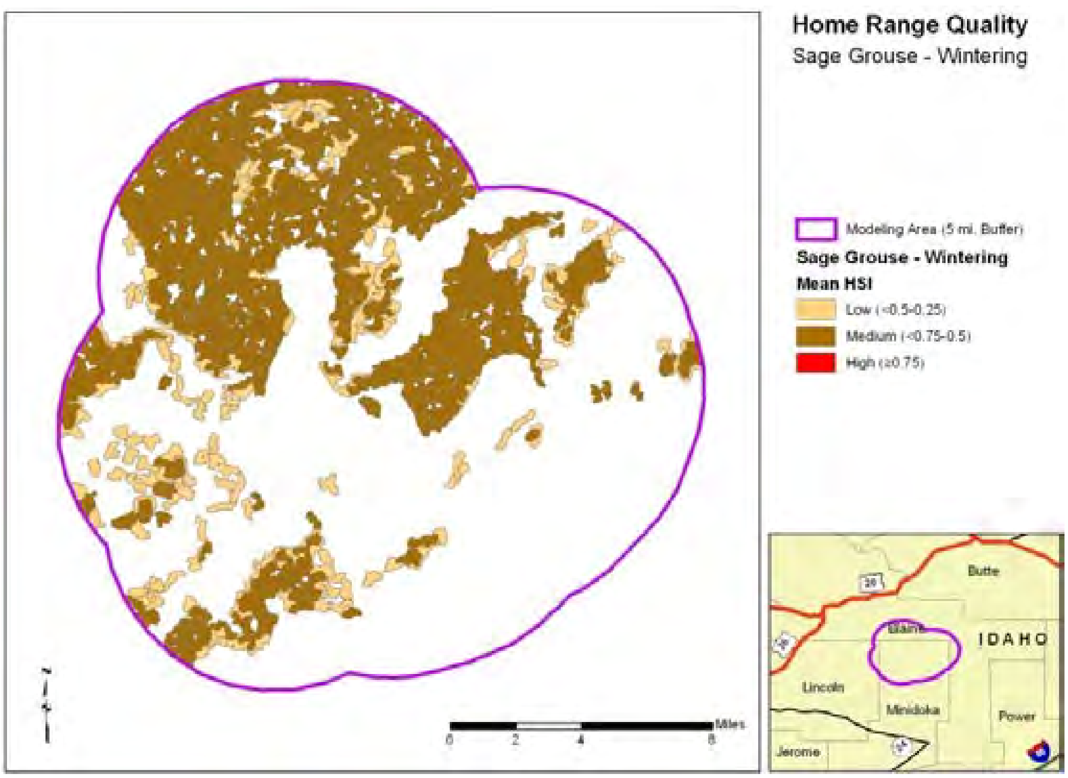


Figure B-122. Pre-treatment potential home range map for sage grouse wintering areas for the Laidlaw Park project, Idaho.

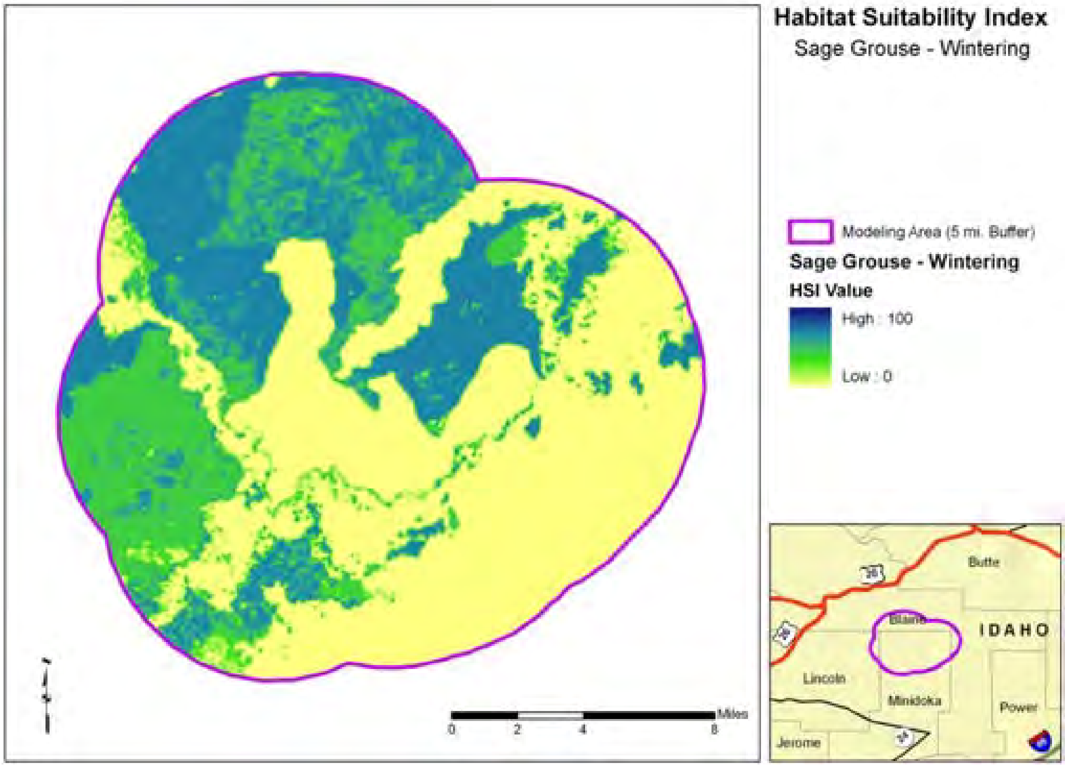


Figure B-123. Post-treatment habitat suitability map for sage grouse wintering habitat for the Laidlaw Park project, Idaho.

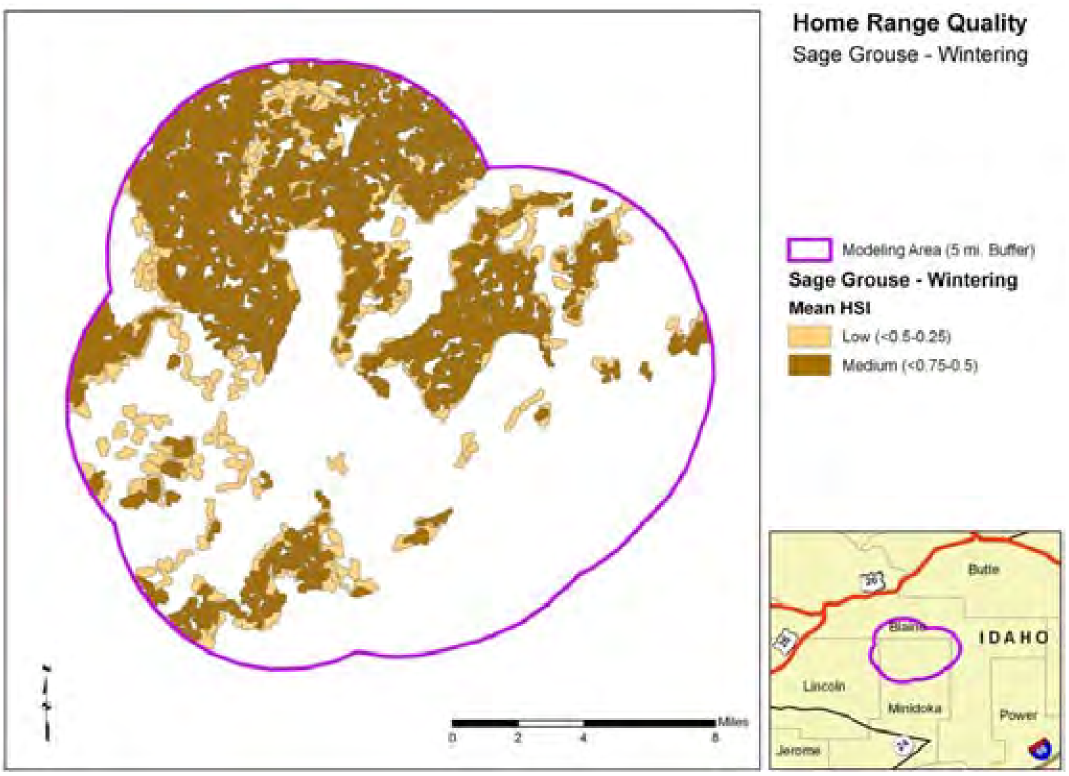


Figure B-124. Post-treatment potential home range map for sage grouse wintering areas for the Laidlaw Park project, Idaho.

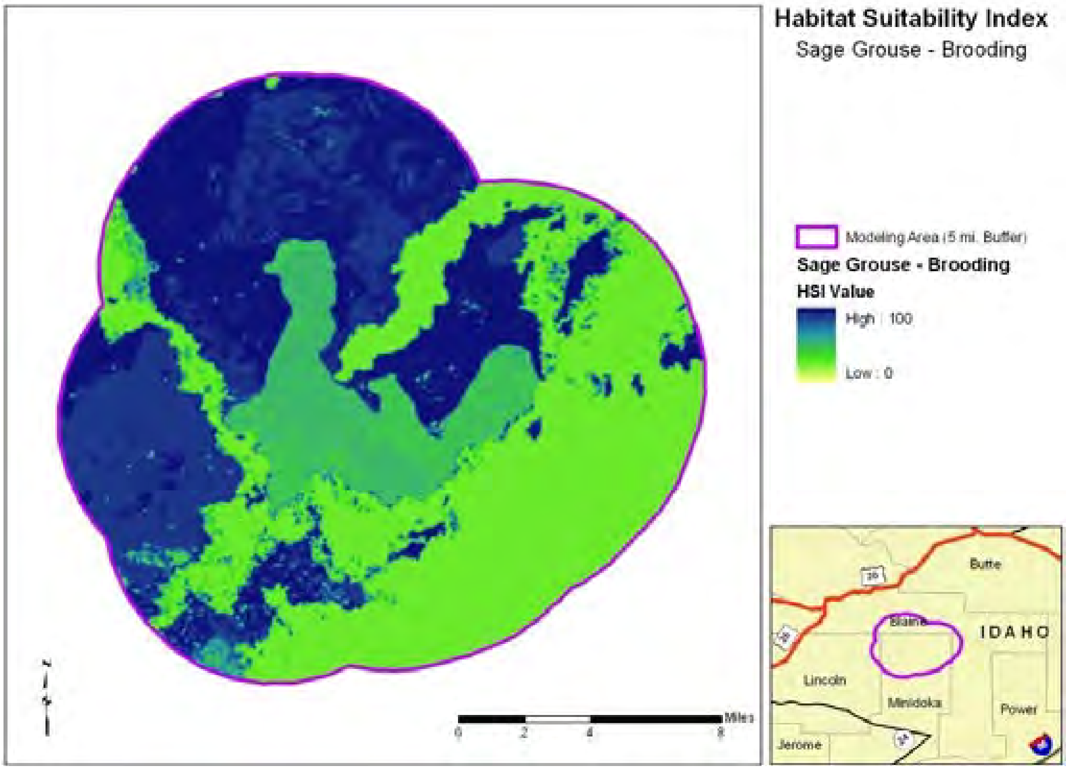


Figure B-125. Pre-treatment habitat suitability map for sage grouse brood habitat for the Laidlaw Park project, Idaho.

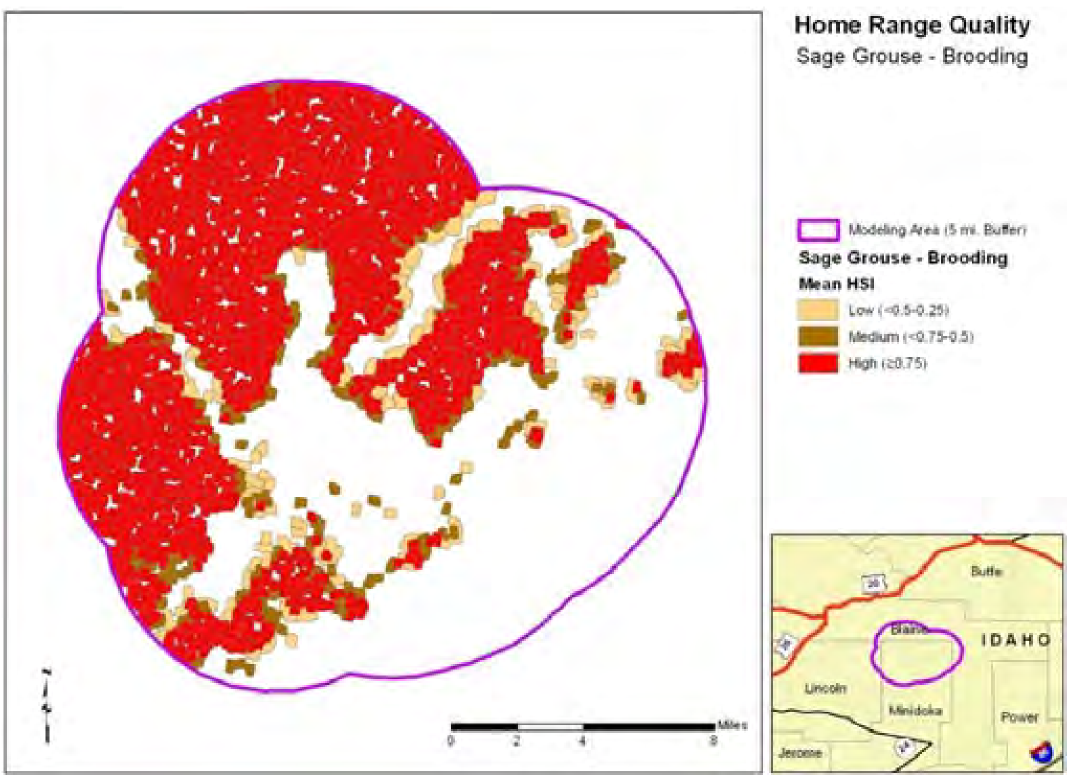


Figure B-126. Pre-treatment potential home range map for sage grouse brood areas for the Laidlaw Park project, Idaho.

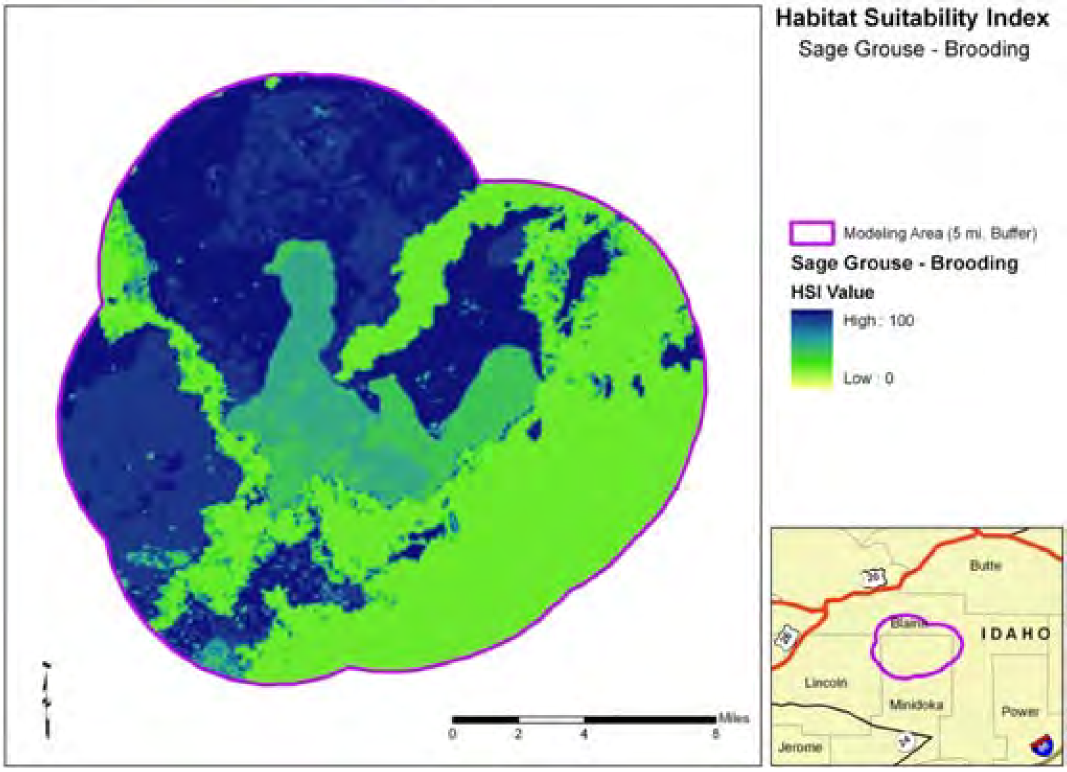


Figure B-127. Post-treatment habitat suitability map for sage grouse brood habitat for the Laidlaw Park project, Idaho.

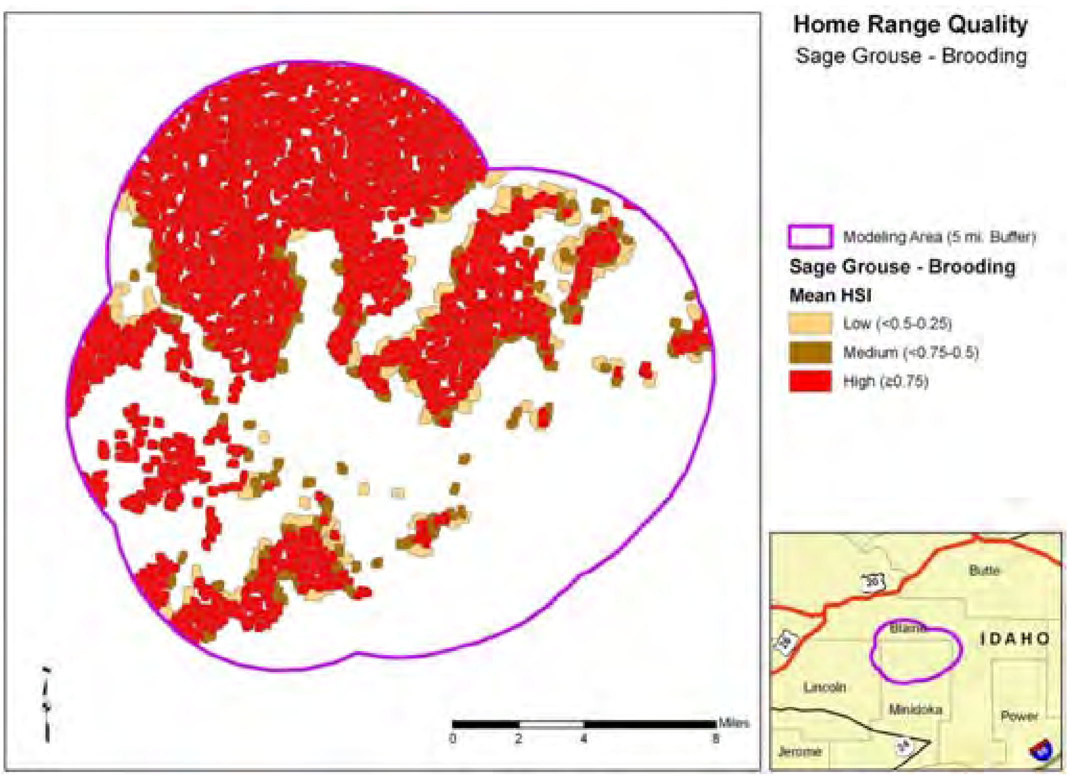


Figure B-128. Post-treatment potential home range map for sage grouse brood areas, Laidlaw Park, ID.

Sagebrush Vole

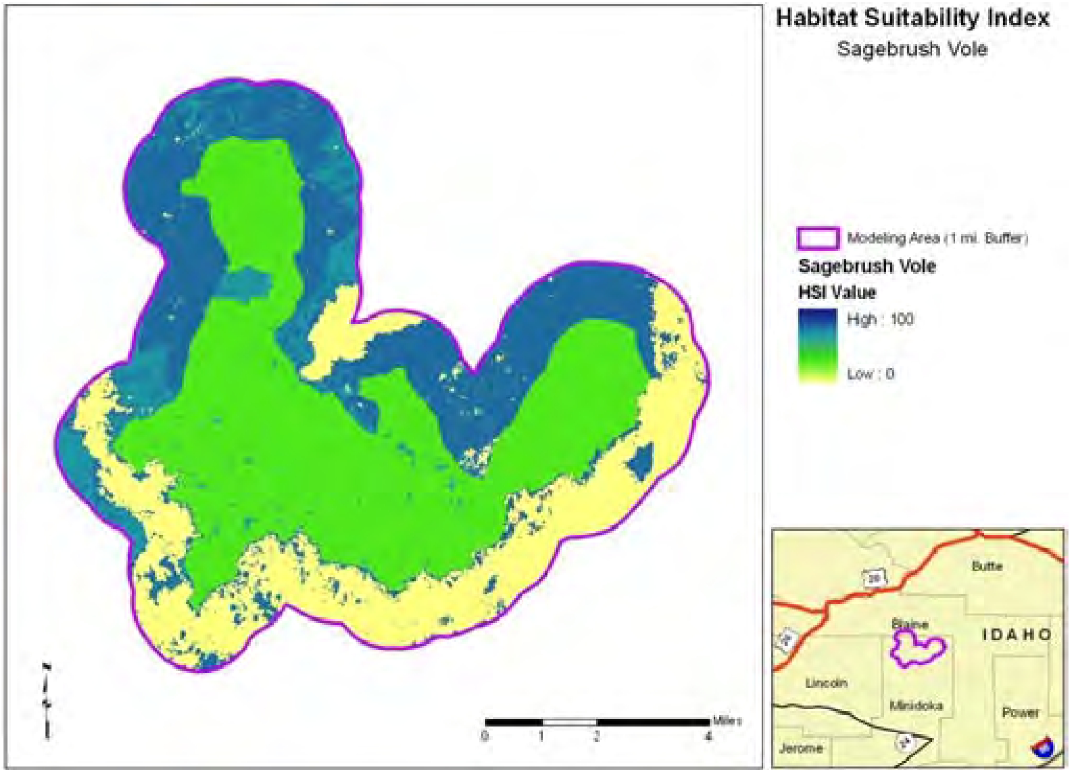


Figure B-129. Pre-treatment habitat suitability map for sagebrush vole for Laidlaw Park project, Idaho.

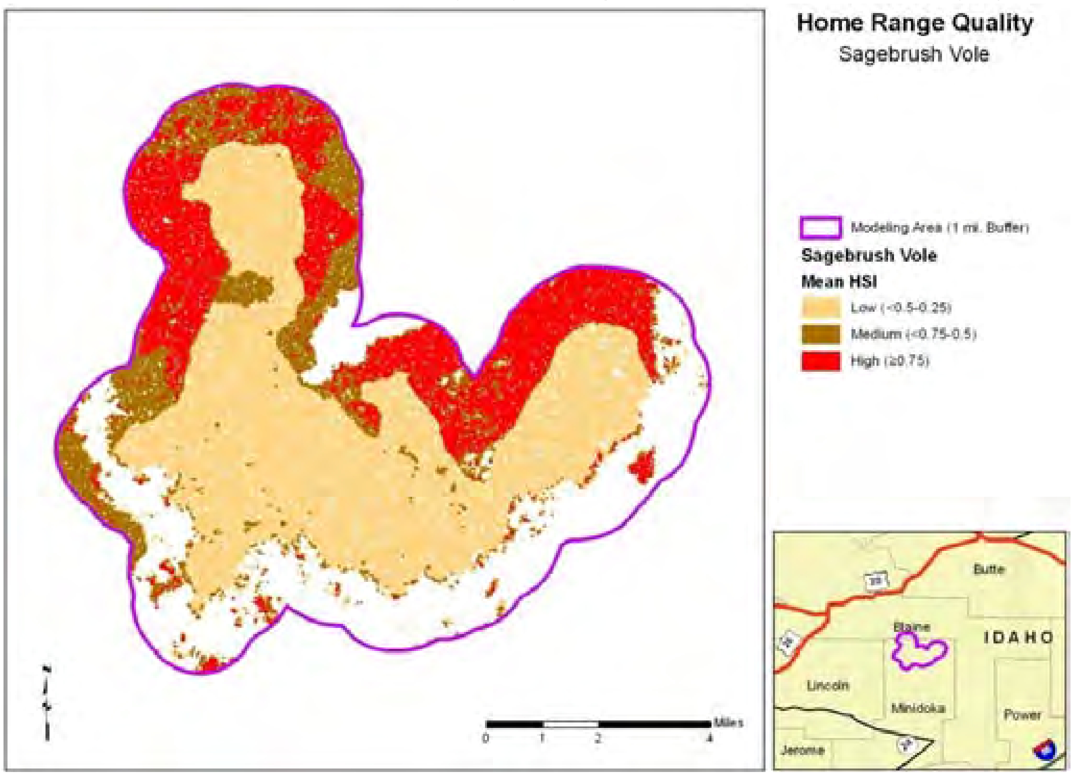


Figure B-130. Pre-treatment potential home range map for sagebrush voles for the Laidlaw Park project, Idaho.

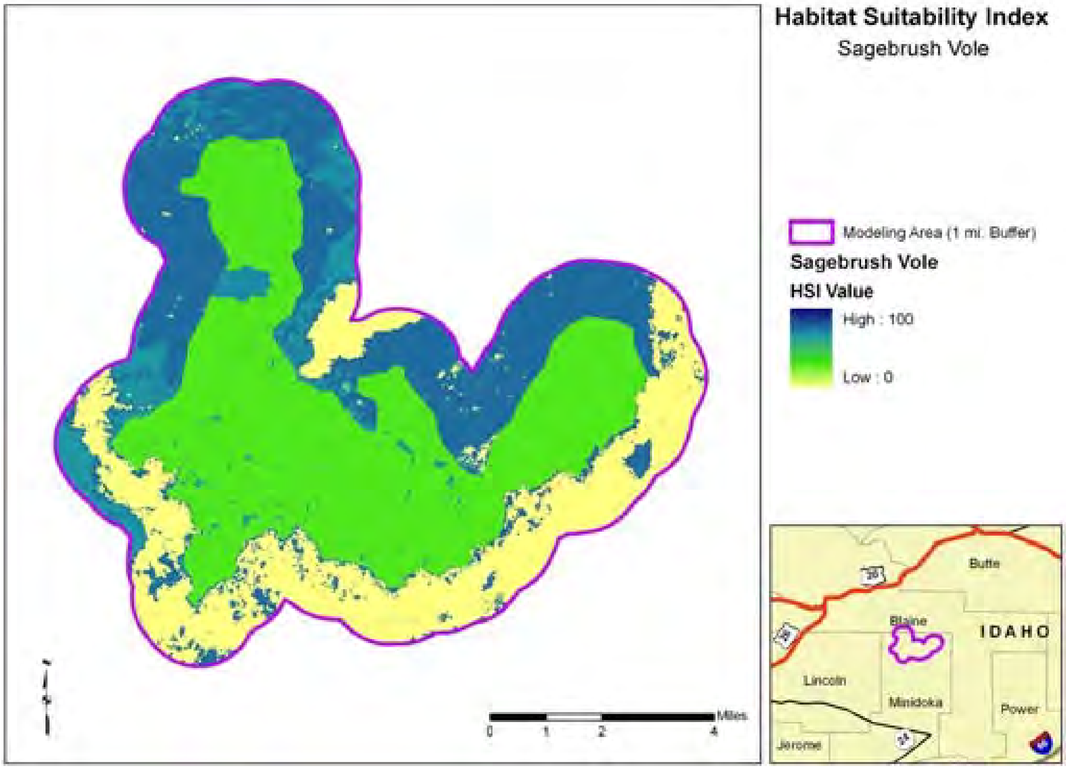


Figure B-131. Post-treatment habitat suitability map for sagebrush vole habitat for the Laidlaw Park project, Idaho.

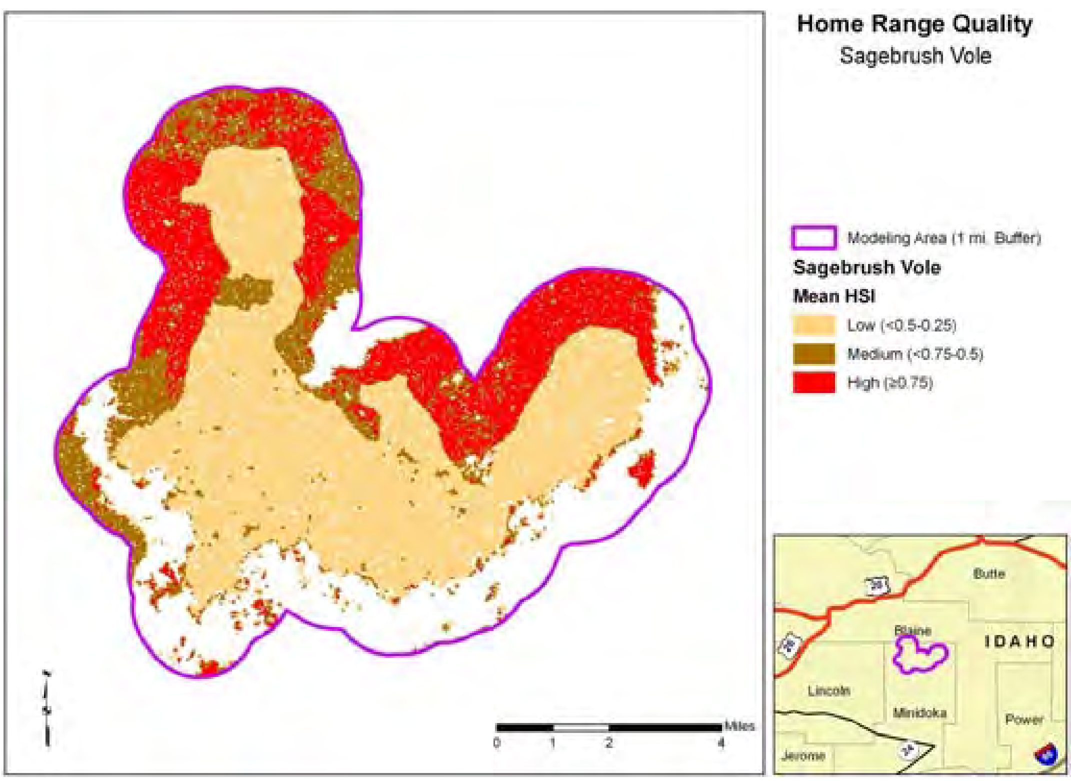


Figure B-132. Post-treatment potential home range map for sagebrush voles, Laidlaw Park project, ID.

Sage Thrasher

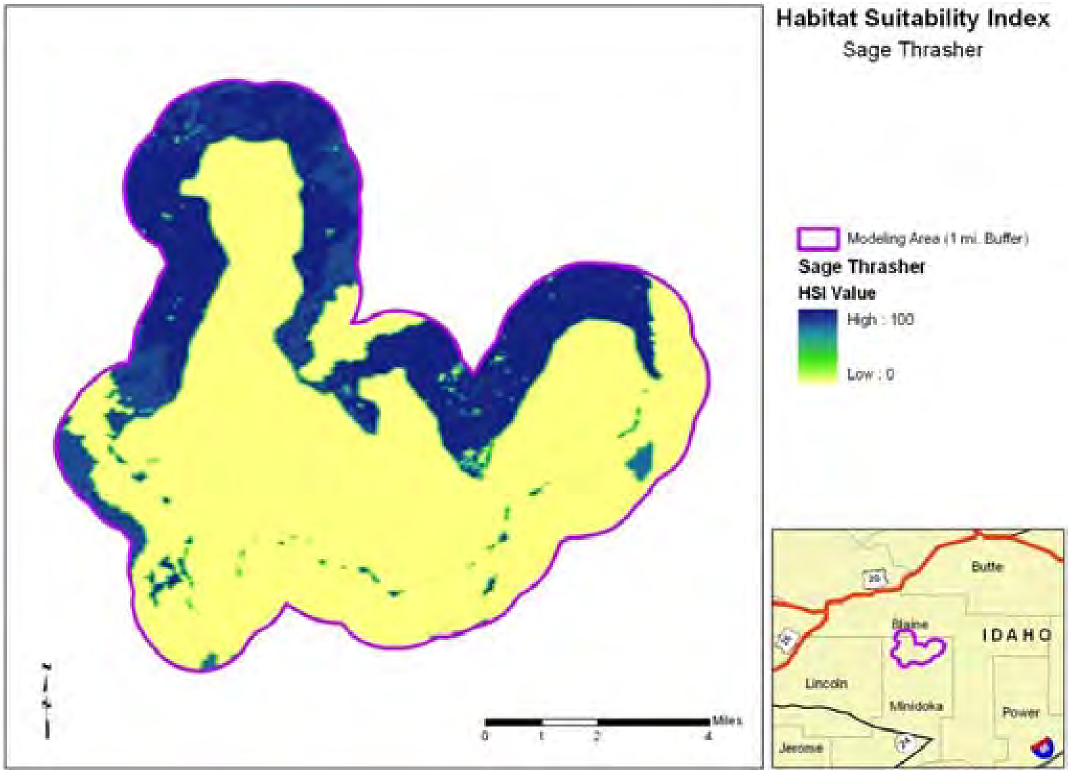


Figure B-133. Pre-treatment habitat suitability map for sage thrasher for Laidlaw Park project, Idaho.

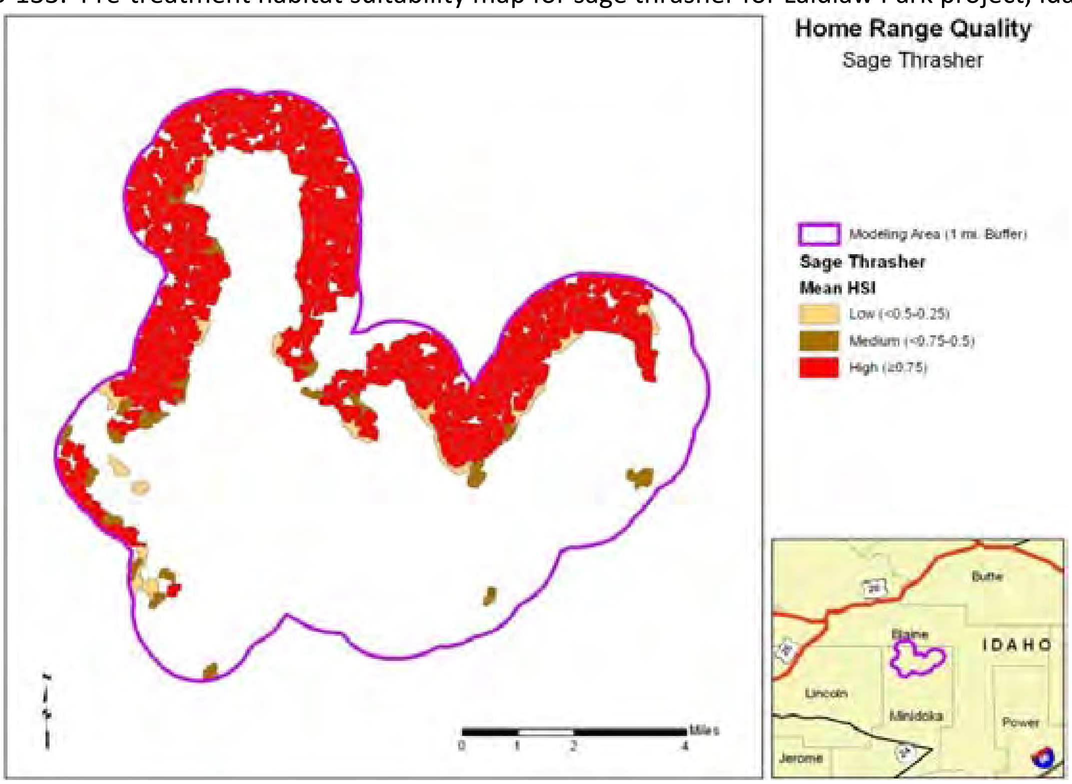


Figure B-134. Pre-treatment potential home range map for sage thrashers for the Laidlaw Park project, Idaho.

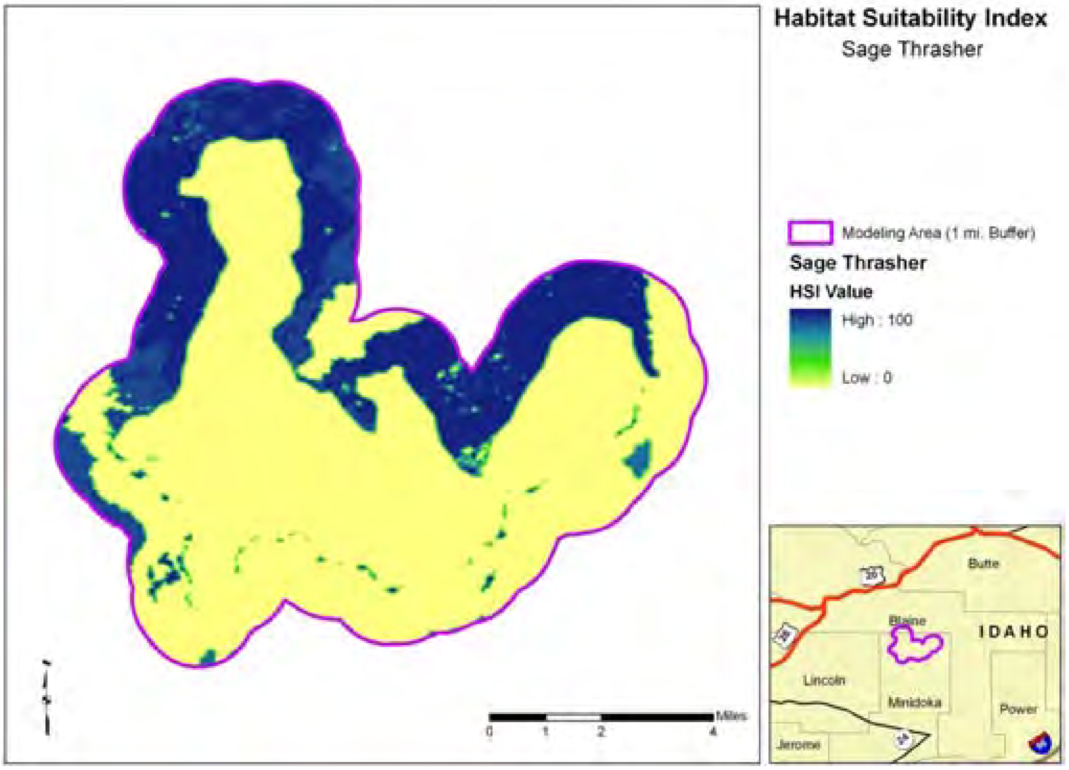


Figure B-135. Post-treatment habitat suitability map for sage thrasher habitat for the Laidlaw Park project, Idaho.

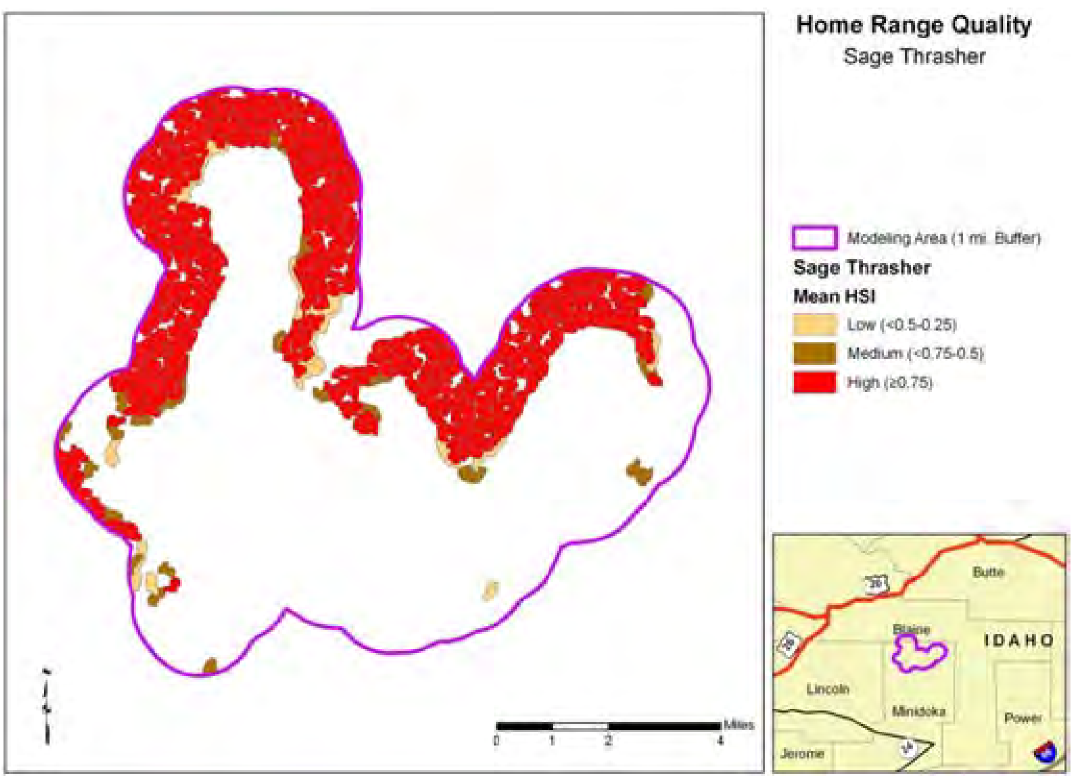


Figure B-136. Post-treatment potential home range map for sage thrashers for the Laidlaw Park project, Idaho.

Anthro Mountain Project, Utah

Sage Grouse

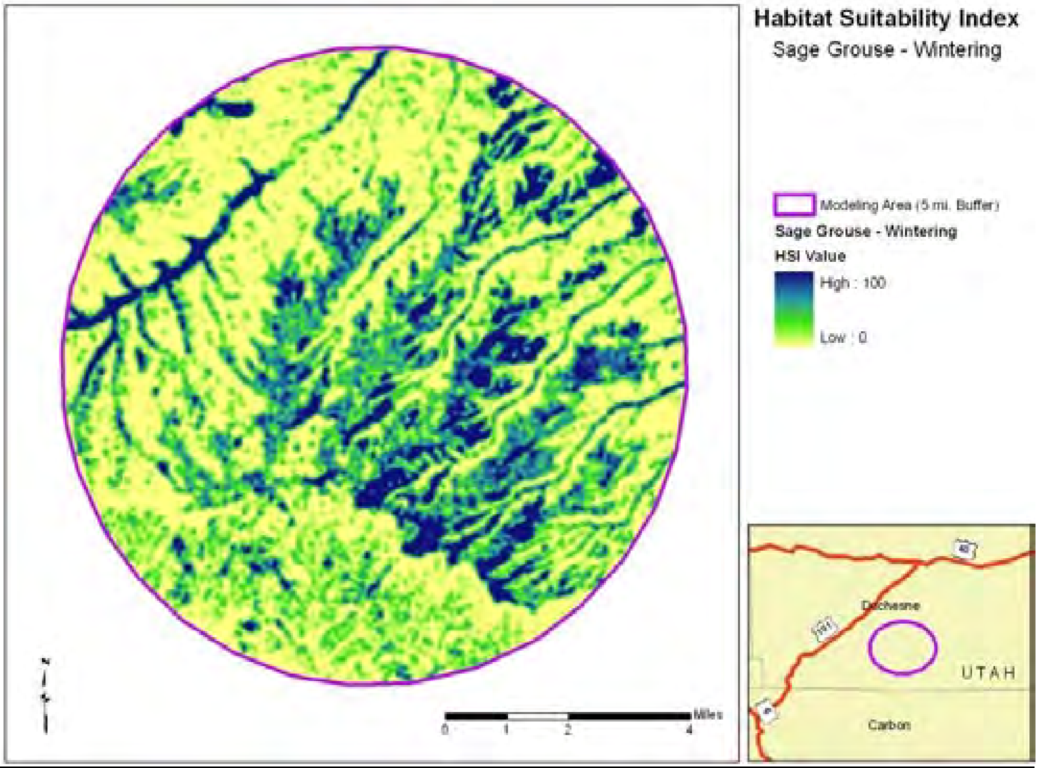


Figure B-137. Pre-treatment habitat suitability map for sage grouse wintering habitat.

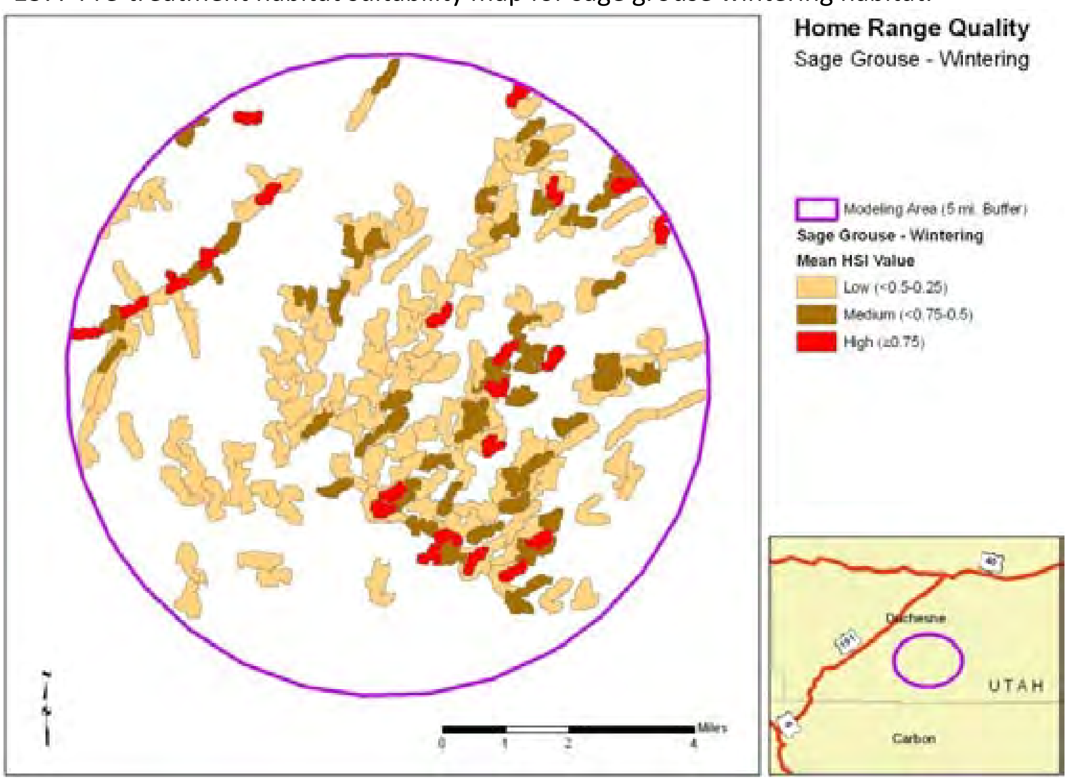


Figure B-138. Pre-treatment potential home range map for sage grouse wintering areas.

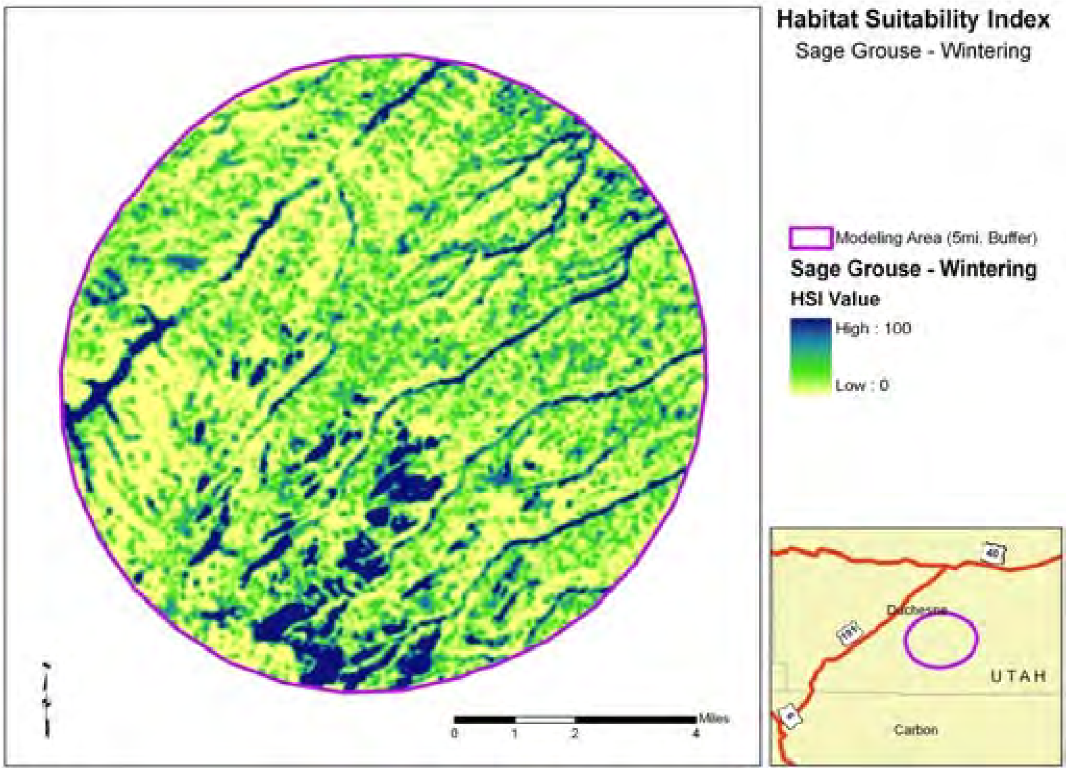


Figure B-139. Post-treatment habitat suitability map for sage grouse wintering habitat for the Anthro Mountain project, Utah.

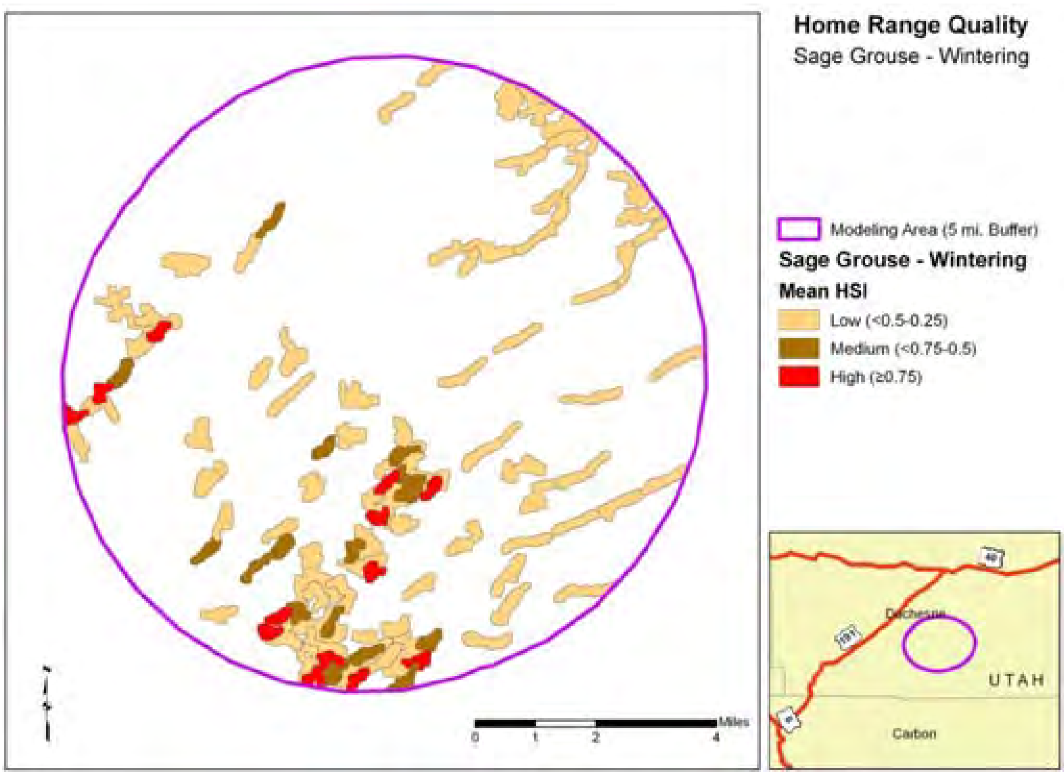


Figure B-140. Post-treatment potential home range map for sage grouse wintering areas for the Anthro Mountain project, Utah.

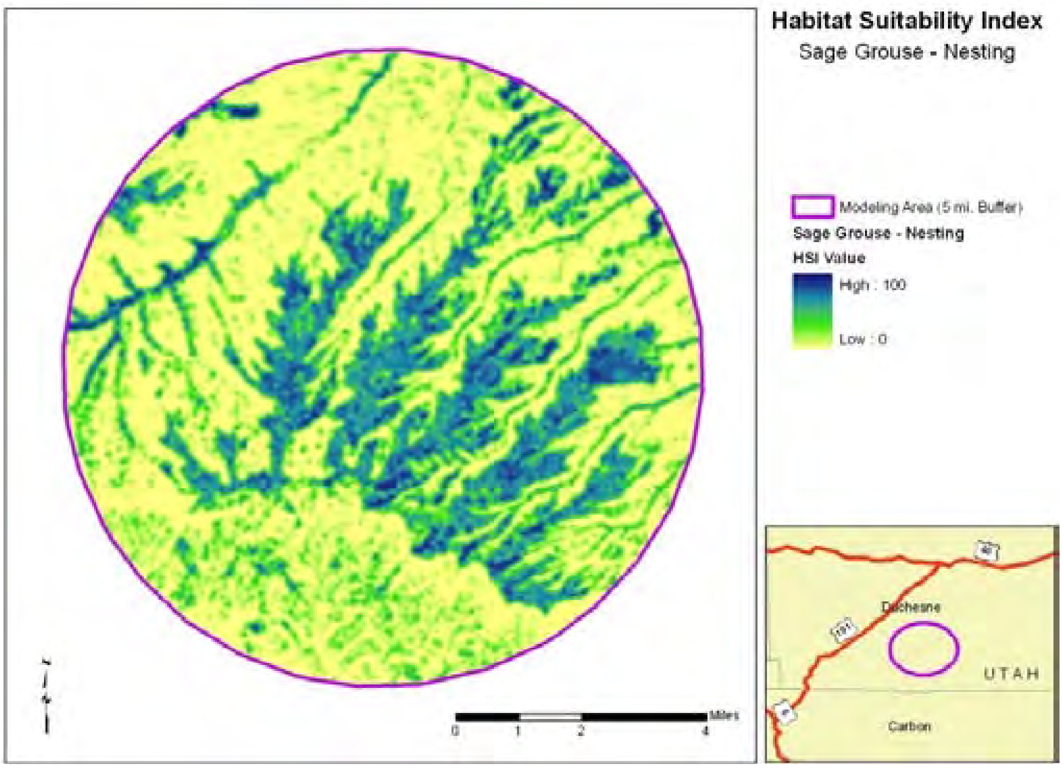


Figure B-141. Pre-treatment habitat suitability map for sage grouse nesting habitat for the Anthro Mountain project, Utah.

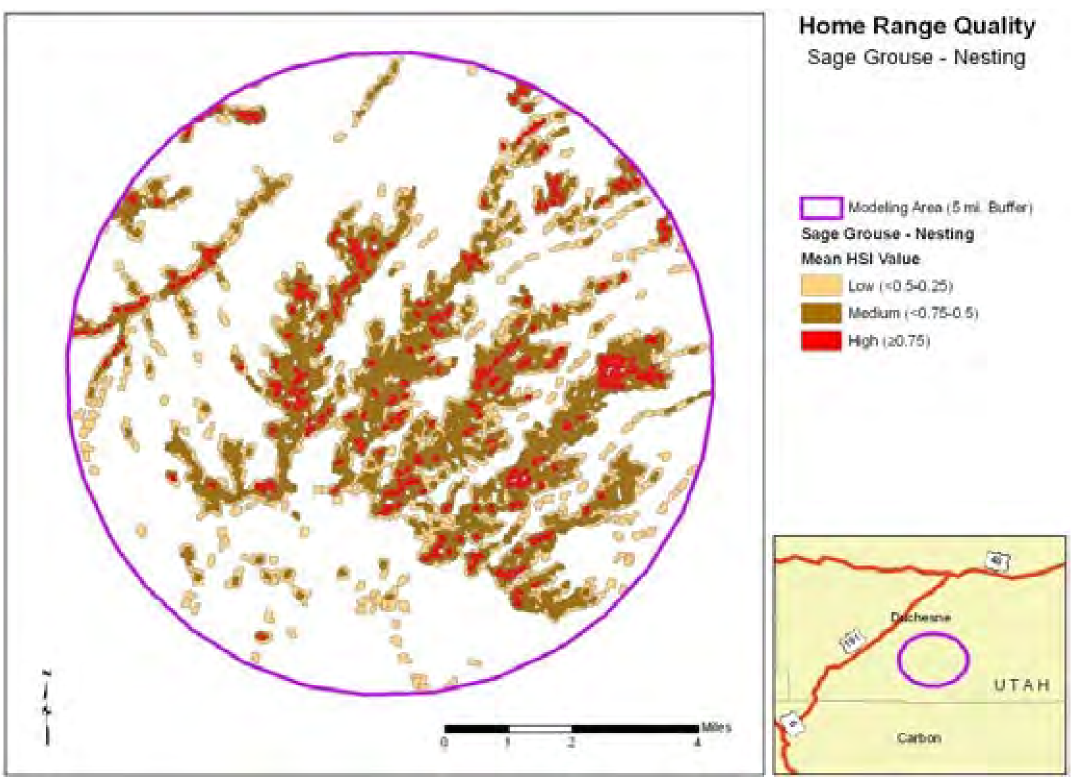


Figure B-142. Pre-treatment potential home range map for sage grouse nesting areas for the Anthro Mountain project, Utah.

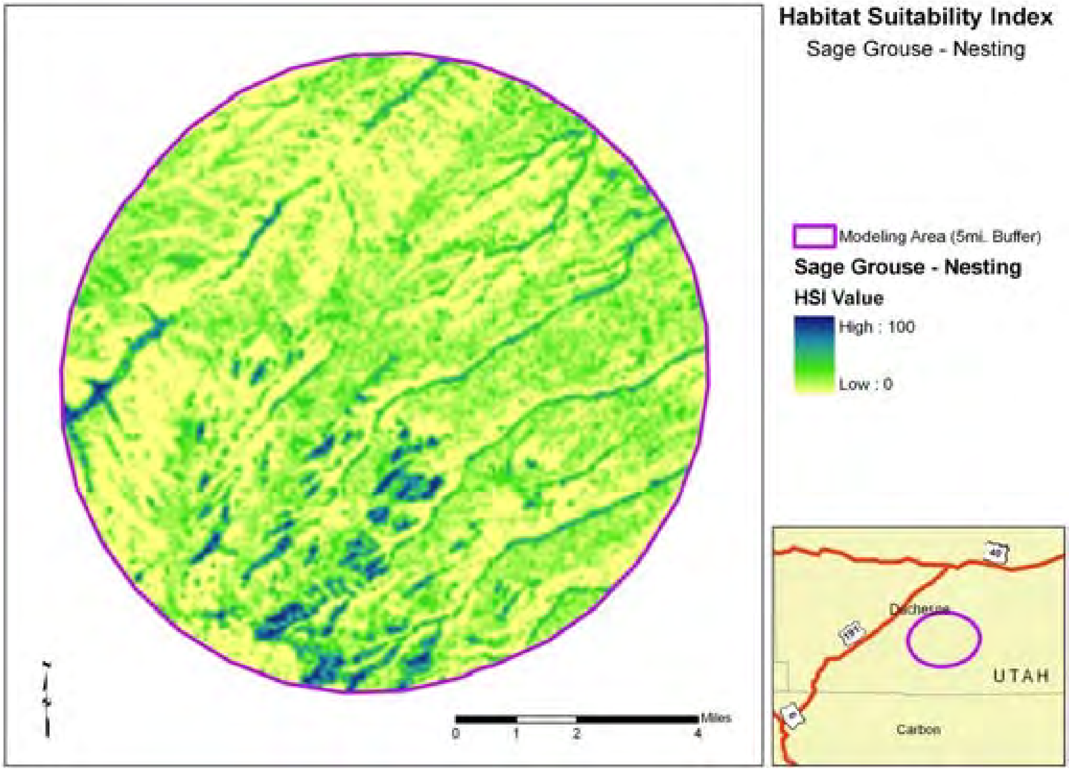


Figure B-143. Post-treatment habitat suitability map for sage grouse nesting habitat for the Anthro Mountain project, Utah.

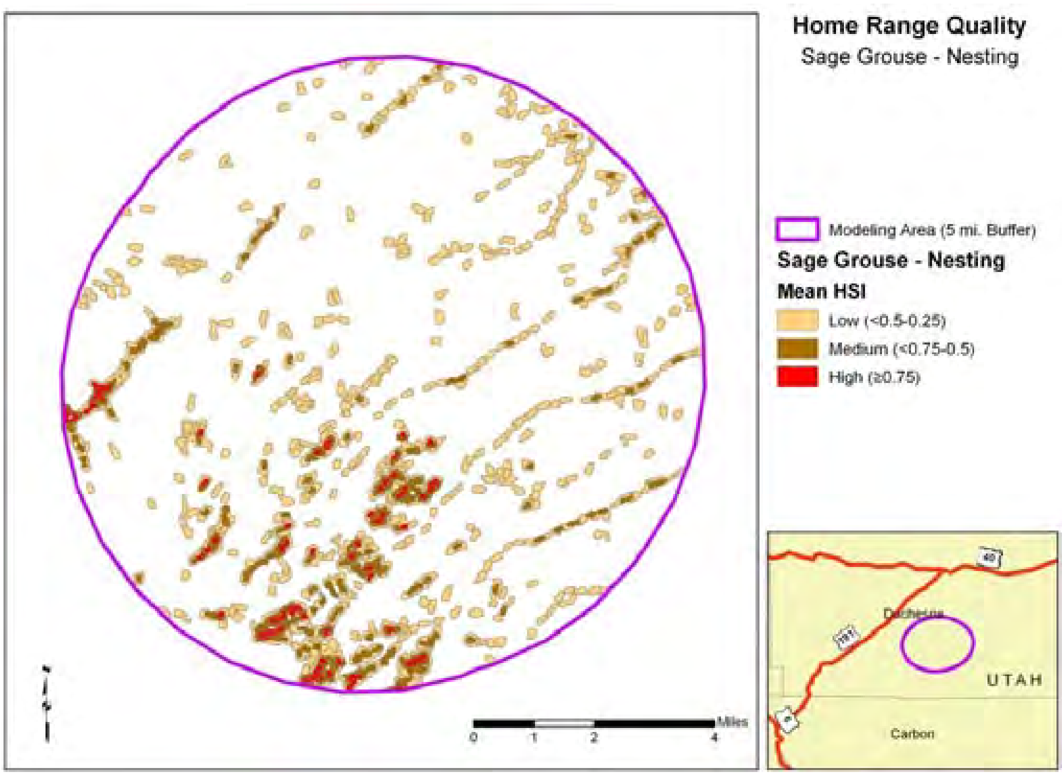


Figure B-144. Post-treatment potential home range map for sage grouse nesting areas for the Anthro Mountain project, Utah.

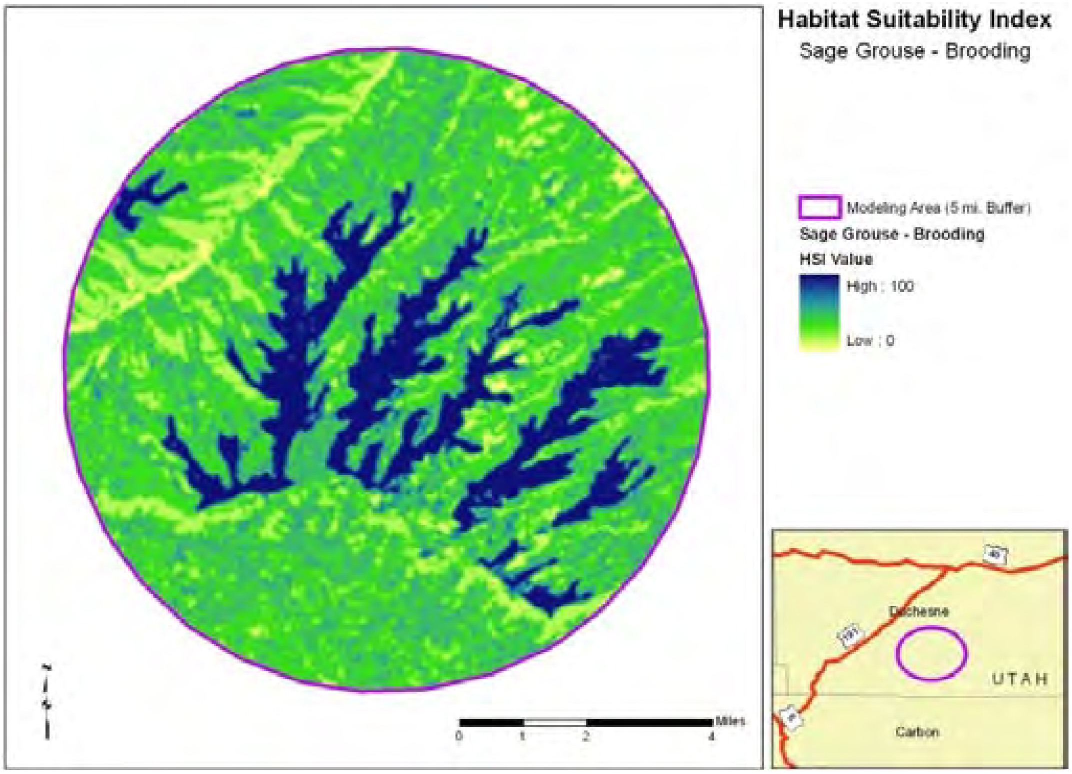


Figure B-145. Pre-treatment habitat suitability map for sage grouse brood habitat for the Anthro Mountain project, Utah.

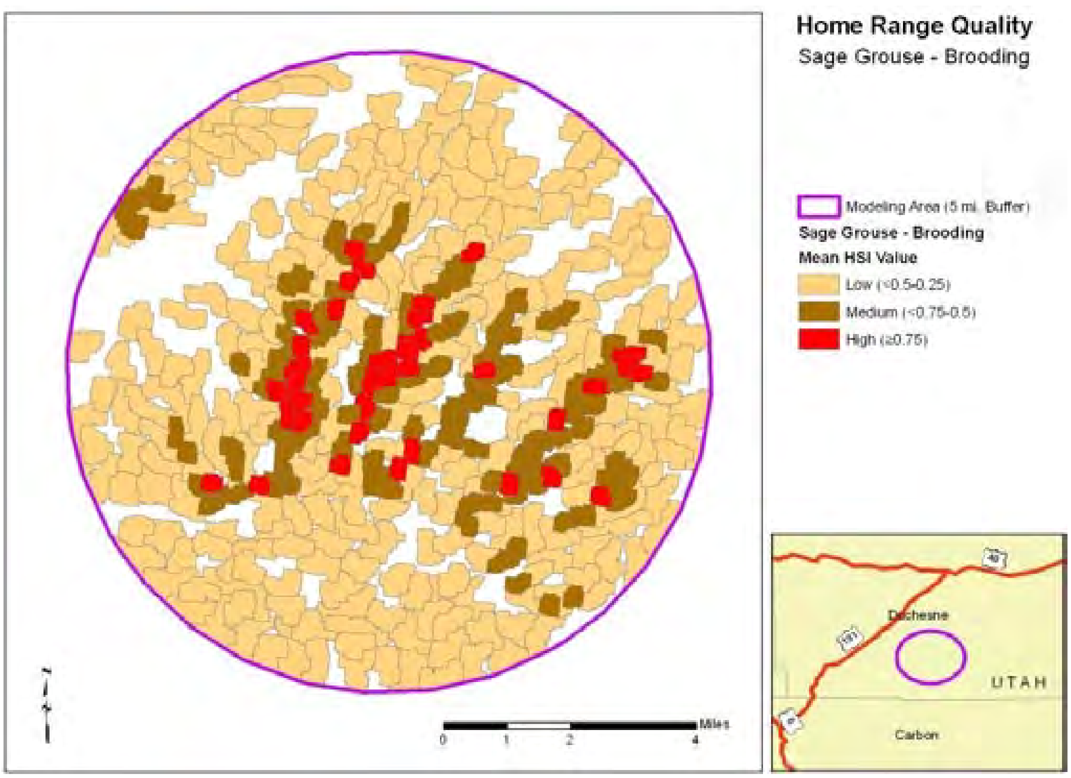


Figure B-146. Pre-treatment potential home range map for sage grouse brooding rearing areas for the Anthro Mountain project, Utah.

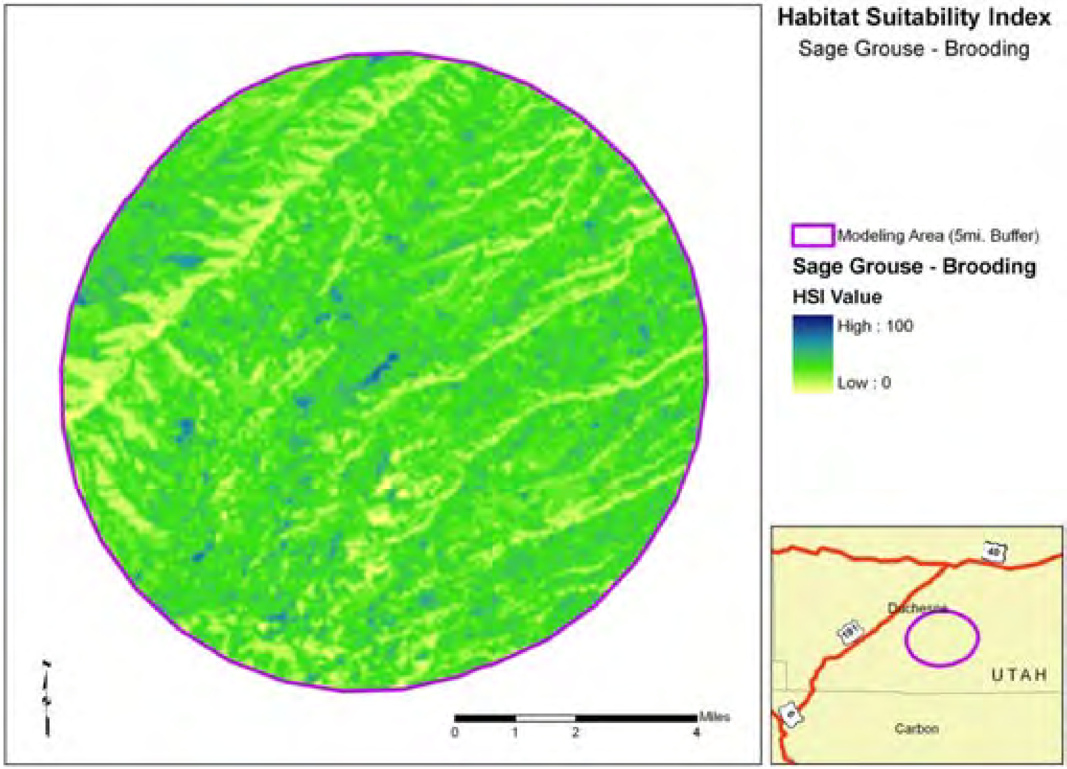


Figure B-147. Post-treatment habitat suitability map for sage grouse brood habitat for the Anthro Mountain project, Utah.

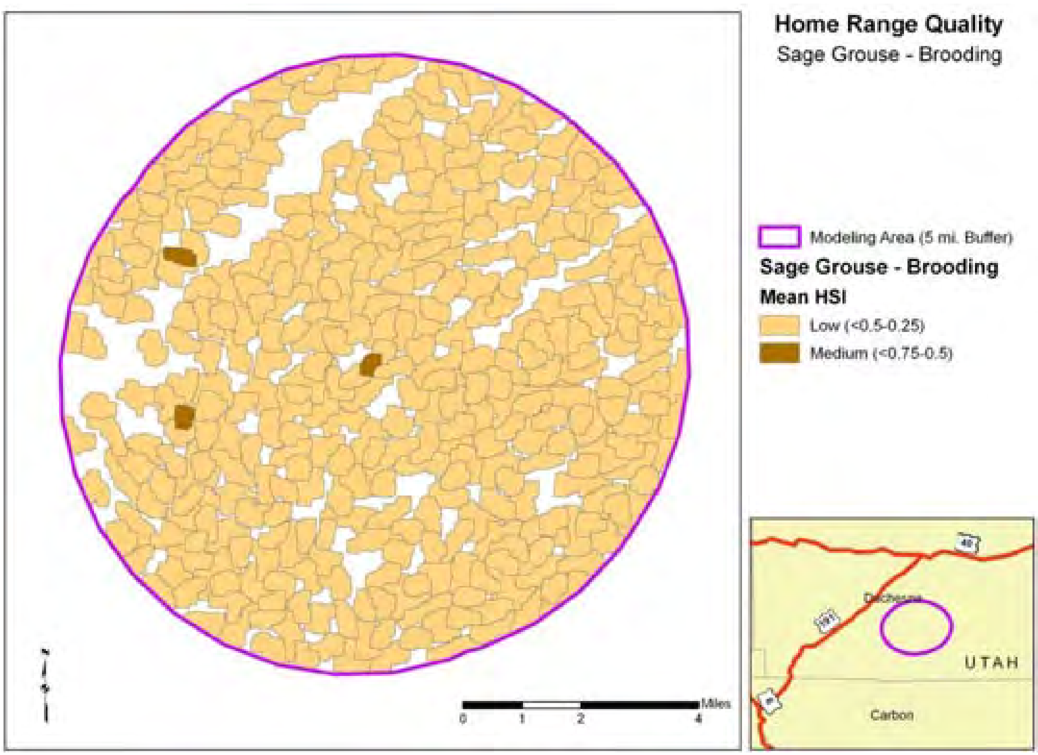


Figure B-148. Post-treatment potential home range map for sage grouse brooding rearing areas for the Anthro Mountain project, Utah.

Sage Thrasher

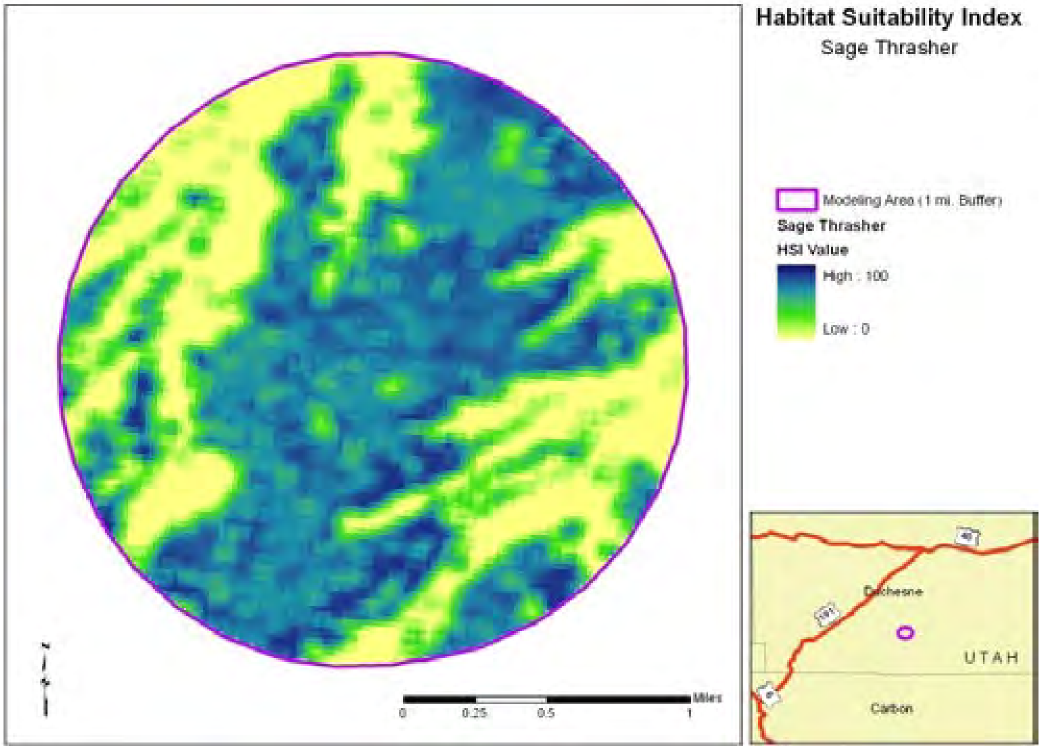


Figure B-149. Pre-treatment habitat suitability map for sage thrasher habitat for the Anthro Mountain project, Utah.

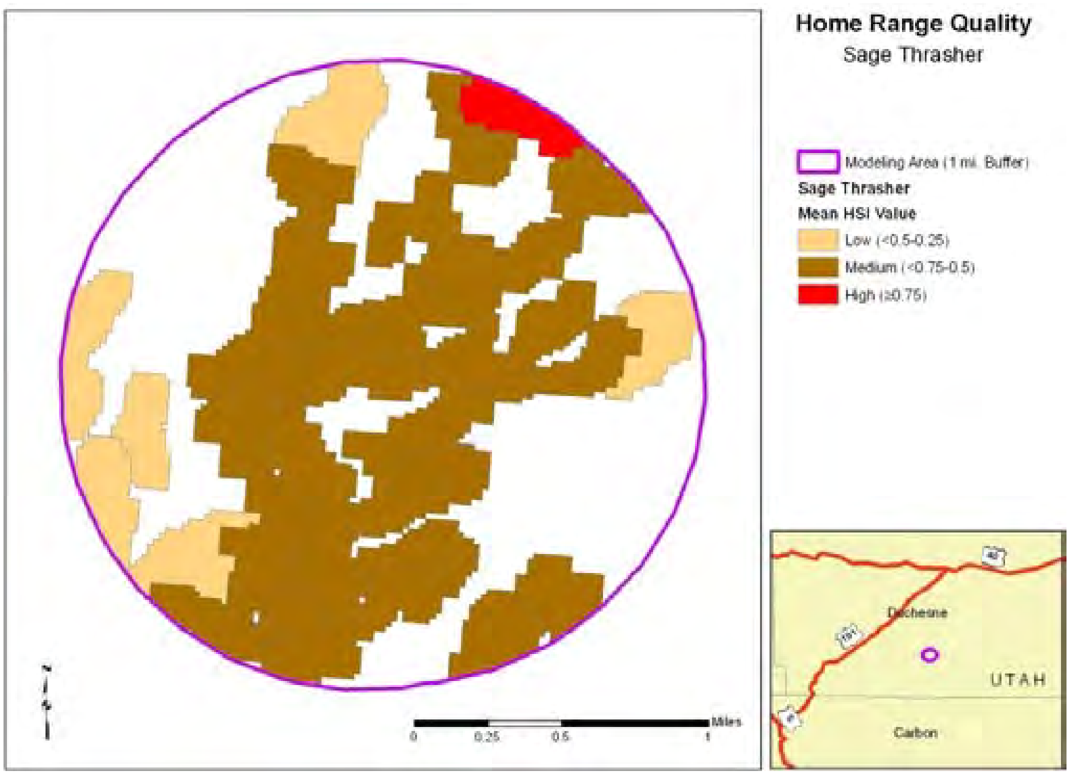


Figure B-150. Pre-treatment potential home range map for sage thrashers for the Anthro Mountain project, Utah.

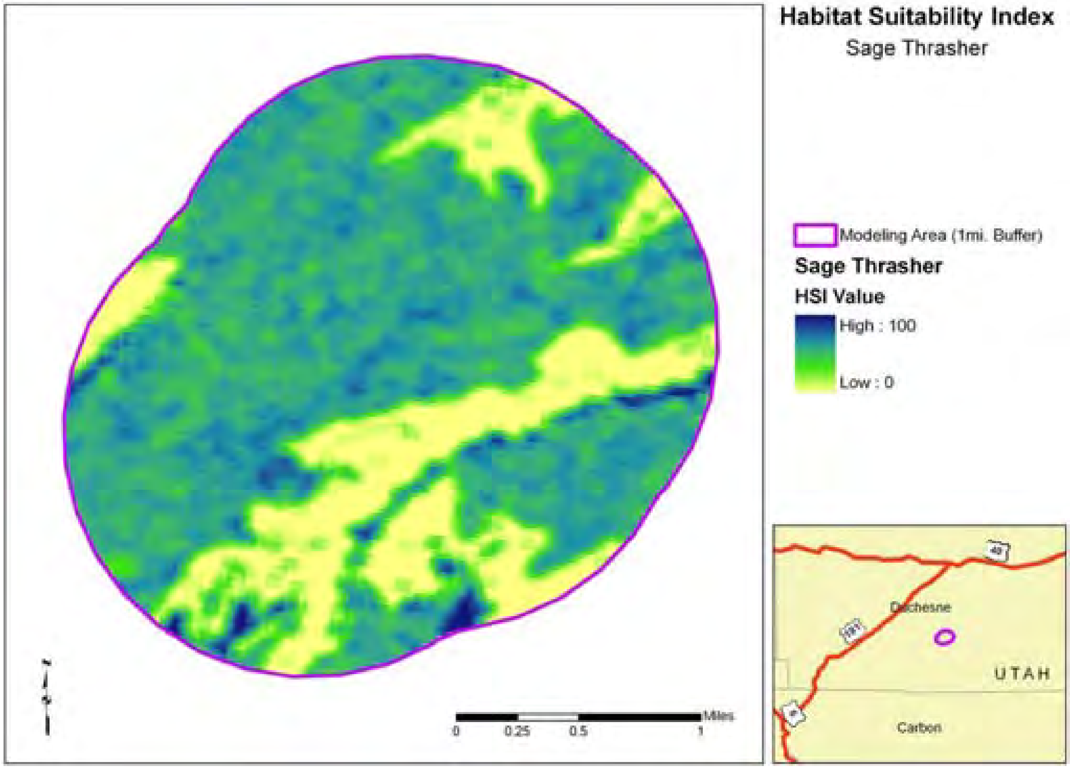


Figure B-151. Post-treatment habitat suitability map for sage thrasher habitat for the Anthro Mountain project, Utah.

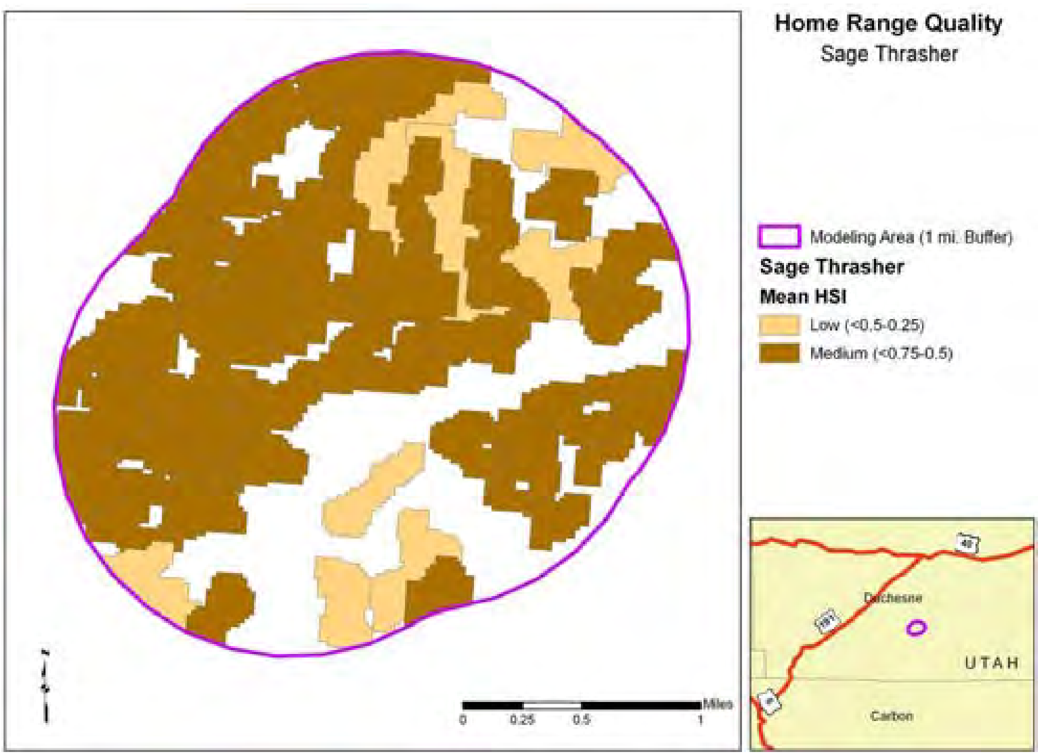


Figure B-152. Post-treatment potential home range map for sage thrashers for the Anthro Mountain project, Utah.

Sage Sparrow

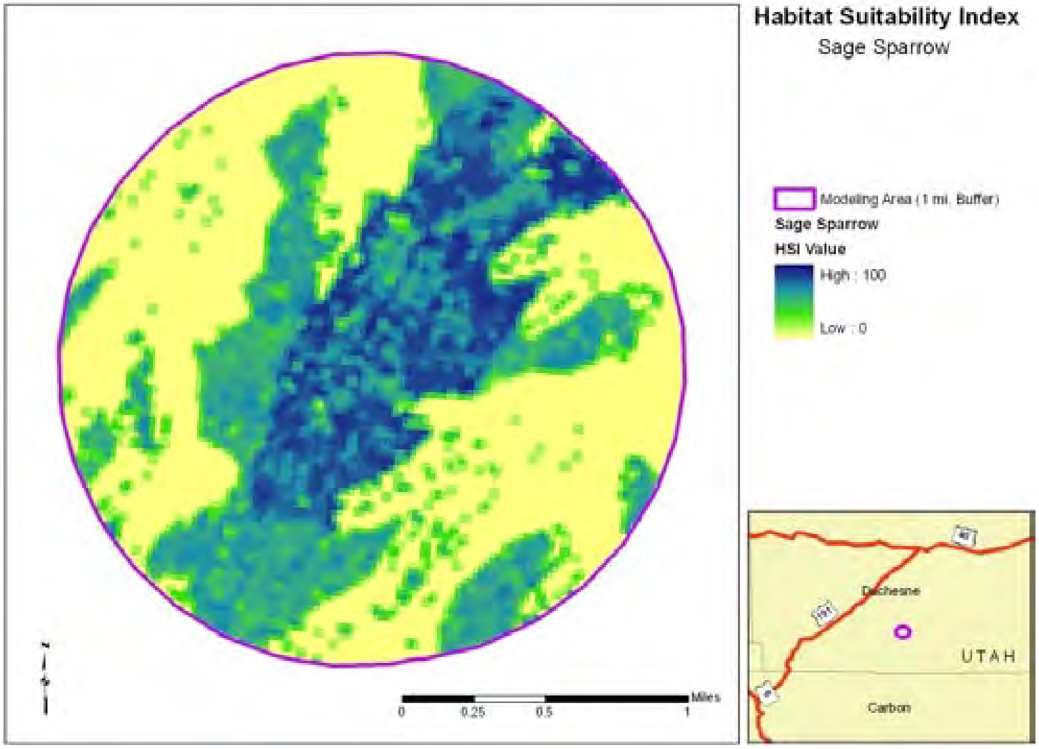


Figure B-153. Pre-treatment habitat suitability map for sage sparrow habitat for the Anthro Mountain project, Utah.

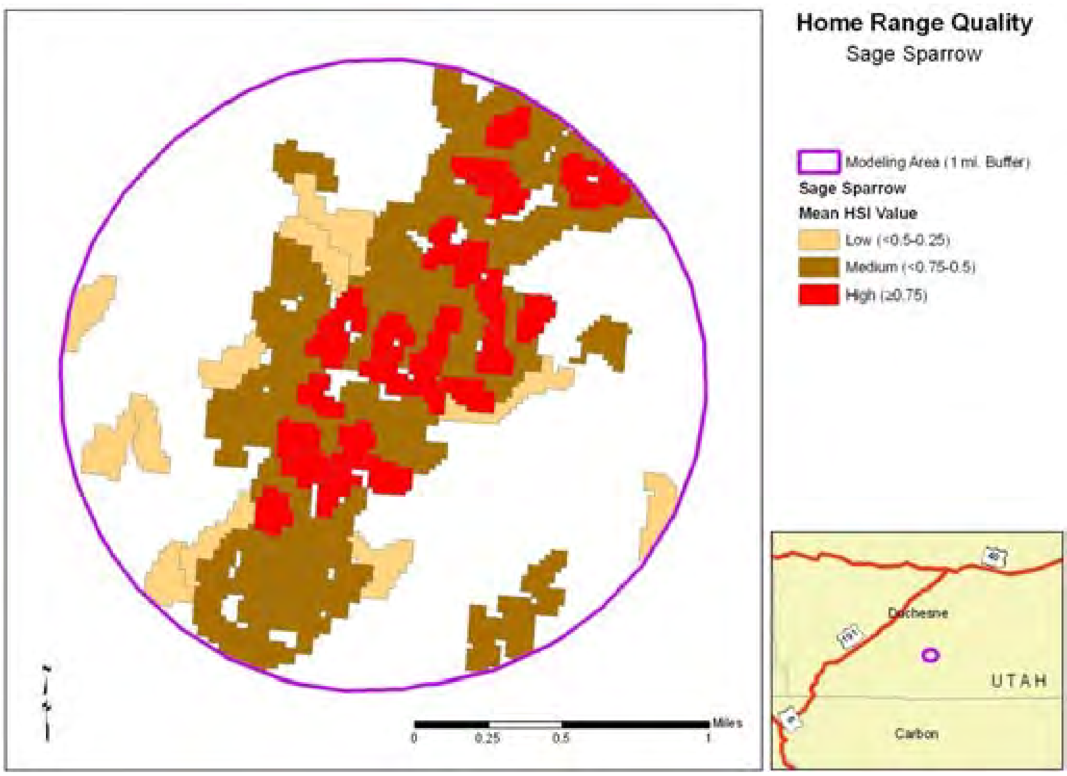


Figure B-154. Pre-treatment potential home range map for sage sparrow for the Anthro Mountain project, Utah.

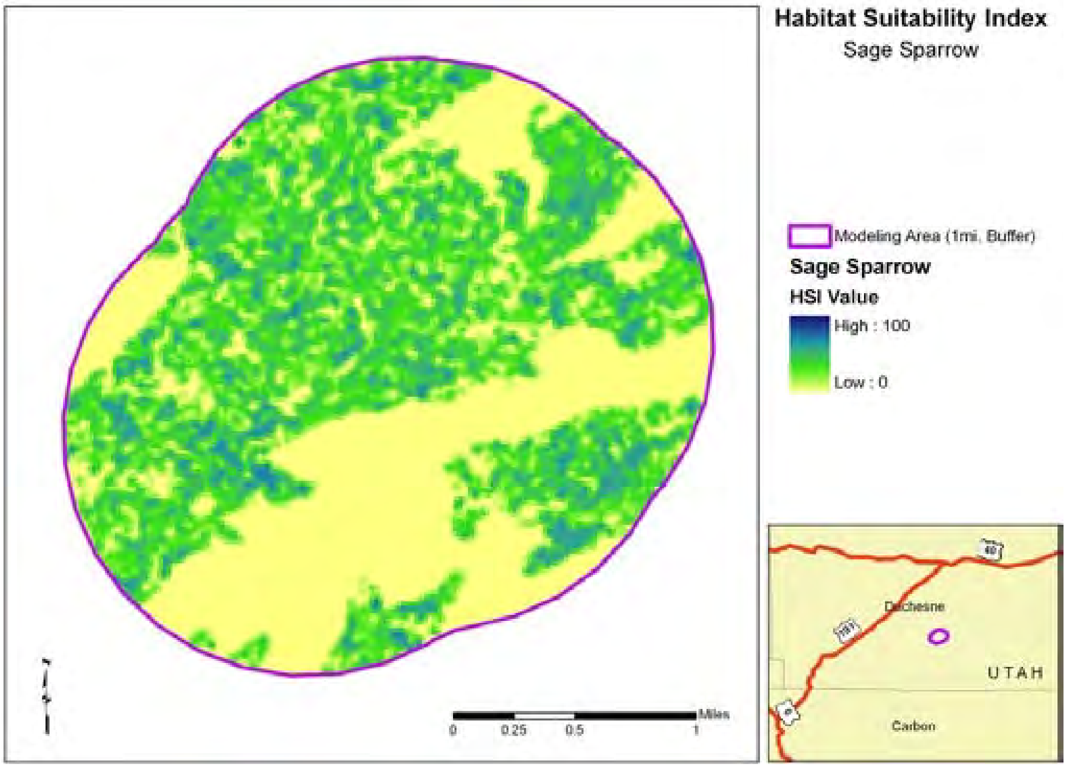


Figure B-155. Post-treatment habitat suitability map for sage sparrow habitat for the Anthro Mountain project, Utah.

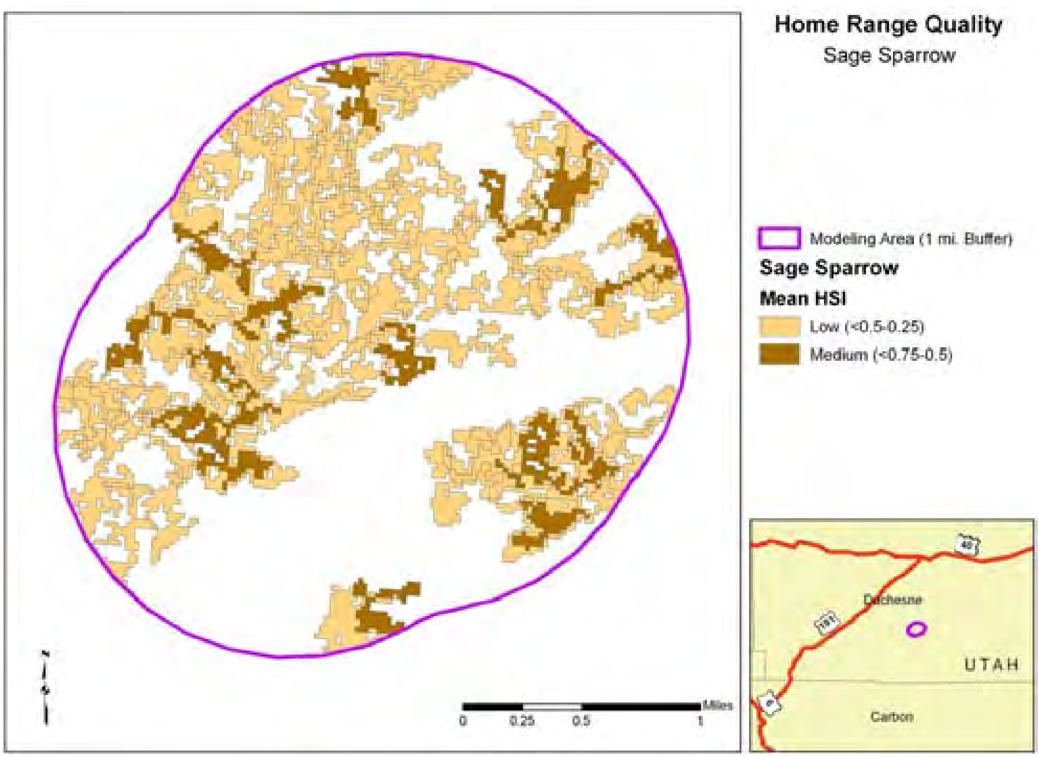


Figure B-156. Pre-treatment potential home range map for sage sparrow for the Anthro Mountain project, Utah.

Sagebrush Lizard

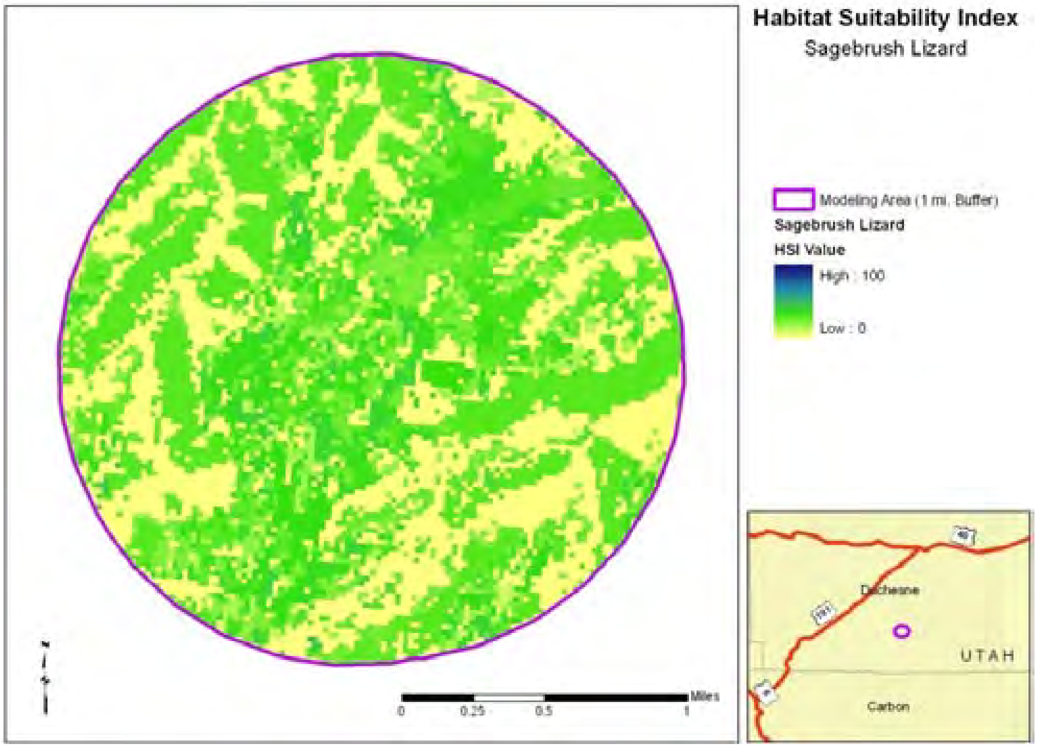


Figure B-157. Pre-treatment habitat suitability map for sagebrush lizard habitat for the Anthro Mountain project, Utah.

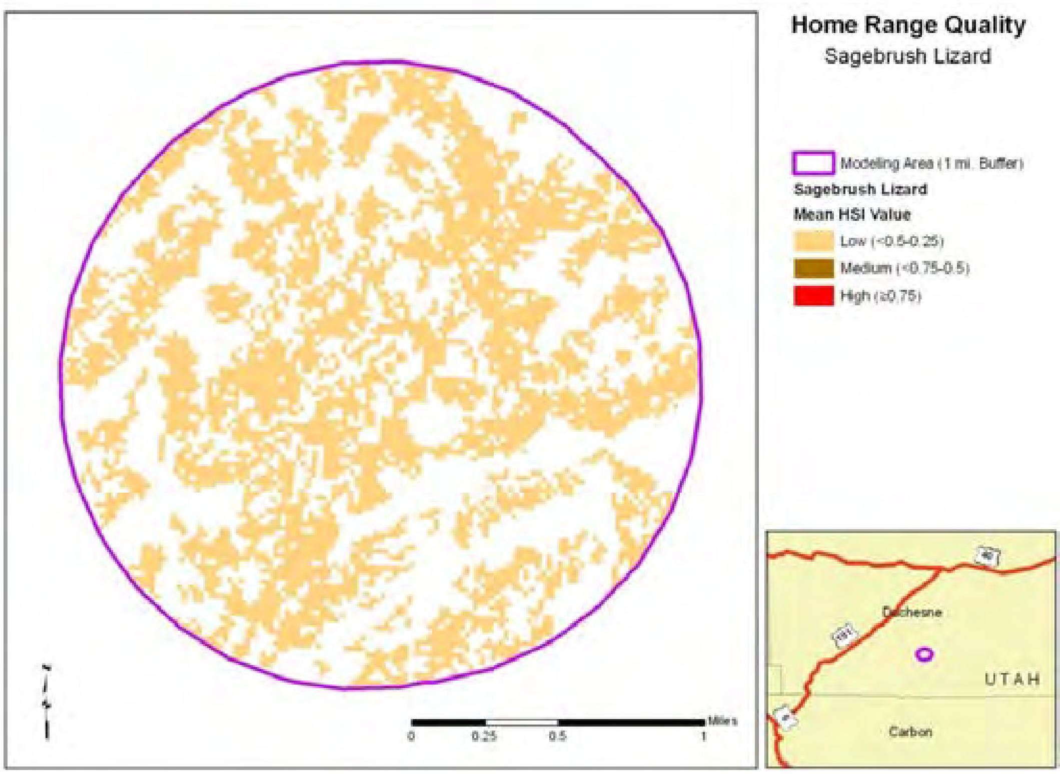


Figure B-158. Pre-treatment potential home range map for sagebrush lizards for the Anthro Mountain project, Utah.

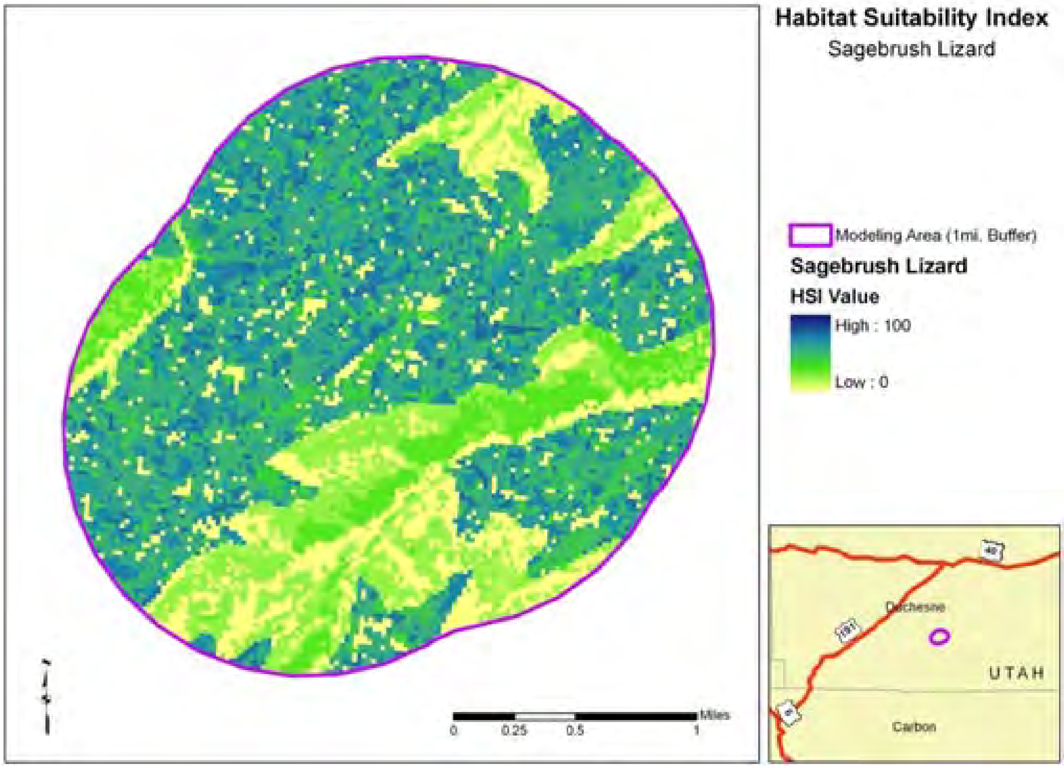


Figure B-159. Post-treatment habitat suitability map for sagebrush lizard habitat for the Anthro Mountain project, Utah.

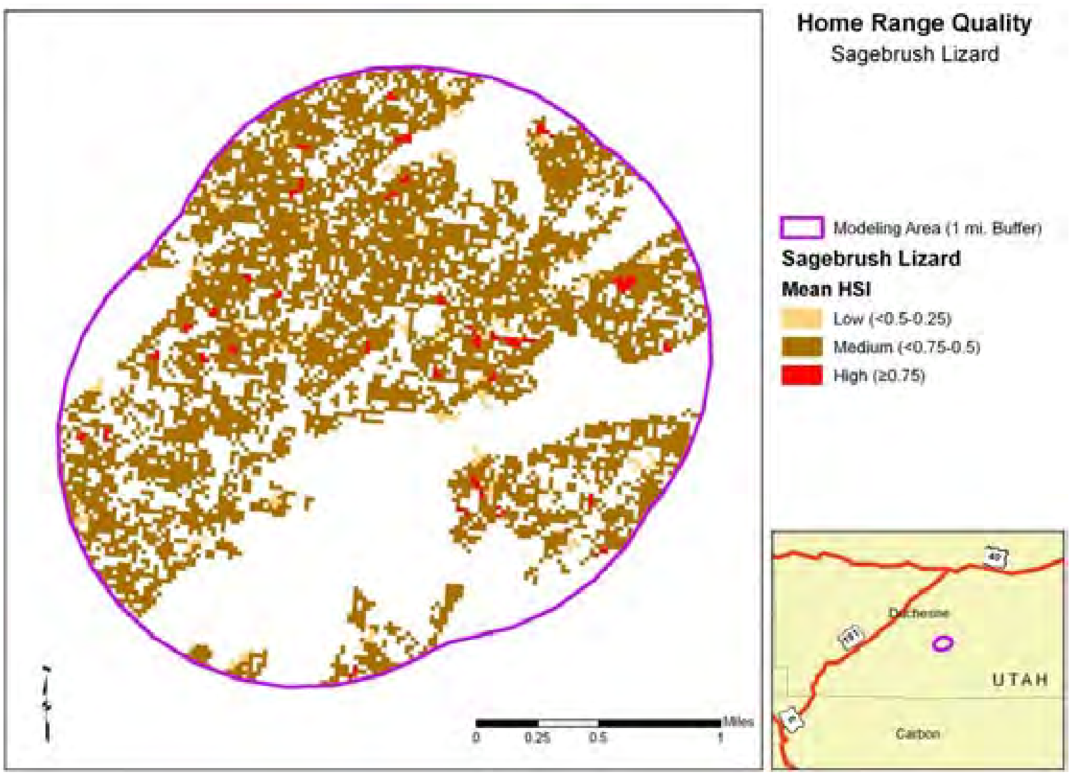


Figure B-160. Post-treatment potential home range map for sagebrush lizards for the Anthro Mountain project, Utah.

Deadman's Bench Project, Utah:

Sage Grouse

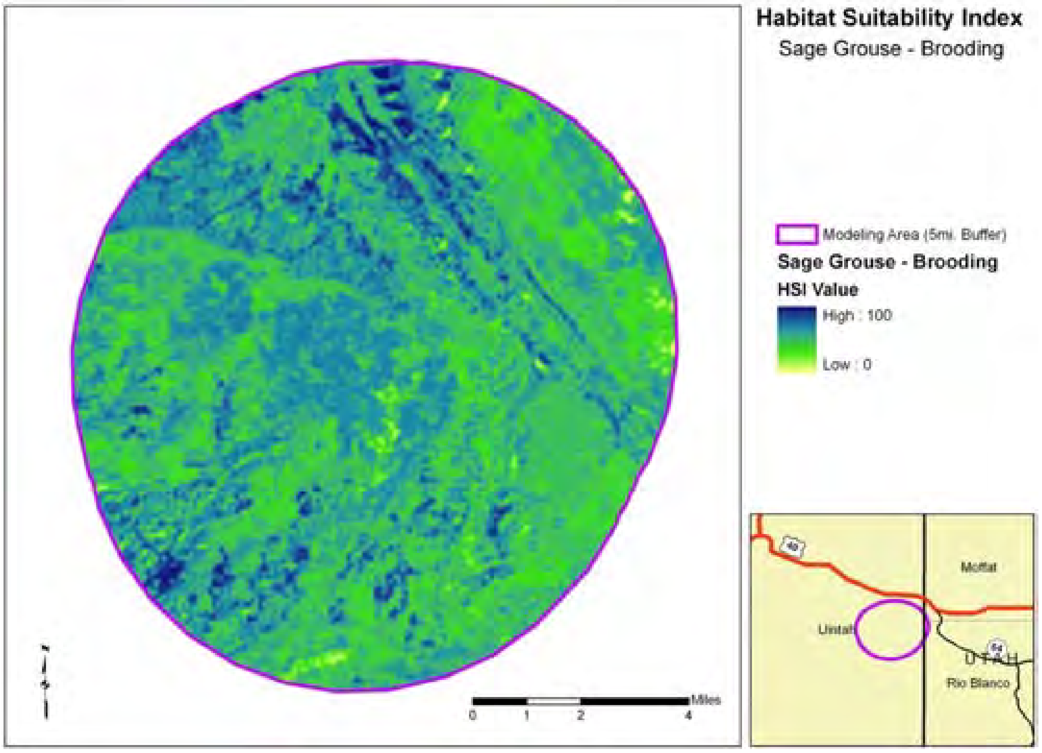


Figure B-161. Pre-treatment habitat suitability map for sage grouse brood habitat.

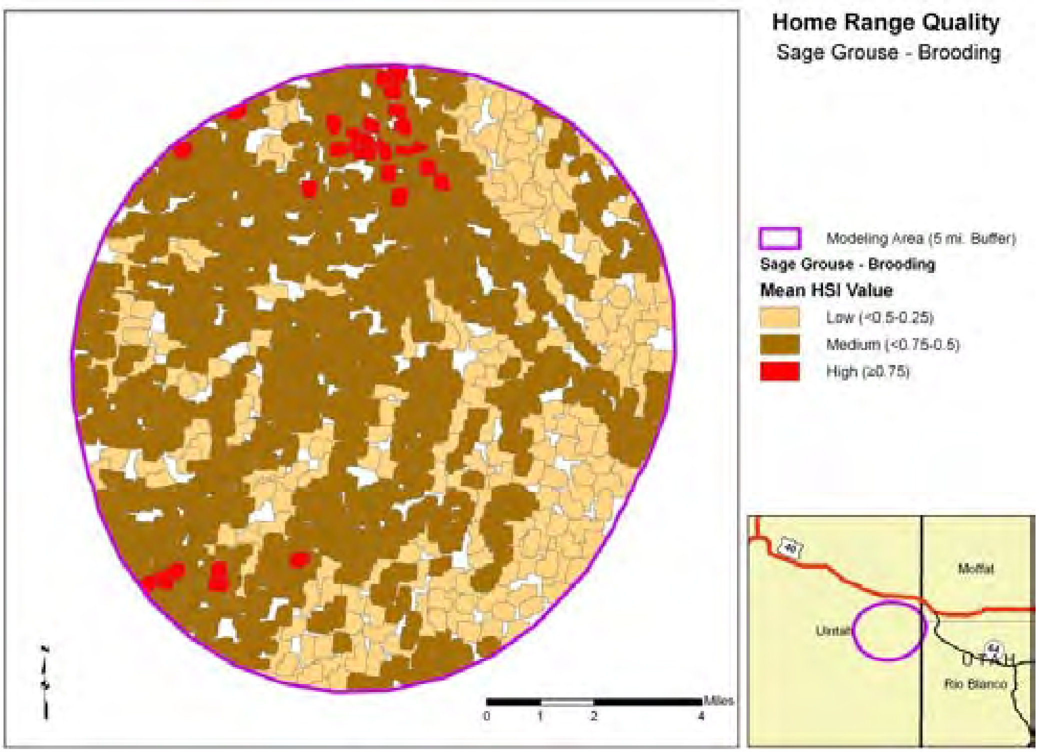


Figure B-162. Pre-treatment potential home range map for sage grouse brood rearing areas for the Deadman's Bench project, Utah.

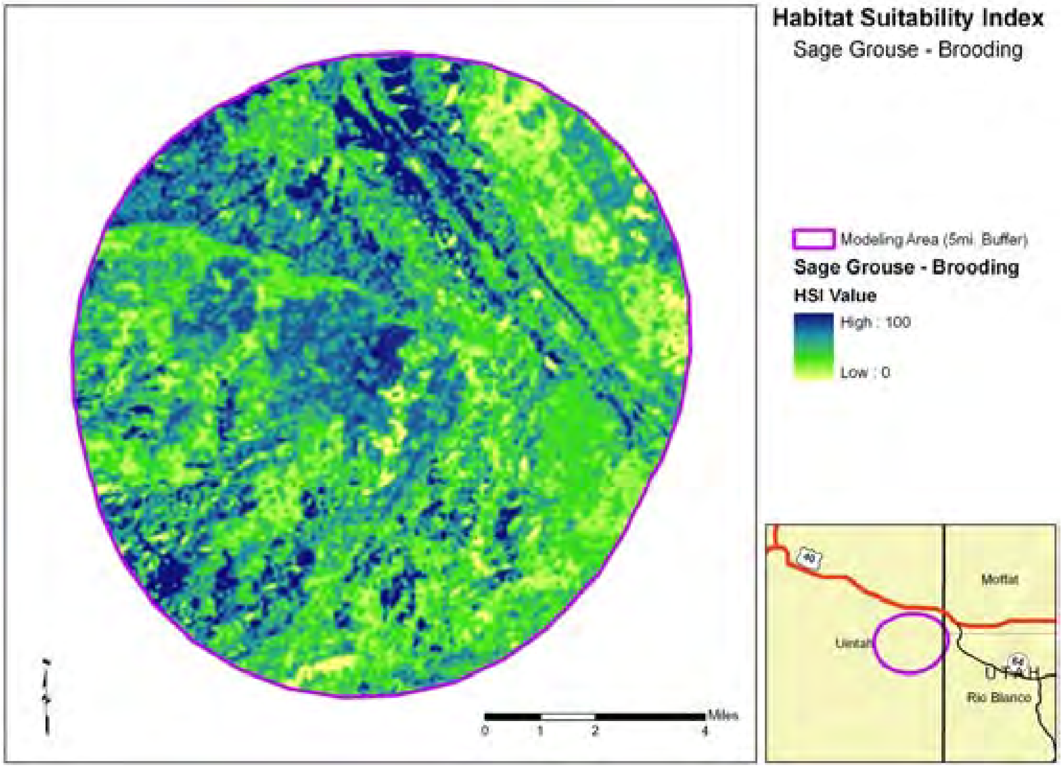


Figure B-163. Post-treatment habitat suitability map for sage grouse brood habitat for the Deadman's Bench project, Utah.

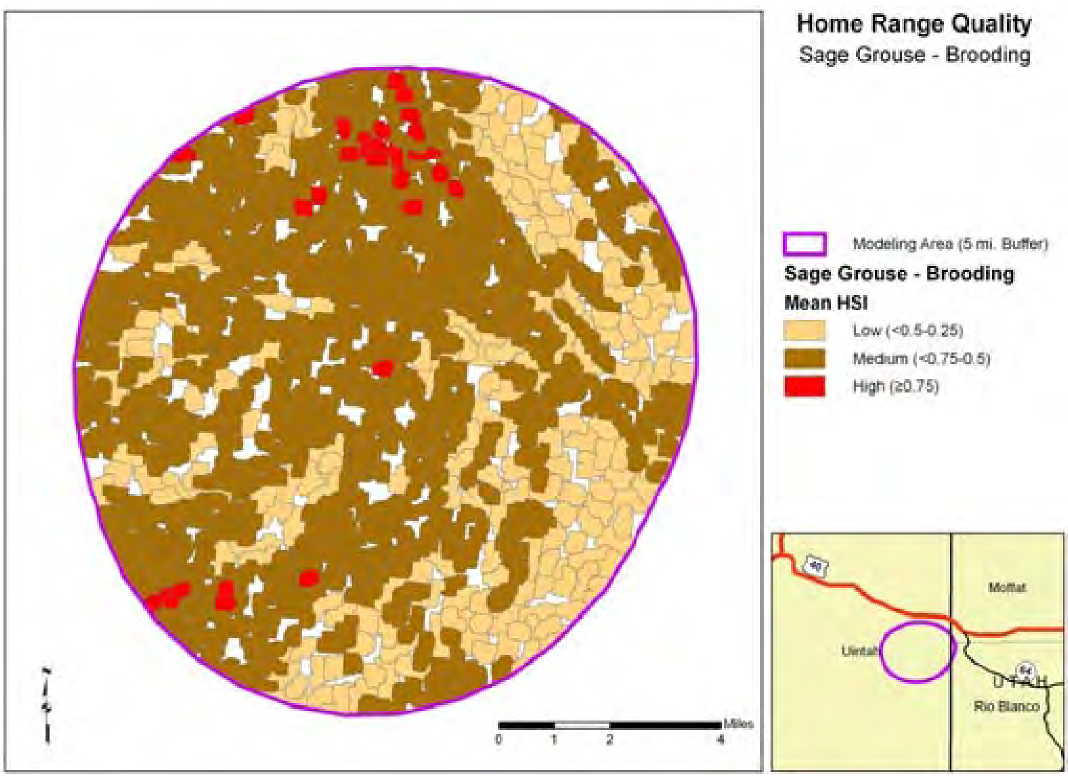


Figure B-164. Post-treatment potential home range map for sage grouse brood rearing areas for the Deadman's Bench project, Utah.

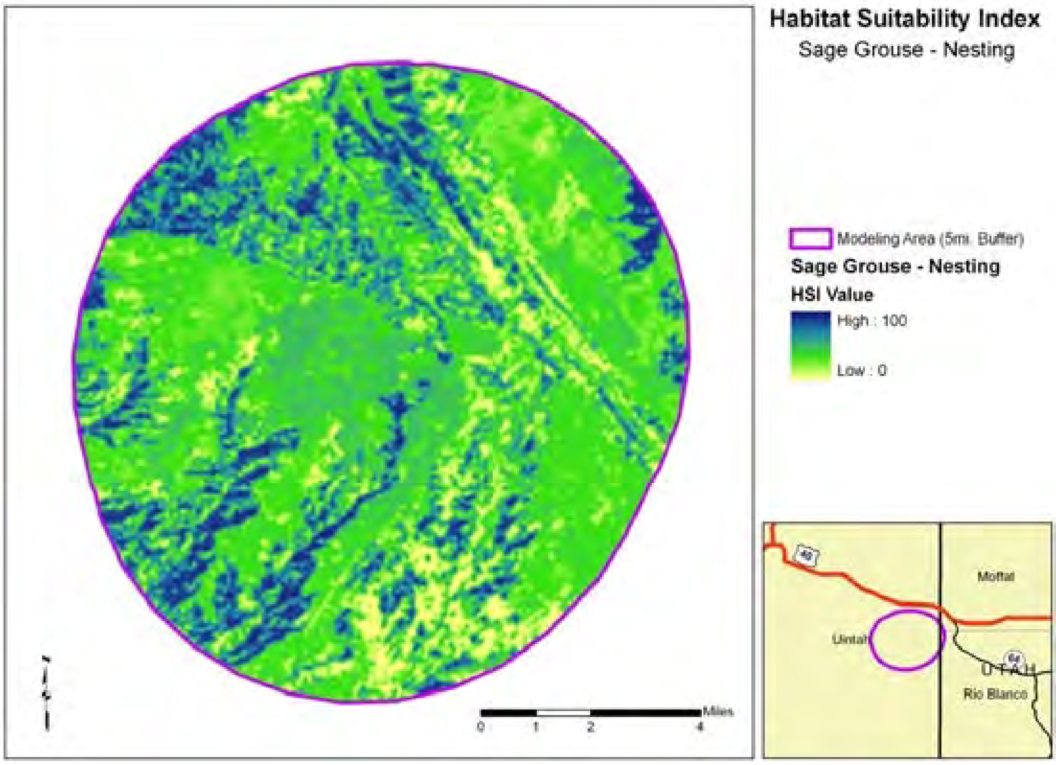


Figure B-165. Pre-treatment habitat suitability map for sage grouse nesting habitat for the Deadman's Bench project, Utah.

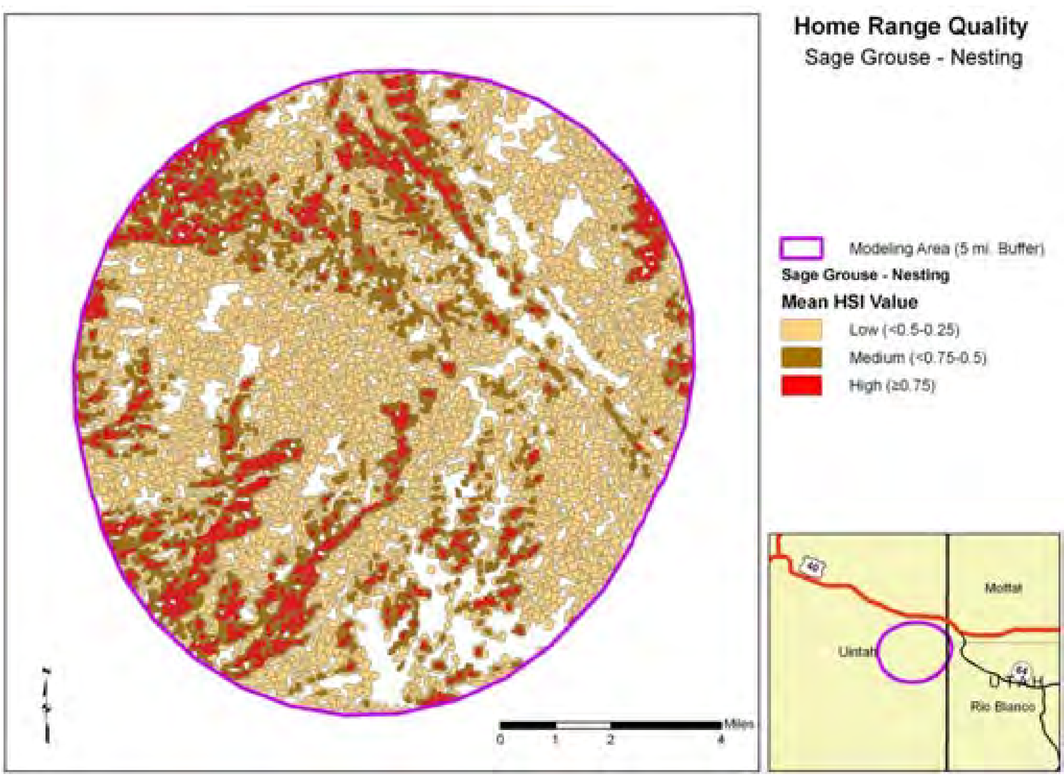


Figure B-166. Pre-treatment potential home range map for sage grouse nesting areas for the Deadman's Bench project, Utah.

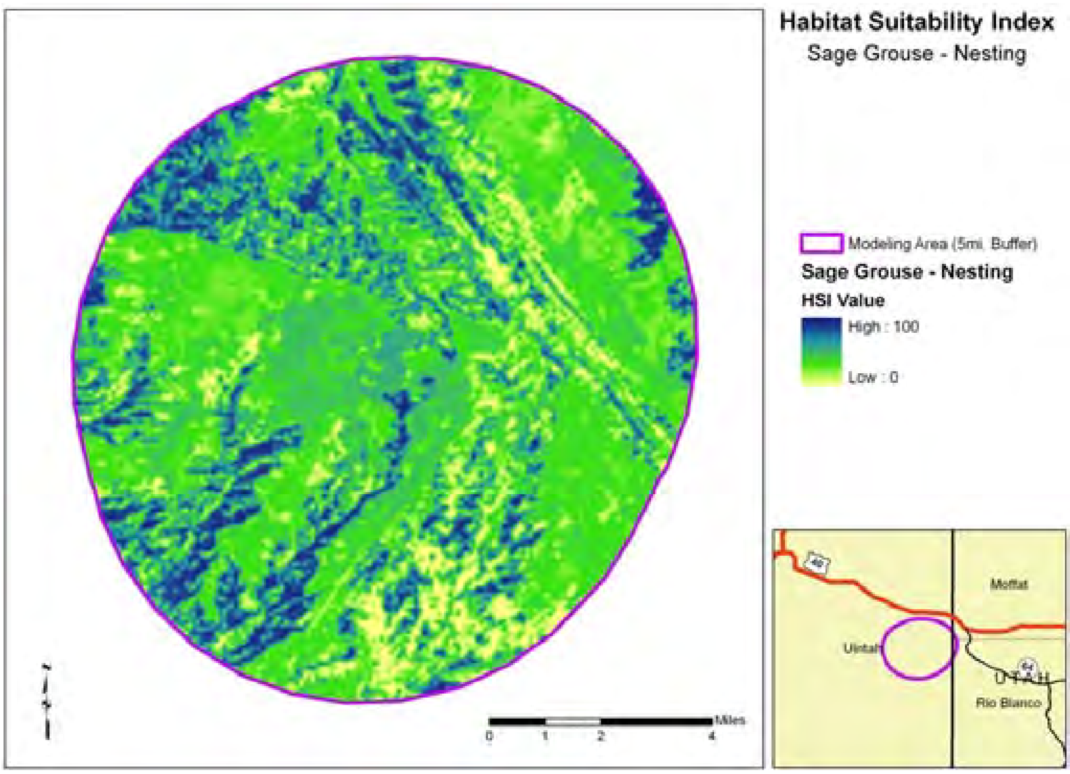


Figure B-167. Post-treatment habitat suitability map for sage grouse nesting habitat for the Deadman's Bench project, Utah.

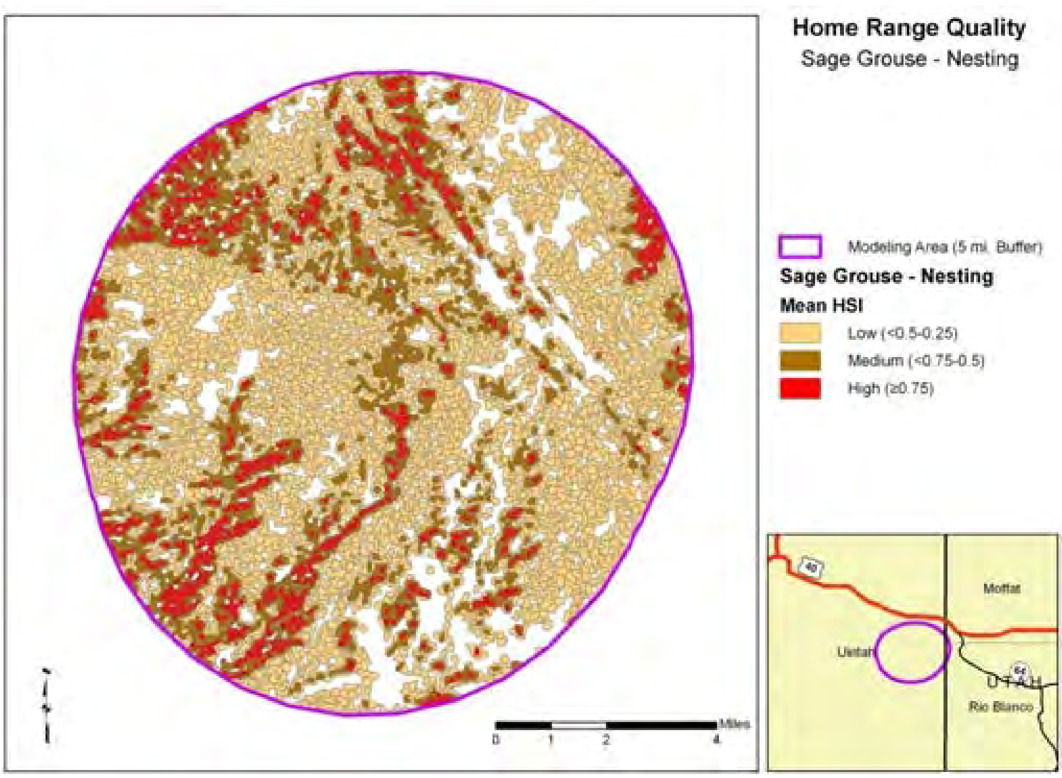


Figure B-168. Post-treatment potential home range map for sage grouse nesting areas for the Deadman's Bench project, Utah.

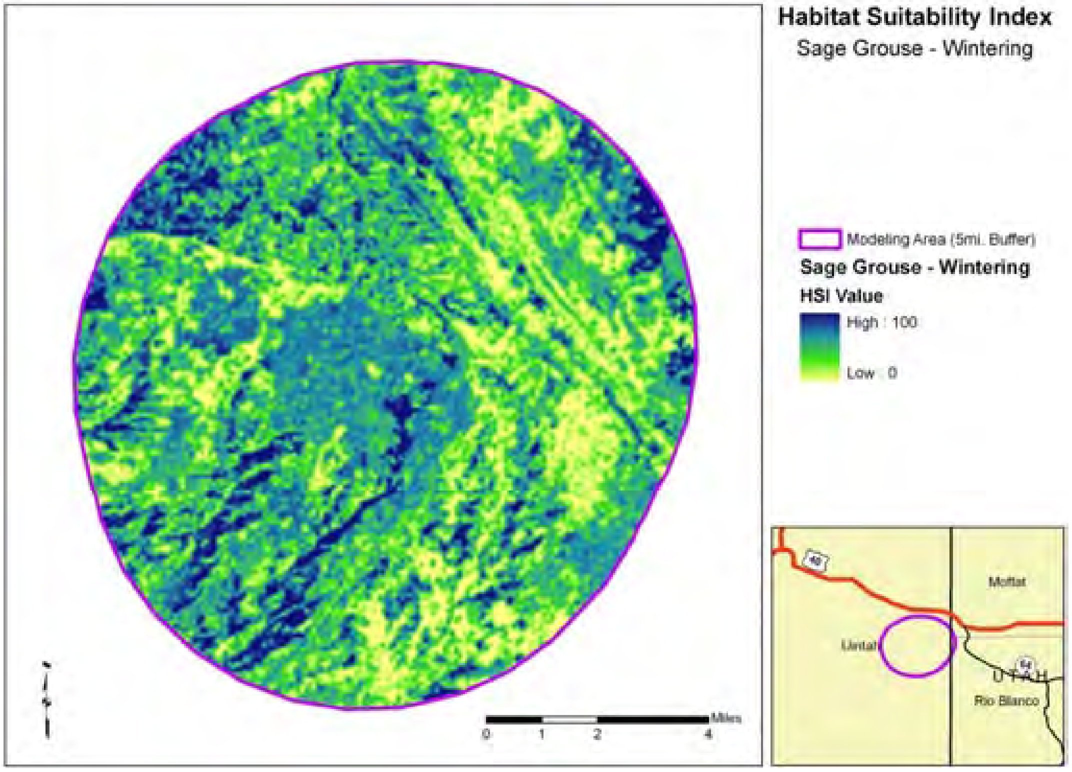


Figure B-169. Pre-treatment habitat suitability map for sage grouse wintering habitat for the Deadman's Bench project, Utah.

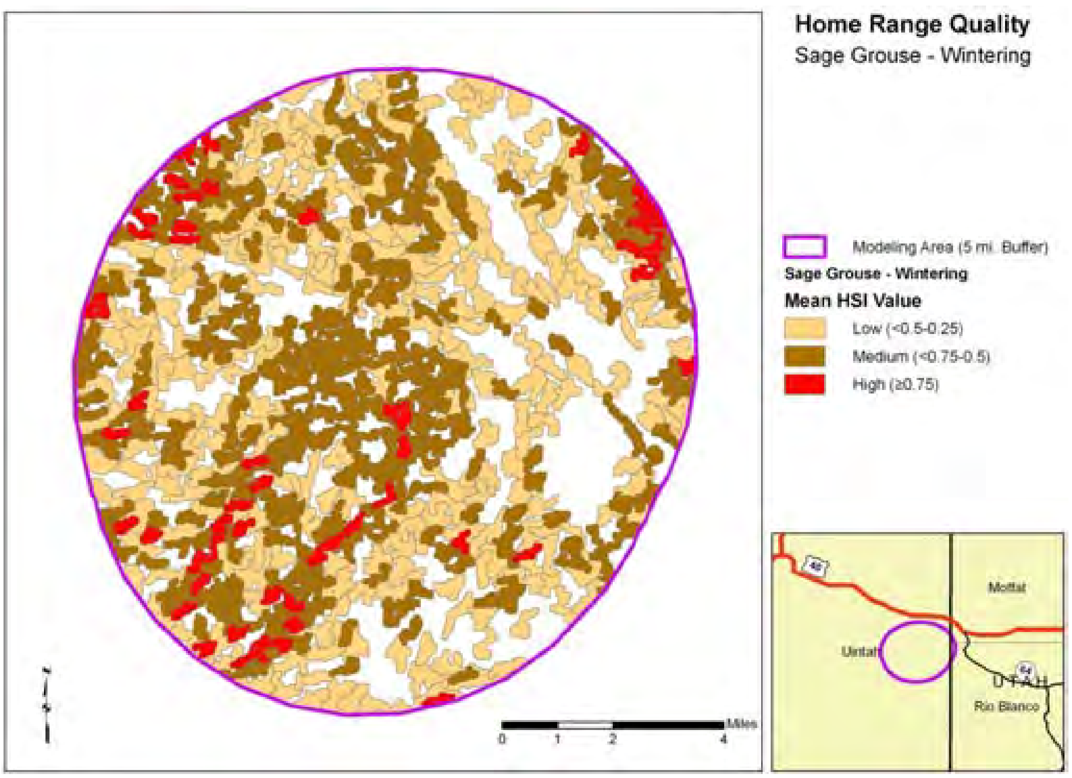


Figure B-170. Pre-treatment potential home range map for sage grouse wintering areas for the Deadman's Bench project, Utah.

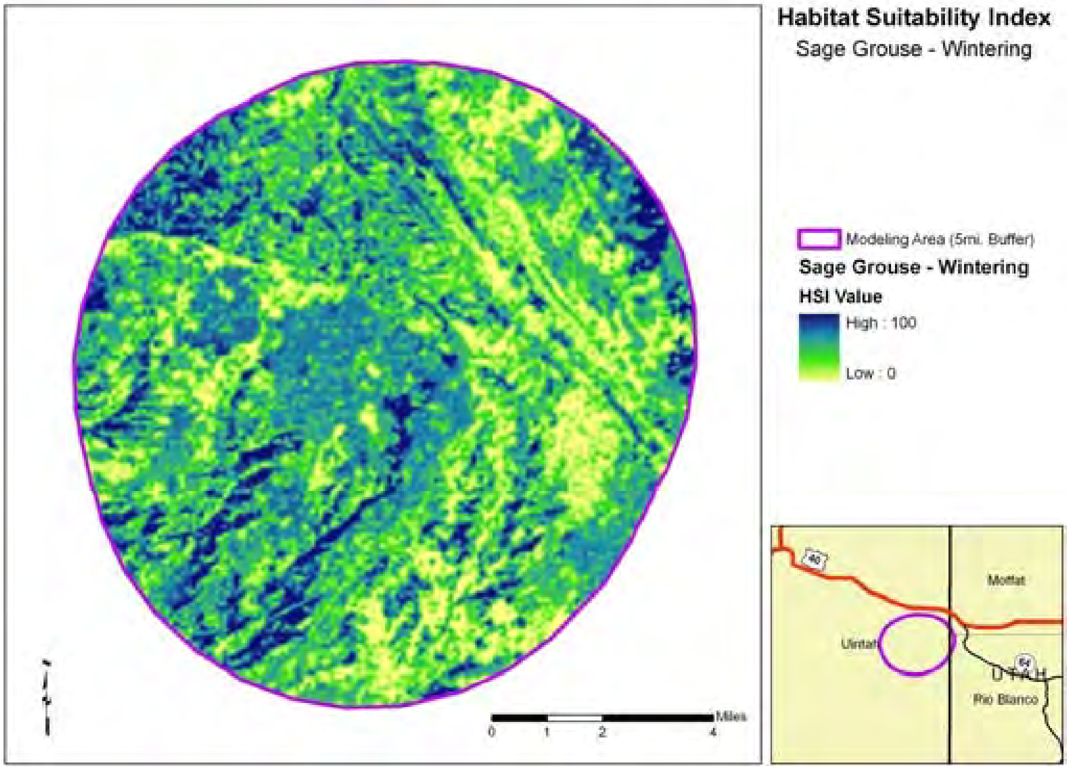


Figure B-171. Post-treatment habitat suitability map for sage grouse wintering habitat for the Deadman's Bench project, Utah.

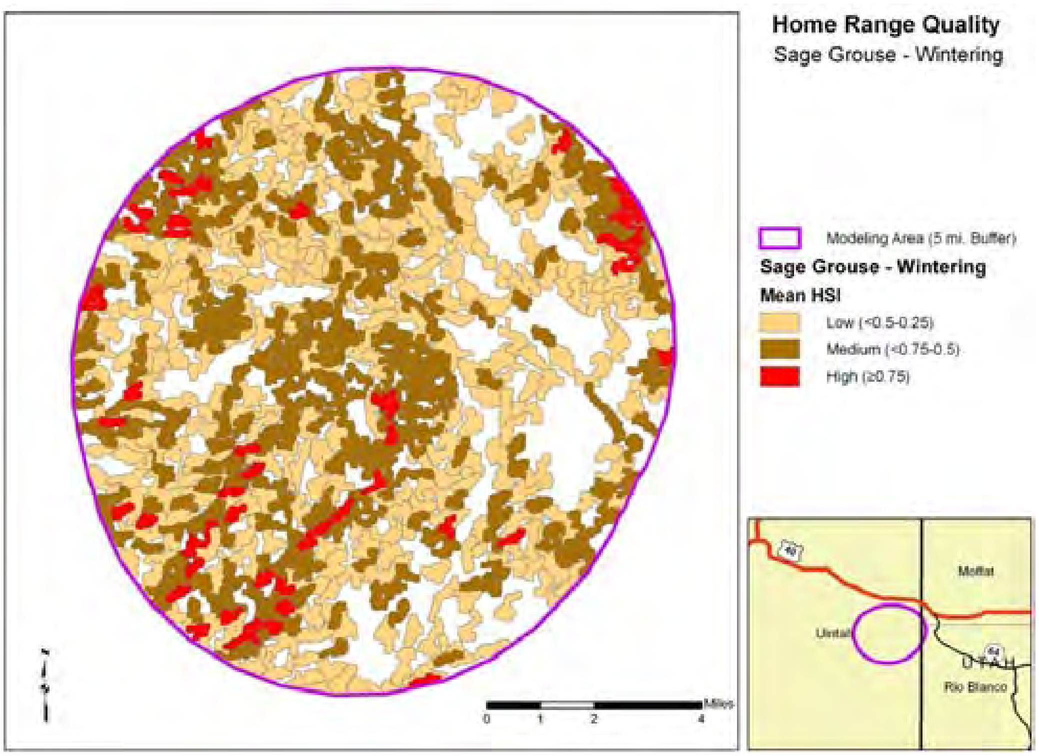


Figure B-172. Post-treatment potential home range map for sage grouse wintering areas for the Deadman's Bench project, Utah.

Sage Thrasher

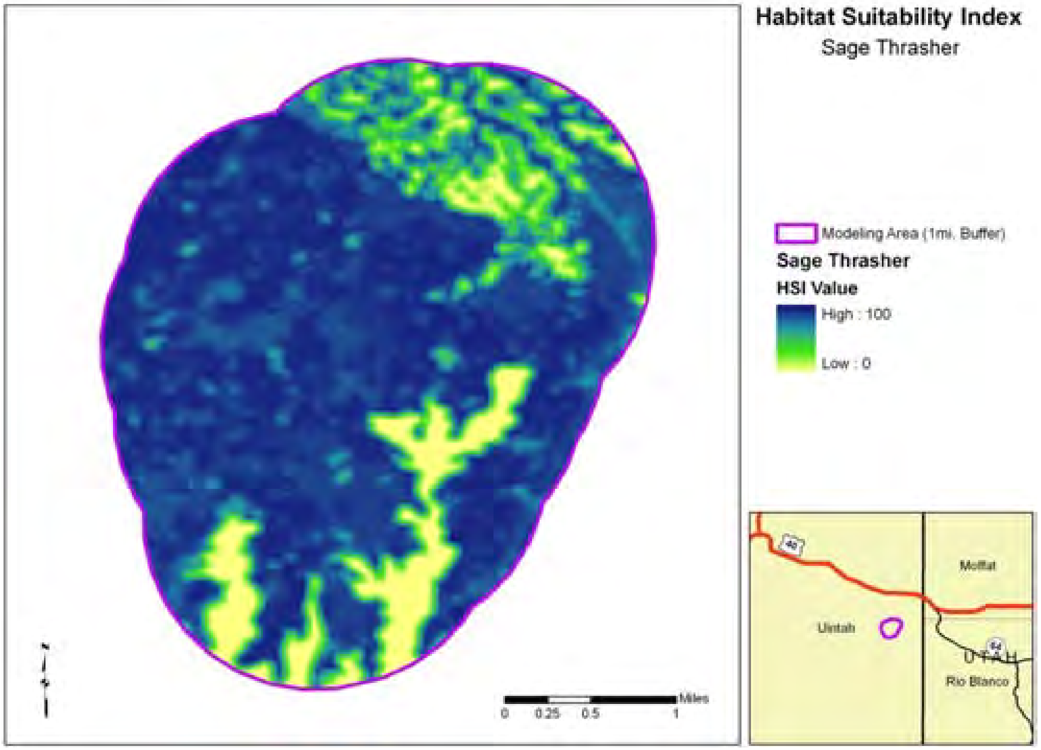


Figure B-173. Pre-treatment habitat suitability map for sage thrasher habitat for the Deadman's Bench project, Utah.

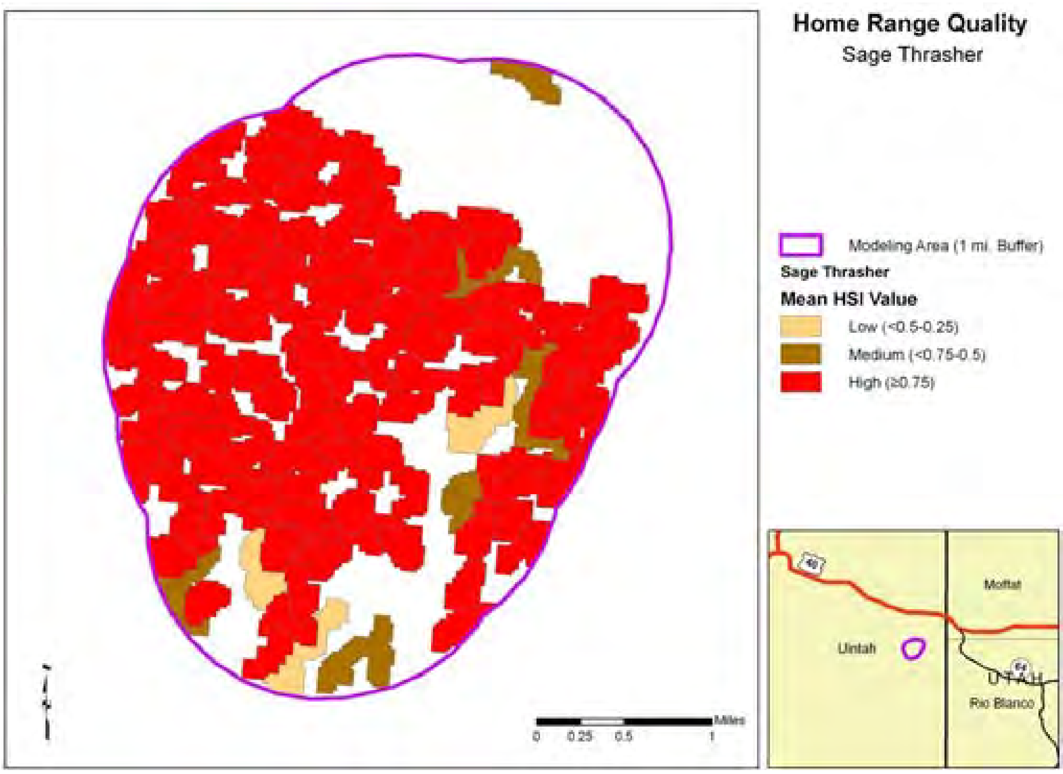


Figure B-174. Pre-treatment potential home range map for sage thrashers for the Deadman's Bench project, Utah.

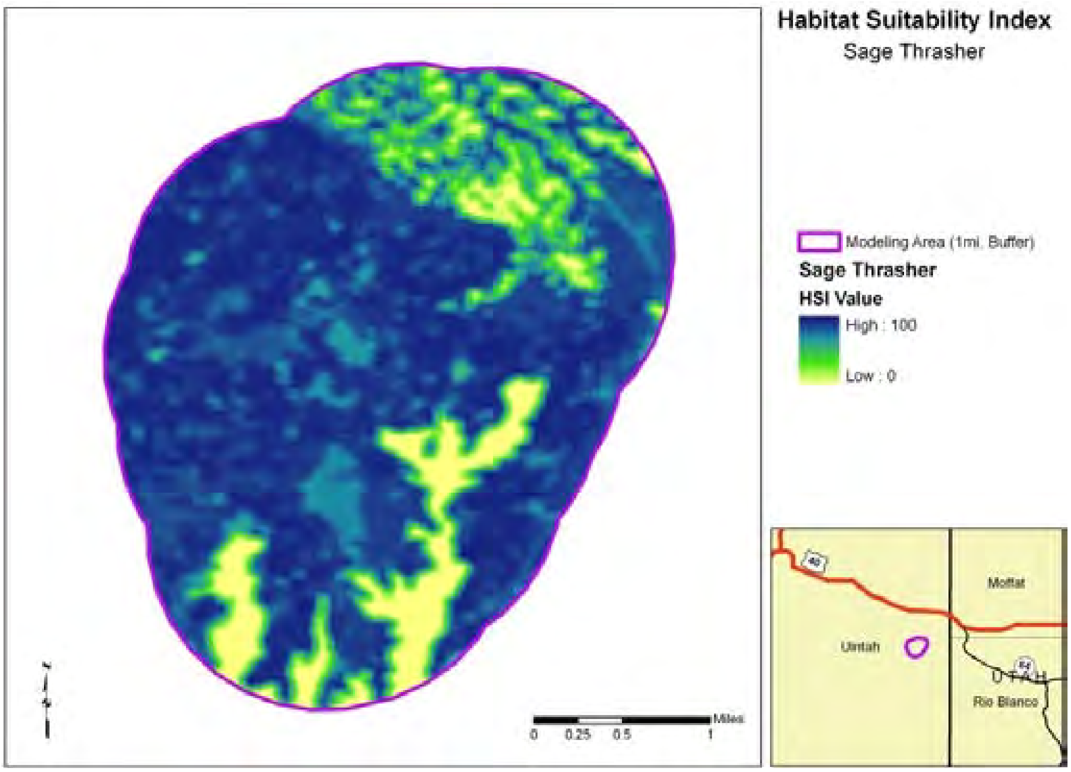


Figure B-175. Post-treatment habitat suitability map for sage thrasher habitat for the Deadman's Bench project, Utah.

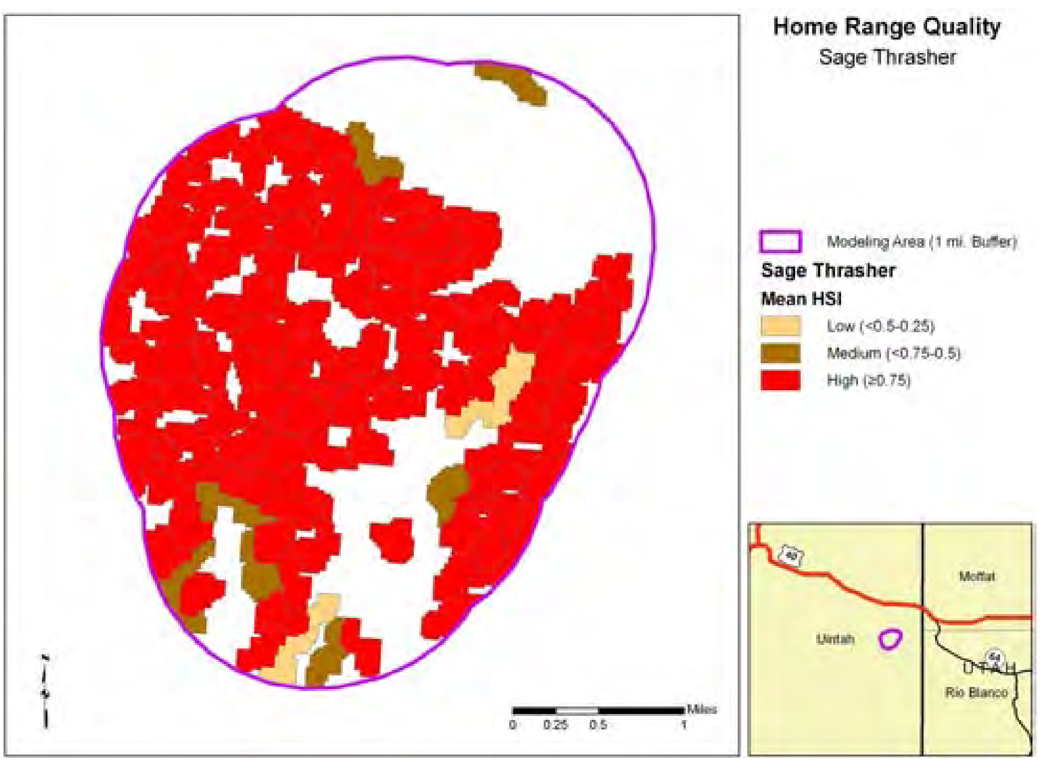


Figure B-176. Post-treatment potential home range map for sage thrashers for the Deadman's Bench project, Utah.

Sage Sparrow

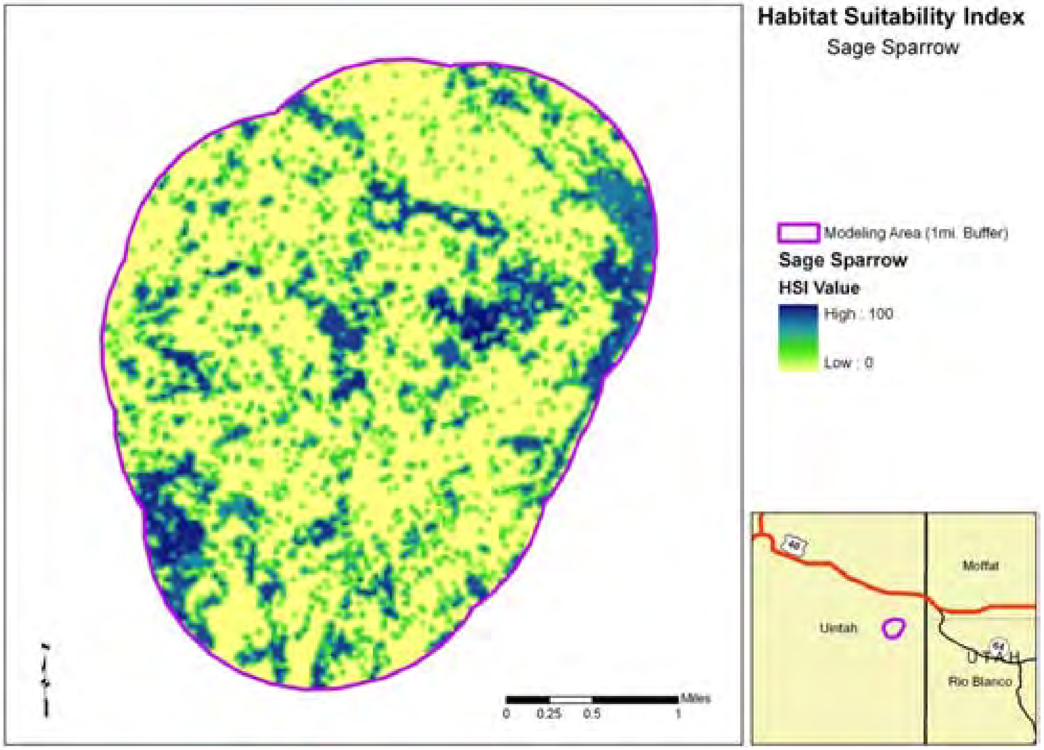


Figure B-177. Pre-treatment habitat suitability map for sage sparrow habitat for the Deadman's Bench project, Utah.

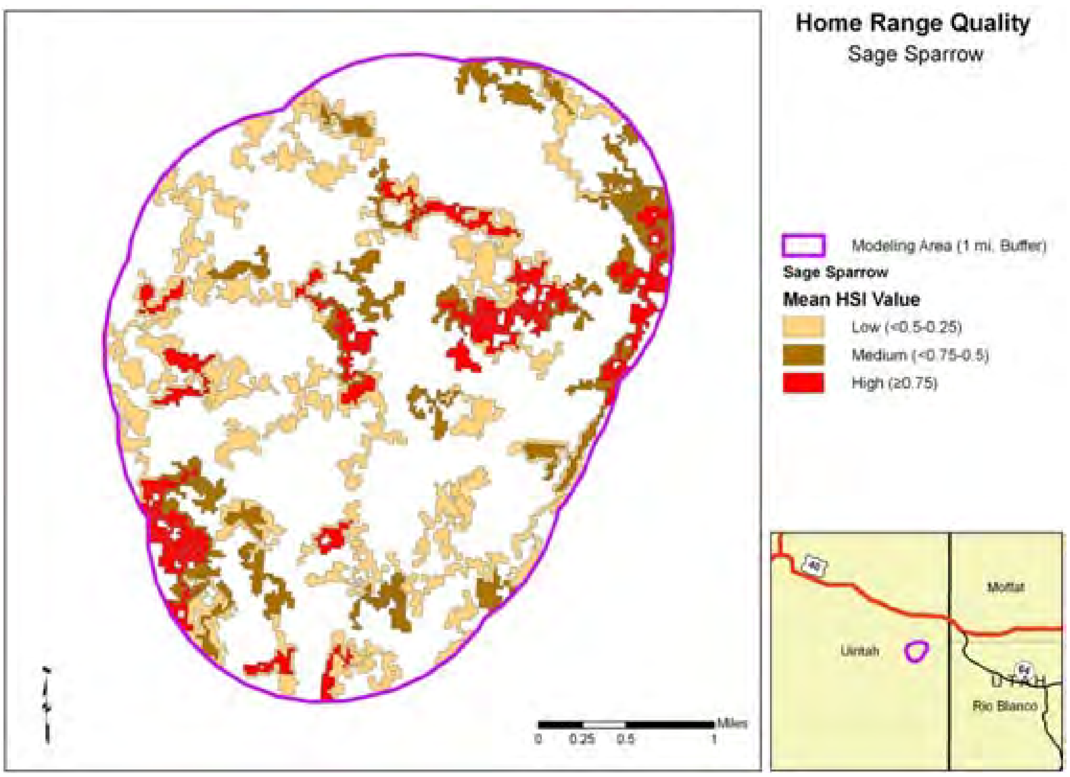


Figure B-178. Pre-treatment potential home range map for sage sparrow for the Deadman's Bench project, Utah.

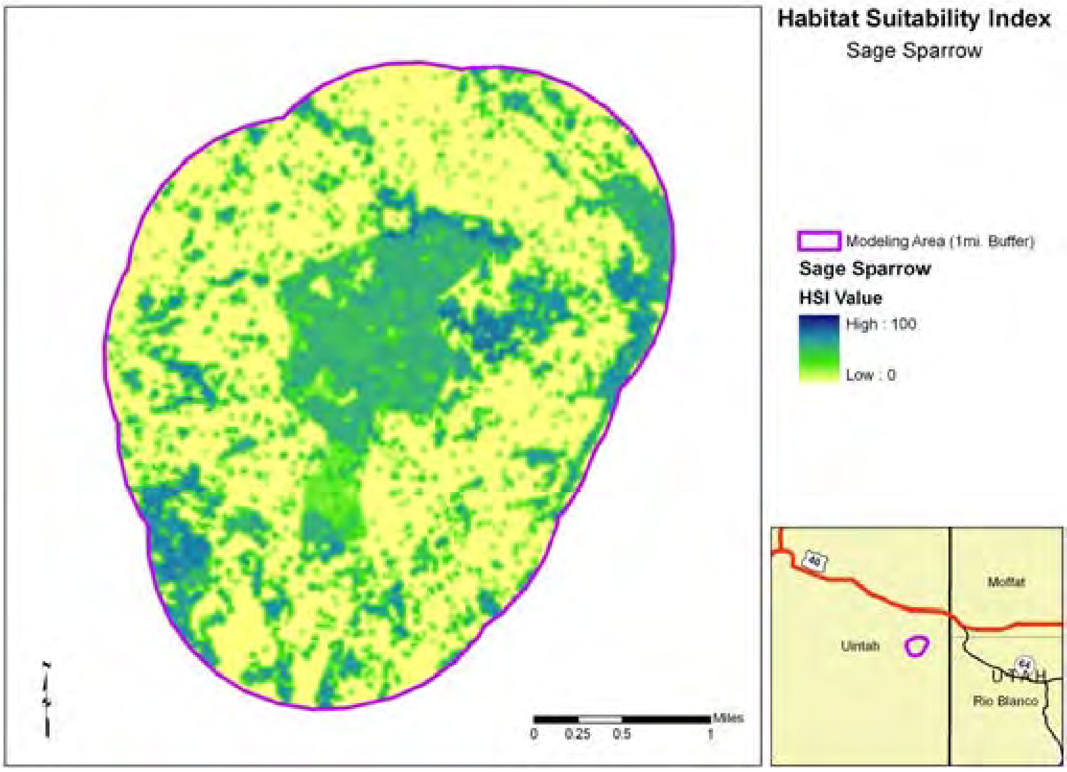


Figure B-179. Post-treatment habitat suitability map for sage sparrow habitat for the Deadman's Bench project, Utah.

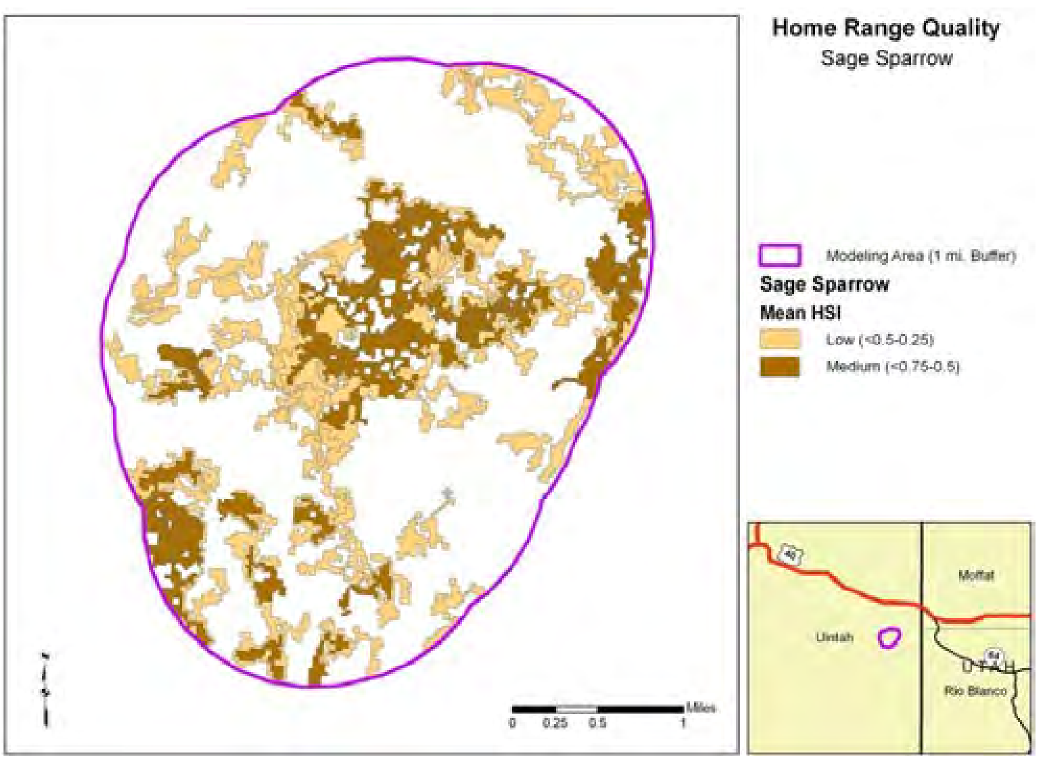


Figure B-180. Post-treatment potential home range map for sage sparrows for the Deadman's Bench project, Utah.

Sagebrush Lizard

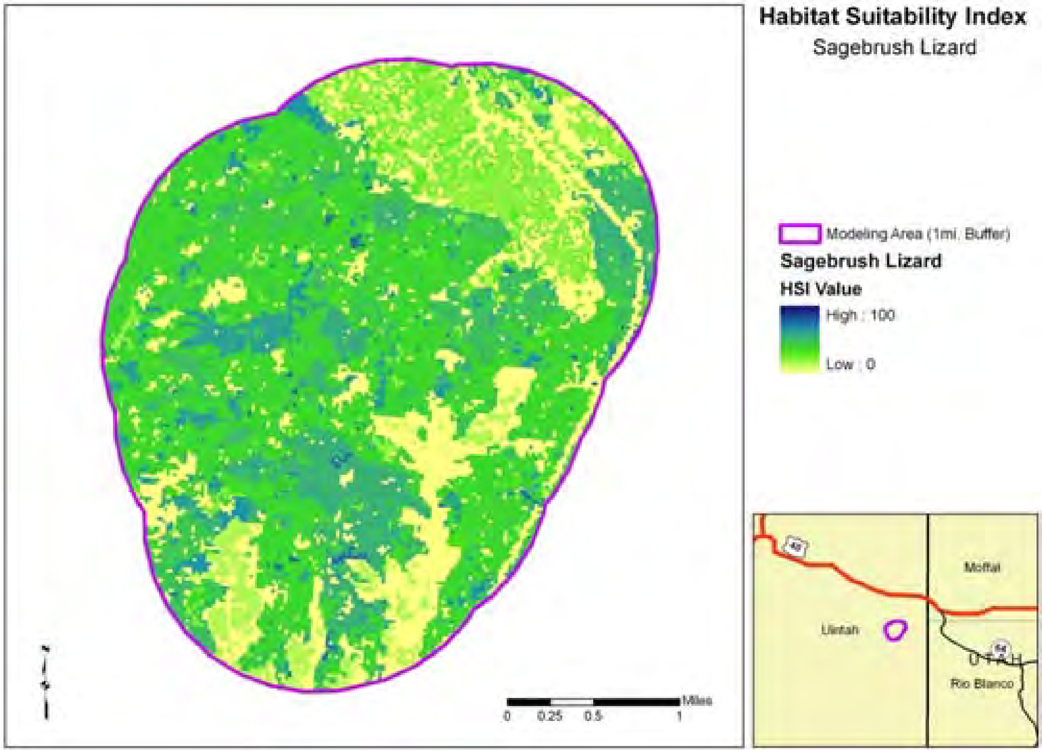


Figure B-181. Pre-treatment habitat suitability map for sagebrush lizard habitat for the Deadman's Bench project, Utah.

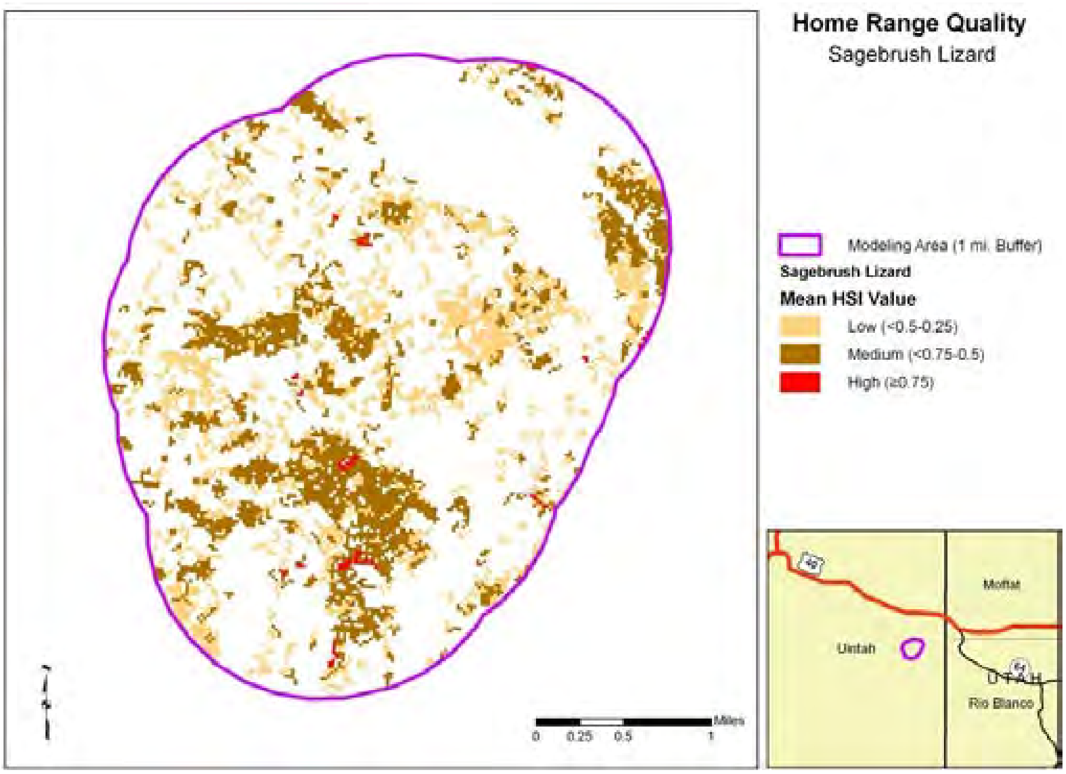


Figure B-182. Pre-treatment potential home range map for sagebrush lizard for the Deadman's Bench project, Utah.

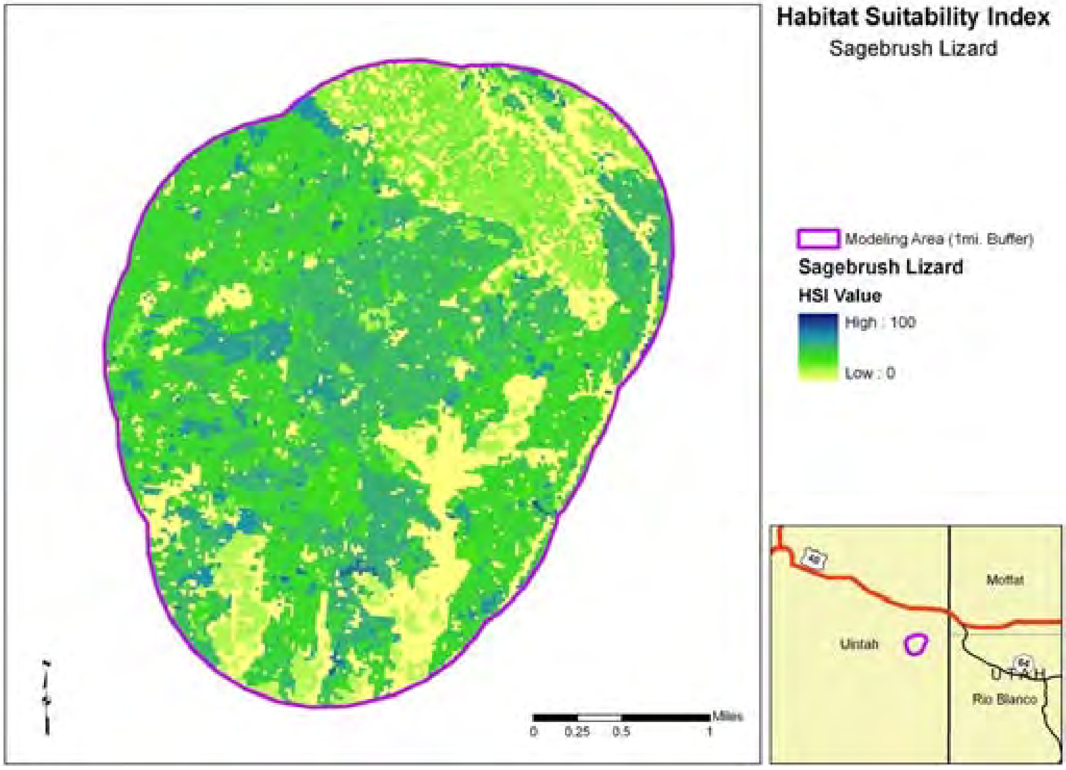


Figure B-183. Post-treatment habitat suitability map for sagebrush lizard habitat for the Deadman's Bench project, Utah.

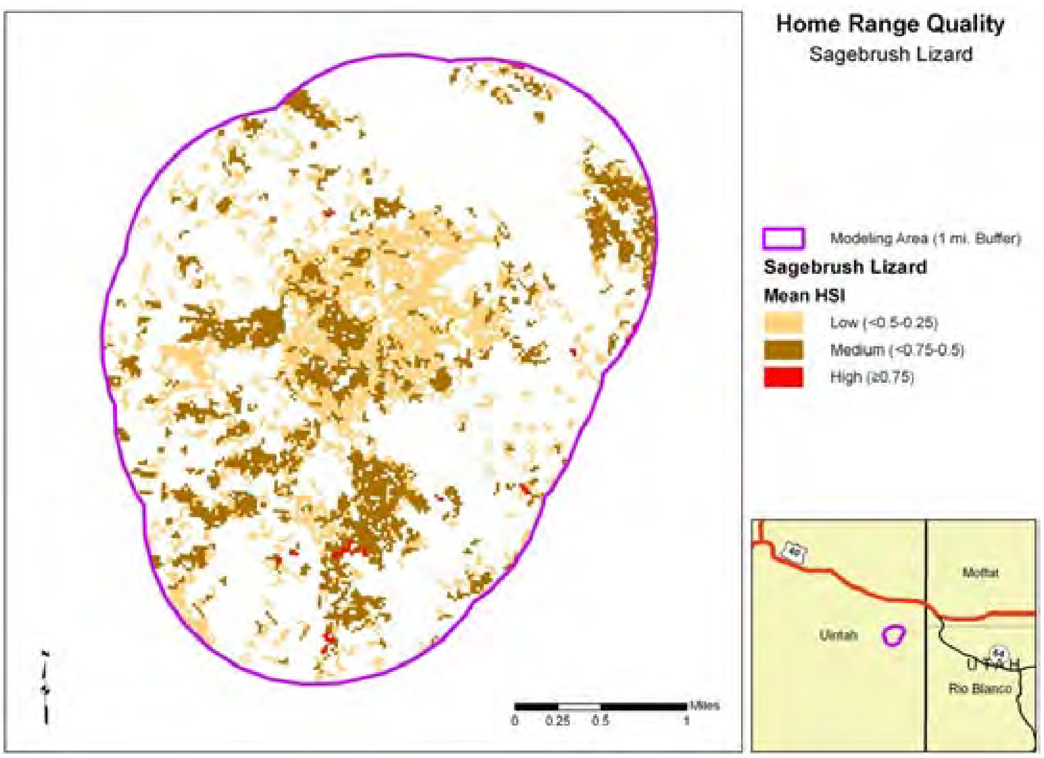


Figure B-184. Post-treatment potential home range map for sagebrush lizards for the Deadman's Bench project, Utah.

Sagebrush Vole

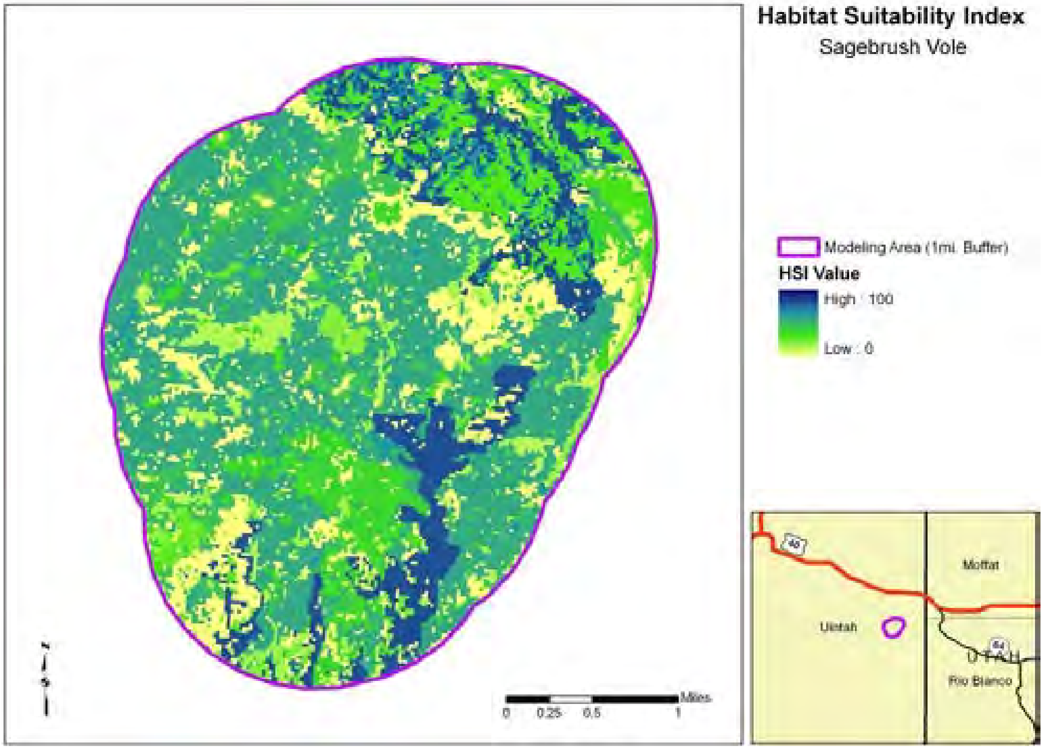


Figure B-185. Pre-treatment habitat suitability map for sagebrush vole habitat for the Deadman's Bench project, Utah.

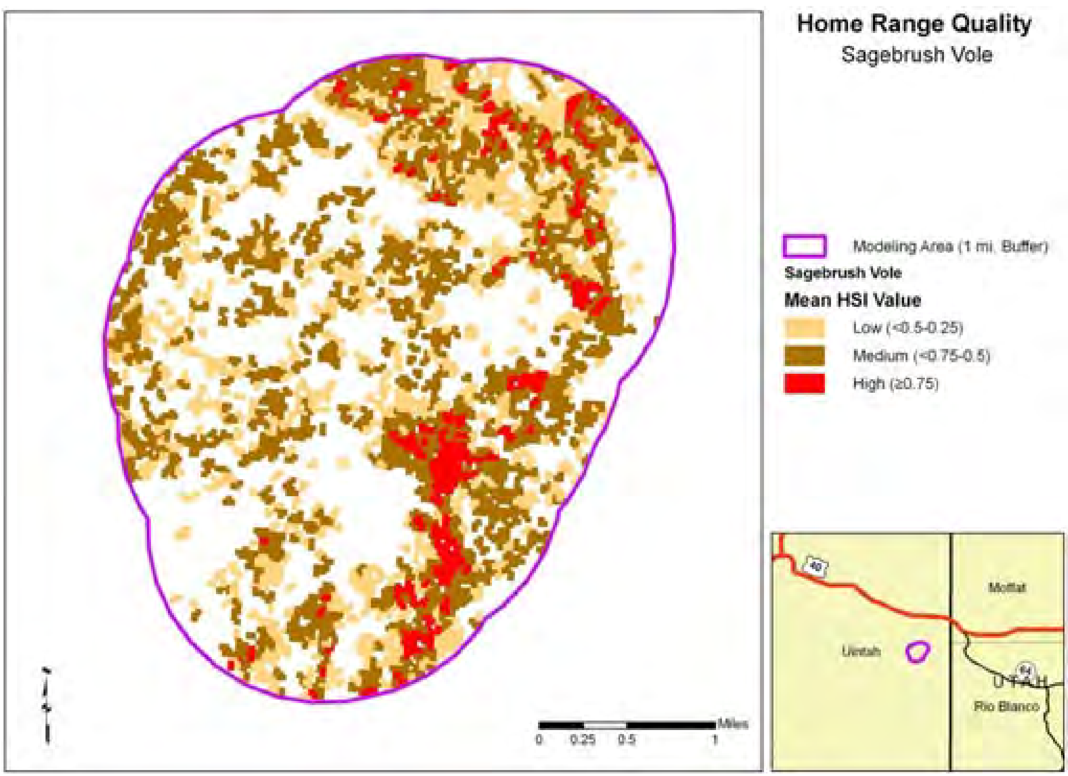


Figure B-186. Pre-treatment potential home range map for sagebrush vole for the Deadman's Bench project, Utah.

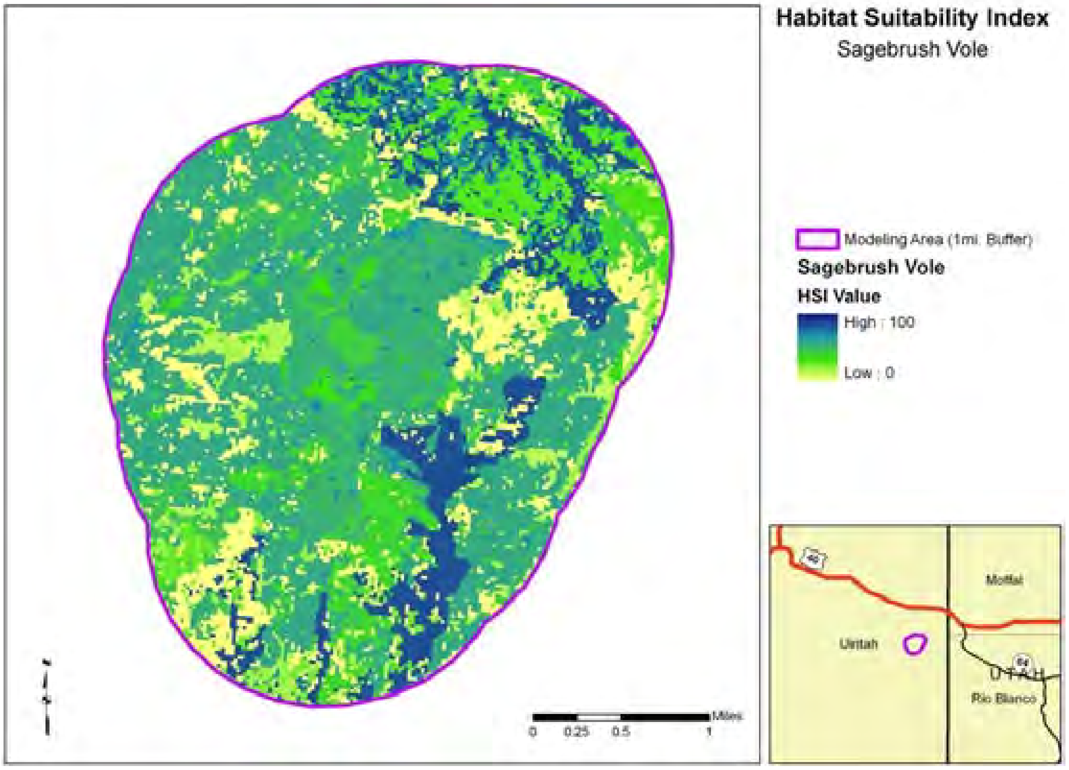


Figure B-187. Post-treatment habitat suitability map for sagebrush vole habitat for the Deadman's Bench project, Utah.

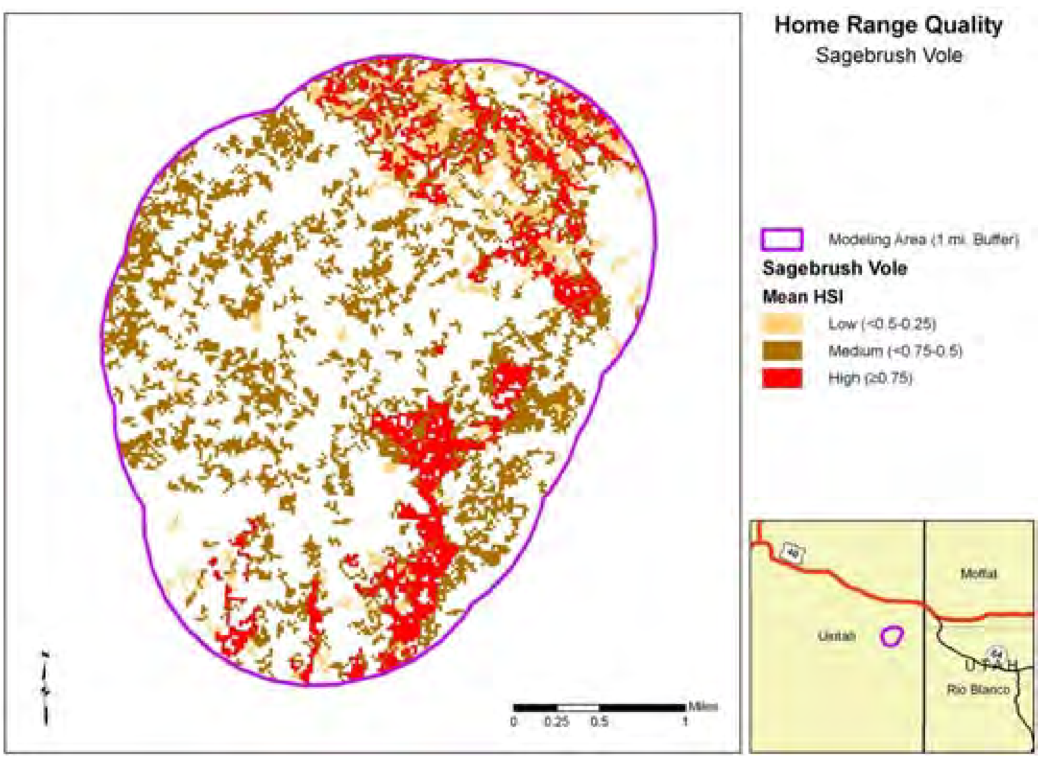


Figure B-188. Post-treatment potential home range map for sagebrush voles for the Deadman's Bench project, Utah.

Pronghorn Antelope

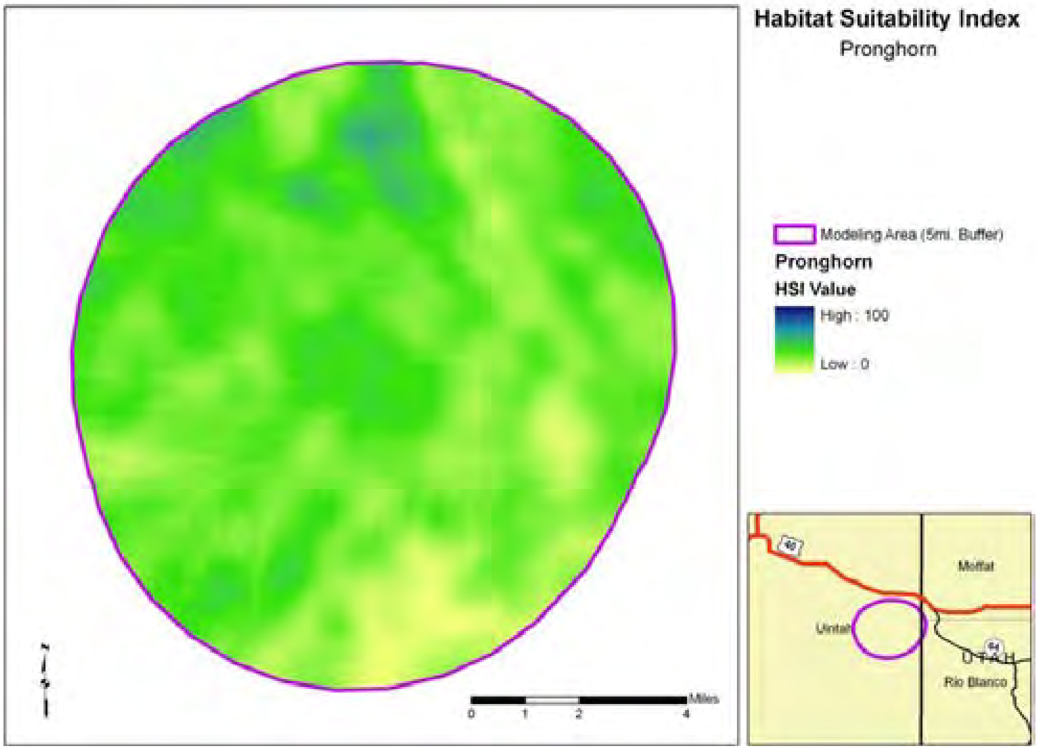


Figure B-189. Pre-treatment habitat suitability map for pronghorn antelope habitat for the Deadman's Bench project, Utah.

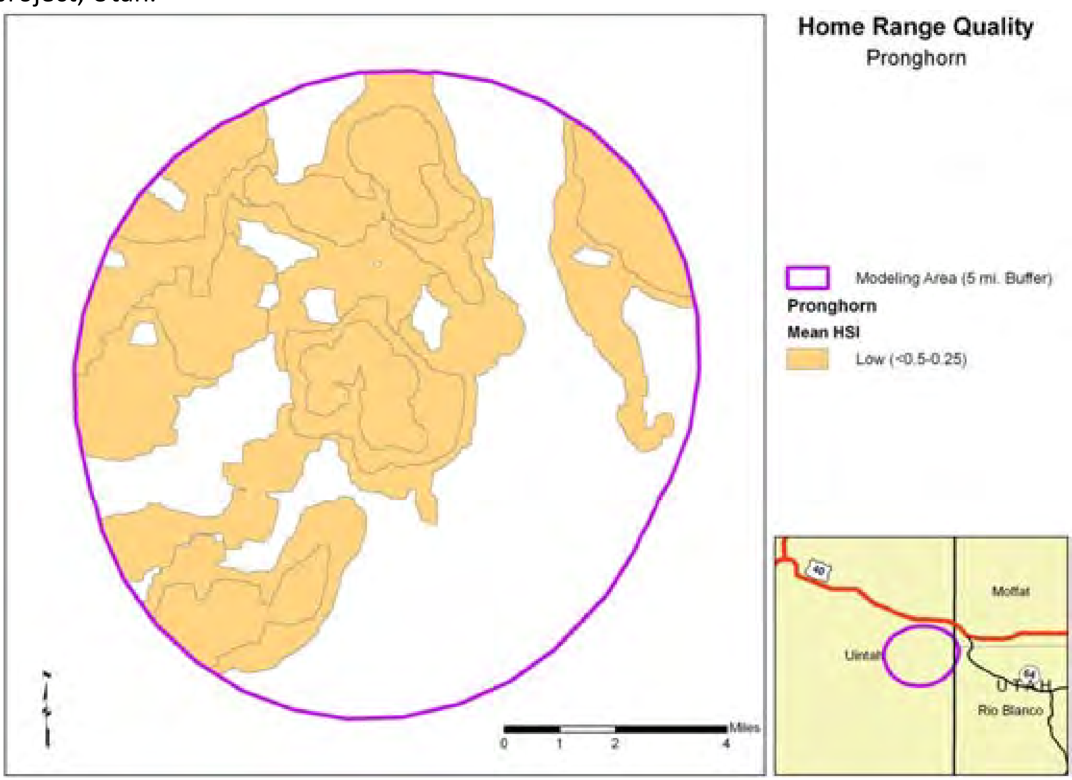


Figure B-190. Pre-treatment potential home range map for pronghorn antelope for the Deadman's Bench project, Utah.

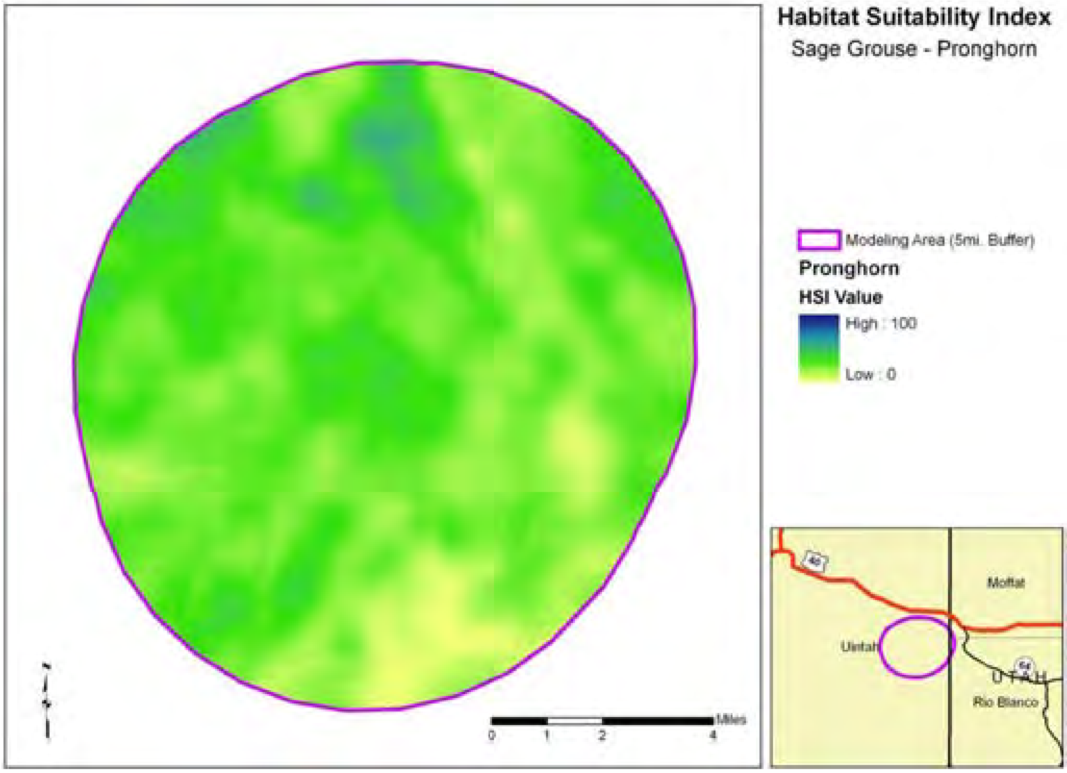


Figure B-191. Post-treatment habitat suitability map for pronghorn antelope habitat for the Deadman's Bench project, Utah.

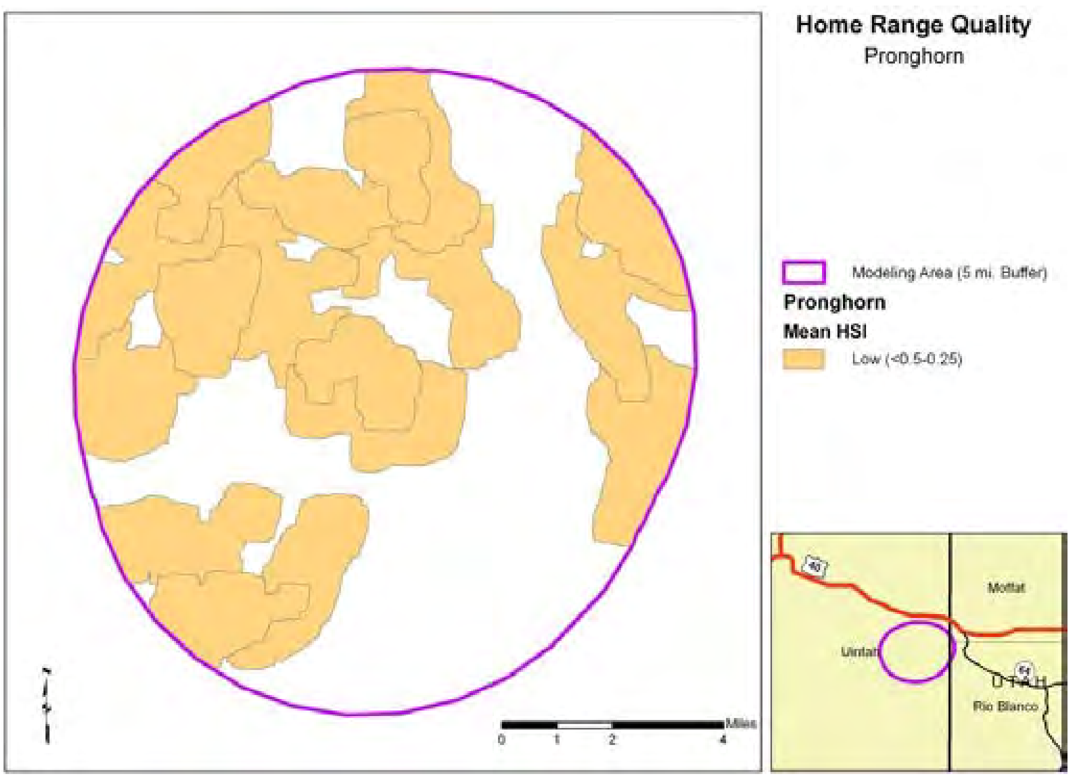


Figure B-192. Post-treatment potential home range map for pronghorn antelope for the Deadman's Bench project, Utah.

Rock Springs Project, Utah

Sage Grouse

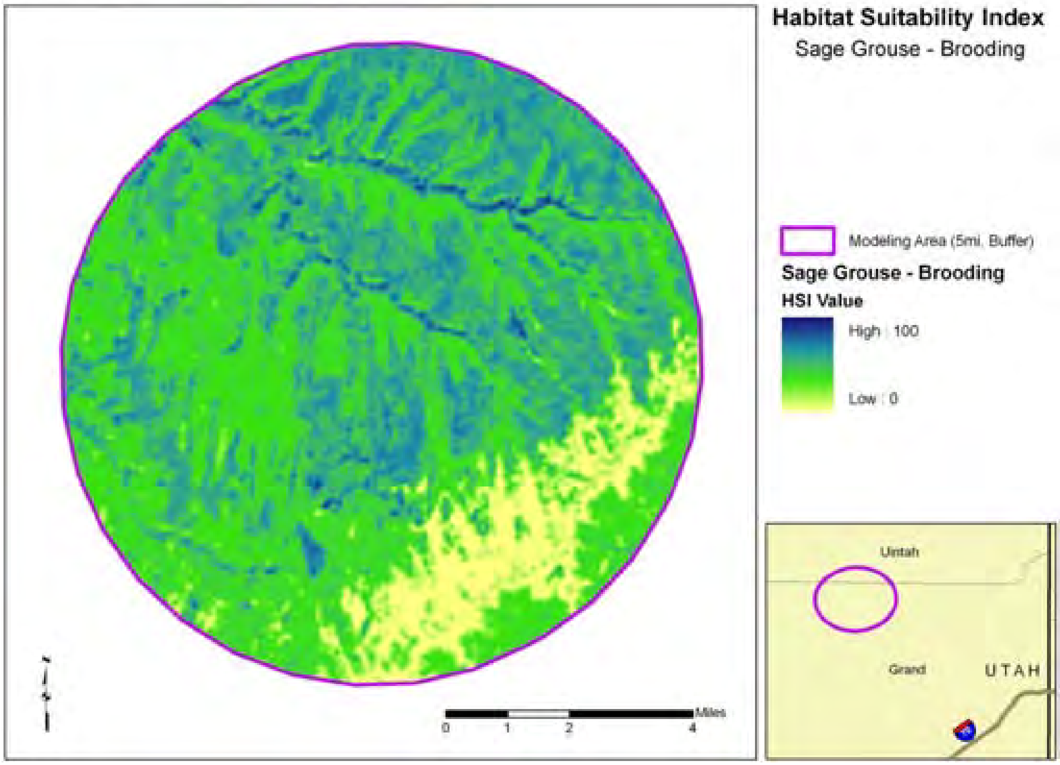


Figure B-193. Pre-treatment habitat suitability map for sage grouse brood habitat.

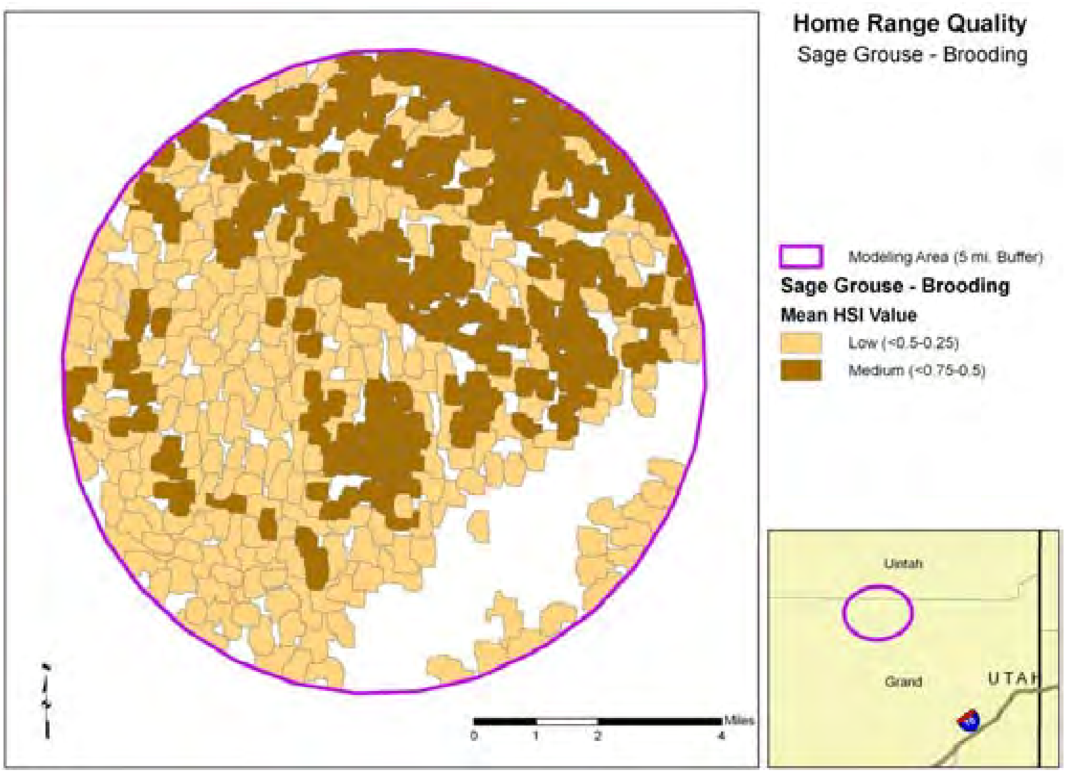


Figure B-194. Pre-treatment potential home range map for sage grouse brood rearing areas.

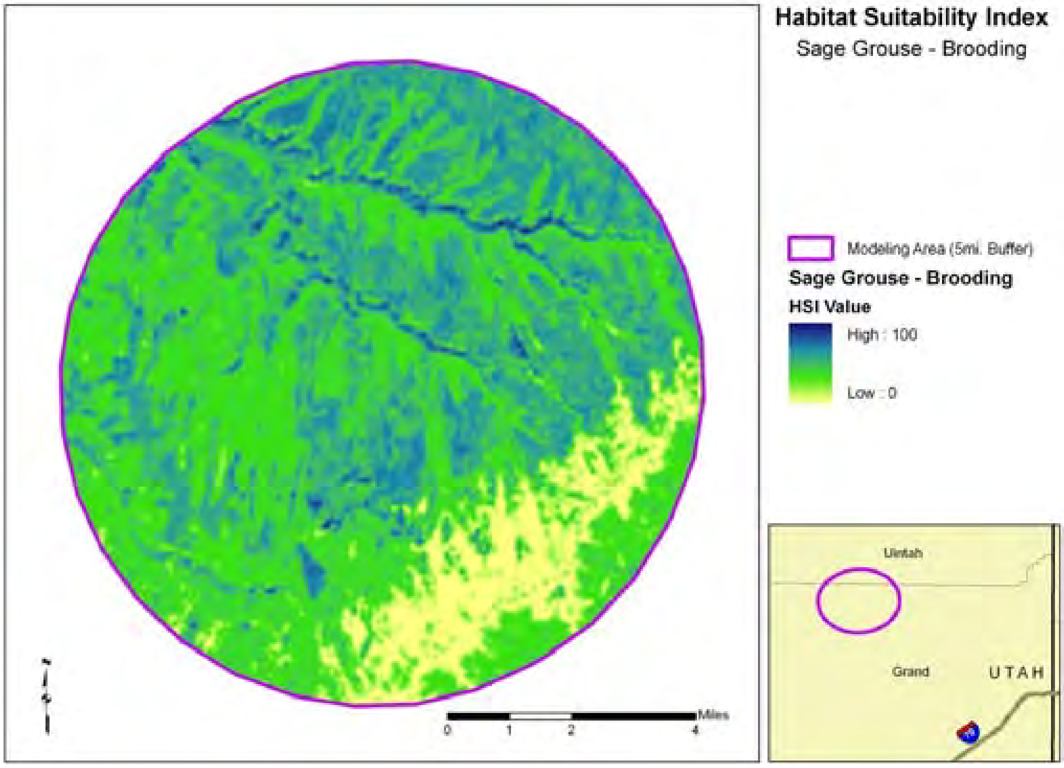


Figure B-195. Post-treatment habitat suitability map for sage grouse brood habitat for the Rock Springs project, Utah.

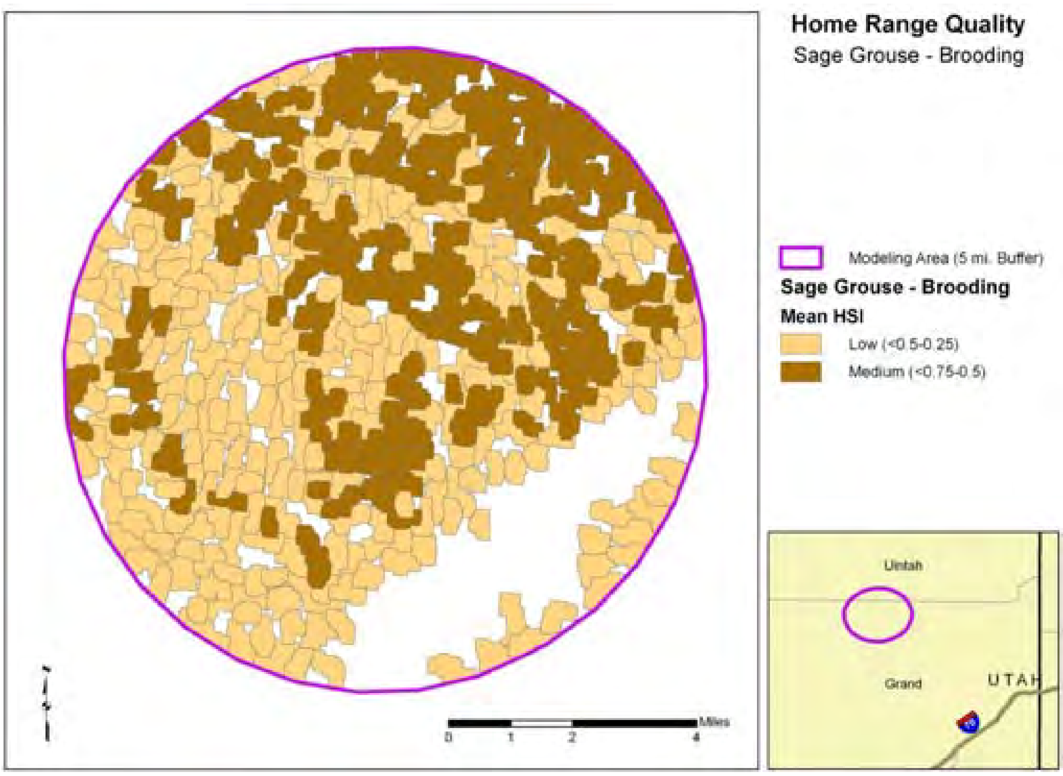


Figure B-196. Post-treatment potential home range map for sage grouse brood rearing areas for the Rock Springs project, Utah.

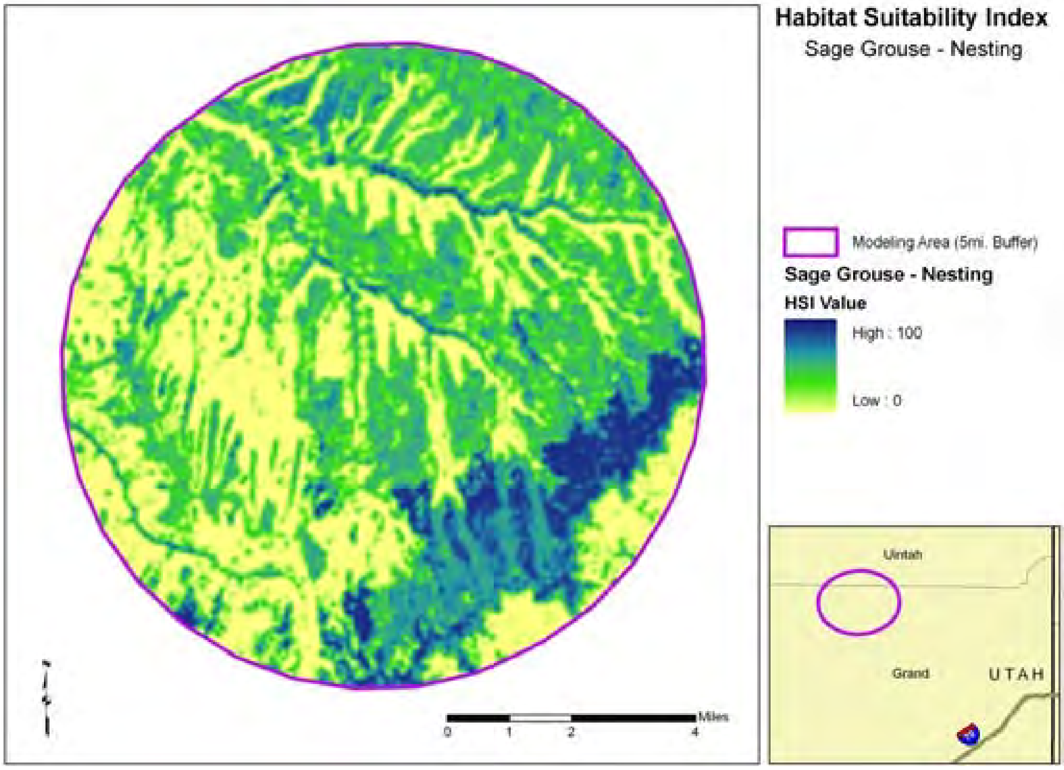


Figure B-197. Pre-treatment habitat suitability map for sage grouse nesting habitat for the Rock Springs project, Utah.

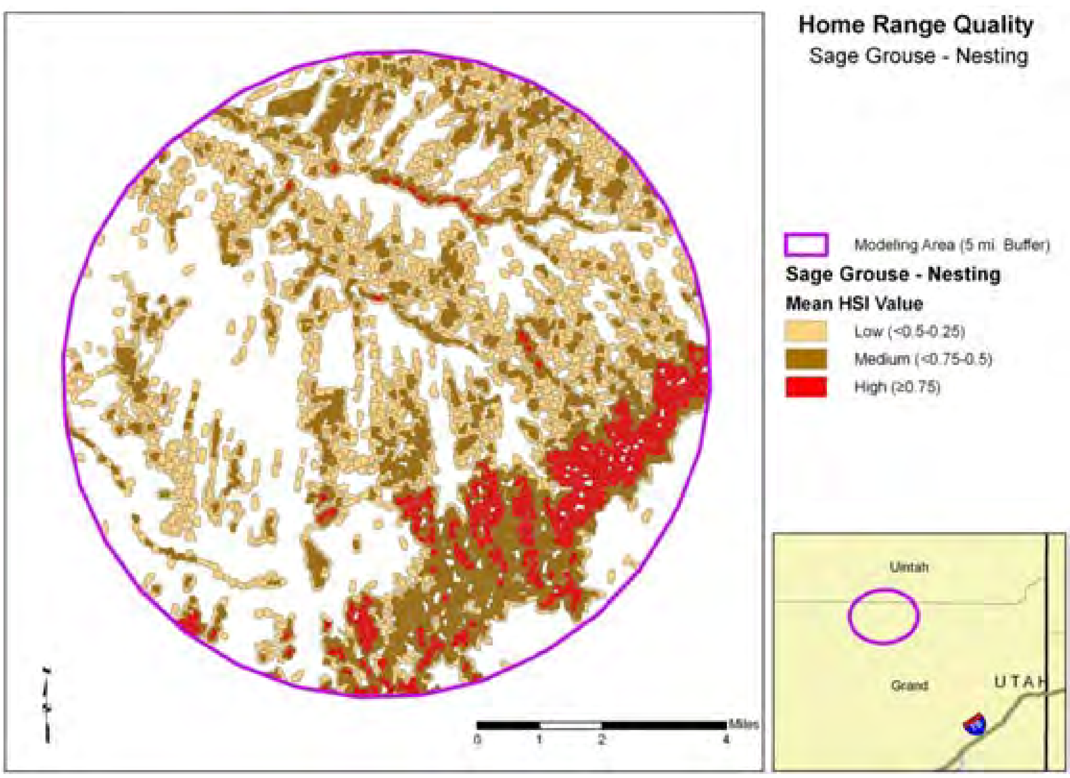


Figure B-198. Pre-treatment potential home range map for sage grouse nesting areas for the Rock Springs project, Utah.

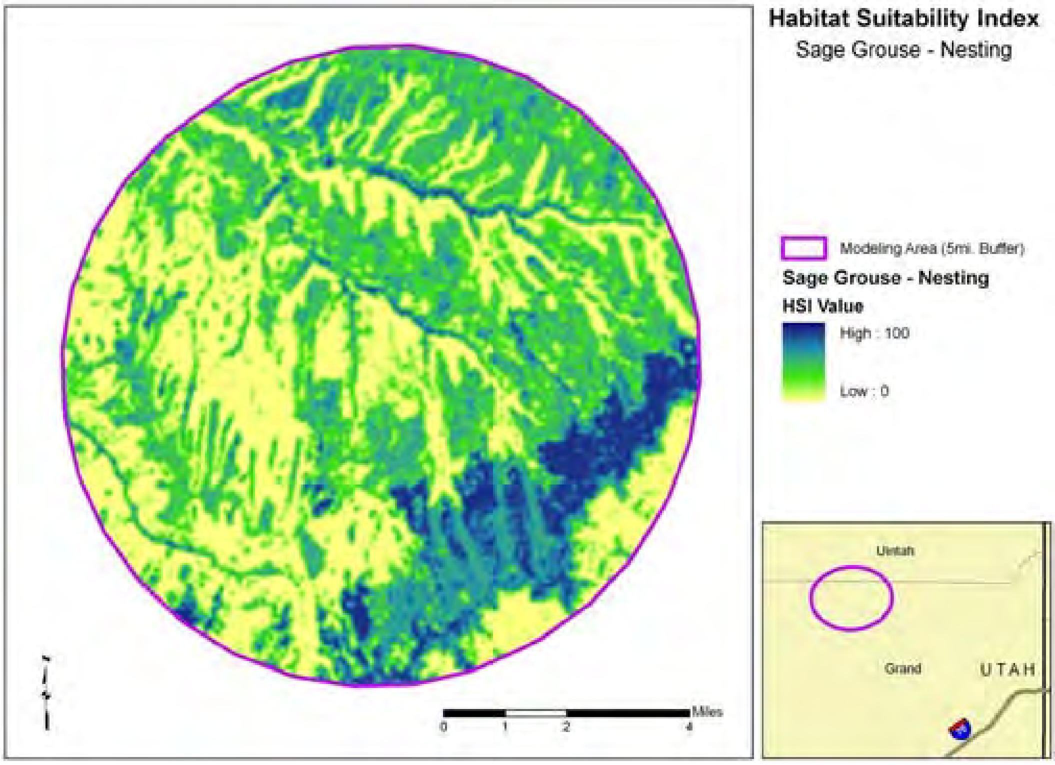


Figure B-199. Post-treatment habitat suitability map for sage grouse nesting habitat for the Rock Springs project, Utah.

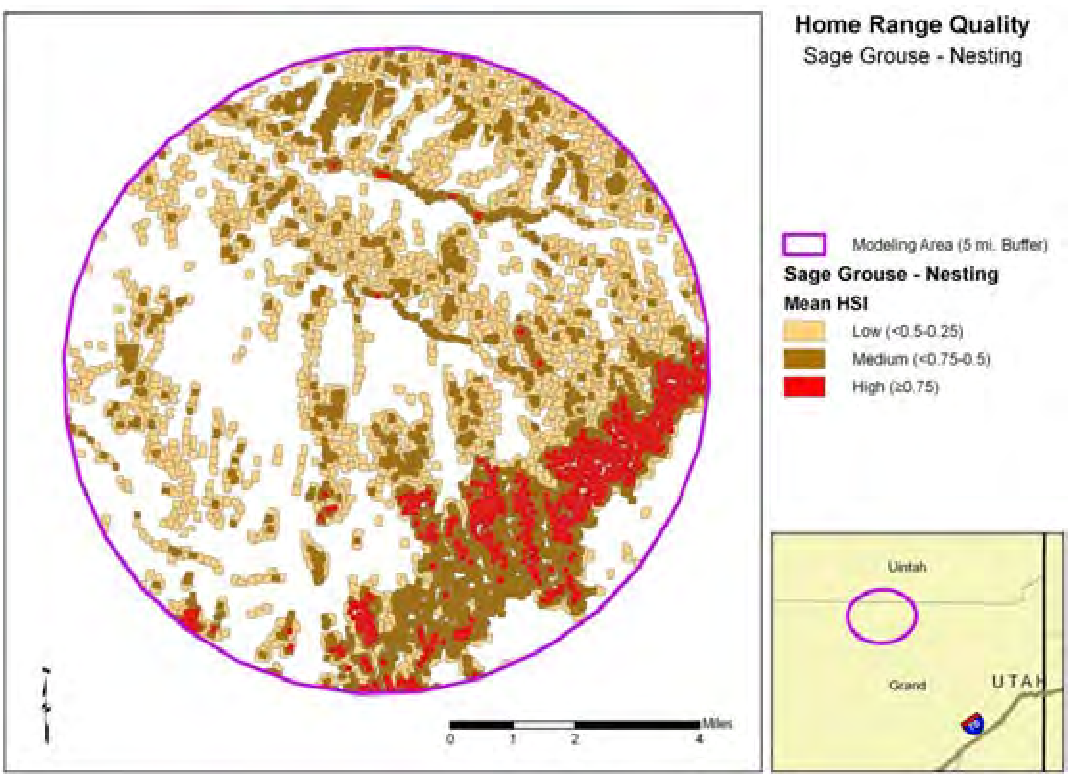


Figure B-200. Post-treatment potential home range map for sage grouse nesting areas for the Rock Springs project, Utah.

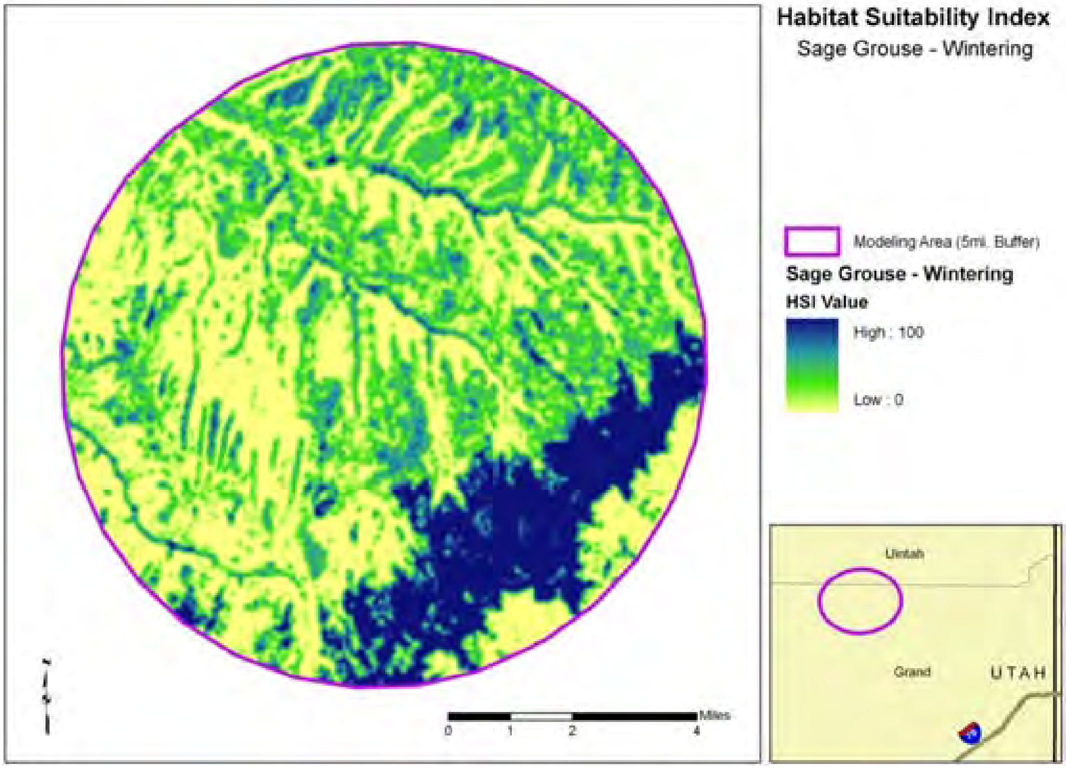


Figure B-201. Pre-treatment habitat suitability map for sage grouse wintering habitat for the Rock Springs project, Utah.

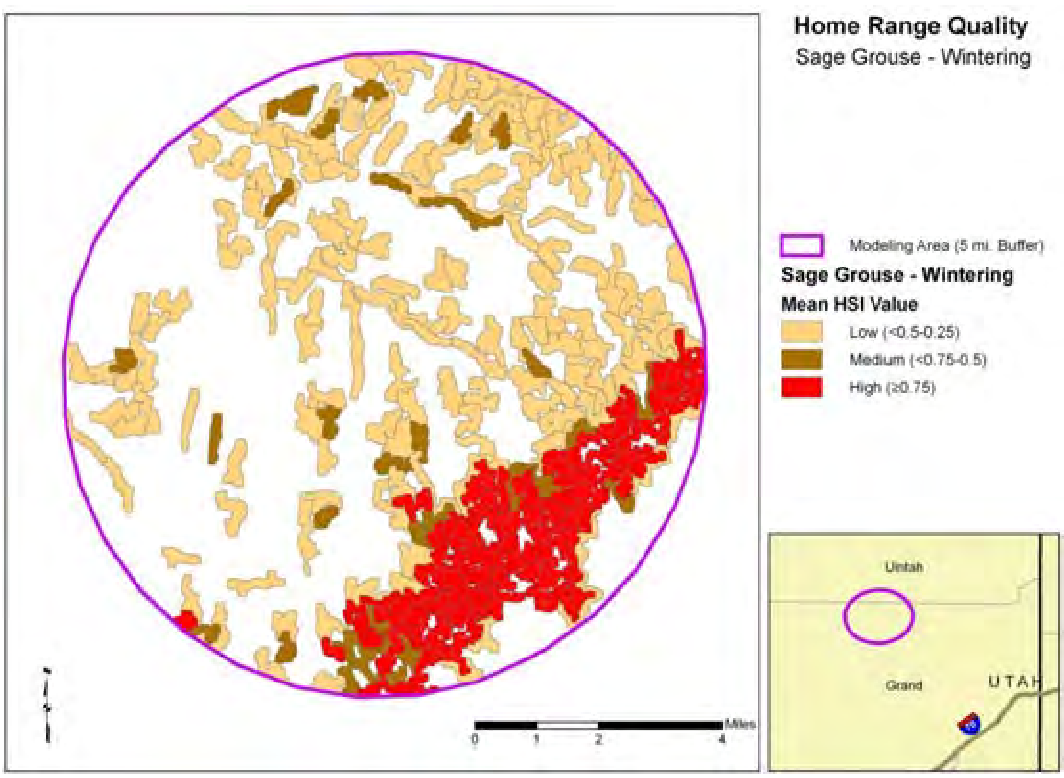


Figure B-202. Pre-treatment potential home range map for sage grouse wintering areas for the Rock Springs project, Utah.

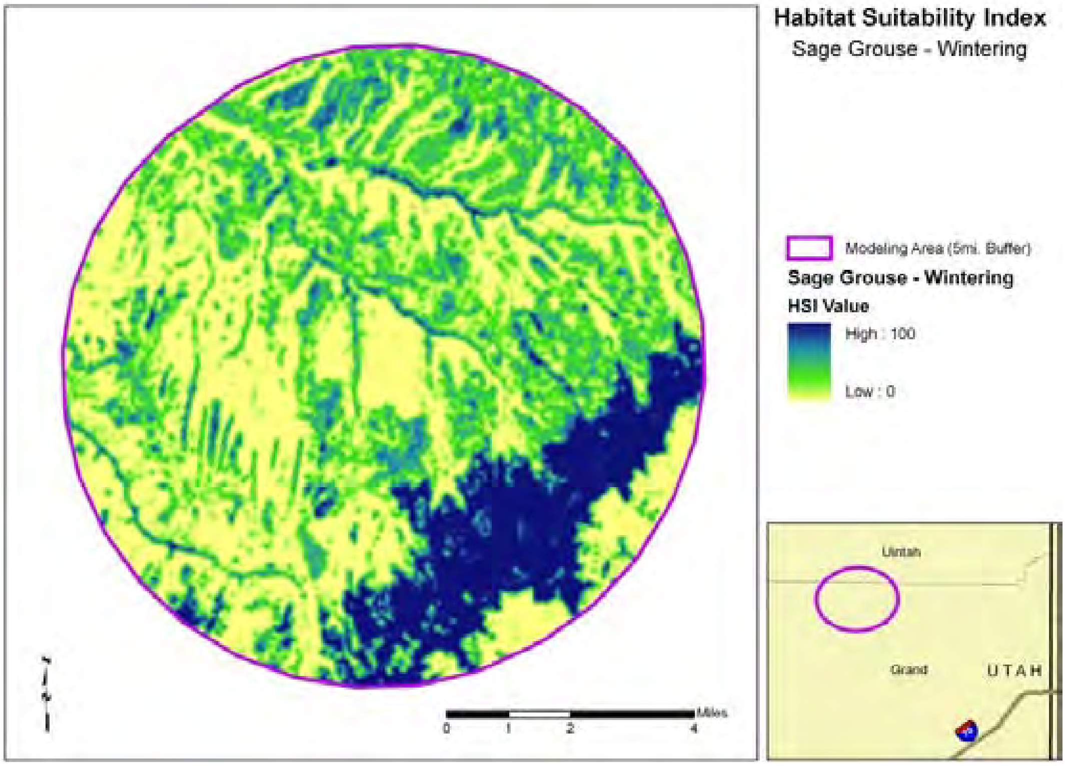


Figure B-203. Post-treatment habitat suitability map for sage grouse wintering habitat for the Rock Springs project, Utah.

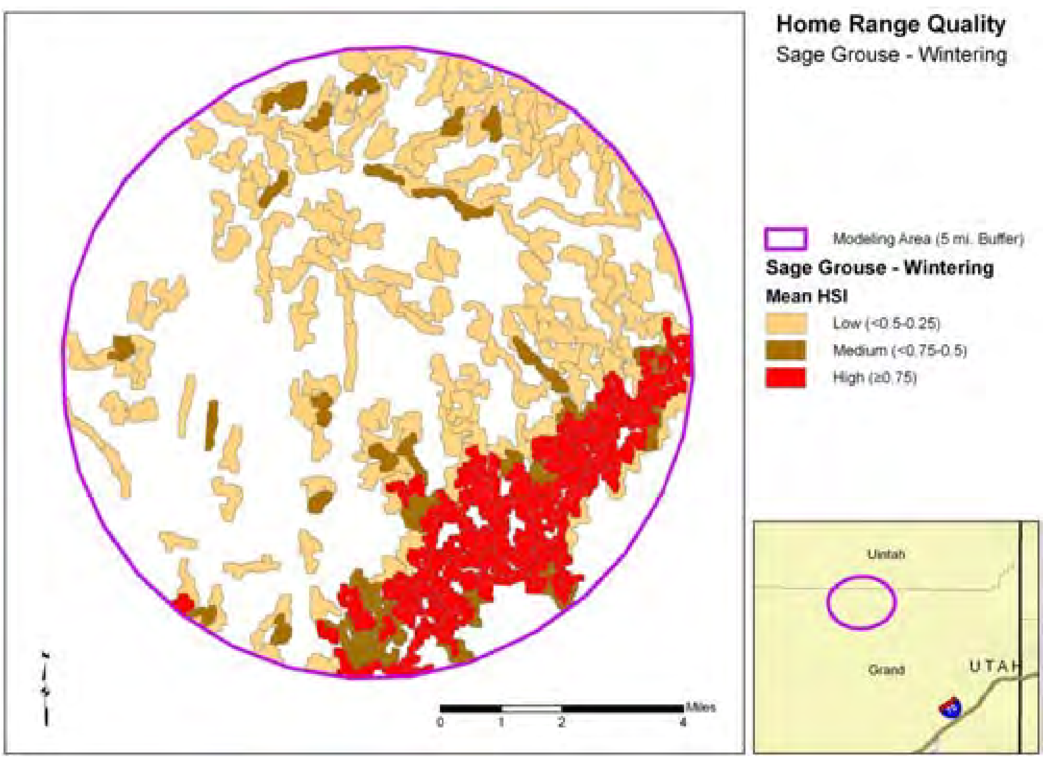


Figure B-204. Post-treatment potential home range map for sage grouse wintering areas for the Rock Springs project, Utah.

Sage Thrasher

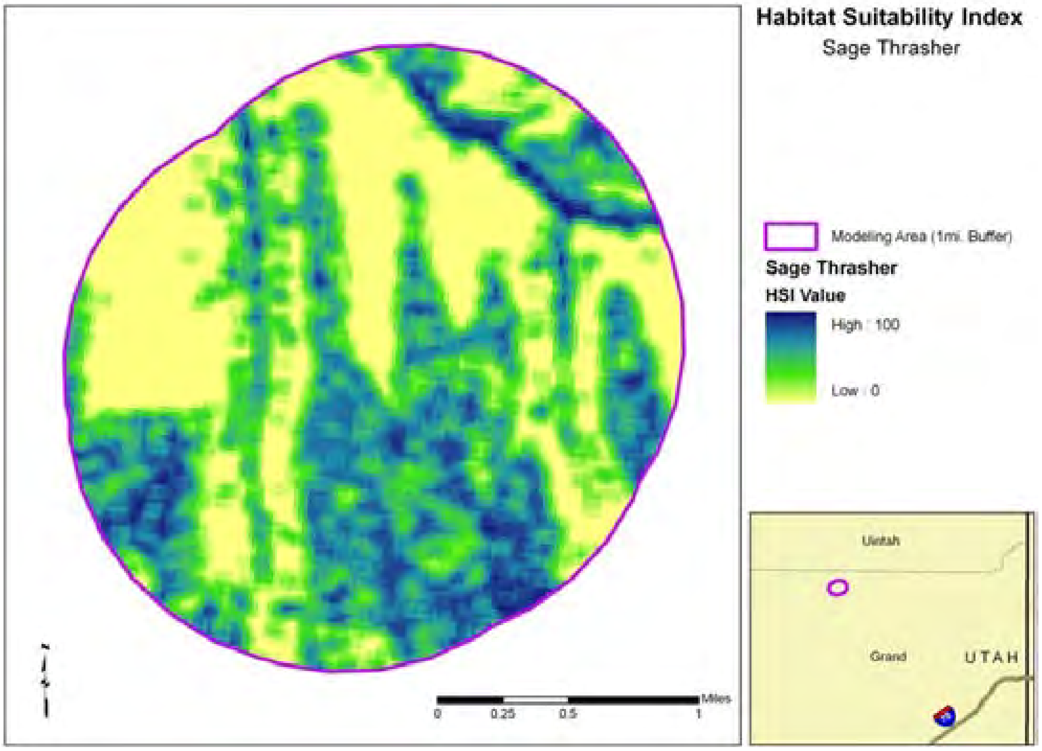


Figure B-205. Pre-treatment habitat suitability map for sage thrasher habitat for the Deadman's Bench project, Utah.

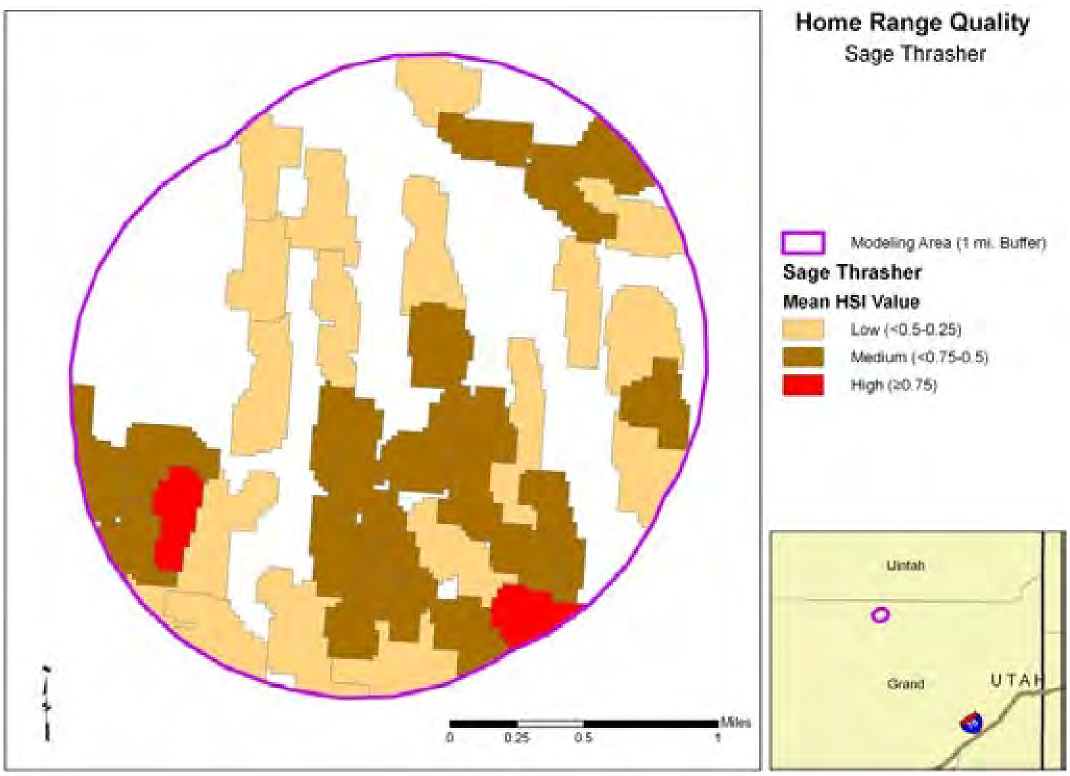


Figure B-206. Pre-treatment potential home range map for sage thrashers for the Rock Springs project, Utah.

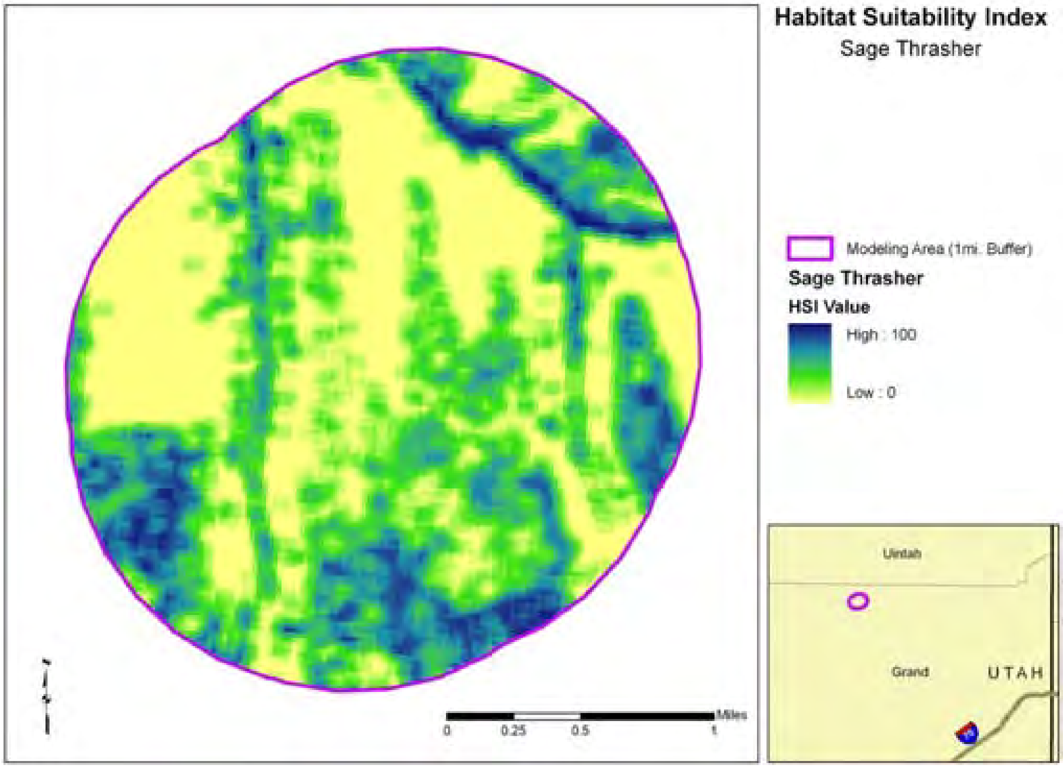


Figure B-207. Post-treatment habitat suitability map for sage thrasher habitat for the Rock Springs project, Utah.

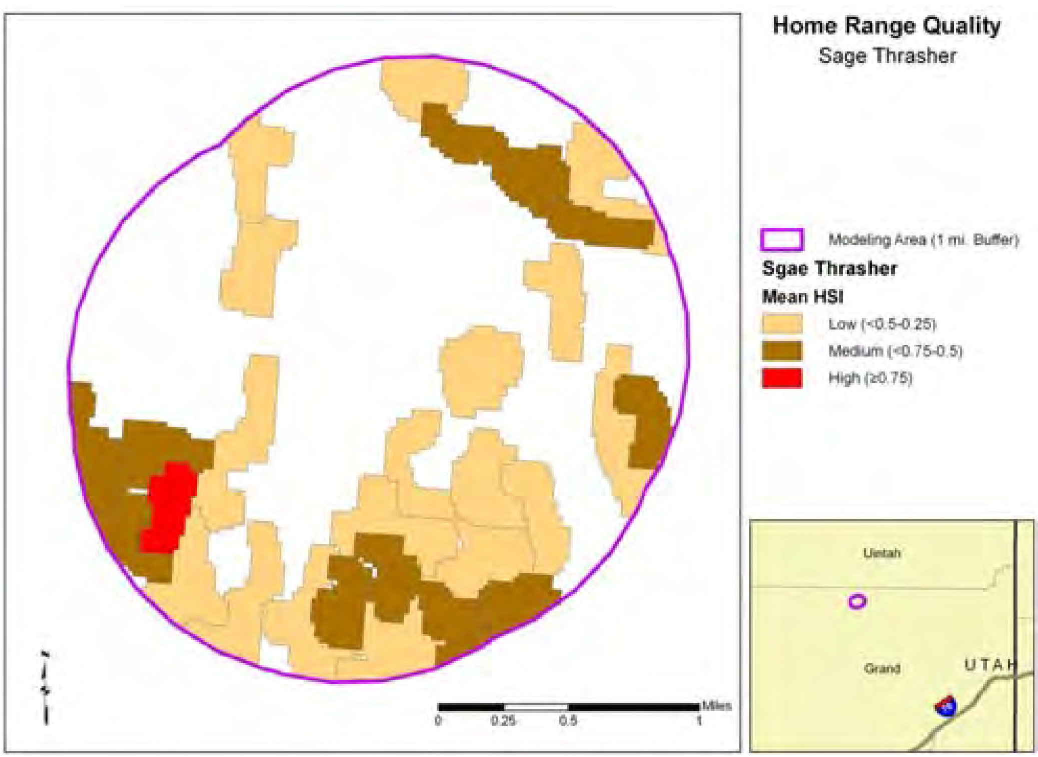


Figure B-208. Post-treatment potential home range map for sage thrashers for the Rock Springs project, Utah.

Sage Sparrow

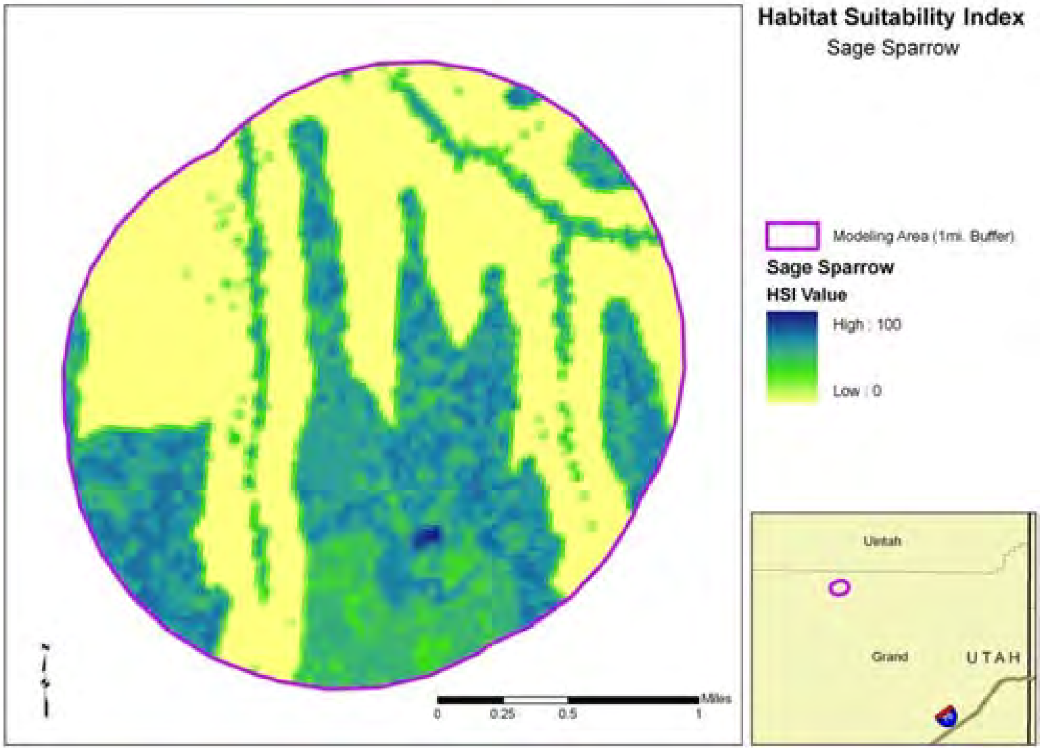


Figure B-209. Pre-treatment habitat suitability map for sage sparrow habitat for the Rock Springs project, Utah.

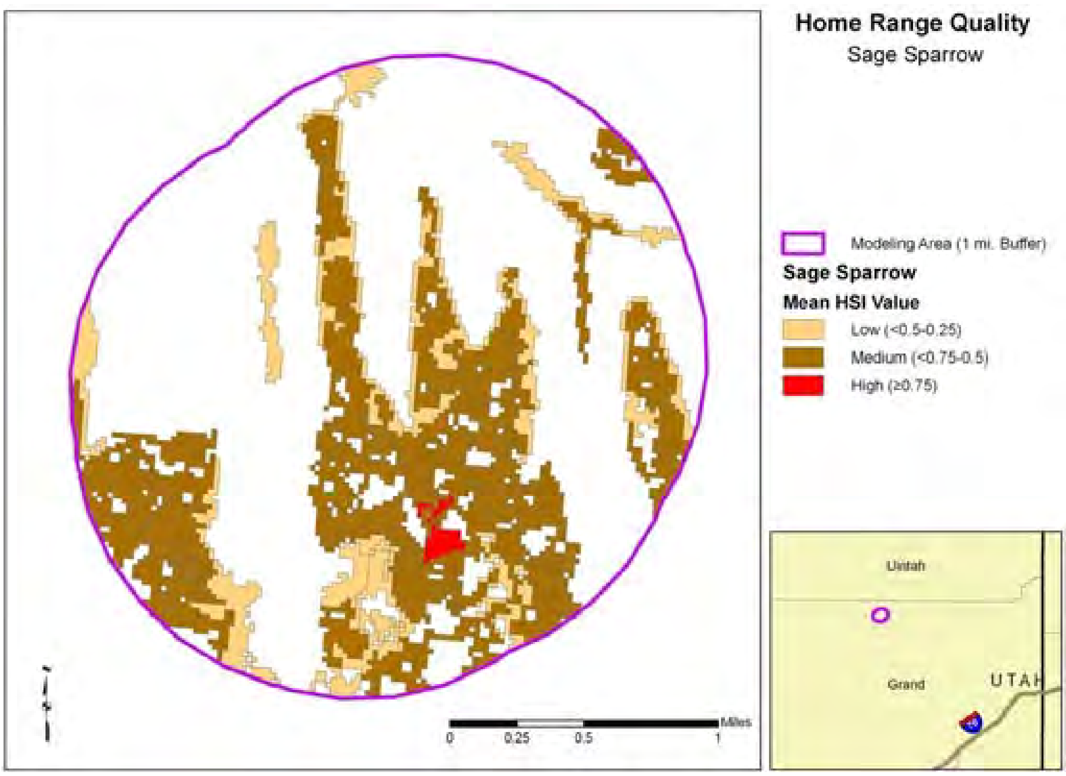


Figure B-210. Pre-treatment potential home range map for sage sparrow for the Rock Springs project, Utah.

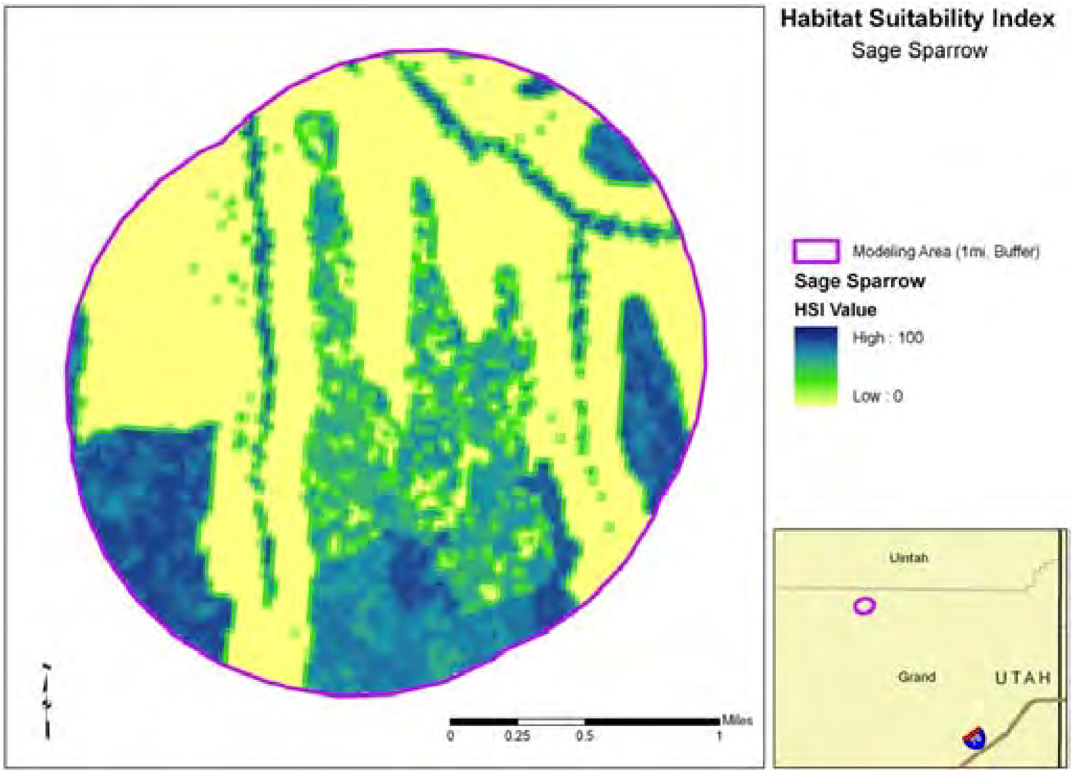


Figure B-211. Post-treatment habitat suitability map for sage sparrow habitat for the Rock Springs project, Utah.

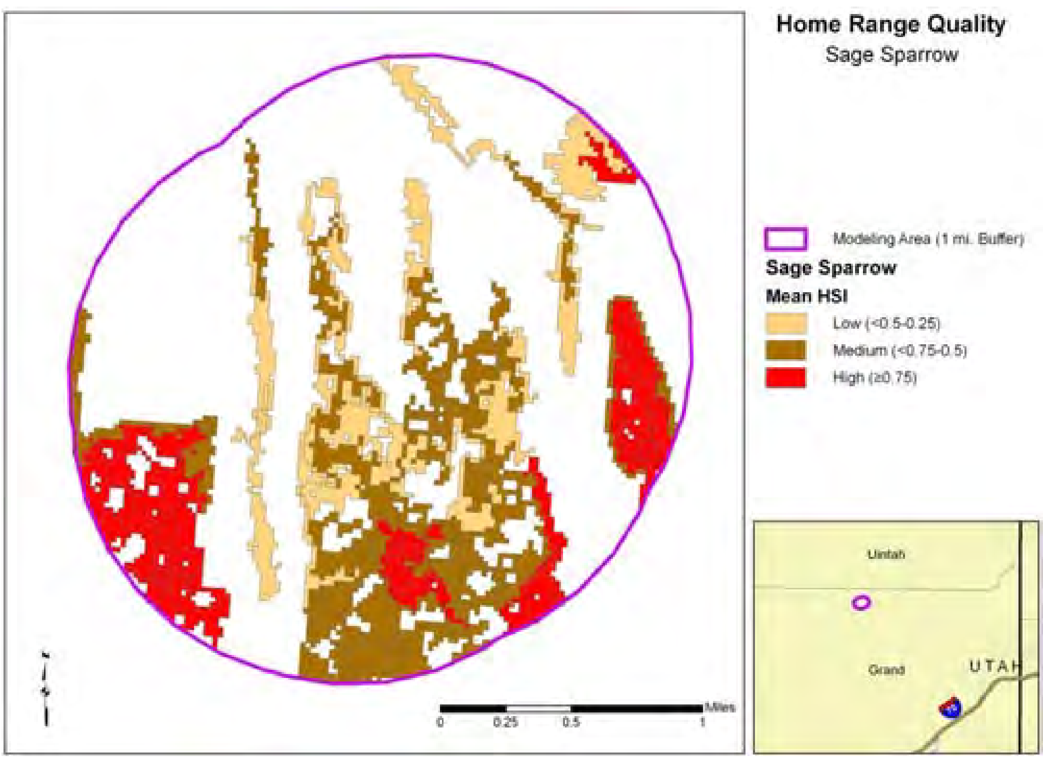


Figure B-212. Post-treatment potential home range map for sage sparrows for the Rock Springs project, Utah.

Sagebrush Lizard

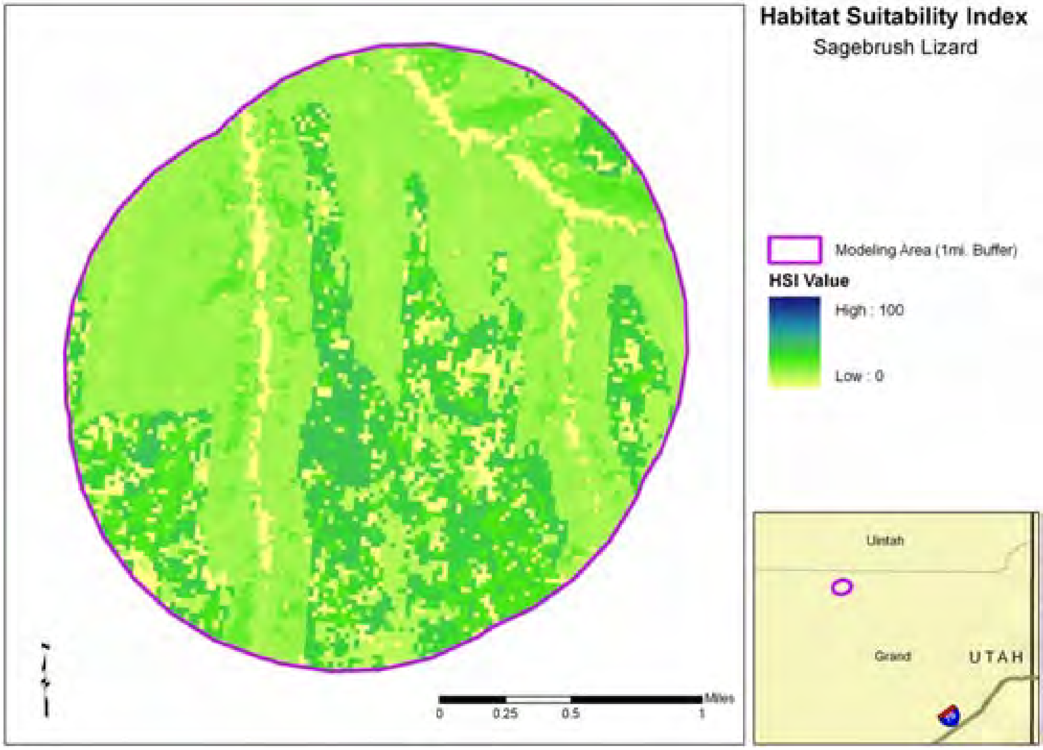


Figure B-213. Pre-treatment habitat suitability map for sagebrush lizard habitat for the Rock Springs project, Utah.

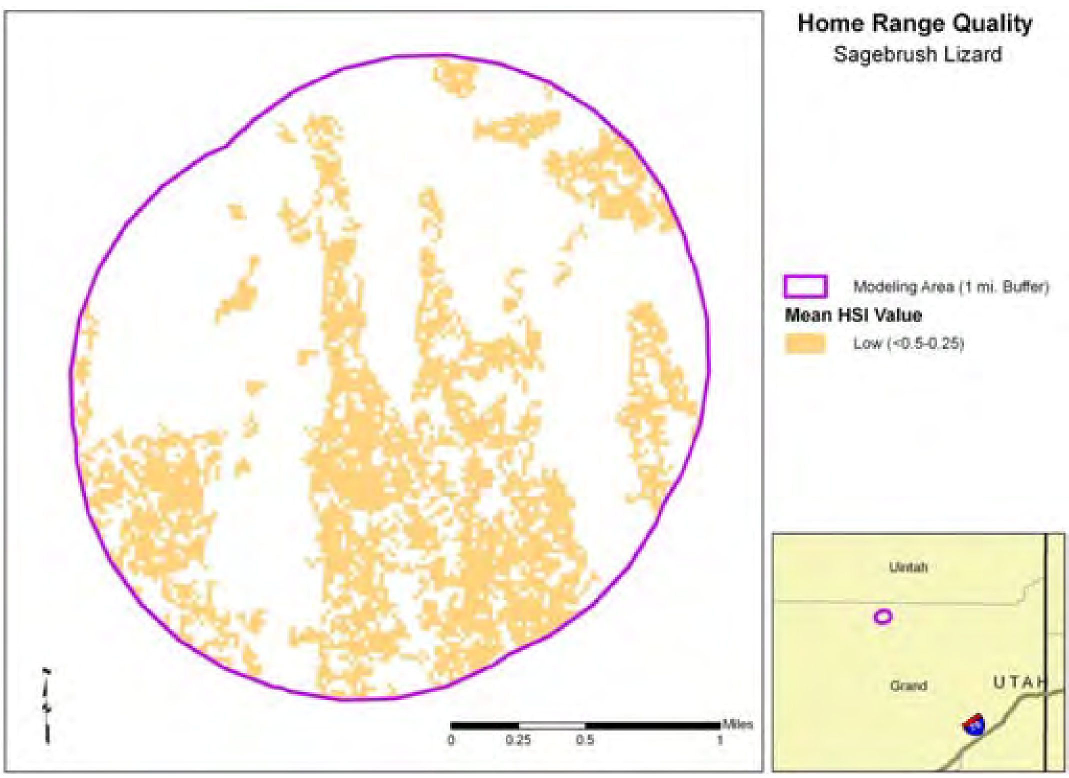


Figure B-214. Pre-treatment potential home range map for sagebrush lizard for the Rock Springs project, Utah.

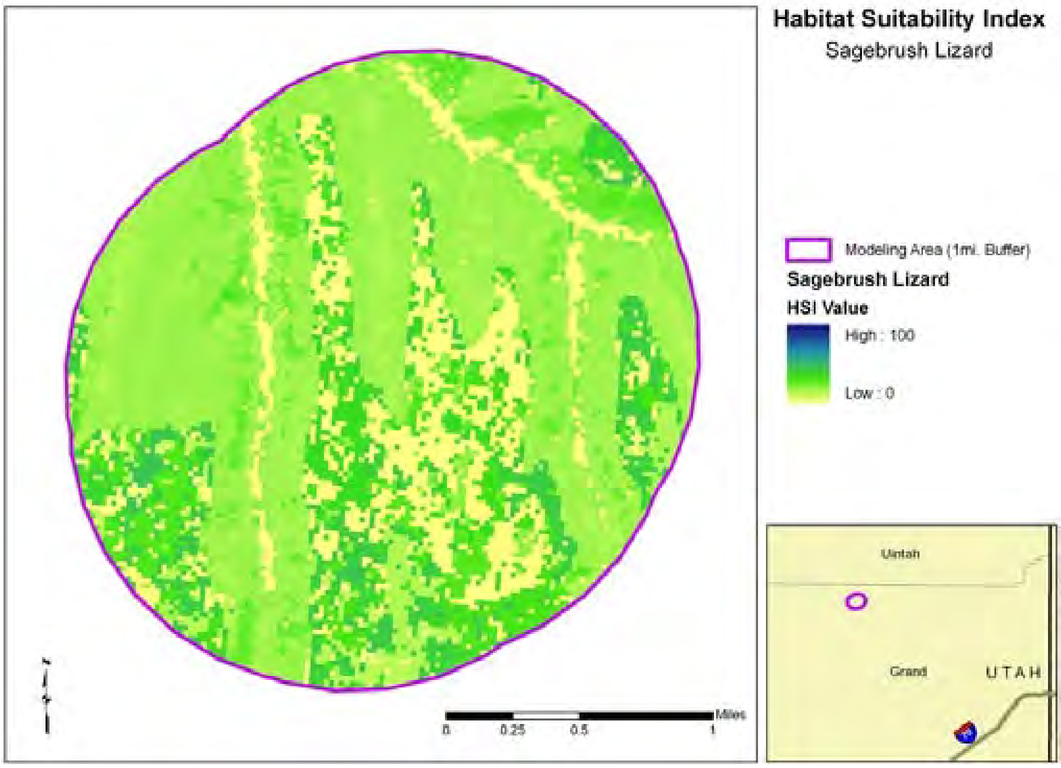


Figure B-215. Post-treatment habitat suitability map for sagebrush lizard habitat for the Rock Springs project, Utah.

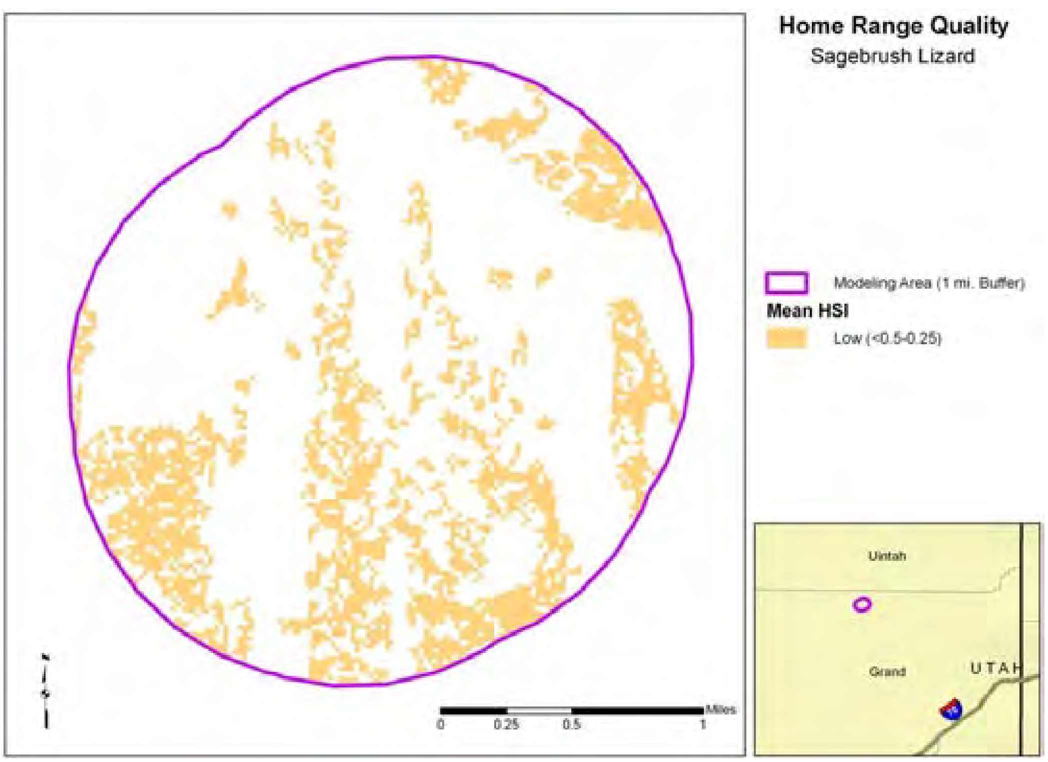


Figure B-216. Post-treatment potential home range map for sagebrush lizards for the Rock Springs project, Utah.

Sagebrush Vole

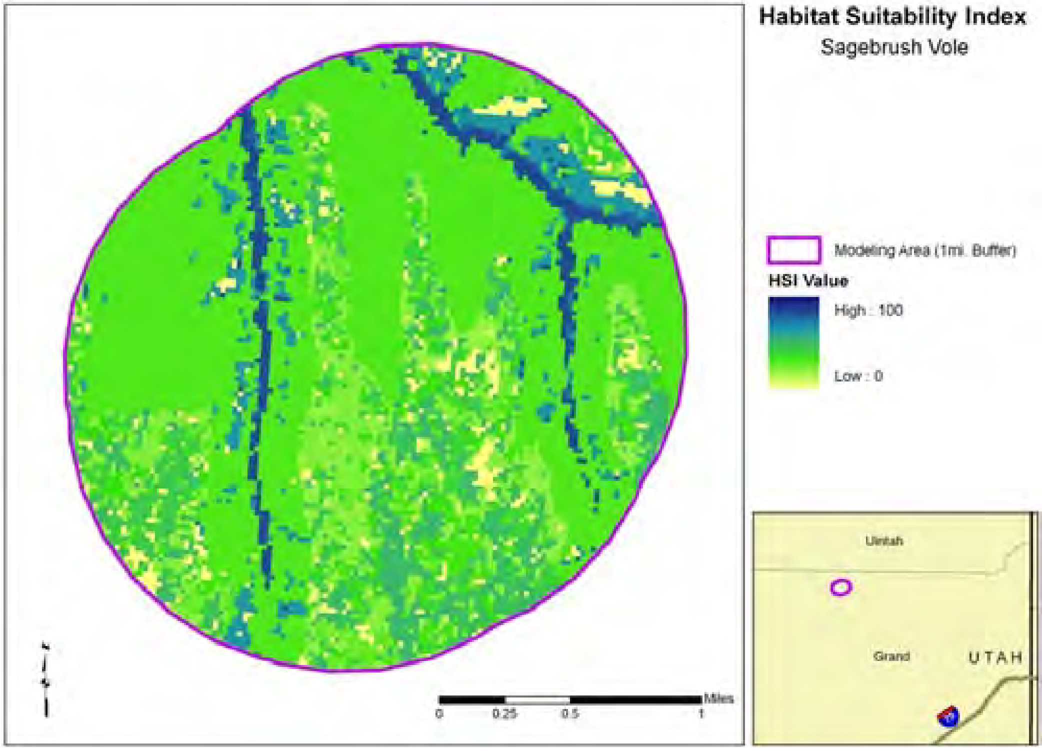


Figure B-217. Pre-treatment habitat suitability map for sagebrush vole habitat for the Rock Springs project, Utah.

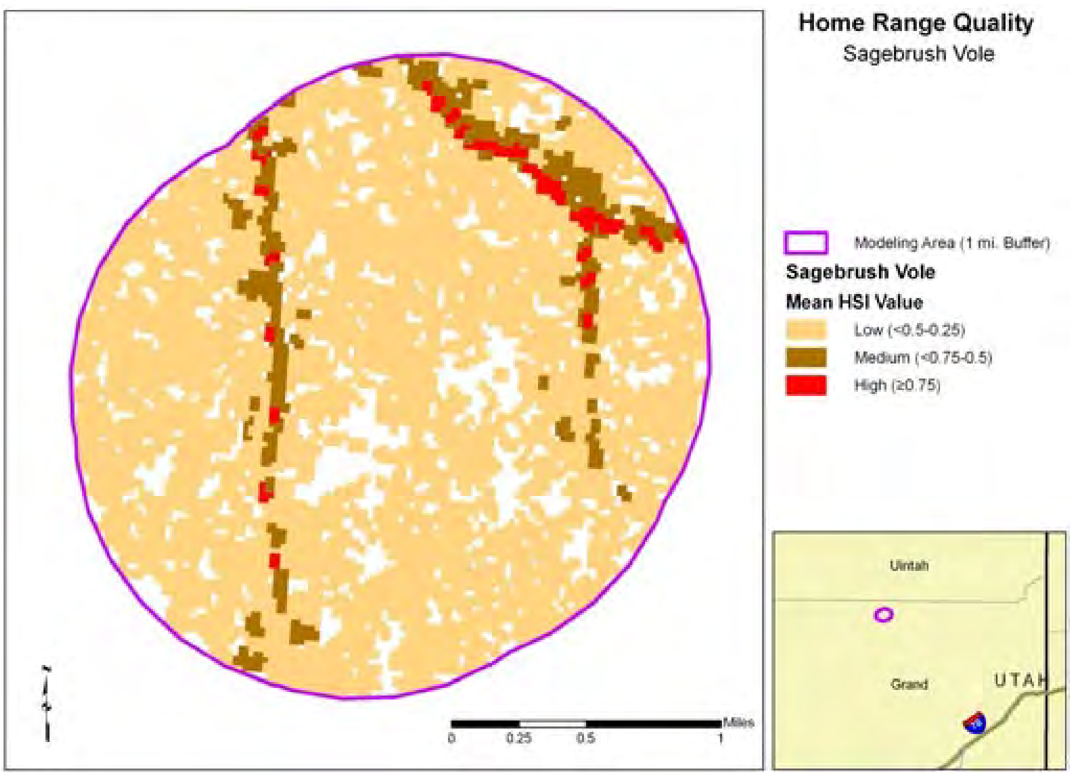


Figure B-218. Pre-treatment potential home range map for sagebrush vole for the Rock Springs project, Utah.

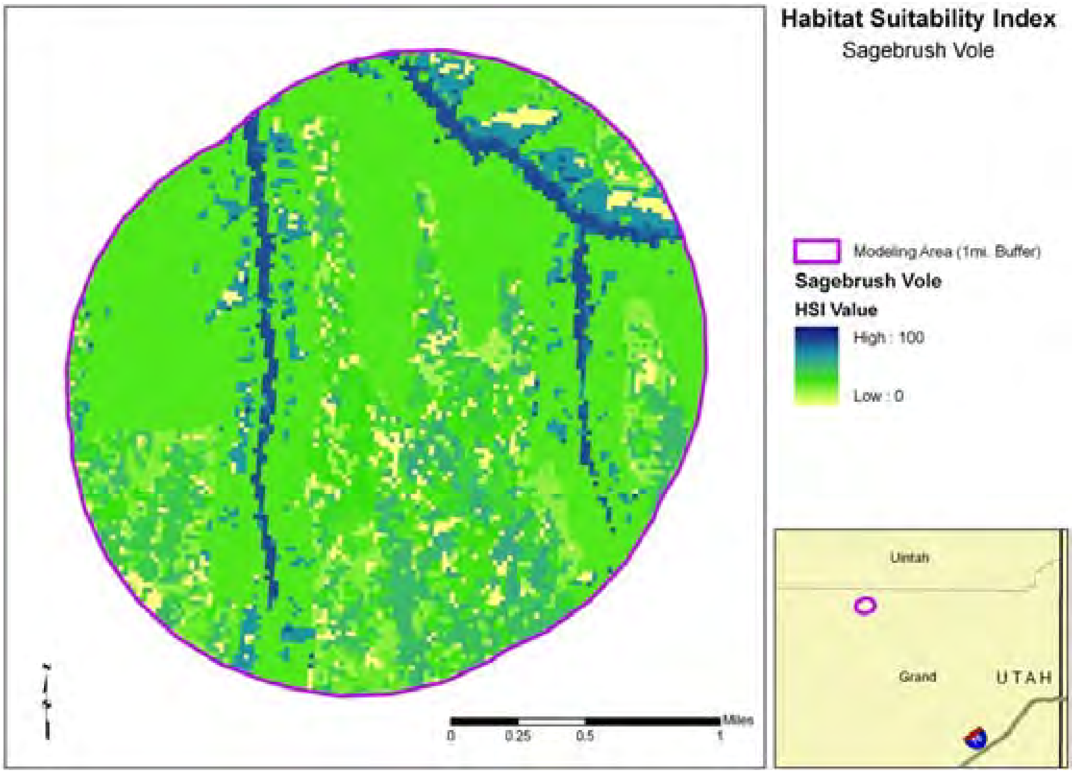


Figure B-219. Post-treatment habitat suitability map for sagebrush vole habitat for the Rock Springs project, Utah.

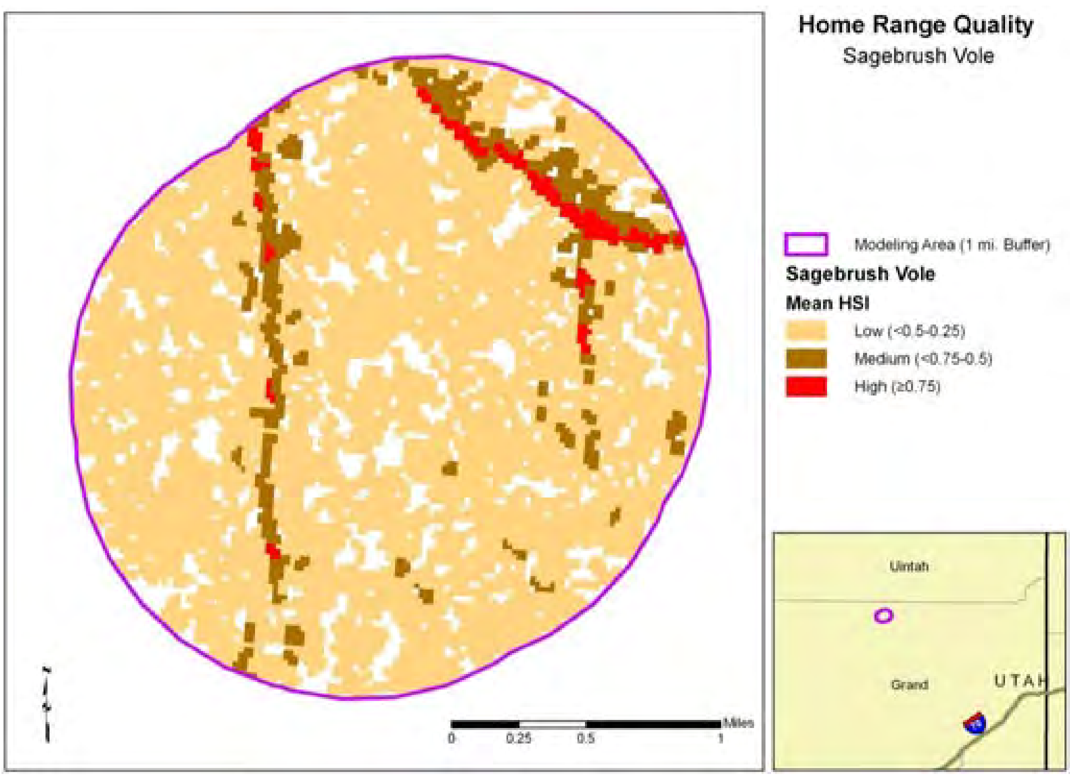


Figure B-220. Post-treatment potential home range map for sagebrush voles for the Rock Springs project, Utah.

12.0 APPENDIX C. SCIENTIFIC NAMES OF SPECIES MENTIONED IN THE REPORT

Animals

Common Name	Scientific Name
Greater sage grouse	*Centrocercus urophasianus*
Pronghorn antelope	*Antilocapra americana*
Pygmy rabbit	*Brachylagus idahoensis*
Sage thrasher	*Oreoscoptes montanus*
Sagebrush vole	*Lemmiscus curtatus*
Sage sparrow	*Amphispiza belli*
Sagebrush lizard	*Sceloporus graciosus*
Mule deeer	*Odocoileus hemionus*
Brewer's sparrow	*Spizella breweri*

Plants

Common Name	Scientific Name	Symbol	Growth Habit	Native Status
agoseris	Agoseris	AGOSE	Forb/herb	
American vetch	Vicia americana	VIAM	Forb/herb	N
antelope bitterbrush	Purshia tridentata	PUTR2	Shrub	N
arrowleaf balsamroot	Balsamorhiza sagittata	BASA3	Forb/herb	N
aster	Aster	ASTER	Forb/herb	
bastard toadflax	Comandra	COMAN	Forb/herb	
beardtongue	Penstemon	PENST	Forb/herb	
beggarticks	Bidens	BIDEN	Forb/herb	
big sagebrush	Artemisia tridentata	ARTR2	Shrub	N
blue grama	Bouteloua gracilis	BOGR2	Graminoid	N
bluebunch wheatgrass	Pseudoroegneria spicata	PSSP6	Graminoid	N
broom snakeweed	Gutierrezia sarothrae	GUSA2	Forb/herb	N
buckwheat	Eriogonum	ERIOG	Forb/herb	
bulbous bluegrass	Poa bulbosa	POBU	Graminoid	I
bull thistle	Cirsium vulgare	CIVU	Forb/herb	I
cheatgrass	Bromus tectorum	BRTE	Graminoid	I
cinquefoil	Potentilla	POTEN	Forb/herb	
clasping pepperweed	Lepidium perfoliatum	LEPE2	Forb/herb	I
common dandelion	Taraxacum officinale	TAOF	Forb/herb	N
common pepperweed	Lepidium densiflorum	LEDE	Forb/herb	N
common woolly sunflower	Eriophyllum lanatum	ERLA6	Forb/herb	N

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common yarrow	Achillea millefolium	ACMI2	Forb/herb	N
crested wheatgrass	Agropyron cristatum	AGCR	Graminoid	I
cryptantha	Cryptantha	CRYPT	Forb/herb	
cudweed	Gnaphalium	GNAPH	Forb/herb	
desertparsley	Lomatium	LOMAT	Forb/herb	
diffuse knapweed	Centaurea diffusa	CEDI3	Forb/herb	I
Douglas' dustymaiden	Chaenactis douglasii	CHDO	Forb/herb	N
Douglas' sedge	Carex douglasii	CADO2	Graminoid	N
field brome	Bromus arvensis	BRAR5	Graminoid	I
field locoweed	Oxytropis campestris	OXCA4	Forb/herb	N
fleabane	Erigeron	ERIGE2	Forb/herb	
gilia	Gilia	GILIA	Forb/herb	N
globemallow	Sphaeralcea	SPHAE	Forb/herb	
granite prickly phlox	Linanthus pungens	LIPU11	Forb/herb	N
green needlegrass	Nassella viridula	NAVI4	Graminoid	N
groundsmoke	Gayophytum	GAYOP	Forb/herb	
hairy false goldenaster	Heterotheca villosa	HEVI4	Forb/herb	N
Idaho fescue	Festuca idahoensis	FEID	Graminoid	N
Indian paintbrush	Castilleja	CASTI2	Forb/herb	
Indian ricegrass	Achnatherum hymenoides	ACHY	Graminoid	N
intermediate wheatgrass	Thinopyrum intermedium	THIN6	Graminoid	I
Junegrass	Koeleria	KOELE	Graminoid	N
juniper	Juniperus	JUNIP	Tree	N
Lava aster	Ionactis alpina	IOAL	Forb/herb	N
lily	Lilium	LILIU	Forb/herb	
little bluestem	Schizachyrium	SCHIZ4	Graminoid	N
little sagebrush	Artemisia arbuscula	ARAR8	Subshrub	N
longleaf phlox	Phlox longifolia	PHLO2	Forb/herb	N
lupine	Lupinus	LUPIN	Forb/herb	
maiden blue eyed Mary	Collinsia parviflora	COPA3	Forb/herb	N
mat penstemon	Penstemon caespitosus	PECA4	Forb/herb	N
milkvetch	Astragalus	ASTRA	Forb/herb	
mountain mahogany	Cercocarpus	CERCO	Shrub	N
muttongrass	Poa fendleriana	POFE	Graminoid	N
needle and thread	Hesperostipa	HESPE11	Graminoid	N
onion	Allium	ALLIU	Forb/herb	
pale madwort	Alyssum alyssoides	ALAL3	Forb/herb	I
phacelia	Phacelia	PHACE	Forb/herb	
phlox	Phlox	PHLOX	Forb/herb	
pine	Pinus	PINUS	Tree	N
plains pricklypear	Opuntia polyacantha	OPPO	Shrub	N

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prairie Junegrass	Koeleria macrantha	KOMA	Graminoid	N
prairie milkvetch	Astragalus laxmannii var. robustior	ASLAR	Forb/herb	N
prairie sagewort	Artemisia frigida	ARFR4	Subshrub	N
prairie sandreed	Calamovilfa longifolia	CALO	Graminoid	N
prickly lettuce	Lactuca serriola	LASE	Forb/herb	I
prickly Russian thistle	Salsola tragus	SATR12	Forb/herb	I
purple locoweed	Oxytropis lambertii	OXLA3	Forb/herb	N
purple threeawn	Aristida purpurea	ARPU9	Graminoid	N
pussytoes	Antennaria	ANTEN	Forb/herb	
ragwort	Packera	PACKE	Forb/herb	
rosy pussytoes	Antennaria rosea	ANRO2	Forb/herb	N
rubber rabbitbrush	Ericameria nauseosa	ERNA10	Shrub	N
sagebrush false dandelion	Nothocalais troximoides	NOTR2	Forb/herb	N
sainfoin	Onobrychis	ONOBR	Forb/herb	
Sandberg bluegrass	Poa secunda	POSE	Graminoid	N
sandwort	Arenaria	ARENA	Forb/herb	
scarlet beeblossom	Gaura coccinea	GACO5	Forb/herb	N
scarlet globemallow	Sphaeralcea coccinea	SPCO	Forb/herb	N
sedge	Carex	CAREX	Graminoid	N
Siberian wheatgrass	Agropyron fragile	AGFR	Graminoid	I
silver sagebrush	Artemisia cana	ARCA13	Shrub	N
silverleaf phacelia	Phacelia hastata	PHHA	Forb/herb	N
sixweeks fescue	Vulpia octoflora	VUOC	Graminoid	N
slender phlox	Microsteris gracilis	MIGR	Forb/herb	N
slender wheatgrass	Elymus trachycaulus	ELTR7	Graminoid	N
slimflower scurfpea	Psoralidium tenuiflorum	PSTE5	Forb/herb	N
spiny phlox	Phlox hoodii	PHHO	Forb/herb	N
spreading groundsmoke	Gayophytum diffusum	GADI2	Forb/herb	N
squirreltail	Elymus elymoides	ELEL5	Graminoid	N
squirreltail	Elymus elymoides	ELEL5	Graminoid	N
stickseed	Hackelia	HACKE	Forb/herb	
sulphur-flower buckwheat	Eriogonum polyanthum	ERPO16	Forb/herb	N
tall annual willowherb	Epilobium brachycarpum	EPBR3	Forb/herb	N
tall tumblemustard	Sisymbrium altissimum	SIAL2	Forb/herb	I
tall wheatgrass	Thinopyrum ponticum	THPO7	Graminoid	I
textile onion	Allium textile	ALTE	Forb/herb	N
thickspike wheatgrass	Elymus lanceolatus	ELLA3	Graminoid	N
thistle	Cirsium	CIRSI	Forb/herb	
threadleaf sedge	Carex filifolia	CAFI	Graminoid	N
Thurber's needlegrass	Achnatherum thurberianum	ACTH7	Graminoid	N

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tiny trumpet	Collomia linearis	COLI2	Forb/herb	N
toadflax	Linaria	LINAR	Forb/herb	
trumpet	Collomia	COLLO	Forb/herb	
twogrooved milkvetch	Astragalus bisulcatus	ASBI2	Forb/herb	N
twoneedle pinyon	Pinus edulis	PIED	Tree	N
Utah juniper	Juniperus osteosperma	JUOS	Tree	N
vetch	Vicia	VICIA	Forb/herb	
western juniper	Juniperus occidentalis	JUOC	Tree	N
western tansymustard	Descurainia pinnata	DEPI	Forb/herb	N
western wheatgrass	Pascopyrum smithii	PASM	Graminoid	N
white prairie aster	Symphyotrichum falcatum	SYFA	Forb/herb	N
whitestem frasera	Frasera albicaulis	FRAL2	Forb/herb	N
Wilcox's woollystar	Eriastrum wilcoxii	ERWI	Forb/herb	N
willowherb	Epilobium	EPILO	Forb/herb	
woodland-star	Lithophragma	LITHO2	Forb/herb	
woolly mule-ears	Wyethia mollis	WYMO	Forb/herb	N
woolly plantain	Plantago patagonica	PLPA2	Forb/herb	N
yellow rabbitbrush	Chrysothamnus viscidiflorus	CHVI8	Shrub	N
yellow salsify	Tragopogon dubius	TRDU	Forb/herb	I