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Spatially Explicit Modeling of Annual and Seasonal Habitat for Greater Sage-Grouse (*Centrocercus urophasianus*) in Nevada and Northeastern California—An Updated Decision-Support Tool for Management

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U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph of a male greater sage-grouse performing a courtship display on a lek in Nevada.
Photograph courtesy of Tatiana Gettleman.

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SALLY JEWELL, Secretary

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)

SI to Inch/Pound

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
square hectometer (hm^2)	2.471	acre
square meter (m^2)	10.76	square foot (ft^2)

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83).

Elevation, as used in this report, refers to distance above the vertical datum.

Acronyms and Abbreviations

AICc	Akaike's information criterion with second-order bias correction
ΔAICc	difference between model of interest and most parsimonious model
AUI	abundance and space use index
CDFW	California Department of Fish and Wildlife
GIS	Geographic Information System
GPS	Global Positioning System
HSI	habitat suitability index
K	number of parameters
κ	Cohen's kappa coefficient
LANDFIRE	Landscape Fire and Resource Management Planning Tools
MCP	Minimum Convex Polygon
PMU	population management unit
PTT	Platform Transmitter Terminal
NDOW	Nevada Department of Wildlife
r	correlation coefficient
RSF	resource selection function
SD	standard deviation
TPI	topographic position index
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
vUD	volume of population level utilization distribution

Supplemental Information

Note to USGS users: Use of hectare (ha) as an alternative name for square hectometer (hm^2) is restricted to the measurement of small land or water areas.

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Spatially Explicit Modeling of Annual and Seasonal Habitat for Greater Sage-Grouse (*Centrocercus urophasianus*) in Nevada and Northeastern California—An Updated Decision-Support Tool for Management

By Peter S. Coates[1], Michael L. Casazza[1], Brianne E. Brussee[1], Mark A. Ricca[1], K. Benjamin Gustafson[1], Erika Sanchez-Chopitea[1], Kimberly Mauch[1], Lara Niell[2,3], Scott Gardner[4], Shawn Espinosa[3], and David J. Delehanty[5]

Abstract

Successful adaptive management hinges largely upon integrating new and improved sources of information as they become available. As a timely example of this tenet, we updated a management decision support tool that was previously developed for greater sage-grouse (*Centrocercus urophasianus,* hereinafter referred to as "sage-grouse") populations in Nevada and California. Specifically, recently developed spatially explicit habitat maps derived from empirical data played a key role in the conservation of this species facing listing under the Endangered Species Act. This report provides an updated process for mapping relative habitat suitability and management categories for sage-grouse in Nevada and northeastern California (Coates and others, 2014, 2016). These updates include: (1) adding radio and GPS telemetry locations from sage-grouse monitored at multiple sites during 2014 to the original location dataset beginning in 1998; (2) integrating output from high resolution maps (1–2 m^2) of sagebrush and pinyon-juniper cover as covariates in resource selection models; (3) modifying the spatial extent of the analyses to match newly available vegetation layers; (4) explicit modeling of relative habitat suitability during three seasons (spring, summer, winter) that corresponded to critical life history periods for sage-grouse (breeding, brood-rearing, over-wintering); (5) accounting for differences in habitat availability between more mesic sagebrush steppe communities in the northern part of the study area and drier Great Basin sagebrush in more southerly regions by categorizing continuous region-wide surfaces of habitat suitability index (HSI) with independent locations falling within two hydrological zones; (6) integrating the three seasonal maps into a composite map of annual relative habitat suitability; (7) deriving updated land management categories based on previously determined cut-points for intersections of habitat suitability and an updated index of sage-grouse abundance and space-use (AUI); and (8) masking urban footprints and major roadways out of the final map products.

[1]U.S. Geological Survey.
[2]Nevada Sagebrush Ecosystem Program.
[3]Nevada Department of Wildlife.
[4]California Department of Fish and Wildlife.
[5]Idaho State University, Department of Biological Sciences.

Seasonal habitat maps were generated based on model-averaged resource selection functions (RSF) derived for 10 project areas (813 sage-grouse; 14,085 locations) during the spring season, 10 during the summer season (591 sage-grouse, 11,743 locations), and 7 during the winter season (288 sage-grouse, 4,862 locations). RSF surfaces were transformed to HSIs and averaged in a GIS framework for every pixel for each season. Validation analyses of categorized HSI surfaces using a suite of independent datasets resulted in an agreement of 93–97 percent for habitat versus non-habitat on an annual basis. Spring and summer maps validated similarly well at 94–97 percent, while winter maps validated slightly less accurately at 87–93 percent.

We then provide an updated example of how space use models can be integrated with habitat models to help inform conservation planning. We used updated lek count data to calculate a composite abundance and space use index (AUI) that comprised the combination of probabilistic breeding density with a non-linear probability of occurrence relative to distance to nearest lek. The AUI was then classified into two categories of use (high and low-to-no) and intersected with the HSI categories to create potential management prioritization scenarios based on information about sage-grouse occupancy coupled with habitat suitability. Compared to Coates and others (2014, 2016), the amount of area classified as habitat across the region increased by 6.5 percent (approximately 1,700,000 acres). For management categories, core increased by 7.2 percent (approximately 865,000 acres), priority increased by 9.6 percent (approximately 855,000 acres), and general increased by 9.2 percent (approximately 768,000 acres), while non-habitat decreased (that is, classified non-habitat occurring outside of areas of concentrated use) by 11.9 percent (approximately 2,500,000 acres). Importantly, seasonal and annual maps represent habitat for all age and sex classes of sage-grouse (that is, sample sizes of marked grouse were insufficient to only construct models for reproductive females). This revised sage-grouse habitat mapping product helps improve adaptive application of conservation planning tools based on intersections of spatially explicit habitat suitability, abundance, and space use indices.

Introduction

Greater sage-grouse (*Centrocercus urophasianus*, hereinafter referred to as "sage-grouse") are considered an umbrella (Rich and Altman, 2001; Rich and others, 2005; Rowland and others, 2006) or indicator species for the ecological integrity of sagebrush (*Artemisia* spp.) ecosystems at large landscape scales due to the species' dependence on sagebrush dominated habitats, as well as their propensity to occupy sagebrush habitat across large spatial scales during the course of seasonal self-maintenance needs and reproduction (Knick and Connelly, 2011). Sage-grouse populations have declined with the loss, degradation, and fragmentation of sagebrush ecosystems (Knick and Connelly, 2011), and currently (circa 2014) occupy slightly more than one-half of their former range across Western North America (Schroeder and others, 2004; Miller and others, 2011). These and other threats have led multiple listing petitions for the species under the Endangered Species Act, the most recent of which ruled that protection was not warranted presently (U.S. Fish and Wildlife Service, 2015). That decision was based, in part, on having adequate management plans in place that are informed by the best-available science.

Sage-grouse occurring within the Great Basin ecoregion of Nevada and northeastern California represent more than 25 percent of the present range-wide distribution of the species. In an effort to provide information necessary for management decisions for sage-grouse within Nevada and California, Coates and others (2014, 2016) developed an analytical tool that used data replicated across broad geographical ranges to inform landscape level decisions, but that could also be downscaled to inform local management decisions. Specifically, the tool utilized a combination of: (1) habitat suitability index (HSI) maps derived from resource selection function models (RSF, Boyce and McDonald, 1999; Manly and others, 2002) informed by radio-telemetry data from sage-grouse marked across 10 sites and 15 years of data; and (2) an index of sage-grouse abundance and space-use (AUI) based on the distribution and density of breeding leks and attendance patterns by males. Spatial intersections between HSI and AUI layers created a joint-index of management categories that can be used to guide different levels of management intensity based on sage-grouse habitat suitability and where sage-grouse are likely to occur. For example, this approach allows identification and classification of "core" management areas where modeled high quality habitat intersects modeled high abundance. Importantly, cutoffs for categories related to different levels of management intensity are derived from a multi-stakeholder process that can be adapted based on desired conservation objectives and thresholds. We refer readers to Coates and others (2014, 2016) for more detailed background and rationale.

Coates and others (2014, 2016) also stressed that the tool be utilized within an adaptive management framework that allows for updates that take into account new and improved sources of data as they become available. For example, Coates and others (2014, 2016) mapped habitat across the annual life-history of sage-grouse in Nevada and northeastern California using Geographical Information Systems (GIS) layers derived primarily from coarser-scale Landsat imagery. Moreover, they accounted for seasonal variation in habitat selection patterns by weighting sage-grouse locations according to season within the annual model, but they did not map habitat suitability specific to life-history stages that are important for sage-grouse, particularly nesting, brooding-rearing, and over-wintering periods (for example, Rice and others, 2013; Fedy and others, 2014). Hence, the maps presented in this report represent an update to Coates and others (2014, 2016) that can facilitate adaptive management, whereby seasonal habitat suitability is now explicitly mapped using finer-scale land cover variables and seasonally binned location data. These updated maps also take into account broad-scale patterns of precipitation that can produce regional differences in the way sage-grouse respond to habitat availability. Seasonal maps are then combined multiplicatively to create composite surfaces and categories of annual habitat suitability, and intersected with an AUI based on the most recent lek counts conducted in 2015. The end-product of this approach is an updated map illustrating example management categories that can be used to prioritize sage-grouse habitat conservation across northeastern California and Nevada. This work was completed in partnership with the State of Nevada Sagebrush Ecosystem Technical Team, the Nevada Department of Wildlife (NDOW), the Bureau of Land Management, and the California Department of Fish and Wildlife (CDFW).

Methods and Results

Overview and Conceptual Models

The updated quantitative approach to develop a spatially explicit support tool for conservation planning consisted of multiple steps that we describe in detail below and outline in a conceptual model (fig. 1). The overall modeling framework comprised input datasets (blue rectangular boxes) that were subjected to a series of processing steps (black rounded boxes) to produce interim (blue parallelograms) and final spatially explicit raster (red parallelograms) and vector (orange parallelograms) based on maps of habitat suitability and abundance-space use (fig. 1).

In summary, we first compiled sage-grouse telemetry location data from multiple areas across Nevada and northeastern California for each season, and divided these data into three independent and season-specific sets for the purposes of (1) model training (80 percent of locations); (2) mapping classification (10 percent); and (3) map validation (10 percent) (see section, "Habitat Suitability Model Development"). Seasons comprised spring, summer, and winter and corresponded to critical to life history periods for sage-grouse (breeding, brood-rearing, over-wintering) (see section, "Delineating Seasons"). The training dataset was linked spatially with corresponding environmental covariates to enable calculation of population-level RSFs (Manly and others, 2002) within seasonal subregions with adequate data. To achieve this, we first identified the relevant spatial scale and linear relationships of environmental characteristics. Next, model-averaged parameter estimates for influential covariates among all candidate models were calculated to account for model selection uncertainty (Burnham and Anderson, 2002) (see section, "RSF Analyses"). We then used those estimates to develop spatially explicit models reflecting the relative probability of selection of habitat features by season for each subregion by (1) transforming the RSF model into an HSI; (2) extrapolating the HSI across the extent of the entire region (that is, the extent of northeastern California and Nevada); and (3) averaging the HSI predictions generated from each subregion to provide interim region-wide HSI raster maps by season. To represent the relative probability of selection on an annual basis based on modeled patterns of selection across seasons, we multiplied the three interim and seasonal region-wide maps together to form a composite annual (and interim) HSI. Because strong patterns of precipitation exist along an approximate north-south gradient in the Great Basin, we accounted for broad-scale variation in selection by clipping each interim HSI (seasonal and annual) by a modified hydrographic boundary (see section, "Accounting for Geographic Variation in Habitat Suitability") that represented two broad 'north' and 'south' categories that represented wetter (mesic) and drier (xeric) areas across the entire region. We then proceeded to re-calculate seasonal and annual HSI raster surfaces and categories for habitat suitability by hydrographic boundary. For continuous HSI surfaces, we (1) rescaled HSI values within each hydrographic category according to their respective maximum value, so that, for example, values indicating high suitability in the south would not be diluted by larger values of high suitability in the north; and (2) mosaicked the clipped surfaces together. The composite annual HSI map comprised the multiplicative product of the three seasonal maps. For deriving categories, we (1) extracted HSI values to the classification datasets, also clipped by the hydrographic boundary; (2) formed four habitat categories representing descending probability of selection based on the distribution (that is, mean and variance) of the extracted values; and (3) re-mosaicked the clipped maps to form region-wide maps.

Independent validation datasets were then used to assess the predictive accuracy of the region-wide map. We calculated the average proportion of validation telemetry data occurring within each habitat category for each bird within each of the training subregions (that is, RSF subregions), which served as a measure of predictability in explicitly modeled areas. We also used independent subregions (that is, non-RSF subregions) that had insufficient telemetry data for formal RSF modeling to assess the map accuracy in interpolated areas. Locations of active leks were used as an additional dataset for map validation (see section, "Region-Wide Habitat Suitability Index and Implementation for Conservation Planning").

From the HSIs, information about the probability of selection was produced solely on predicted associations of sage-grouse with environmental covariates. However, the model does not incorporate knowledge of sage-grouse abundance and density that represents space occupied currently by sage-grouse. Therefore, an AUI was created based on the most up-to-date data from lek counts that describe how sage-grouse are distributed spatially and numerically in relation to traditional breeding congregation areas. Specifically, the AUI integrated information on lek density, lek size (that is, average yearly maximum count of males attending a lek over a 5-year period), and the non-linear relation between probability of space use and distance to lek, which was then used to delineate categories of high use or low-to-no use across the region. To provide a modeling tool that can aid conservation planning, the region-wide annual HSI (categorized into high, moderate, low, and non-habitat based on the variance distribution of HSI values) and high and low-to-no use AUI categories (derived from stakeholder consensus) were combined into an updated single region-wide map. This map simultaneously reflects both the presence of sage-grouse and the presence of habitat features associated with sage-grouse occupancy, and can then be used to prioritize areas for different management scenarios. The strength of this map is that it accounts for characteristics that describe the quality of the environment for sage-grouse within and among seasons and incorporates an index of population abundance and distribution. This technique can be used to aid decision-making processes across the landscape (see section, "Implementation of the Region-Wide HSI Map for Conservation Planning—An Example").

Habitat Suitability Model Development

Delineating the Region-Wide Extent

The region-wide extent of the project area was defined by using the outer perimeter of all combined sage-grouse Population Management Units (PMU; Nevada Department of Wildlife, 2014) in Nevada and northeastern California plus a 8.5-km buffer (fig. 2). This approached yielded an area of 21.2 million ha that approximated the total potential sage-grouse range in Nevada and California We excluded the Bi-State Distinct Population Segment on the eastern side of the central Sierra Nevada Mountains. The region-wide extent in this study varied from the extent used in Coates and others (2014, 2016) by excluding the northern edge of the Nevada Test Range that bordered the southeastern extent of the project area, and portions of Modoc County to the north of the Buffalo-Skedaddle PMU in northeastern California. These areas lacked coverage for high resolution sagebrush or pinyon-juniper GIS layers that were used in the updated RSF modeling (see section, "Classification of Landscape Habitat Features"). A 10-km buffer was originally set to allow adequate area for moving window analyses to accurately quantify habitat availability near the PMU edges. We then subtracted the outer 1.5 km to exclude incorrect values (arising from truncated moving window) at the buffer boundary, which yielded the final 8.5-km buffer.

Floristically, the region was typical of the Great Basin and dominated by Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and black (*Artemisia nova*) and low (*Artemisia arbuscula*) sagebrush occurring at elevations below 2,100 m. Mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana*) occurred more frequently at high elevations. Common non-sagebrush shrubs included rabbitbrush (*Chrysothamnus* ssp.), Mormon tea (*Ephedra viridis*), snowberry (*Symphoricarpos* ssp.), western serviceberry (*Amelanchier alnifolia*), and antelope bitterbrush (*Purshia tridentata*). Conifer forests were most frequently comprised of single-leaf pinyon pine (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) (hereinafter, "pinyon-juniper"). Non-native and highly invasive annual grasses included cheatgrass (*Bromus tectorum*) and medusahead rye (*Taeniatherum caput-medusae*). Native perennial grasses included needle and thread (*Hesperostipa comata*), Indian ricegrass (*Achnatherum hymenoides*), and squirreltail (*Elymus elymoides*).

Sage-Grouse Telemetry Data

Data used in the study were generated from multiple sage-grouse telemetry studies across Nevada and northeastern California conducted from 1998 through 2014 by USGS, NDOW, CDFW, Idaho State University, University of Idaho, and University of Nevada-Reno. Field data collection protocols for tracking and locating sage-grouse were generally consistent across sites and years. Data were excluded from the analyses in situations where data collection procedures or supporting information differed substantially from norms. For example, telemetry data were removed from the analyses when a unique bird identifier or location date was absent or birds had less than two locations total.

Generally, sage-grouse were captured in close proximity to leks in spring (March–April) and at various areas where sage-grouse congregate in autumn (October–December) using spotlighting techniques at night (Giesen and others, 1982; Wakkinen and others, 1992). Captured sage-grouse were outfitted with necklace-style VHF radio-transmitters (Kolada and others, 2009). Over the 16-year period (1998–2014), personnel across agencies and organizations conducted on-the-ground monitoring of sage-grouse. In lieu of VHF only radio-transmitters, a subsample of sage-grouse at some sites during 2012, 2013, and 2014 were outfitted with a combined Global Positioning Systems (GPS) - Platform Transmitter Terminals (PTTs; North Star Science and Technology, LLC, King George, Virginia) and VHF transmitter system. This system had a combined weight of less than 3 percent of sage-grouse body mass. The purpose of the GPS transmitter was to collect locations remotely, and the PTT transmitted stored location data via satellite communication to a central database. The VHF marked sage-grouse were relocated using hand-held radio receivers and antennas, whereby ground observers circled sage-grouse at a radius of 30–50 m and used the loudest signal method to minimize location error. Location coordinates for VHF-marked sage-grouse were obtained using a hand-held GPS (Universal Transverse Mercator, UTM). Capture, handling, and marking procedures were approved by the U.S. Geological Survey Western Ecological Research Center Animal Care and Use Committee (ACUC 2015-02).

Both VHF and GPS–PTT telemetry data were used in our analyses, and were screened for completeness and comparability prior to inclusion in models. GPS–PTT transmitters were programmed to collect 9–12 locations per day. To prevent autocorrelation among GPS–PTT location data, only a single random location per day (during daylight hours) was used in our analyses, and the remaining daily locations were removed. In total, 44,872 telemetry locations from 1,800 sage-grouse were compiled into a region-wide database for model-training, classification, and validation. The majority of locations from marked sage-grouse were obtained within a single year (that is, few unique grouse were marked across multiple years). All locations were generated from adult sage-grouse (that is, older than 1 year of age) of each sex across all seasonal life stages.

Sage-grouse telemetry locations were divided into three independent data subsets for each season for use in different steps of model processing and validation. These data subsets were considered independent in that no telemetry locations across subsets were shared by the same individual sage-grouse. Thus, different sage-grouse were used for each dataset. These data subsets consisted of (1) an RSF model training subset employing 80 percent of location data; (2) a classification subset using 10 percent of location data to delineate areas of differing habitat quality; and (3) a validation subset using 10 percent of location data from RSF subregions to assess predictability and consistency of habitat quality areas. Individual sage-grouse were randomly assigned to these three categories at the given proportions.

Delineating Subregions

Spatial associations between marked sage-grouse and existing PMU boundaries (Nevada Department of Wildlife, 2014) were used as an initial starting point for delineating subregions for habitat selection analyses and naming conventions across Nevada and northeastern California (fig. 3). Ultimately, data were partitioned into 24 subregions based on movement patterns of individual radio-marked sage-grouse for habitat analyses, with each grouse occupying only one subregion. Some subregions contained too few marked sage-grouse (that is, less than 20 marked sage-grouse or less than 100 telemetry locations) for sufficient training data to develop a seasonal habitat model, which resulted in the exclusion of seven subregions. After data-screening, we included telemetry data from 10 subregions in the habitat training models used for at least one season: Buffalo-Skedaddle, Cortez, Desert-Tuscarora, Gollaher-O'Neil, Lincoln-Schell-Snake Valley, Midway, North SWIP (that is, Southwest Intertie Project), South SWIP, Toiyabe, and Virginia Mountains (fig. 4). The spatial extent of habitat availability for use in habitat modeling was defined by first calculating a minimum convex polygon (MCP) that encompassed all telemetry locations within each subregion, and then buffering each MCP by the maximum average daily sage-grouse movement (1,451 m). Using the MCP to identify the study extent is a common and useful approach for habitat studies (Aebischer and others, 1993), and buffering by the maximum average daily movement helps ameliorate underestimation of habitat availability.

Delineating Seasons

Data from each subregion were divided into each of three seasons. Spring included telemetry locations (n=14,058) from mid-March to June; summer included locations (n=11,743) from July to mid-October; winter included locations (n=4,862) from November to early March. Importantly, all age and sex classes of marked grouse were used in the analysis; so it is imperative to note that the map represents habitat used by all grouse during a particular season, but does not explicitly represent habitat used by reproductive females (that is; nesting females and females with broods). Data were too sparse to allow estimation of the latter. Hence, spring represents habitat conditions for all sage-grouse during breeding and nesting, summer during brood-rearing, and winter during non-reproductive periods. Sufficient data (that is, minimum 100 locations and 20 marked sage-grouse) for modeling existed in 10 subregions for spring and summer, and 7 subregions in winter. The Midway, South SWIP, and Virginia Mountains subregions had insufficient data for the winter season and were not included in the winter RSF analysis. However, data from these excluded 'non-RSF' subregions were sufficient to provide further validation of the region-wide model in areas that were not used to inform RSF analyses (see section, "HSI Classification and Validation—An Example").

Classification of Landscape Habitat Features

We quantified a broad suite of biotic and abiotic variables potentially associated with sage-grouse occurrence for input into HSI models as spatially explicit environmental covariates. Since the publication of Coates and others (2014, 2016), several high resolution (less than 2 m^2) GIS mapping products have been developed. These products include maps of shrubland community components (for example, cover of sagebrush, non-sagebrush, and herbaceous understory and interspace) and pinyon-juniper woodlands and encroachment. These data represent a substantial improvement upon coarser (that is, 900 m^2) Landsat-based maps of land cover types typically used in large-scale habitat analyses, and are described briefly as follows.

Shrubland land cover types within the region-wide extent were derived with the methods of Xian and others (2015) and provided by C. Homer (U.S. Geological Survey, Earth Resources Observations Systems, Sioux Falls South Dakota, written commun., July 2015). In brief, the method first produces training estimates derived from a regression-tree model predicting land cover from relations between a smaller sample of multi-spectral (8 band), high-resolution (2 m) WorldView-2 imagery and ground-truthed field measurements of shrubland components. In an independent step, Landsat-8 scenes across the entire region of interest are corrected for phenological variation to form a seamless mosaic. A second regression tree model is then constructed to predict climate zone-adjusted estimates of shrubland community land cover across the Landsat-8 mosaic using values the from the training model, and each 900 m^2 pixel represent a continuous percentage of cover within that pixel (trained by the World-View imagery and ground-truthed values) rather than a binary classification. For our mapping and covariate extraction, we used layers depicting percent cover of bare ground, herbaceous perennial vegetation, big-sagebrush (for example, mountain big sagebrush, Wyoming big sagebrush), other sagebrush (for example, low sagebrush), sagebrush height, and non-sagebrush shrub (for example, rabbitbrush, bitterbrush) (table 1).

In addition, we developed a relatively fine resolution map of conifers (hereinafter pinyon-juniper) for our analyses because the available generalized land cover mapping products based on Landsat Imagery represent pinyon-juniper as a binary classification at the scale of a 900 m^2 pixel. This resolution did not allow for accurate classification of areas with relatively low tree density, and performed poorly in identifying early stages of pinyon-juniper encroachment (that is, less than 20 percent areal coverage), especially areas with isolated and sporadic trees that are likely important to sage-grouse movement and demography (Baruch-Mordo and others, 2013). Thus, we mapped pinyon-juniper cover at a 1 m^2 resolution using 2013 National Agriculture Imagery Program imagery, whereby circular canopy extent was classified with object recognition algorithms in Feature Analyst™ (Overwatch Systems, Sterling, VA). The map rescaled to 900 m^2 resolution using a circular moving window with a 50 m radius (ArcGIS Spatial Analyst™, Environmental Systems Research Institute, Redlands, CA) that represented a continuous proportion of pinyon-juniper within each pixel (table 1).

All other land cover types representing the dominant vegetation within 30 × 30 m pixels were classified into binary raster layers using existing Landsat-based mapping products as was done in Coates and others (2014, 2016). For Nevada, the remaining land cover classes were derived from the Nevada SynthMap (Peterson, 2008). Land cover classes were then reclassified into broad habitat categories that were guided by classification levels from NatureServe (2013), Landscape Fire and Resource Management Planning Tools (LANDFIRE, 2010), and The Nature Conservancy. Land cover classes for the northeastern California portion of the project area were derived from LANDFIRE, SageStitch (Comer and others, 2002), and California Department of Forestry and Fire Protection (2006) datasets. To facilitate region-wide compatibility across land cover classes, each dataset was reclassified into the broadest categories used to reclassify the Nevada SynthMap, and then compared across pixels. Pixel values that matched for at least two of the datasets were chosen, whereas the reclassified Landfire value was used when no agreement occurred. The final Nevada and northeastern California layers were then merged. The final set of Landsat-based land cover classes used in the analysis comprised agricultural cropland, annual grass, forest (that is, trees and woodlands other than pinyon-juniper), riparian, and wet meadow (table 1).

Because sage-grouse often select habitat in a scale-dependent fashion (Aldridge and Boyce, 2007; Doherty and others, 2008; Casazza and others, 2011; Aldridge and others, 2012), the analysis was performed on each land cover raster at three different spatial scales relevant to sage-grouse movement patterns. Specifically, the scale-dependent analysis used a circular moving window (neighborhood analysis tool, ArcGIS™ Spatial Analyst) with a radius of 167.9 m (8.7 ha), 439.5 m (61.5 ha), or 1,451.7 m (661.4 ha) that represented averages across sage-grouse of the minimum, mean, and maximum daily distance traveled by sage-grouse in this study, respectively, to calculate the proportion of a particular habitat within a respective spatial scale. Other land cover related variables measured at the three spatial scales included variety of land cover types (that is, the number of unique land cover types), and variety of edge types (that is, the number of unique combinations of adjacent land cover types) (table 1).

Distance Metrics and Topographic Indices

Distances to landscape features that may affect the probability of sage-grouse use were calculated from the GIS (table 1). These landscape features included various water features, agricultural development, and habitat edge (table 1). The influence of distance to water was measured using multiple landscape features from the National Hydrography Dataset (U.S. Geological Survey, 2014) that included all streams, perennial streams, intermittent streams, springs, and open water bodies. Distance to wet meadows as identified by the land cover maps was also measured. For all landscape features, linear distance was calculated as a simple Euclidean distance from a used or available point using the Distance tool in Spatial Analyst (ArcGIS™ 10.1). Non-linear relationships were assessed with an exponential decay function, $e^{-d/\alpha}$, where d was the Euclidean distance from a used or available point to a landscape feature, and α was the mean linear distance from that feature. This decay function allowed estimation of the degree to which the effect of a habitat feature strengthened or weakened with increasing distance from that feature. A metric estimating the distance to road was also calculated but not included in the set of variables because the sage-grouse locations obtained by hand-held VHF were closer to roads than those obtained by GPS-PTT and could result in biased results across data sources (P.S. Coates, U.S. Geological Survey, unpub. data, 2014).

Topographic characteristics were calculated to assess the probability of sage-grouse use with several indices. Elevation and topographic roughness (within 30 × 30 m pixels) were determined from the National Elevation Dataset (U.S. Geological Survey, 2009). Topographic roughness, which measures variance in elevation change (Riley and others, 1999), was calculated using the Geomorphometry and Gradient Metrics Toolbox (Evans and Oakleaf, 2012) and normalized by dividing each pixel value by the maximum value. Topographic position indices (TPI; Jenness, 2006) were calculated as the difference between elevation at a central point and the surrounding average elevation within radii of 510 and 2,010 m. Positive and negative TPI values indicated central point elevations that were higher and lower than the surrounding area, respectively, and depressions or valleys can represent areas of increased moisture (De Reu and others, 2013).

Values of all landscape habitat features, distance metrics, and topographic indices were extracted from the GIS for input into the habitat selection analyses (see section, ”Subregional RSF Modeling by Season”) at used locations (telemetry data) and random locations. The purpose of generating random locations was to characterize the environment available to sage-grouse populations. Five random locations within the buffered MCP were generated for every used location to account for heterogeneity of available land cover types (Aldridge and others, 2012). To avoid fitting models that included land cover types not available to sage-grouse, a land cover type needed to comprise > 0.1 percent of MCP area to be included in resource selection modeling for a particular site.

RSF Analyses

Subregional RSF Modeling by Season

Resource selection functions (RSFs) are calculated frequently using data from wildlife telemetry studies. Typically, selection and avoidance for particular landscape features are estimated by contrasting measurements at used locations (telemetry data) with measurements at random locations that represent areas available to all individuals within a population (Boyce and McDonald, 1999; Manly and others, 2002; Johnson and others, 2006). For each subregion and season combination (n=27, 10 spring, 10 brood, 7 winter), we estimated population-level RSFs using generalized linear models with a binomial error distribution and specified logit-link function (that is, logistic regression) in a mixed effects model framework, where environmental variables (described above) were modeled as explanatory covariates (predictors). The number of sample locations was not equal across individual sage-grouse. Therefore, the individual sage-grouse was treated as a random effect (that is, random intercept) to account for potential autocorrelation among locations associated with each individual (Gillies and others, 2006). Year was also included as a random effect for those subregions with more than 1 year of telemetry data to account for temporal intraclass correlation. A weight of 0.2 was specified in the model structure for each random location that was used to characterize available habitat. This value allowed equal influence by used (weight=1) and random points because five random points were generated per actual grouse location. We fit all models using the lme4 package (Bates and others, 2012) in Program R (R-Core-Team, 2012).

For each subregion and season, a two-part selection procedure identical to Coates and others (2014, 2016) was used to reduce the number of covariates. This procedure relied on bias-corrected Akaike's information criterion (AIC_c) (Burnham and Anderson, 2002) to identify the most parsimonious RSF model for each subregion. In the first part, proposed covariates (table 1, appendixes A–AA) were evaluated for the spatial scale, distance function, or topographic index that best approximated the probability of selection relative to a null model (that is, random effect only) in an information-theoretic framework. The most appropriate fit for percent cover estimated at the three spatial scales (8.7, 61.5, or 661.4 ha) was evaluated for each land cover type. The most relevant distance function (linear or exponential decay) was evaluated for water features, edge habitat, and agriculture. All topographic measures were evaluated relative to a null model. Candidate covariates from models that represented the best performing scale/distance function were then carried forward providing that the model also outperformed the null model by greater than 2.0 ΔAIC_c units (Burnham and Anderson, 2002).

The second part of model development comprised a series of additive models containing all possible 2-covariate combinations of our "candidate" covariates carried over from the first stage. We sought to reduce multicollinearity by removing variables with evidence of correlated effects ($r \geq |0.65|$). If correlation existed between variables, only the best variable was carried forward. Models in this set estimated the effect (slope) of a covariate on probability of selection while accounting for the presence of all other covariates. We then calculated model-averaged parameter estimates (βs; appendixes A–AA) for each covariate across the set of additive models to account for model selection uncertainty (Burnham and Anderson, 2002). The purpose of this stage was not to develop the most parsimonious additive model with multiple covariates, but instead estimate the effect of each covariate and use the model-averaged parameter estimates to calculate an RSF. Covariates were excluded when their model-averaged 95-percent confidence intervals overlapped zero. The RSF took the form:

$$\mathrm{w}(x) = exp(\beta_1 \mathrm{X}_1 + \beta_2 \mathrm{X}_2 +, \ldots, +\beta_\mathrm{k} \mathrm{X}_k) \quad (1)$$

where

$w(x)$ is the resource selection function (RSF), and

β is the averaged parameter estimate for each covariate $(\mathrm{X}_1, \ldots, \mathrm{X}_k)$ (Manly and others, 2002).

Although the RSF cannot be considered an absolute probability because unused areas were not known, the RSF is useful as a representation for the probability of selection (Manly and others, 2002).

Summary of Subregional RSF Results by Season

A total of 24 covariates were modelled in 27 RSF analyses by subregion and season (tables 2–4; appendixes A–AA). Coefficient direction and magnitude for many covariates varied across subregions and seasons, yet some consistent patterns were evident in covariate coefficients that indicated use or avoidance of specific habitat features by sage-grouse. During spring (table 2), areas with herbaceous perennial cover were most consistently selected (8 out of 10 subregions), while big and other sagebrush were either selected or used in proportion to their availability at all subregions. Similar patterns were observed during summer (table 3) with respect to selection for herbaceous perennial cover and big sagebrush. Sage-grouse also showed strong selection for areas closer to water bodies (8 out of 10 subregions), and tended to select areas closer to cropland (5 out of 10 subregions). Big sagebrush was typically either selected or used in proportion to its availability, while pinyon juniper was never selected in subregions during summer. In contrast, selection patterns were highly variable for modeled winter habitat (table 4). Big and other sagebrush were selected in 4 and 5 out of 7 subregions, respectively, while the most consistent avoidance occurred for non-sagebrush shrub and riparian (6 out of 7 subregions).

Region-Wide Habitat Suitability Index and Implementation for Conservation Planning

Seasonal Region-Wide Average Habitat Suitability Surface Maps

The final RSF equation was applied for each combination of modeled subregion and season across all pixels in the region-wide extent using the Raster Calculator in Spatial Analyst. Because RSFs consisted of extreme values that resulted in highly skewed distributions of values, a monotonic transformation of the RSF was conducted, expressed as:

$$\mathrm{HSI} = \frac{w(x)}{1+w(x)}, \tag{2}$$

which resulted in subregion HSI surfaces by season. These HSI surfaces provided a relative metric of habitat quality for any given pixel where habitat quality reflects range-wide mean propensity to be used by sage-grouse given the attributes of the pixel. The HSI equation is equivalent to a logistic transformation on the $\beta_k X_k$, for each covariate X_k. However, the function was used only to express relative influence among different RSF values by expressing influence as a value between 0 and 1. Although we did not assume that HSI values represent absolute probabilities, an increase in HSI corresponds to an increase in the probability of selection.

For each season, the corresponding seasonal subregion HSIs were averaged across each pixel to calculate a single continuous region-wide surface for each season. This was an appropriate technique for developing seasonal region-wide HSIs because it reduces the potential for non-typical selection patterns at a local site to influence HSI values elsewhere within the region. Further refinement by averaging across subregions at smaller scales or applying distance-based weighting is possible; however, we suspect that representation from the sample of subregions in this study is not broad enough to warrant further delineation.

Accounting for Geographic Variation in Habitat Suitability

Strong patterns of precipitation exist along approximate north-south gradients in the Great Basin (Miller and others, 2013). Hence, we used a hydrographic boundary layer, modified from flood-regions developed by Mason (1999), to divide the region-wide extent into North and South regions that align coarsely with respective mesic (wet) and xeric (dry) regions of the State (fig. 5), which also corresponded roughly to sage-grouse management zones. We included the more xeric Owyhee Desert (located in the center of the northern part of Nevada) within the South region. The boundary was used to account for broad-scale variation in habitat availability and selection (for example, habitat classified as highly suitable in wet areas could be classified as less suitable in drier areas because these habitats are less available).

So that the statewide HSI surface was comparable with habitat categories based on north-south classification data (see section, "HSI Classification and Validation—An Example"), interim region-wide HSI maps were first clipped by the hydrographic boundary to create separate HSIs for the North and South regions. HSI values were then relativized according to their respective maximum value to rescale between 0 and 1, and mosaicked back together into a region-wide surface. The end result was a region-wide HSI surface for each season that accounted for spatial variability in predicted HSI values from each of the subregional areas (figs. 6–8), and was comparable to habitat classification maps.

Annual Region-Wide Average Habitat Suitability Surface Map

To create a map of habitat suitability indices across the annual life history of sage-grouse (that is, an annual HSI), we created a composite HSI by incorporating information from all three seasonal HSIs (fig. 9). We first accounted for variation along north-south gradients using identical methods described in section, "Accounting for Geographic Variation in Habitat Suitability." We then relativized each seasonal HSI by their maximum value so that all three seasons were weighted equally. We then multiplied the three seasonal HSIs to create one annual HSI, which is akin to multiplying probabilities. Coates and others (2014, 2016), accounted for seasons by including a weighting factor for each season with the RSF model function, whereas the updated method described here explicitly incorporates spatial differences in habitat use and selection throughout the different seasons.

Implementation of the Region-Wide HSI Map for Conservation Planning—An Example

Effective conservation planning is an inherent stakeholder-driven process, and stakeholders may use quantitative tools to aid in decision making. Here, an example is provided for how a continuous map of HSI values can be used as a tool to aid conservation planning and the decision-making process. In this example, two categorized sources of information are employed to identify spatially explicit management areas: (1) suitability of landscape characteristics; and (2) likelihood of sage-grouse occurrence.

HSI Classification and Validation—An Example

The relative suitability of habitat occurring in an area may be obtained directly from the region-wide HSI map. However, the continuous index at each 900 m^2 pixel provided by the map is an unwieldy mechanism for decision-making related to distinct areas, especially at relatively large scales. Therefore, it can be valuable to categorize the region-wide HSI surface into classes that represent habitat quality at larger spatial scales. To do this, pixels that represented large bodies of water (for example, lakes and reservoirs) identified from Landsat land cover classifications were first masked from the region-wide HSI. The region-wide HSI was then objectively binned into four discrete categories in multiple steps.

First, the habitat classification dataset (an independent data set comprising 10 percent of the total telemetry location sample) was split into locations falling within respective North and South hydrographic regions (fig. 10). Second, HSI values from the statewide HSI surface described above were then extracted to classification datasets located within the North and South regions. We used the same cutoff values for deriving habitat suitability categories (that is, high, moderate, low, non-habitat) developed by Coates and others (2014, 2016) based on the standard deviation (SD) from the mean HSI ($\bar{x}$) derived from the classification datasets. For these purposes, we assumed the data arose from a normal distribution. High suitability habitat was comprised of all HSI values greater than 0.5 SD below $\bar{x}$. This constituted a percentile rank range of 30.9–100.0 percent of HSI values. Moderate suitability habitat was comprised of HSI values between 1.0 and 0.5 SD below $\bar{x}$, constituting a percentile rank range of 15.0–30.9 percent. Low suitability habitat was comprised of HSI values between 1.5 and 1.0 SD below $\bar{x}$, constituting a percentile rank range of 6.7–15.0 percent. Non-suitable habitat was comprised of HSI values 1.5 SD below $\bar{x}$ (less than 6.7 percent). Third, these cutoff values were used to classify the region-wide HSI surface into the four habitat selection categories based on the distributions of classification dataset values within the North and South hydrographic regions. Fourth, the two classified North and South region-wide maps were clipped by the hydrographic boundary layer and mosaicked together to create a single statewide categorical surface for habitat selection. This process was done separately for each of the seasonal maps (using corresponding seasonal validation data), and for the seasonal composite map for annual habitat. The final step was to mask major roads that were buffered by 50 m (U.S. Census Bureau, 2014), lakes (Peterson, 2008) and urban areas. The existing urban layer (U.S. Census Bureau, 2010) was not sufficient for our needs because it excluded towns with a population less than 1,500. Hence, we masked smaller towns (populations of 100 to 1,500) and development with Census Block polygons (U.S. Census Bureau, 2015) that had at least 50 percent urban development within their boundaries when viewed with reference imagery (ArcGIS World Imagery Service Layer).

For each of the seasonal maps (figs. 11–13) and for the seasonal composite annual map (fig. 14), we used three datasets to assess the accuracy of the habitat suitability categories. The first set was comprised of locations from the 10 percent validation set within RSF regions (n=2,116 for spring, n=1,543 for summer, n=695 for winter, n=4,354 for composite). The second set was comprised of all locations from non-RSF subregions with insufficient sample size for inclusion in the original RSF analyses (n=1,347 for spring, n=1,069 for summer, n=3,632 for winter, n=6,048 for composite). This validation dataset represents how well the map extrapolates to areas that were not used in the RSF modeling. Within these two validation datasets, the number of sample locations was not equal across individual sage-grouse. Therefore, for each bird, we first calculated a ratio of locations in each of the four habitat types (that is, high, moderate, low, and non-habitat) to total number of locations for that bird. We then averaged the ratios across all birds in the validation dataset to get our accuracy assessment. The third validation dataset was comprised of locations for active leks (see section, "Abundance and Space Use Index"). This dataset was only used for validation of the spring season habitat classification and the annual habitat classification. Locations from all validation sets were overlaid onto the categorized HSI map, and then evaluated for agreement between percentages of locations falling within each habitat category and SD percentile classes used for the habitat classification (figs. 15–18). In addition, Cohen's kappa coefficient (κ) was used to assess agreement between the frequencies of observed (actual) validated HSI values versus expected values based on SD percentile bins. Cohen's kappa is a more robust measure than a simple percentage of agreement because κ takes into account the agreement that can occur by chance alone. Values of κ greater than 0.75 constitute excellent agreement, 0.40–0.75 are acceptable, and less than 0.40 are poor (Fleiss, 1981).

For spring and summer rearing seasonal maps, good to exceptional agreement occurred among the validation data and habitat categories based on both percentages and κ (table 5). For RSF and non-RSF subregion sets, percentages of validation points falling within cumulative habitat (that is, high, moderate, and low combined) met or exceeded expected values. Distributions of leks along habitat categories in the spring season also closely matched expected values. Agreement was less strong for the winter validation dataset, likely owing to fewer subregions for modeling during that season, and more generalized patterns of habitat selection in response to variation in snow-depth (Dzialak and others, 2013).

Agreement was good to exceptional across all habitat categories and validations sets for the seasonal composite annual map (table 6). In particular, greater than 93 percent of RSF and non-RSF validation points, and 97 percent of leks fell within cumulative habitat. Notably, the composite annual map has better predictability over non-RSF modeled areas, and classified more leks into cumulative habitat, in comparison to the original Coates and others (2014, 2016) version (table 6).

Abundance and Space Use Index

Habitat suitability categories provide a crucial piece of information to support decision-making. The second source of information that we used incorporated data regarding lek sites to estimate use of areas by sage-grouse across the landscape. We re-calculated a composite AUI (using the most current lek count data) that combined the density of lek sites (breeding density) with the non-linear probability of space use relative to distance to lek (distance) as described by Coates and others (2014, 2016). Lek locations were the basis for both indices for multiple reasons. Leks are ideal locations to conduct space use analyses because they are considered hubs for nesting (Autenrieth, 1985; Connelly and others, 2004) and generally are centered within seasonal use areas, meaning lek location provides an appropriate focal point for areas critical to all life phases of sage-grouse (Doherty and others, 2010a; Coates and others, 2013). Leks also are detectable using standard survey procedures and established protocols exist for counting male sage-grouse at these sites (Connelly and others, 2004), whereby males at leks were typically counted 3–4 times per season and the maximum count was recorded. Spatial coordinates for leks and associated data on sage-grouse abundance and activity were obtained from databases compiled by the NDOW for Nevada, and CDFW and the Western Association of Fish and Wildlife Agencies for northeastern California. Although 3–4 counts were typically conducted for counted leks, not all leks were counted every year across the project area. All leks were classified by agency personnel as "active" or "pending." Active leks had two or more males observed attending during at least 2 of the last 5 years (2011–2015), whereas pending leks had two or more males observed attending only once during the last 5 years. Pending leks were included to allow for a more robust estimate of sage-grouse occupancy across the landscape given the uncertainty associated with whether or not a pending lek is persistent and will eventually be classified as either active or inactive given future male attendance, or lack thereof, respectively. A total of 917 active and pending leks were used to estimate the updated AUI.

To estimate density of lek sites (breeding density), we used a kernel density analysis (Silverman, 1986) and estimated the smoothing parameter (that is, bandwidth) using likelihood based cross-validation (Horne and Garton, 2006). Because substantial variation in lek size (number of attending males) existed among lek sites, individual leks were weighted by the most recent 5-year average for maximum male attendance per year. Therefore, breeding density was a function of lek distribution on the landscape (that is, proximity to each other) and lek size. Parameter estimation was conducted using Geospatial Modeling Environment (Beyer and others, 2010) and in Program R (R-Core-Team, 2012) with the 'ks' package (Duong, 2012).

The other component of the AUI consisted of adjusting for the use of space around lek sites (lek distance index), largely because leks are considered points on the landscape whereas sage-grouse use areas in relation to lek sites. Because the probability of occurrence is not likely to be a linear relationship with the Euclidean distance from a lek, we used a non-linear effect based on an average space use response curve derived by Coates and others (2013) from nearby populations of sage-grouse within the Bi-State Distinct Population Segment. Specifically, the curve was derived from quantification of the volume of population level utilization distribution (vUD) within a range of areas that varied in size and were centered on leks, up to a distance of 30 km. Utilization distributions were represented by an individual probability density function for each of 193 sage-grouse totaling nearly 11,878 sage-grouse locations. To obtain the distance index for our purposes, we simply subtracted the derived vUD value from one for every 30 m distance away from leks up to 30 km. Therefore, the lek point received a value of one, and as distance increased the value declined exponentially until it flattened at distances of 5–8 km. This calculated value provided a relative likelihood of occurrence based on previously published probability density functions from radio-telemetry data for sage-grouse. The curve developed for the Bi-State was appropriate to adopt for this analysis because the curve: (1) accounted for seasonal patterns; (2) represented multiple isolated populations; (3) represented a relatively large spatial extent; and (4) likely represents other areas of the Great Basin because it consisted of substantial variation among populations as described in Coates and others (2013, 2014).

To create the AUI, grid-cell (900 m^2) values for lek density index and lek distance index were first normalized by dividing by the maximum of their respective index, and then averaged across all grid cells. The AUI, therefore, is a continuous, spatially explicit relative measure of sage-grouse occurrence weighted by local population size. For development of the example decision support tool, the AUI was categorized into two categories: “high use” and “low-to-no use” areas. High use areas consisted of areas that included 85 percent of the highest AUI density (cumulative density values). Low-to-no use areas of the landscape consisted of areas with less than 15 percent of the cumulative AUI density (fig. 19). The identification of high use regions allowed for spatial connectivity among areas of likely sage-grouse use and is consistent with previously used standards for sage-grouse breeding density (for example, Doherty and others, 2010b). The 85 percent cutoff was identical to that used by Coates and others (2014, 2016).

Developing a Decision-Support Tool—Combining HSI Categories with Abundance and Space Use

To promote clear and effective policy decisions, it is often desirable to simplify a suite of important considerations regarding habitats or populations into a few non-overlapping classes, each of which are subject to specific rules, valuations, or interpretation for aiding in the decision-making process. The following is an example of how the intersection between habitat quality (a function of environmental attributes) and sage-grouse space use (a function of sage-grouse occurrence) can provide spatially explicit information to policymakers. Four habitat management classes were developed from the intersection of HSI and AUI categories (table 7). The rubric used to develop management classes and rationale was identical to that used by Coates and others (2014, 2016) and is described as follows:

1. Core Areas (fig. 20): Defined as the intersection between all suitable habitats (high, moderate, and low categories) and the high use AUI category. This habitat management class is intended to incorporate all suitable habitats that have relatively high certainty of current sage-grouse occupancy.

2. Priority Areas (fig. 20): Defined as either high suitability habitat that is present within the low-to-no use AUI category or non-suitable habitat occurring within the high use AUI category. This combined habitat management class encompasses: (1) high-quality habitats based on environmental covariates with a lower potential for occupancy given the current distribution of sage-grouse; and (2) sage-grouse incursion into areas of low quality habitat that is potentially important for local populations (for example, corridors of non-habitat connecting higher quality habitat).
3. General Areas (fig. 20): Defined as moderate and low habitat suitability that is present within the low-to-no use AUI category. This habitat management class represents areas with appropriate environmental conditions for sage-grouse, but are less frequently used by sage-grouse.
4. Non-habitat Areas (fig. 20): Defined as non-suitable habitat that is present within the low-to-no use AUI. This scenario represents habitat of marginal value to sage-grouse populations.

Changes in Habitat and Management Area Size

Overall, the amount of area classified as sage-grouse habitat (that is, high, moderate, and low combined) across Nevada and northeastern California increased by 6.5 percent (approximately 1,700,000 acres) as measured by the updated maps in this study in comparison to Coates and others (2014) (table 8). Variation for management categories between studies was similarly low, whereby core increased by 7.2 percent (approximately 865,000 acres), priority increased by 9.6 percent (approximately 855,000 acres), and general increased by 9.2 percent (approximately 768,000 acres), while non-habitat decreased (that is, classified non-habitat occurring outside of areas of concentrated use) by 11.9 percent (approximately 2,500,000 acres). The total area classified as a management category increased by 8.5 percent. Changes in management category area between studies are partly attributable to an increase (11.4 percent) in the amount of area estimated in the updated AUI map as high use.

Conclusions

This report presents an update to the spatially explicit map of greater sage-grouse (*Centrocercus urophasianus*) habitat suitability across Nevada and northeastern California first presented in Coates and others (2014, 2016). These updates included: (1) adding radio and GPS telemetry locations from sage-grouse monitored at multiple sites during 2014 to the original location dataset beginning in 1998; (2) integrating output from high resolution maps (1–2 m^2) of sagebrush and pinyon-juniper cover as covariates in resource selection models; (3) modifying the spatial extent of the analyses to match newly available vegetation layers; (4) explicit modeling of relative habitat suitability during three seasons (spring, summer, over-wintering) critical to sage-grouse life history; (5) accounting for differences in habitat availability between more mesic sagebrush steppe communities in the northern part of the study area and drier Great Basin sagebrush in more southerly regions by categorizing continuous region-wide surfaces of habitat suitability index (HSI) with independent locations falling within two hydrological zones; (6) integrating the three seasonal maps into a composite map of annual relative habitat suitability; (7) deriving updated land management categories based on previously determined cut-points for intersections of habitat suitability and an updated index of sage-grouse abundance and space-use (AUI); and (8) masking urban footprints and major roadways out of the final map products.

Importantly, the map was informed by updated resource selection functions derived from new data across multiple site-specific studies of sage-grouse and scaled up to a region-wide level as a habitat suitability index. The power of this approach rests within the map output that can be downscaled back to the local level that may help inform specific, "on the ground," habitat-management decisions, with full recognition that field data and other sources of information and expertise should be used in conjunction with inferences from this model. This version is an improvement over the previous map by also incorporating variation in resources acquired by sage-grouse to meet seasonal life-history requirements. Furthermore, the management area outcomes can facilitate adaptive management that support BLM and USFS Resource Management Plans (U.S. Bureau of Land Management 2015) and Secretarial Order 3336 (U.S Department of the Interior, 2015). Importantly, relatively low variation between mapping products (that is, this study versus Coates and others, 2014, 2016) indicate that our modeling approach consistently identifies landscape patterns of sage-grouse habitat. Because only 6.5 and 8.5 percent area classified as habitat and management category changed between studies, the updated maps represent model refinement based on better input data rather than a complete mapping overhaul.

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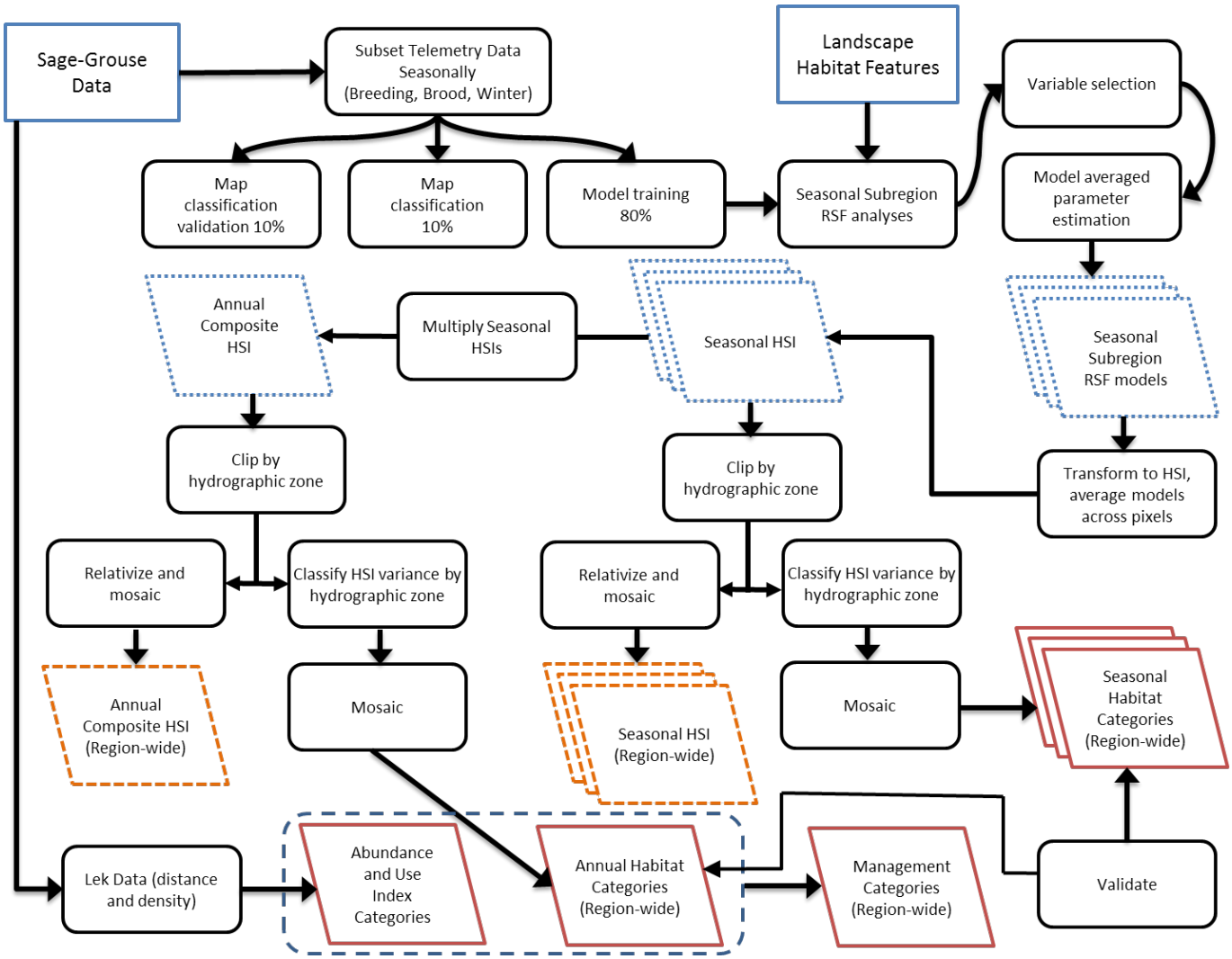

Figure 1. Diagram showing conceptual model for a statewide greater sage-grouse (*Centrocercus urophasianus*) annual and seasonal habitat suitability, and habitat management scenario map, Nevada and northeastern California. Input data (blue rectangular box) were subjected to a series of processing steps (black rounded boxes) to produce interim (blue parallelograms with dotted lines) and final spatially explicit maps (raster maps are orange parallelograms with dashed lines, vector maps are red parallelograms with solid lines). HSI, habitat suitability index; RSF, resource selection function; %, percent.

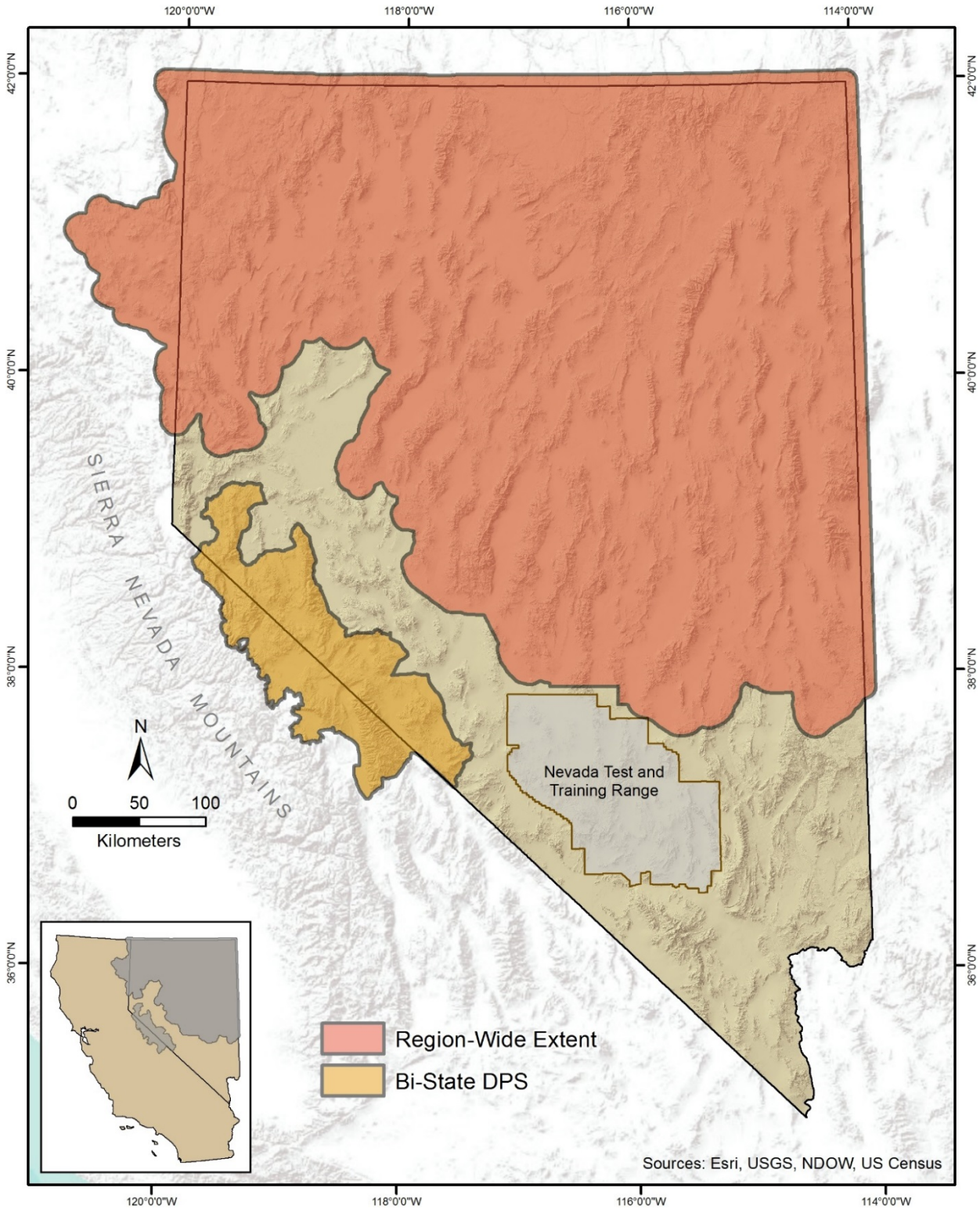

Figure 2. Map showing project area, which included the segment of greater sage-grouse (*Centrocercus urophasianus*) range in Nevada and northeastern California, excluding the Bi-State Distinct Population Segment (Bi-State DPS) and Nevada Test and Training Range.

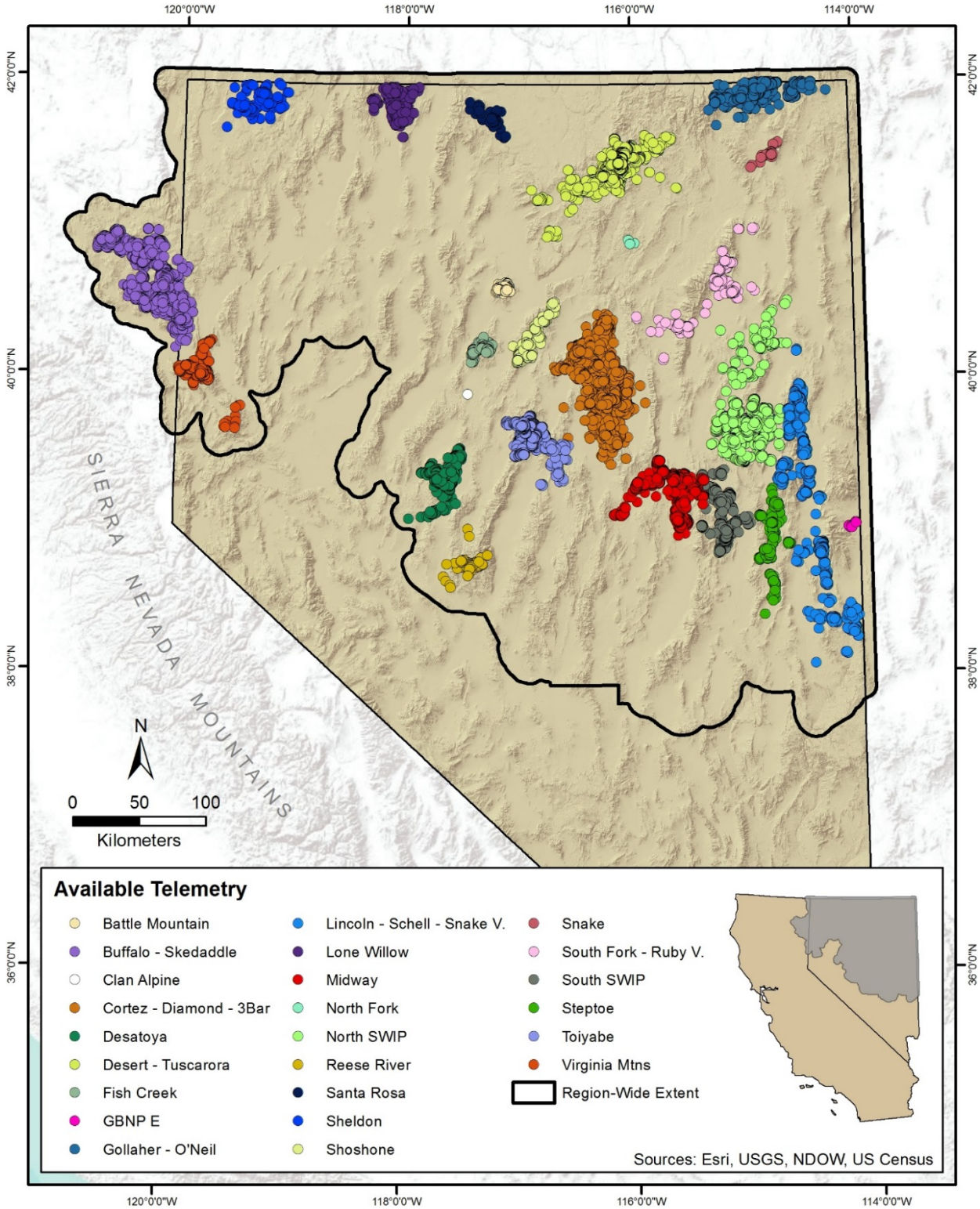

Figure 3. Map showing telemetry points (colored dots) comprising greater sage-grouse (*Centrocercus urophasianus*) locations available for use in resource selection function modeling, Nevada and northeastern California. Names refer to locations associated with NDOW Population Management Units.

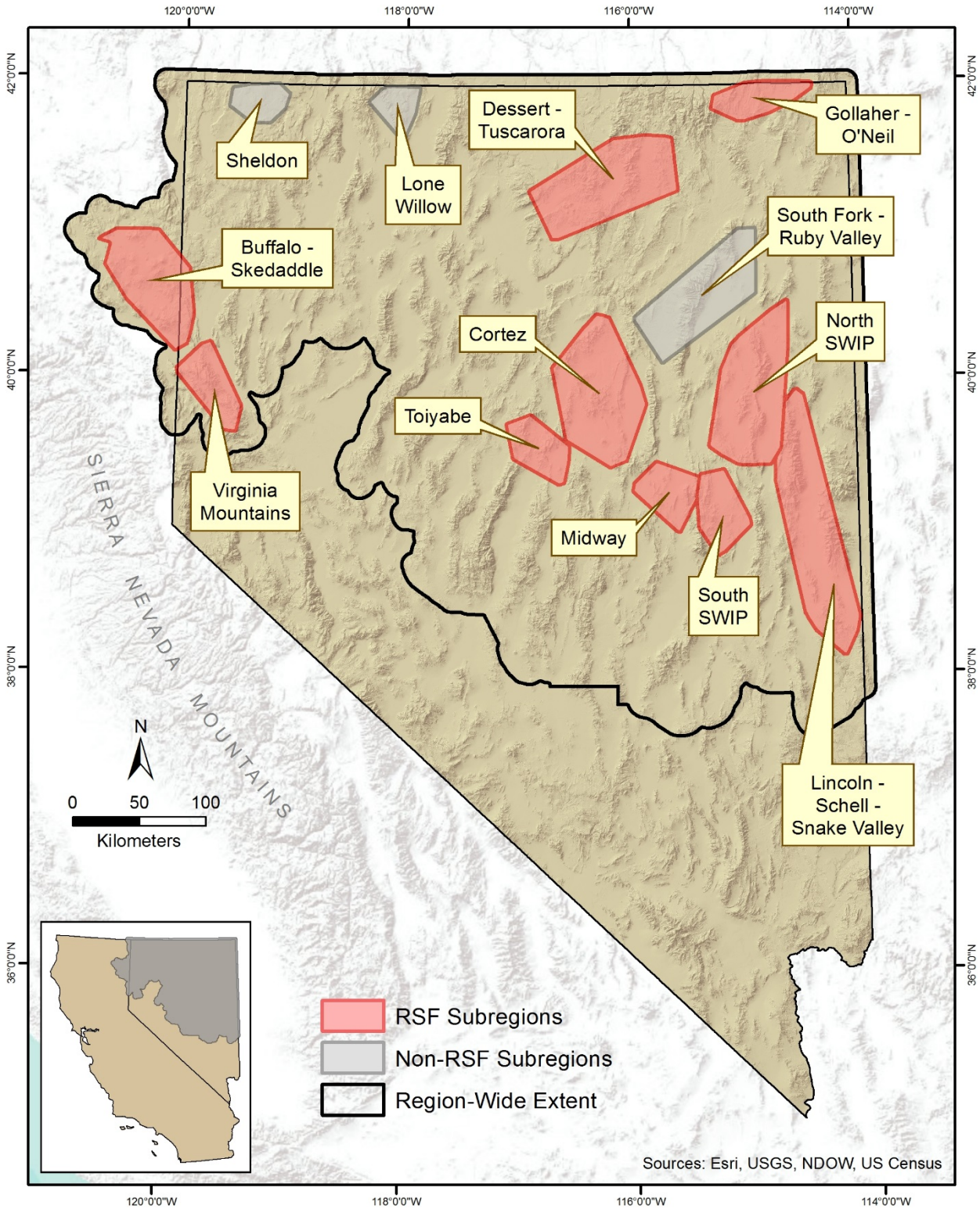

Figure 4. Map showing subregions with suitable greater sage-grouse (*Centrocercus urophasianus*) location data for resource selection function analyses (that is, RSF subregions), and those used for model valdiation (that is, non-RSF subregions), Nevada and northeastern California. Not all subregions were modeled for each season.

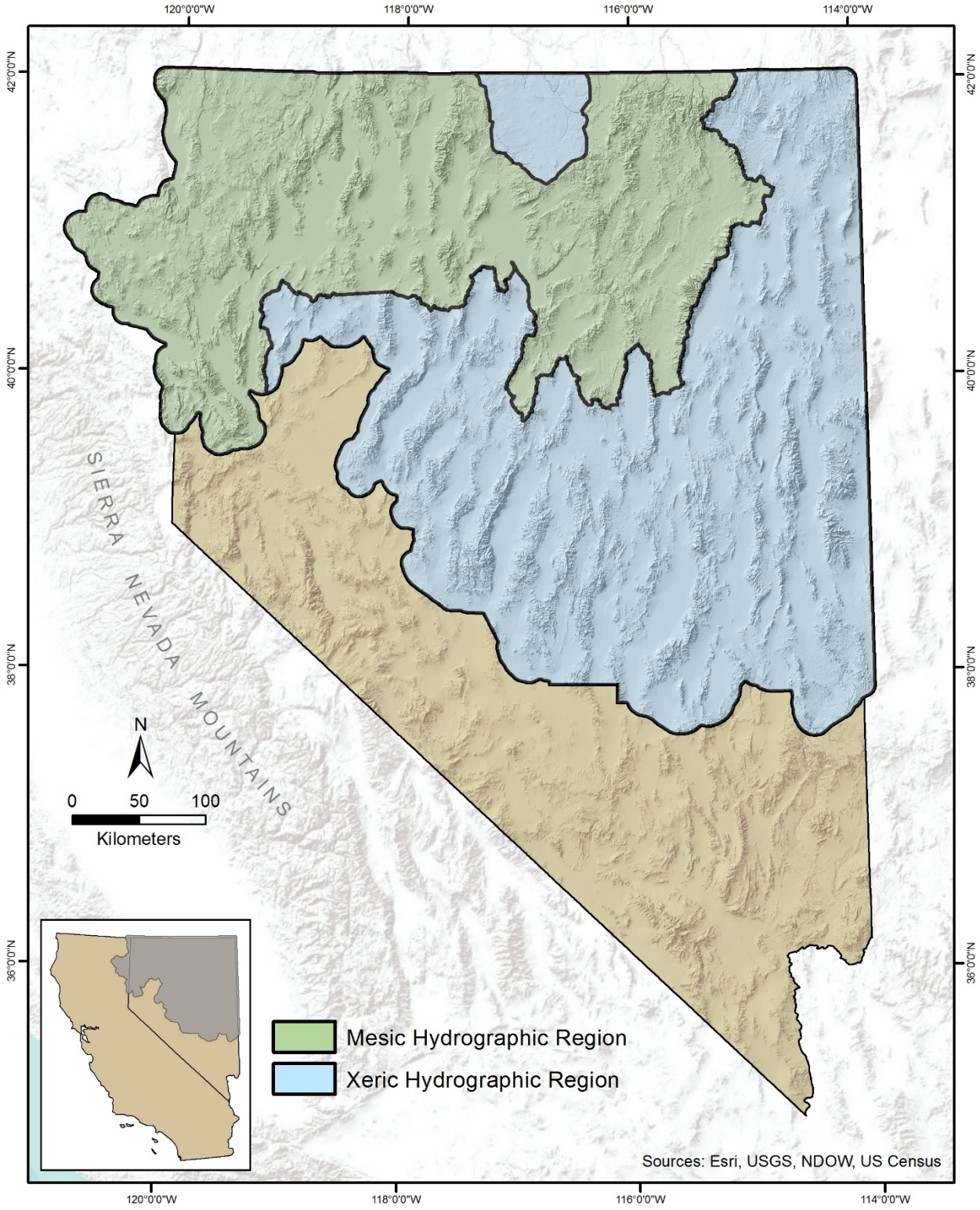

Figure 5. Map showing North (Mesic) and South (Xeric) hydrographic regions of Nevada and northeastern California.

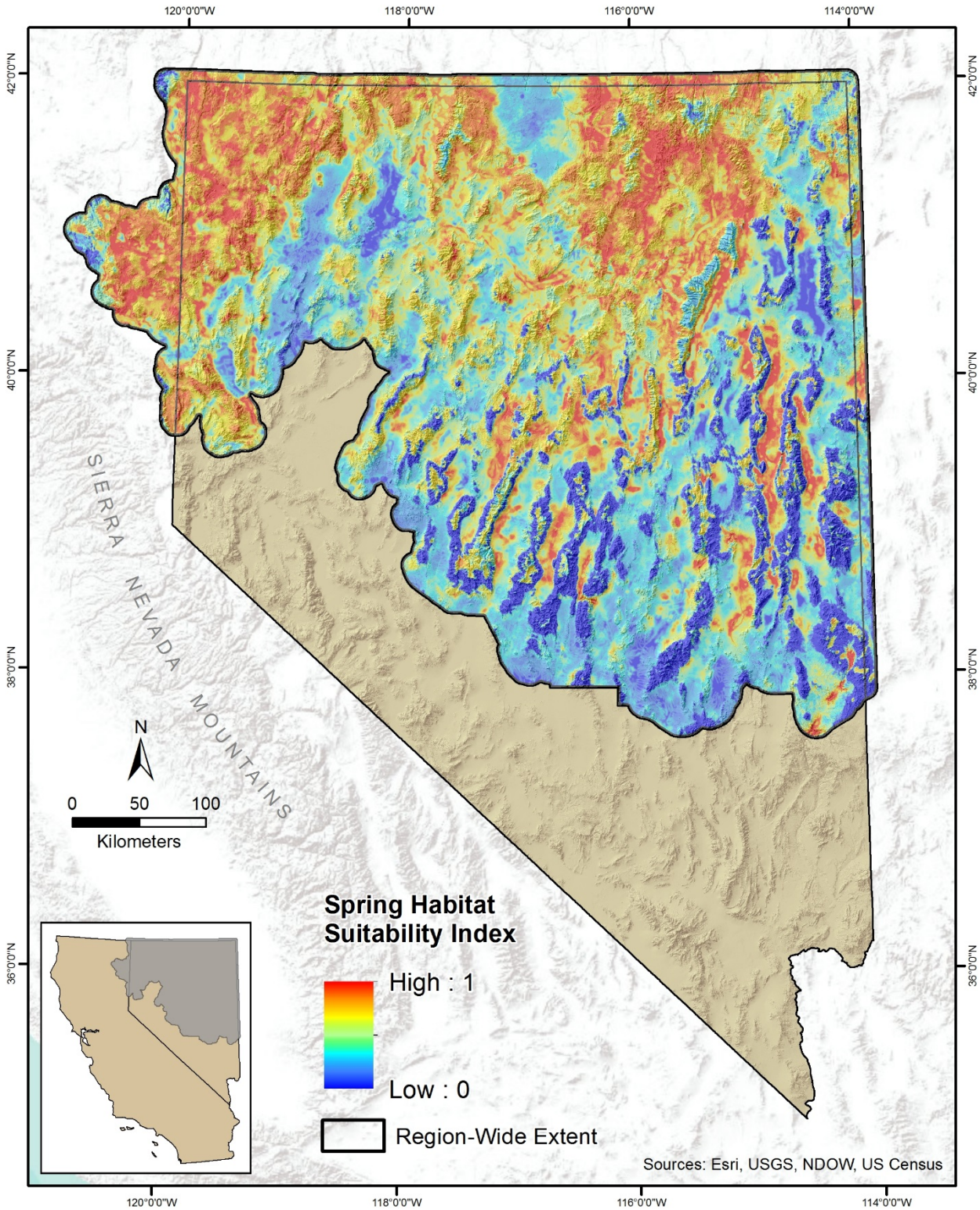

Figure 6. Map showing model-averaged estimate (derived from 10 subregions) of region-wide habitat suitability for greater sage-grouse (*Centrocercus urophasianus*) during spring, Nevada and northeastern California.

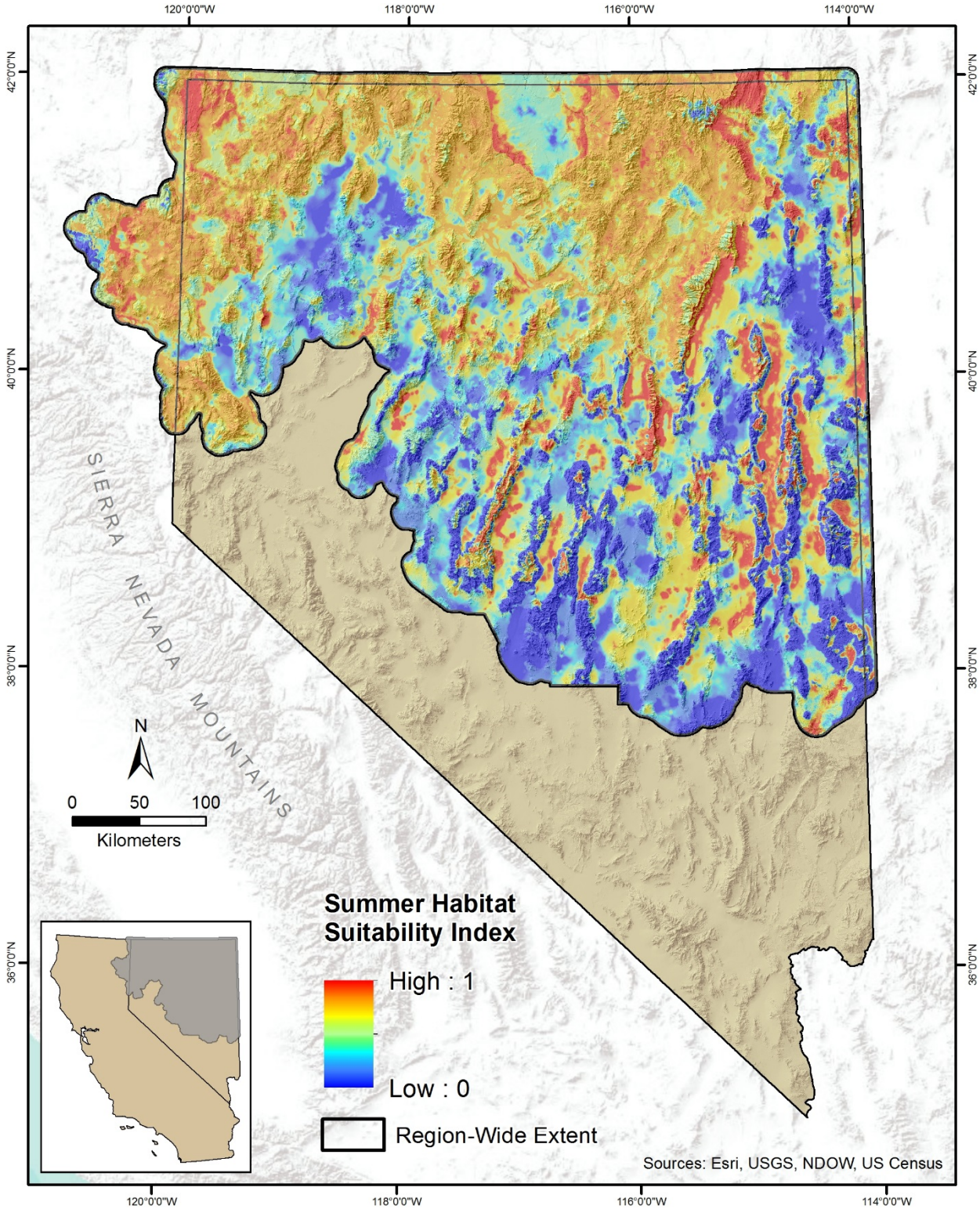

Figure 7. Map showing model-averaged estimate (derived from 10 subregions) of region-wide habitat suitability for greater sage-grouse (*Centrocercus urophasianus*) during summer, Nevada and northeastern California.

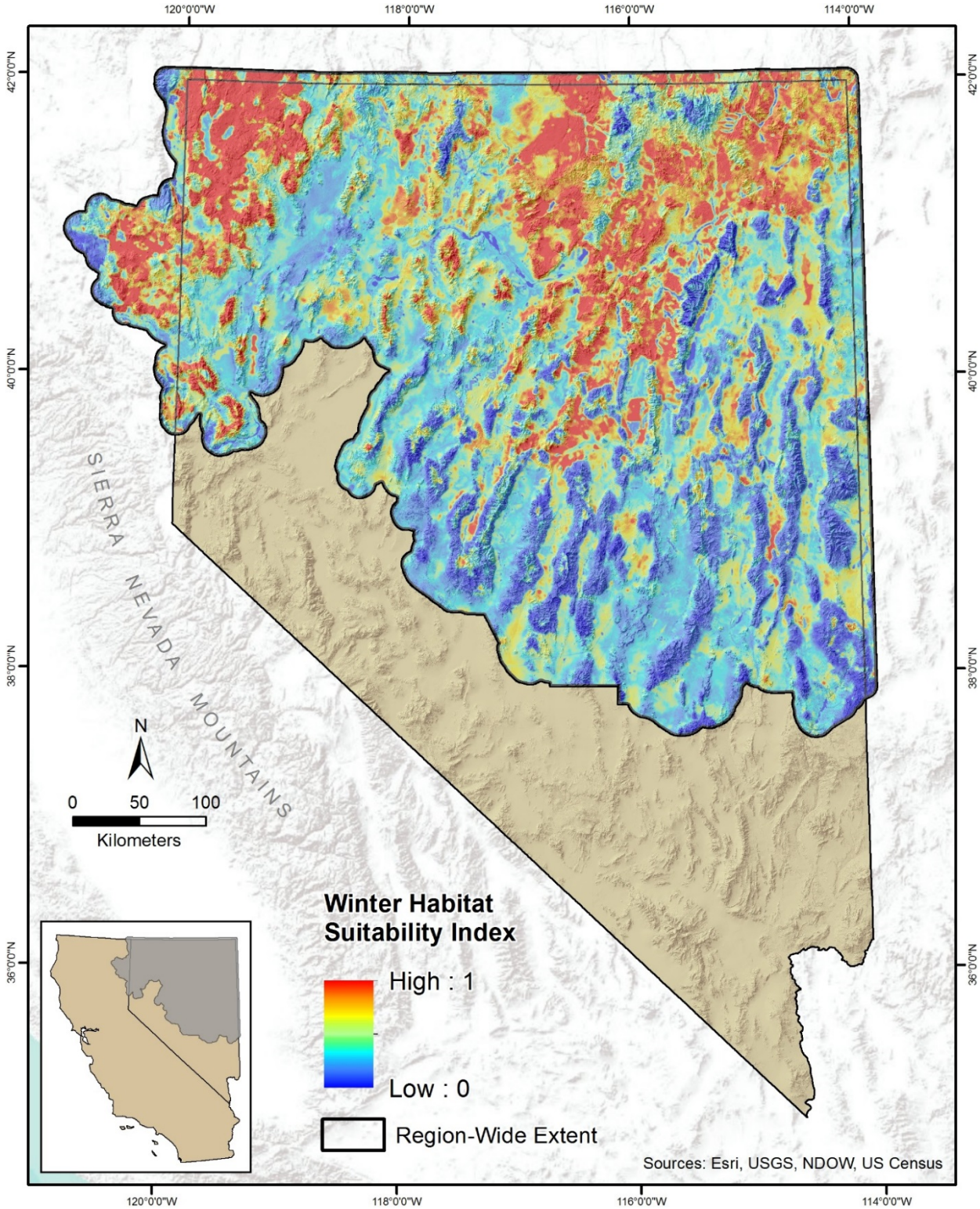

Figure 8. Map showing model-averaged estimate (derived from 7 subregions) of region-wide habitat suitability for greater sage-grouse (*Centrocercus urophasianus*) during winter, Nevada and northeastern California.

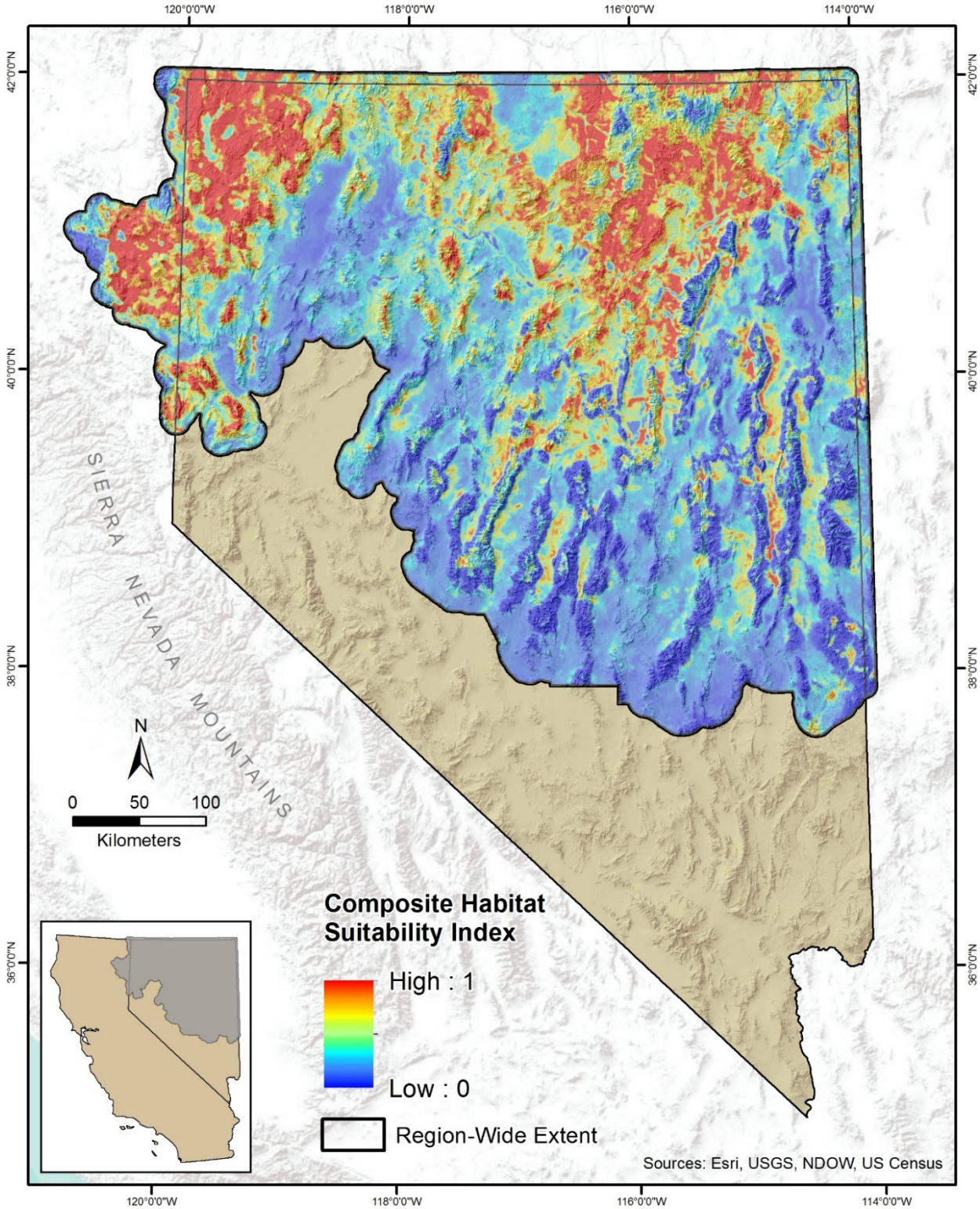

Figure 9. Map showing model-averaged estimate (derived from the multiplicative composite of the 3 seasonal HSIs) of region-wide habitat suitability for greater sage-grouse (*Centrocercus urophasianus*) on an annual basis, Nevada and northeastern California.

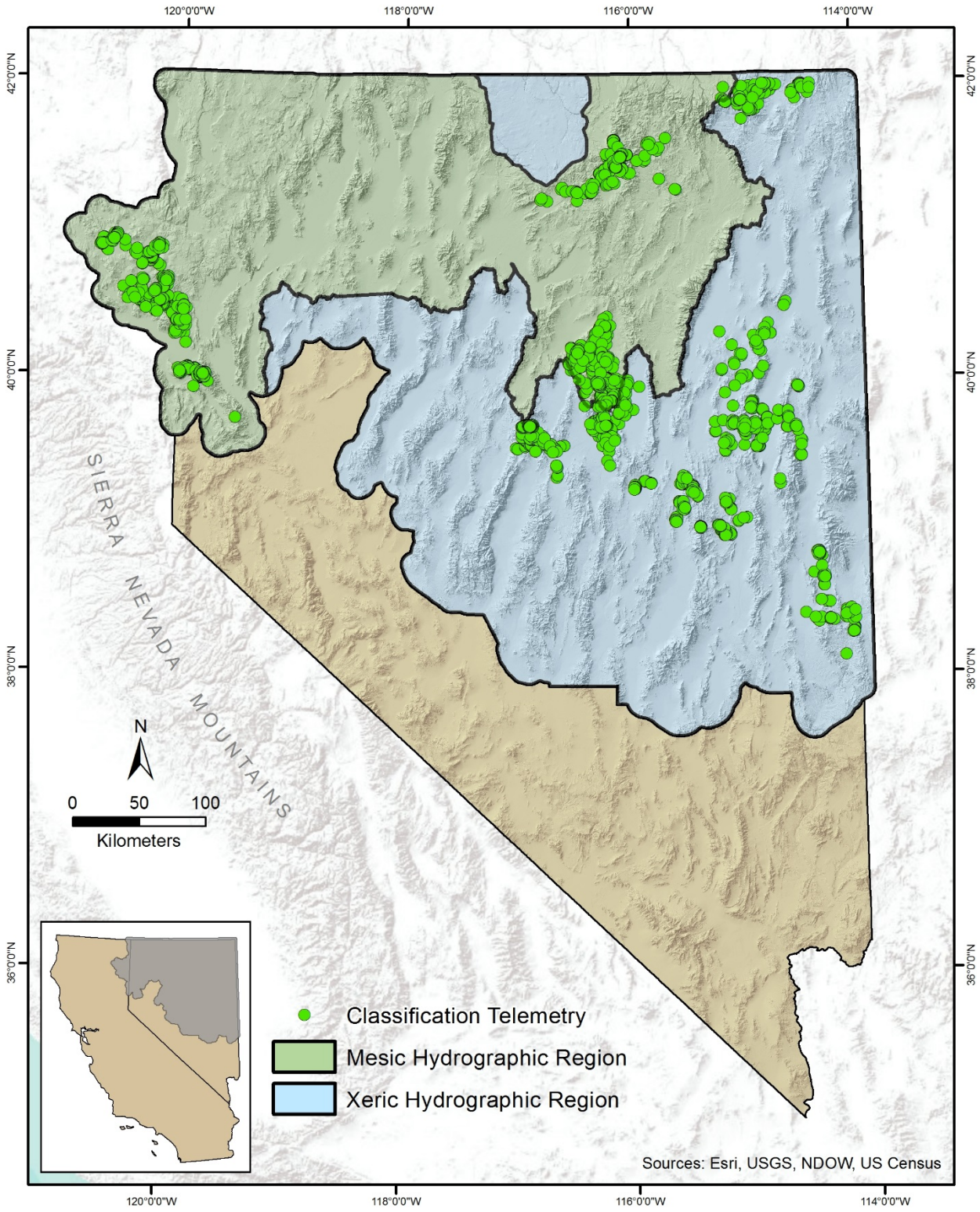

Figure 10. Map showing overlay of radio-telemetry data used to classify habitat suitability classes for greater sage-grouse (*Centrocercus urophasianus*) in the North (Mesic) and South (Xeric) hydrographic regions of Nevada and northeastern California.

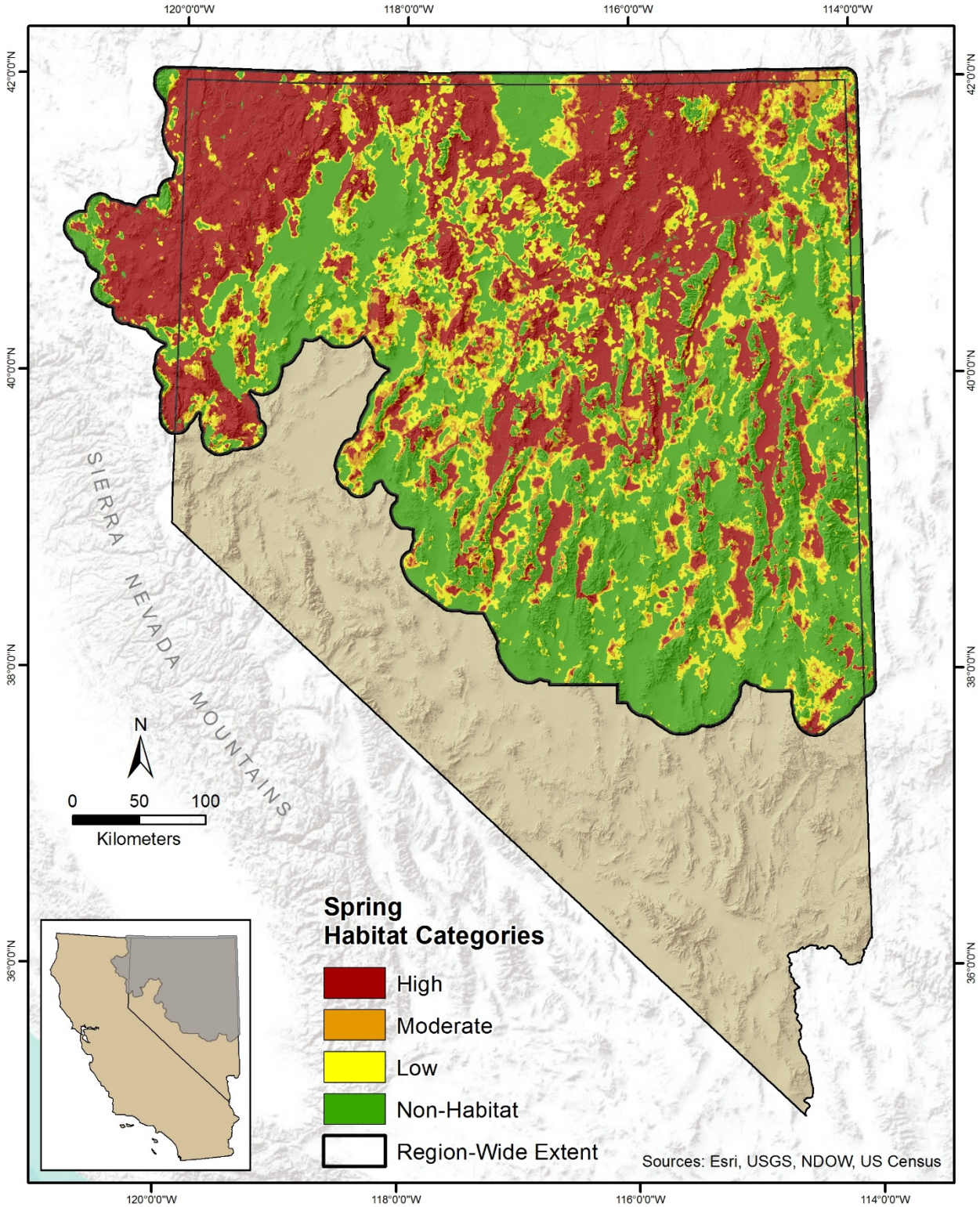

Figure 11. Map and showing example region-wide distribution of categorized habitat suitability for greater sage-grouse (*Centrocercus urophasianus*) during spring, Nevada and northeastern California.

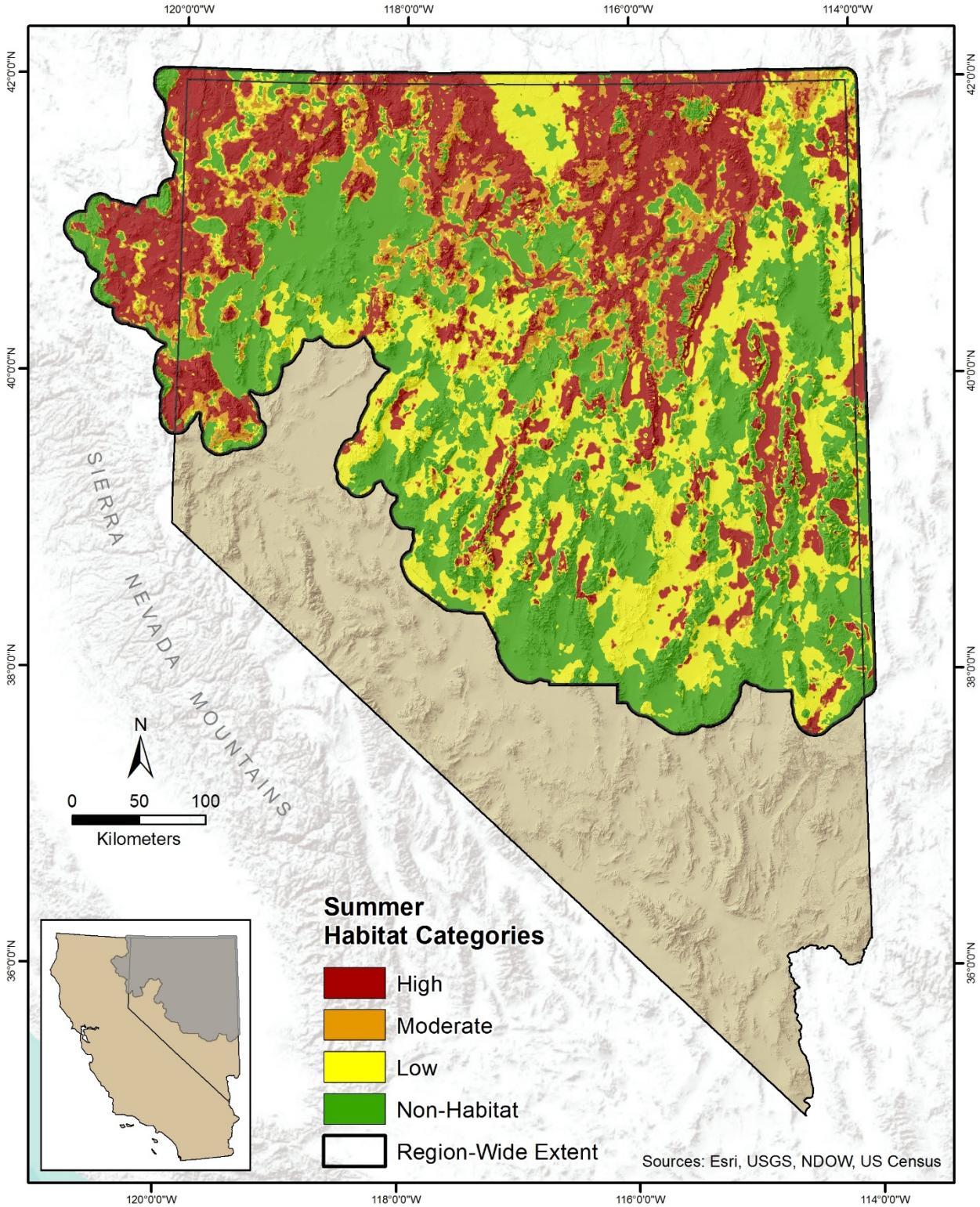

Figure 12. Map showing example region-wide distribution of categorized habitat suitability for greater sage-grouse (*Centrocercus urophasianus*) during summer, Nevada and northeastern California.

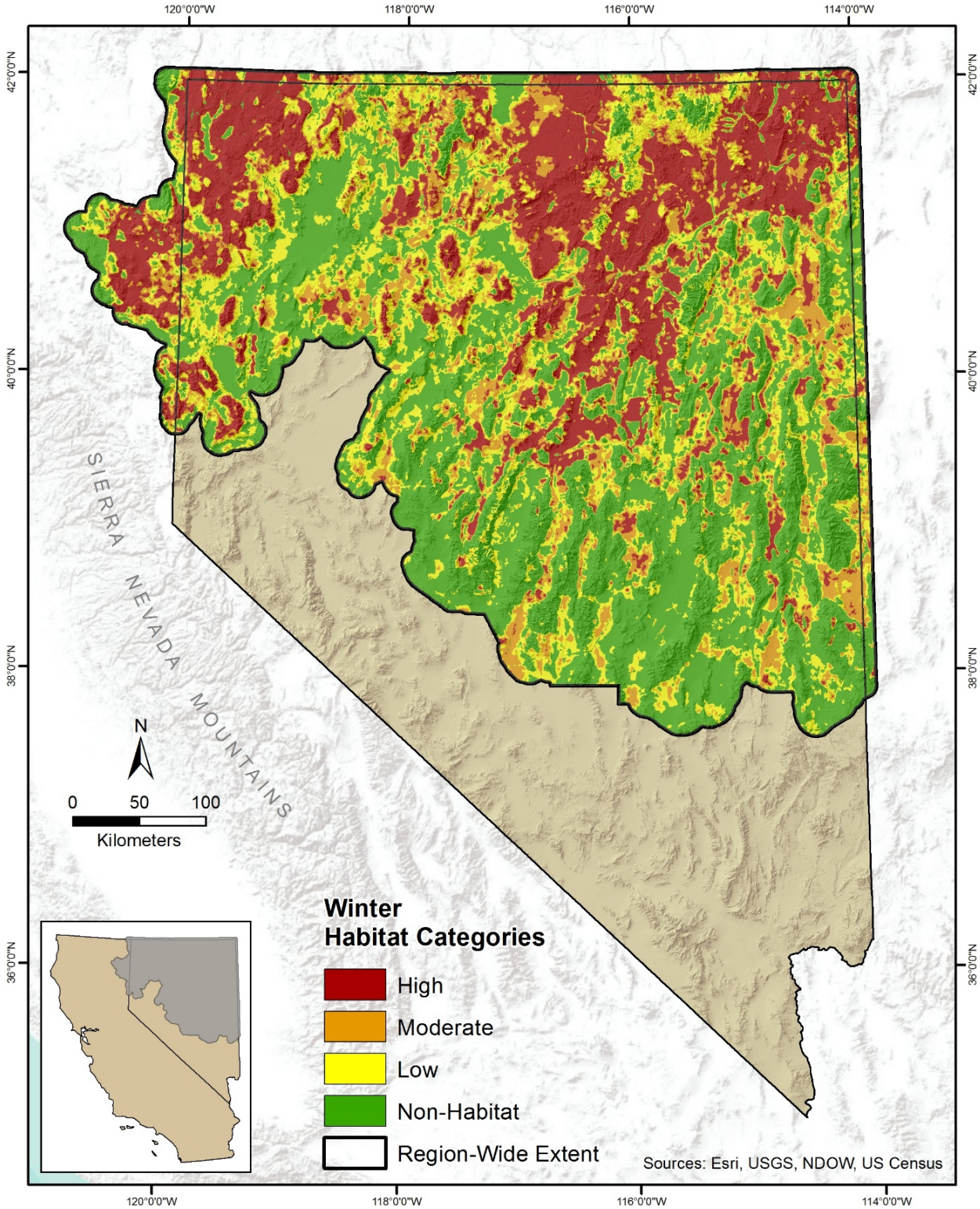

Figure 13. Map showing example region-wide distribution of categorized habitat suitability for greater sage grouse (*Centrocercus urophasianus*) during winter, Nevada and northeastern California.

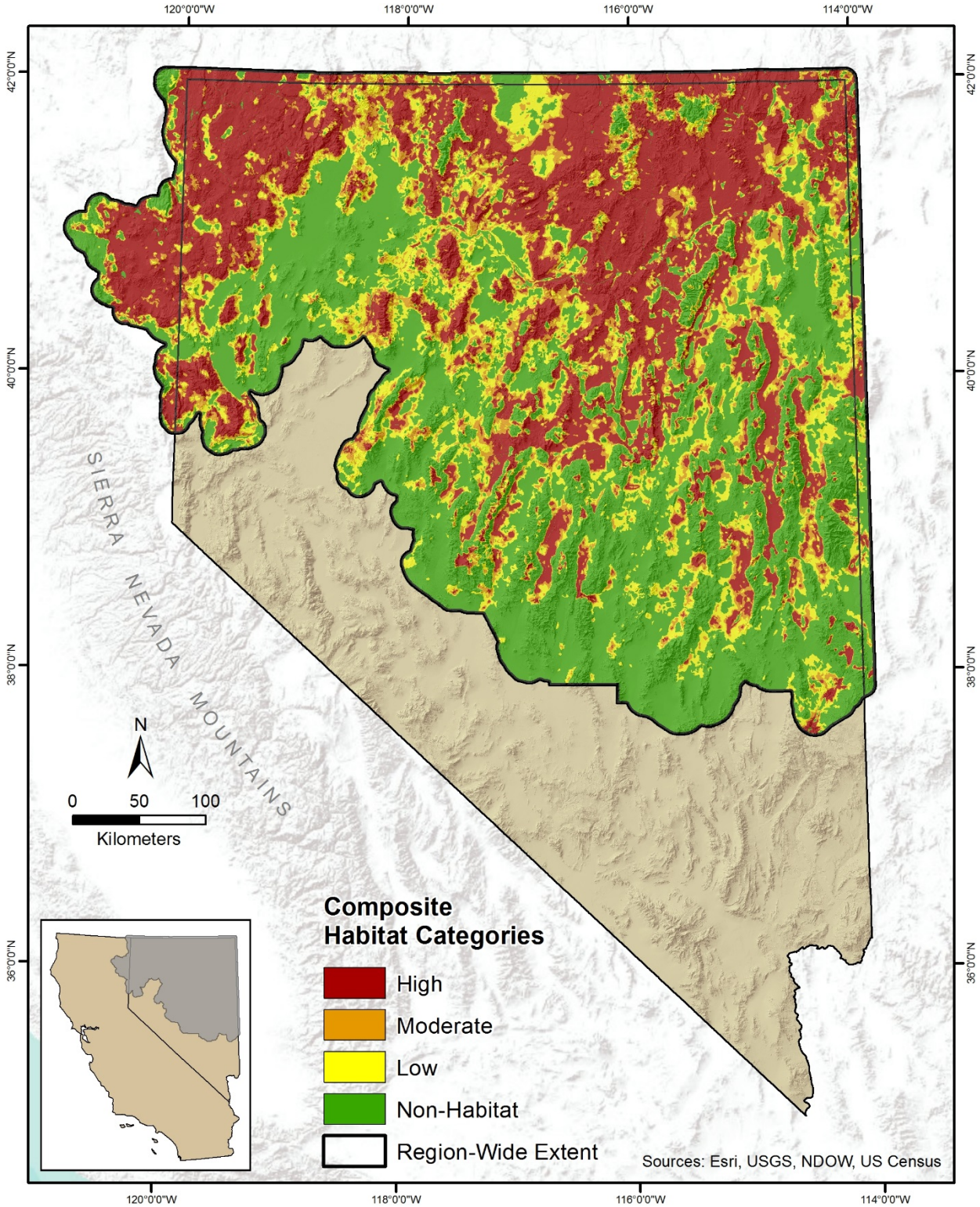

Figure 14. Map showing example region-wide distribution of categorized habitat suitability for greater sage grouse (*Centrocercus urophasianus*) on an annual basis, Nevada and northeastern California.

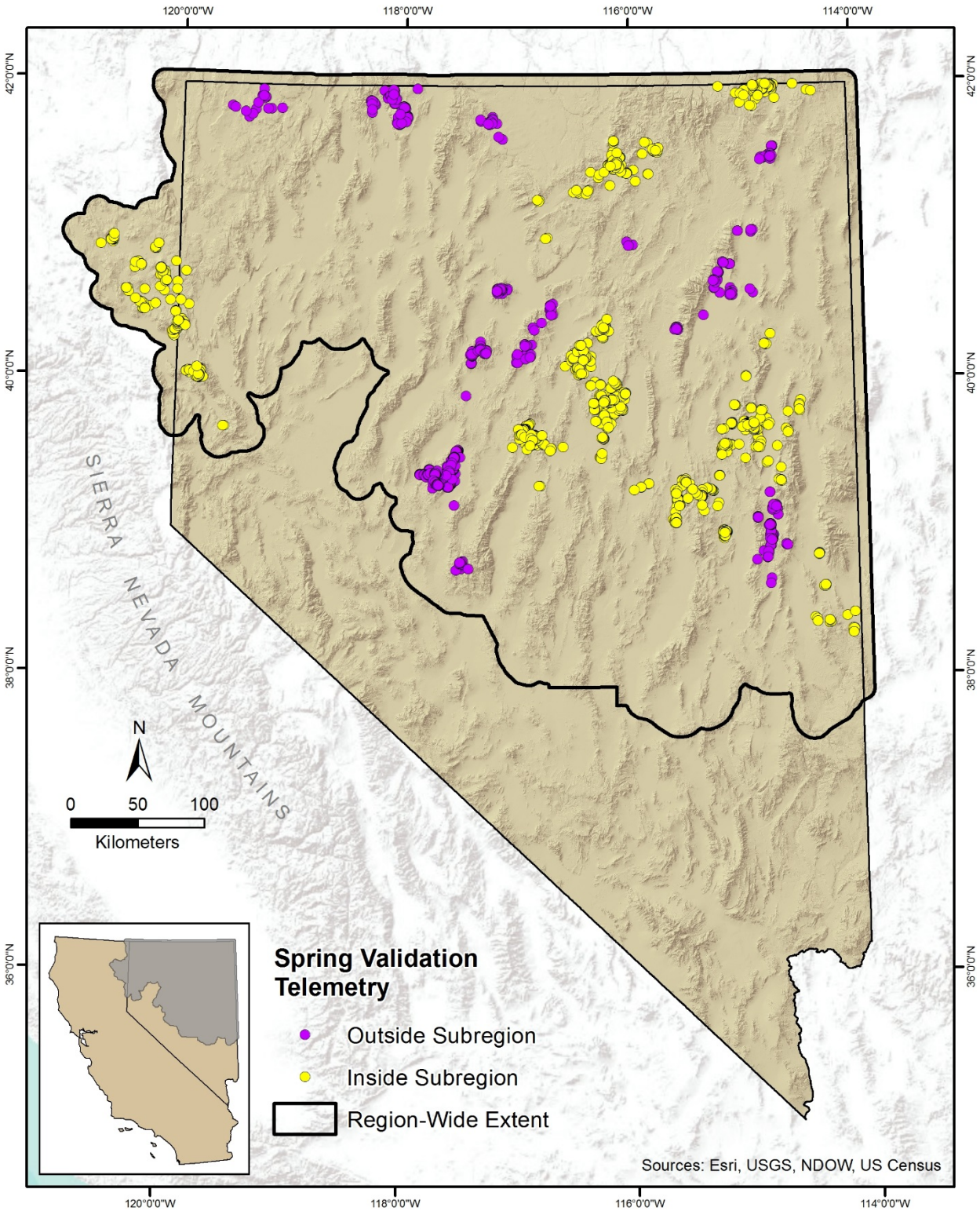

Figure 15. Map showing overlay of radio-telemetry data used to validate habitat suitability classes for greater sage grouse (*Centrocercus urophasianus*) during spring, Nevada and northeastern California.

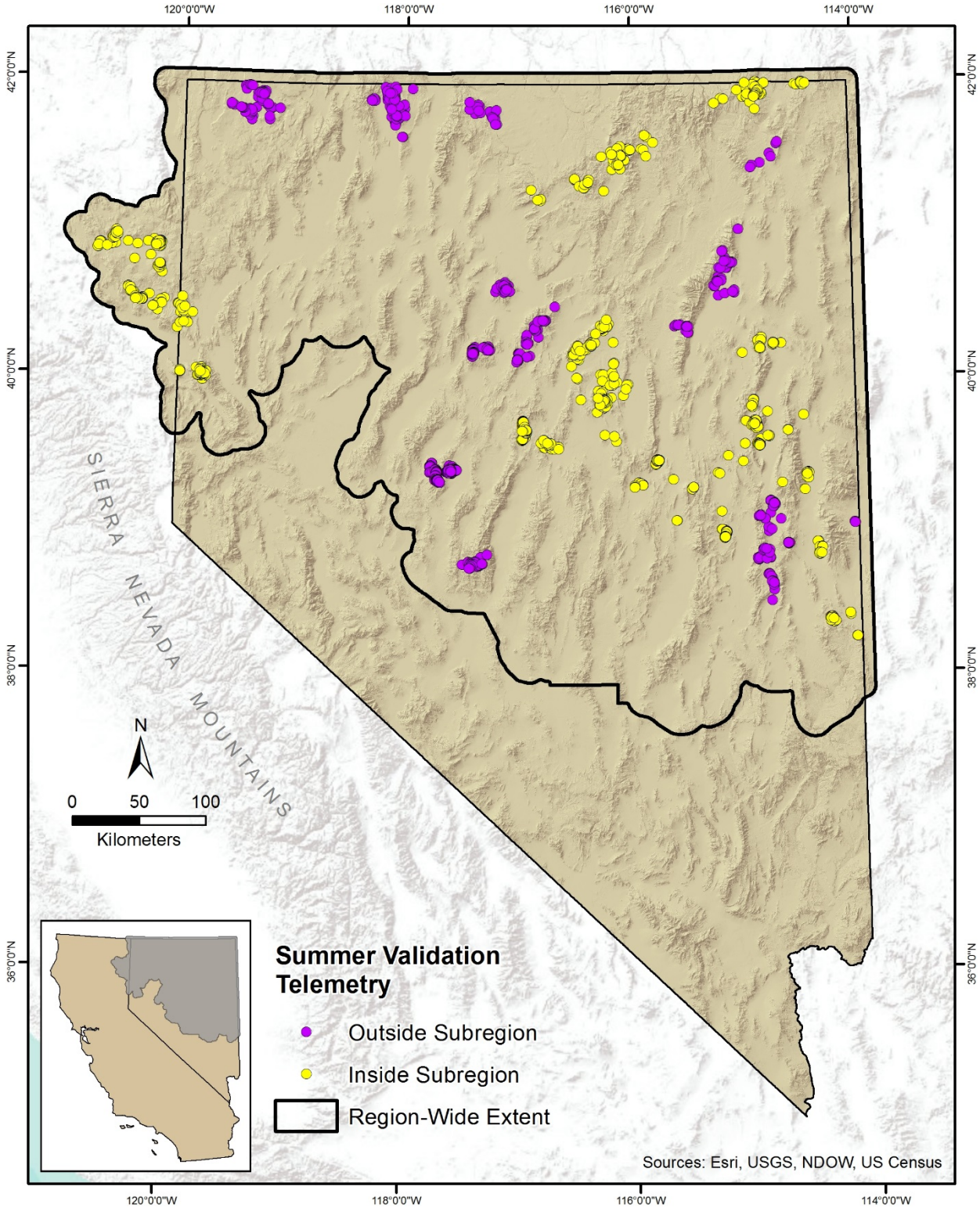

Figure 16. Map showing overlay of radio-telemetry data used to validate habitat suitability classes for greater sage grouse (*Centrocercus urophasianus*) during summer, Nevada and northeastern California.

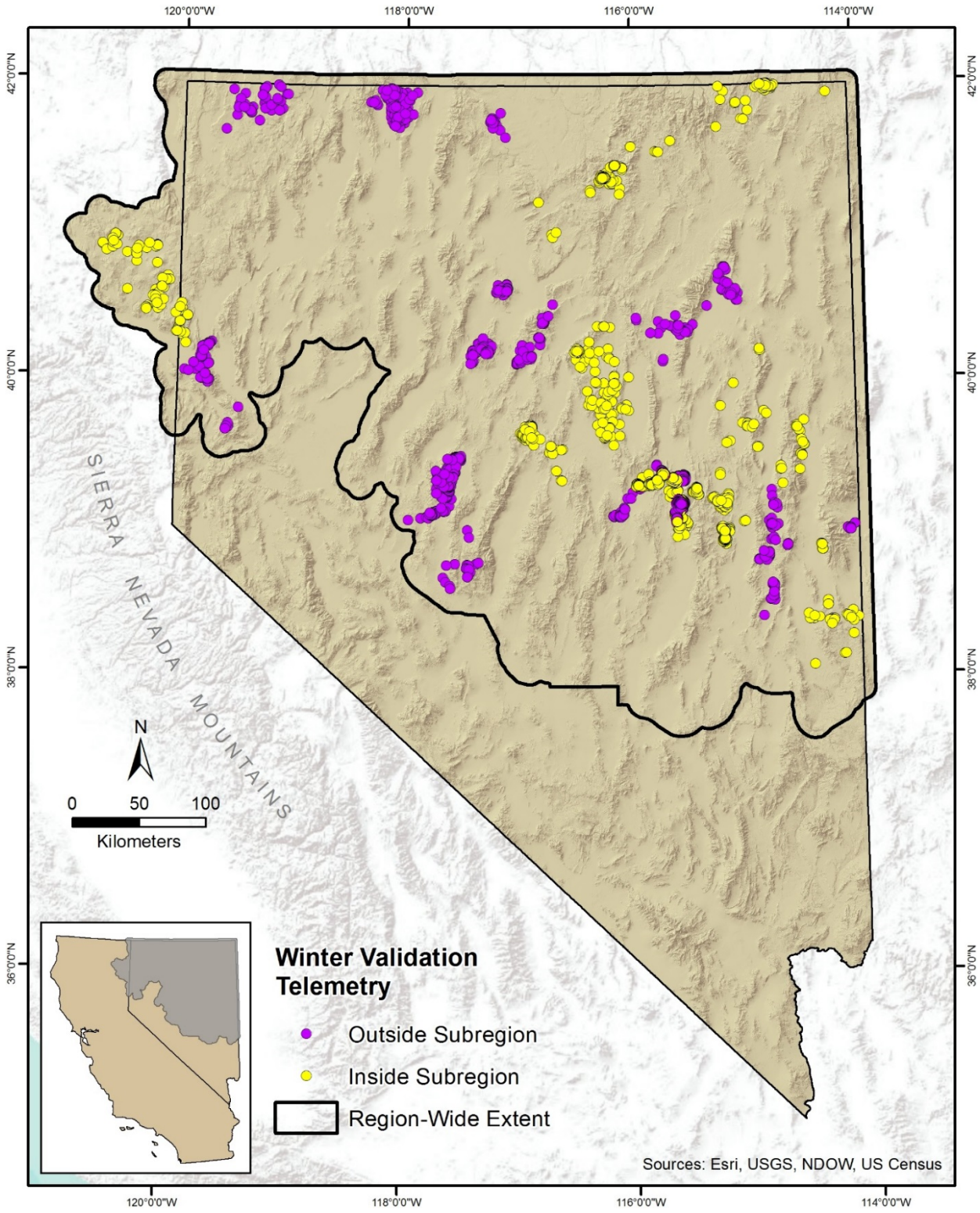

Figure 17. Map showing overlay of radio-telemetry data used to validate habitat suitability classes for greater sage-grouse (*Centrocercus urophasianus*) during winter, Nevada and northeastern California.

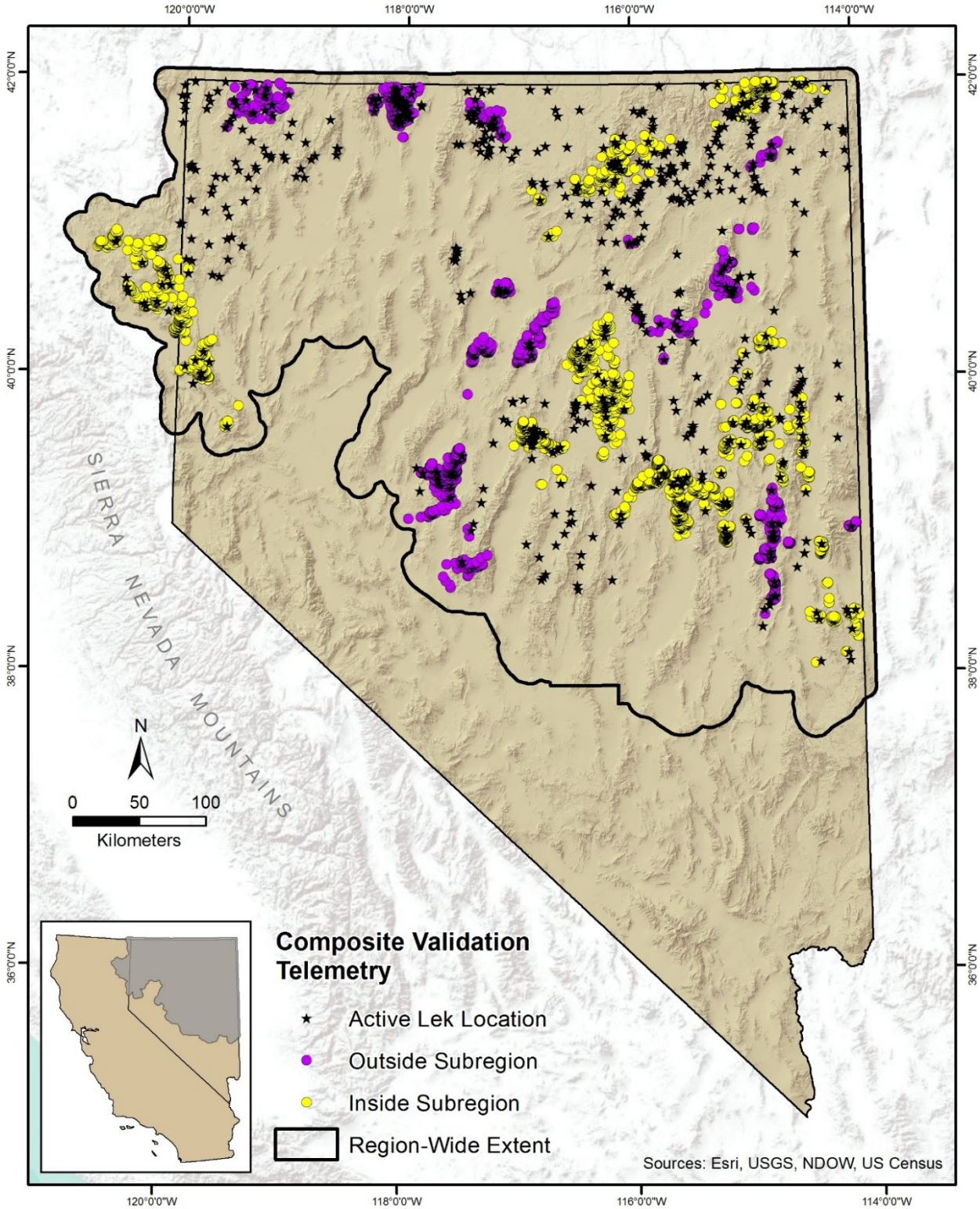

Figure 18. Map showing overlay of radio-telemetry data and lek locations used to validate composite habitat suitability classes for greater sage-grouse (*Centrocercus urophasianus*) on an annual basis, Nevada and northeastern California.

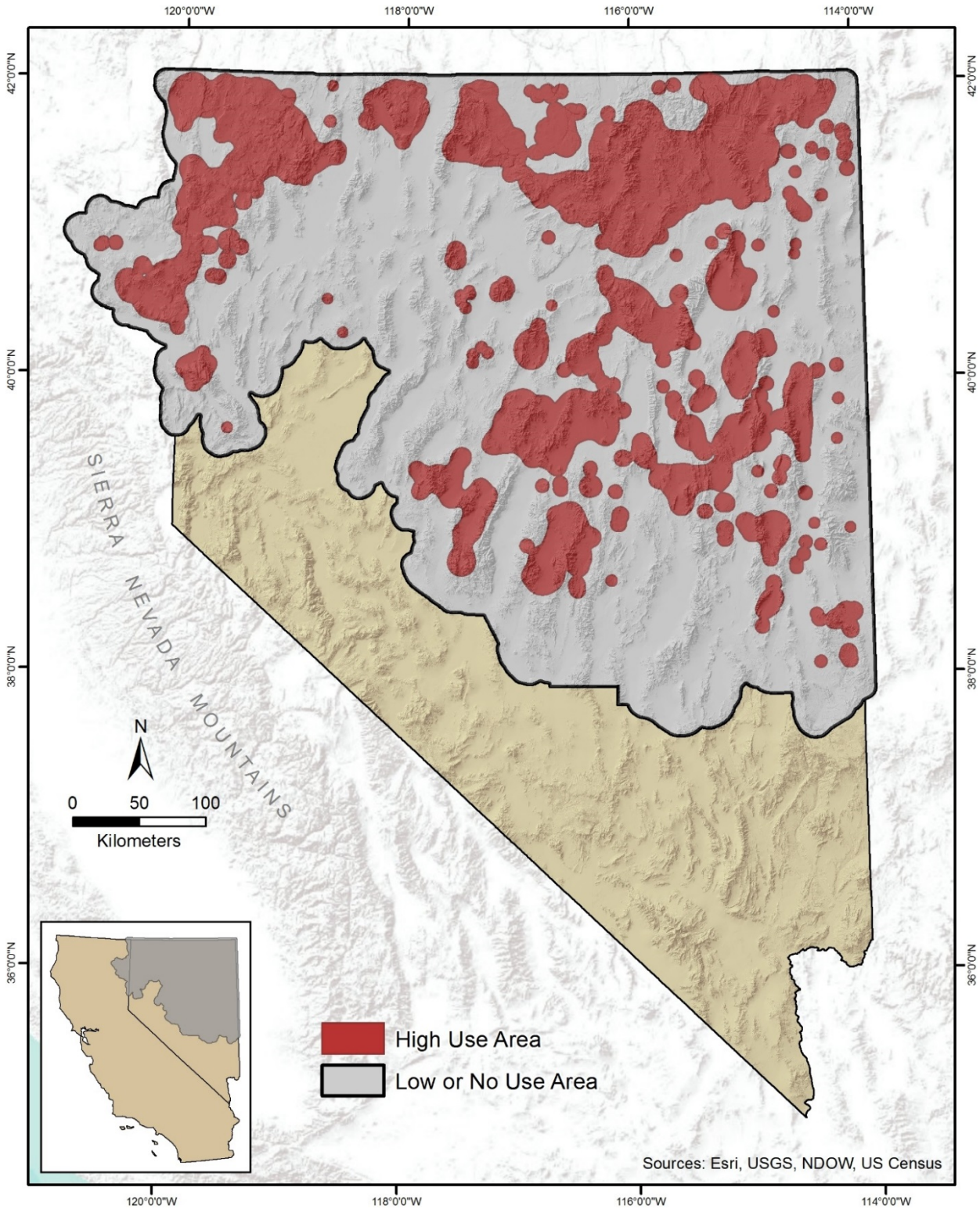

Figure 19. Map showing an abundance and space use index (AUI) that was developed compiling data on greater sage-grouse (*Centrocercus urophasianus*) use and distribution of leks, Nevada and northwestern California. Areas that contained 85 percent (%) of the total AUI density were identified as “high use” areas (reddish-brown).

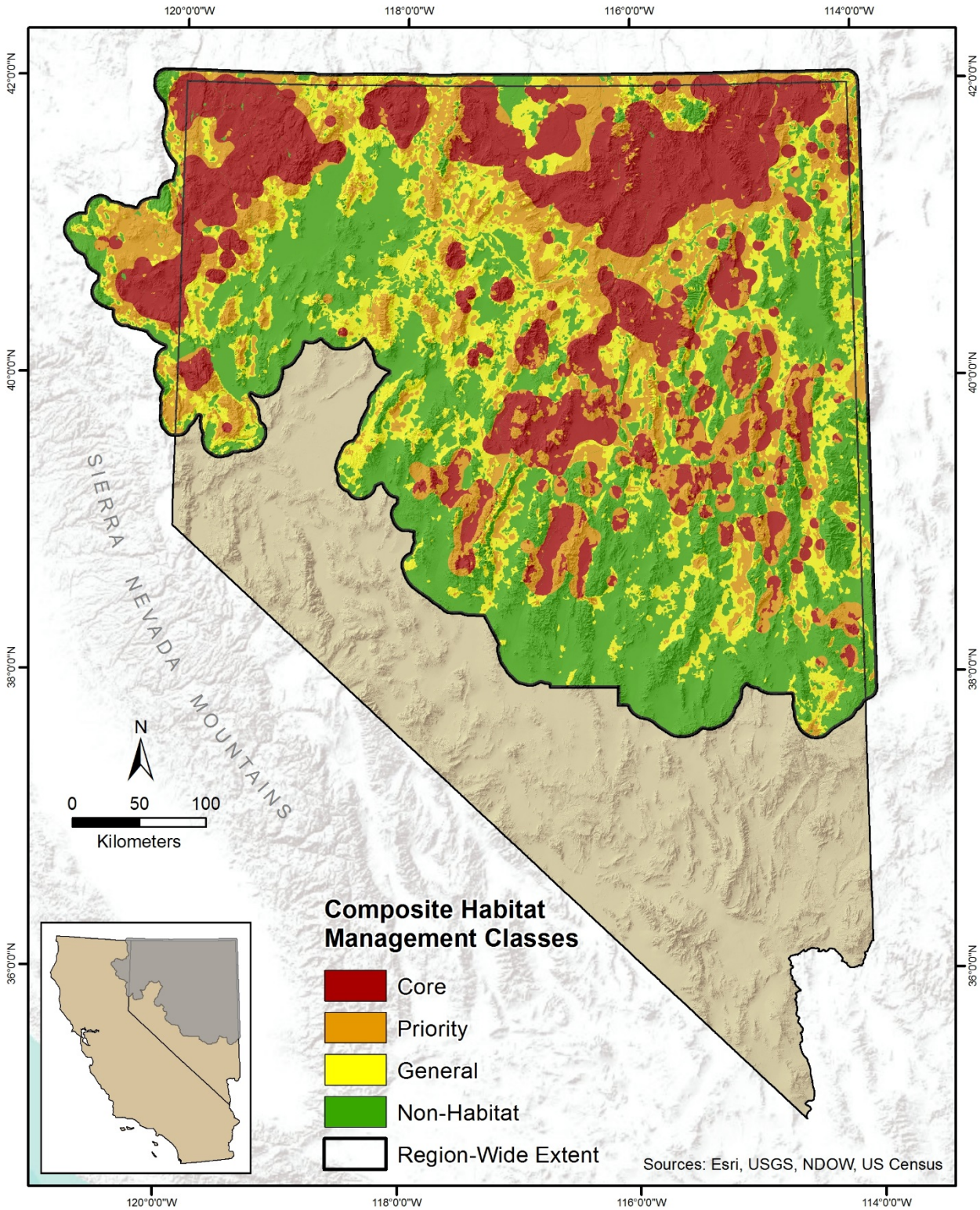

Figure 20. Map showing habitat management classes that can be determined based on the intersection of habitat suitability classes and space use index categories for greater sage-grouse (*Centrocercus urophasianus*), Nevada and northeastern California.

Table 1. Proposed variables assessed in resource selection function model development for each subregion, Nevada and northeastern California.

[ha, hectare; m, meter]

Variable type	Scales		
Land cover			
Annual grass	8.7 ha	61.5 ha	661.4 ha
Agriculture	8.7 ha	61.5 ha	661.4 ha
Bare ground	8.7 ha	61.5 ha	661.4 ha
Big sagebrush	8.7 ha	61.5 ha	661.4 ha
Forest	8.7 ha	61.5 ha	661.4 ha
Herbaceous	8.7 ha	61.5 ha	661.4 ha
Non-sagebrush shrubs	8.7 ha	61.5 ha	661.4 ha
Other sagebrush	8.7 ha	61.5 ha	661.4 ha
Pinyon-juniper	8.7 ha	61.5 ha	661.4 ha
Riparian	8.7 ha	61.5 ha	661.4 ha
Wet meadow	8.7 ha	61.5 ha	661.4 ha
Sagebrush height			
Sagebrush height	8.7 ha	61.5 ha	661.4 ha
Agriculture			
Distance to cropland	Linear	Exponential decay	
Edge			
Variety of edge types	8.7 ha	61.5 ha	661.4 ha
Landscape variation			
Variety of land cover types	8.7 ha	61.5 ha	661.4 ha
Water sources			
Any stream	Linear	Exponential decay	
Perennial stream	Linear	Exponential decay	
Intermittent stream	Linear	Exponential decay	
Spring	Linear	Exponential decay	
Water body	Linear	Exponential decay	
Wet meadow	Linear	Exponential decay	
Topography			
Elevation	Linear		
Roughness index	1 ha		
Topographic position index	510 m	2,010 m	

Table 2. Direction of significant model-averaged effects among 10 subregional resource selection function models for all proposed variables included in modeling of greater sage-grouse (*Centrocercus urophasianus*) habitat during the spring season, Nevada and northeastern California.

[**Symbols**: +, positive RSF coefficient; -, negative RSF coefficient; 0, RSF coefficient not used in final product; V, topographic position index coefficient indicates selection for valleys; R, topographic position index coefficient indicates selection for ridges]

		Subregion									
Group	Covariate	Buffalo Skedaddle	Cortez	Gollaher	Lincoln	Midway	North SWIP	South SWIP	Toiyabe	Tuscarora	Virginia Mountains
Land cover	Annual grass	0	-	0	0	0	-	0	+	-	+
	Bare ground	+	+	0	0	0	0	0	0	-	-
	Big sagebrush	-	+	0	+	0	+	+	0	0	0
	Cropland	0	0	0	0	+	+	0	0	0	-
	Forest	-	0	-	-	0	-	0	0	-	+
	Herbaceous	+	0	+	+	+	+	-	+	+	+
	Non-sagebrush shrubs	-	+	-	-	+	-	-	+	-	+
	Other sagebrush	0	+	+	0	+	+	0	+	+	+
	Pinyon-juniper	0	-	0	-	-	-	-	-	0	0
	Riparian	-	-	-	+	0	-	-	+	-	0
	Wet meadow	-	0	0	0	0	0	0	0	0	0
Sagebrush height	Sagebrush height	0	-	-	0	+	0	0	+	0	+
Agriculture	Distance to cropland	-	-	+	+	0	0	+	+	+	0
Edge	Variety of edge types	0	0	-	0	+	0	-	+	+	0
Landscape Variation	Variety of land cover	-	-	-	+	+	-	+	0	-	+

Group	Covariate	Subregion									
		Buffalo Skedaddle	Cortez	Gollaher	Lincoln	Midway	North SWIP	South SWIP	Toiyabe	Tuscarora	Virginia Mountains
	types										
Water Sources	Distance to nearest stream	0	0	0	0	+	+	0	0	-	-
	Distance to perennial stream	-	0	0	+	0	0	0	0	0	0
	Distance to intermittent stream	0	+	-	0	0	0	+	0	0	0
	Distance to spring	-	+	0	+	+	-	-	+	-	0
	Distance to water body	+	+	+	+	-	-	+	+	-	-
	Distance to wet meadow	0	+	0	+	+	-	0	+	+	+
Topography	Elevation	0	+	0	0	0	+	0	0	-	0
	Roughness index	0	-	-	-	-	0	-	0	-	+
	Topographic position index	R	R	R	V	V	0	R	0	R	R

Table 3. Direction of significant model-averaged effects among 10 subregional resource selection function models for all proposed variables included in modeling of greater sage-grouse (*Centrocercus urophasianus*) habitat during the summer season, Nevada and northeastern California.

[**Symbols**: +, positive RSF coefficient; -, negative RSF coefficient; 0, used in proportion to availability and RSF coefficient not used in final product; V, topographic position index coefficient indicates selection for valleys; R, topographic position index coefficient indicates selection for ridges]

		Subregion									
Group	Covariate	Buffalo Skedaddle	Cortez	Gollaher	Lincoln	Midway	North SWIP	South SWIP	Toiyabe	Tuscarora	Virginia Mountains
Land cover	Annual grass	+	+	0	0	0	-	0	-	-	+
	Bare ground	-	-	0	0	0	0	0	0	-	+
	Big sagebrush	-	+	0	+	0	+	+	+	0	0
	Cropland	+	0	0	0	0	0	0	0	+	0
	Forest	-	-	-	-	-	-	0	0	-	+
	Herbaceous	+	+	+	+	+	+	-	+	-	+
	Non-sagebrush shrubs	0	+	-	+	+	+	0	-	0	+
	Other sagebrush	-	+	+	0	+	+	0	+	+	-
	Pinyon-juniper	0	-	0	-	-	-	-	-	0	0
	Riparian	-	-	-	+	0	+	-	+	-	0
	Wet meadow	-	0	0	0	0	0	0	0	0	0
Sagebrush height	Sagebrush height	0	+	-	+	-	+	0	0	0	0
Agriculture	Distance to cropland	0	-	+	+	+	-	+	+	0	-
Edge	Variety of edge types	0	0	-	+	+	+	-	+	0	0
Landscape Variation	Variety of land cover types	-	+	+	+	-	+	0	0	-	0

Group	Covariate	Subregion									
		Buffalo Skedaddle	Cortez	Gollaher	Lincoln	Midway	North SWIP	South SWIP	Toiyabe	Tuscarora	Virginia Mountains
Water Sources	Distance to nearest stream	0	0	0	0	0	0	+	0	0	0
	Distance to perennial stream	-	+	0	+	0	0	0	+	0	+
	Distance to intermittent stream	0	0	-	0	0	0	0	0	0	0
	Distance to spring	-	+	+	+	+	+	+	0	-	0
	Distance to water body	+	+	+	+	+	+	+	+	-	0
	Distance to wet meadow	0	-	0	0	+	-	+	+	+	+
Topography	Elevation	-	+	0	0	0	+	-	0	0	0
	Roughness index	-	+	-	0	0	0	0	-	-	-
	Topographic position index	R	V	R	0	V	V	V	V	0	R

Table 4. Direction of significant model-averaged effects among 10 subregional resource selection function models for all proposed variables included in modeling of greater sage-grouse (*Centrocercus urophasianus*) habitat during the winter season, Nevada and northeastern California.

[**Symbols**: +, positive RSF coefficient; -, negative RSF coefficient; 0, used in proportion to availability and RSF coefficient not used in final product; V, topographic position index coefficient indicates selection for valleys; R, topographic position index coefficient indicates selection for ridges.]

		Subregion						
Group	Covariate	Buffalo Skedaddle	Cortez	Gollaher	Lincoln	North SWIP	Toiyabe	Tuscarora
Land cover	Annual grass	+	+	0	0	0	-	-
	Bare ground	+	+	0	0	+	0	0
	Big sagebrush	-	+	0	+	+	-	0
	Cropland	+	-	-	0	0	0	0
	Forest	0	0	-	+	-	0	-
	Herbaceous	+	+	-	0	+	-	+
	Non-sagebrush shrubs	-	+	-	-	-	-	-
	Other sagebrush	-	+	+	+	+	+	+
	Pinyon-juniper	0	0	0	-	0	-	0
	Riparian	0	-	-	-	-	0	-
	Wet meadow	0	0	0	0	0	0	0
Sagebrush height	Sagebrush height	0	0	-	+	0	0	+
Agriculture	Distance to cropland	0	0	0	+	+	+	+
Edge	Variety of edge types	0	0	0	0	-	-	0
Landscape Variation	Variety of land cover types	-	-	-	-	0	0	-
Water Sources	Distance to nearest stream	0	0	0	+	0	0	-
	Distance to	-	+	0	0	0	0	0

Group	Covariate	Subregion						
		Buffalo Skedaddle	Cortez	Gollaher	Lincoln	North SWIP	Toiyabe	Tuscarora
	perennial stream							
	Distance to intermittent stream	0	0	-	0	0	0	0
	Distance to spring	-	+	0	+	0	+	+
	Distance to water body	0	+	+	+	-	+	-
	Distance to wet meadow	0	+	0	+	-	+	+
Topography	Elevation	+	+	0	0	0	0	-
	Roughness index	-	+	-	0	0	0	-
	Topographic position index	R	R	R	R	V	R	V

Table 5. Summary of habitat suitability model validation tests used to evaluate habitat suitability classes described in seasonal maps for greater sage-grouse (*Centrocercus urophasianus*), Nevada and northeastern California.

[Three independent sets used for validation included: (1) radio telemetry data selected from within the subregions where RSFs were calculated (RSF subregions); (2) telemetry data outside the subregions (Non-RSF subregions); and (3) Active leks. Percent, %; Values for Cohen's kappa coefficient (κ) are in parentheses]

Habitat Suitability Classification	Expected %	Validation Sets		
		RSF subregions % (κ)	Non - RSF subregions % (κ)	Active leks % (κ)
Spring				
High	69	73 (0.92)	81 (0.97)	70 (0.90)
Moderate	15	14 (0.99)	8 (0.99)	11 (0.69)
Low	9	8 (0.91)	6 (0.96)	8 (0.90)
Non-Habitat	7	5 (0.94)	4 (0.99)	7 (0.96)
Summer				
High	69	74 (0.91)	62 (0.74)	N/A
Moderate	15	10 (0.97)	22 (0.87)	N/A
Low	9	7 (0.74)	14 (0.78)	N/A
Non-Habitat	7	8 (0.76)	3 (0.83)	N/A
Winter				
High	69	57 (0.28)	26 (0.70)	N/A
Moderate	15	16 (0.81)	19 (0.98)	N/A
Low	9	13 (0.31)	42 (0.82)	N/A
Non-Habitat	7	13 (0.51)	13 (0.87)	N/A

Table 6. Summary of habitat suitability model validation tests used to evaluate habitat suitability classes described in the composite annual map for greater sage-grouse (*Centrocercus urophasianus*), and comparisons with validation results from Coates and others (2014, 2016), Nevada and northeastern California.

[Three independent sets used for validation included: (1) radio telemetry data selected from within the subregions where RSFs were calculated (RSF subregions); (2) telemetry data outside the subregions (Non-RSF subregions); and (3) Active leks. Percent, %; Values for Cohen's kappa coefficient (κ) are in parentheses. RSF and non-RSF percent validation for Coates and others (2014, 2016) were recalculated using the average proportion per bird method described in this report]

Habitat Suitability Classification	Expected %	RSF subregions; % (κ)		Non-RSF subregions; % (κ)		Leks; % (κ)	
		This study	Coates and others (2014, 2016)	This study	Coates and others (2014, 2016)	This study	Coates and others (2014, 2016)
High	69	68 (0.75)	68 (0.97)	72 (0.89)	53 (0.50)	79 (0.74)	79 (0.73)
Moderate	15	15 (0.92)	18 (0.83)	17 (0.95)	32 (0.37)	9 (0.72)	15 (0.98)
Low	9	9 (0.78)	8 (0.89)	6 (0.99)	2 (0.61)	8 (0.94)	3 (0.50)
Non-Habitat	7	7 (0.41)	6 (0.81)	5 (0.93)	13 (0.85)	3 (0.67)	3 (0.57)

Table 7. Rubric for determining habitat management classes from habitat suitability index and abundance and space use index categories.

	Abundance and Space Use Index Category	
Region-wide HSI Category	High Use Area	Low-to-No Use Areas
High Habitat Suitability	*Core Habitat*	*Priority Habitat*
Moderate Habitat Suitability	*Core Habitat*	*General Habitat*
Low Habitat Suitability	*Core Habitat*	*General Habitat*
Non-suitable Habitat	*Priority Habitat*	*Non Habitat*

Table 8. Areal and percent differences in greater sage-grouse habitat, management, and abundance and space use categories between this study and Coates and others (2014, 2016), Nevada and northeastern California.

Map Type	Category	Acres (This study)	Change in acres (from Coates and others, 2014, 2016)	% Change (from Coates and others, 2014, 2016)
Habitat Class	High	15,910,205	1,195,966	8.1%
	Mod	5,542,893	-2,962,427	-34.8%
	Low	7,282,679	3,531,047	94.1%
	All Habitat	28,735,777	1,764,586	6.5%
	Non-Habitat	21,471,029	-1,764,586	-7.6%
Management Class	Core	12,890,158	865,850	7.2%
	Priority	9,807,410	855,369	9.6%
	General	9,150,735	768,395	9.2%
	All Management	31,848,303	2,489,613	8.5%
	Non-Habitat (Mgmt.)	18,358,504	-2,489,613	-11.9%
Abundance and Space Use	High AUI	16,068,615	1,643,064	11.4%
	Low-to-No AUI	34,138,192	-1,643,064	-4.6%

Appendixes

Appendix A. Supplemental material for Buffalo-Skedaddle spring RSF modeling

Table A1. Variable selection results from the "proposal set" of variables from the Buffalo-Skedaddle subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	Null	3	-8,934.7	0.0	0.41
		8.7 ha	4	-8,934.0	0.7	0.29
		61.5 ha	4	-8,934.6	1.9	0.16
		661.4 ha	4	-8,934.7	2.0	0.15
	Bare ground	61.5 ha	4	-8,909.4	0.0	0.99
		8.7 ha	4	-8,914.3	9.8	0.01
		661.4 ha	4	-8,922.5	26.1	0.00
		Null	3	-8,934.7	48.4	0.00
	Big sagebrush	661.4 ha	4	-8,829.8	0.0	1.0
		61.5 ha	4	-8,887.0	114.4	0.0
		8.7 ha	4	-8,911.0	162.3	0.0
		Null	3	-8,934.7	207.7	0.0
	Cropland	661.4 ha	4	-8,753.1	0.0	1.0
		61.5 ha	4	-8,828.3	150.4	0.0
		8.7 ha	4	-8,868.7	231.3	0.0
		Null	3	-8,934.7	361.2	0.0
	Forest	661.4 ha	4	-8,669.0	0.0	1.0
		61.5 ha	4	-8,711.3	84.7	0.0
		8.7 ha	4	-8,768.8	199.7	0.0
		Null	3	-8,934.7	529.4	0.0
	Herbaceous	661.4 ha	4	-8,749.9	0.0	1.0
		61.5 ha	4	-8,783.8	67.8	0.0
		8.7 ha	4	-8,798.8	97.9	0.0
		Null	3	-8,934.7	367.6	0.0
	Non-sagebrush shrub	61.5 ha	4	-8,803.4	0.0	1.0
		661.4 ha	4	-8,824.4	41.9	0.0
		8.7 ha	4	-8,837.1	67.3	0.0
		Null	3	-8,934.7	260.5	0.0
	Other sagebrush	661.4 ha	4	-8,911.8	0.0	1.0
		61.5 ha	4	-8,917.2	10.8	0.0
		8.7 ha	4	-8,917.7	11.9	0.0
		Null	3	-8,934.7	43.8	0.0
Land cover	Riparian	661.4 ha	4	-8,600.1	0.0	1.0
		61.5 ha	4	-8,733.0	265.8	0.0
		8.7 ha	4	-8,817.9	435.6	0.0
		Null	3	-8,934.7	667.1	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
	Wet meadow	661.4 ha	4	-8,841.5	0.0	1.0
		61.5 ha	4	-8,889.6	96.2	0.0
		8.7 ha	4	-8,914.5	146.0	0.0
		Null	3	-8,934.7	184.3	0.0
Sagebrush height	Sagebrush height	661.4 ha	4	-8,900.2	0.0	1.0
		61.5 ha	4	-8,924.1	47.9	0.0
		8.7 ha	4	-8,930.0	59.6	0.0
		Null	3	-8,934.7	67.0	0.0
Agriculture	Distance to cropland	Expon. decay	4	-8,732.0	0.0	1.0
		Linear	4	-8,778.3	92.6	0.0
		Null	3	-8,934.7	403.4	0.0
Edge	Variety of edge cover types	61.5 ha	4	-8,184.6	0.0	1.0
		661.4 ha	4	-8,259.5	149.9	0.0
		8.7 ha	4	-8,363.6	358.2	0.0
		Null	3	-8,934.7	1,498.2	0.0
Landscape variation	Variety of land cover types	61.5 ha	4	-8,135.4	0.0	1.0
		8.7 ha	4	-8,298.7	326.6	0.0
		661.4 ha	4	-8,605.6	940.4	0.0
		Null	3	-8,934.7	1,596.6	0.0
Water sources	Distance to perennial stream	Expon. decay	4	-8,717.2	0.0	1.0
	Distance to spring	Expon. decay	4	-8,760.9	87.3	0.0
	Distance to spring	Linear	4	-8,800.8	167.1	0.0
	Distance to perennial stream	Linear	4	-8,828.7	223.0	0.0
	Distance to water body	Linear	4	-8,879.3	324.2	0.0
	Distance to water body	Expon. decay	4	-8,923.2	412.0	0.0
	Distance to nearest stream	Linear	4	-8,925.2	416.0	0.0
	Distance to wet meadow	Expon. decay	4	-8,927.5	420.5	0.0
	Distance to intermittent stream	Linear	4	-8,931.3	428.2	0.0
	Distance to wet meadow	Linear	4	-8,931.9	429.4	0.0
	Distance to nearest stream	Expon. decay	4	-8,932.0	429.6	0.0
	Null	Null	3	-8,934.7	432.9	0.0
	Distance to intermittent stream	Expon. decay	4	-8,933.7	433.0	0.0
Topography	Roughness index*	1 ha	4	-8,409.9	0.0	1.0
	Elevation	Linear	4	-8,801.9	784.0	0.0
	Topographic position index	510 m	4	-8,920.8	1,021.7	0.0
	Topographic position index	2010 m	4	-8,931.5	1,043.1	0.0
	Null		3	-8,934.7	1,047.5	0.0

*Model failed to converge. Was not carried forward in the RSF modeling procedure.

Table A2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Buffalo-Skedaddle spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Bare ground	61.5 ha	0.38 (0.09, 0.66)	Selection
Big sagebrush	661.4 ha	-13.26 (-14.78, -11.74)	Avoidance
Forest	661.4 ha	-25.97 (-33.16, -18.77)	Avoidance
Herbaceous	661.4 ha	8.57 (7.77, 9.38)	Selection
Non-sagebrush shrub	61.5 ha	-6.53 (-7.78, -5.29)	Avoidance
Riparian	661.4 ha	-57.72 (-67.65, -47.79)	Avoidance
Wet meadow	661.4 ha	-16.05 (-20.31, -11.79)	Avoidance
Distance to cropland	Expon. decay	-0.70 (-0.86, -0.53)	Avoidance
Variety of land cover types	61.5 ha	-0.48 (-0.51, -0.46)	Avoidance
Distance to perennial stream	Expon. decay	-1.11 (-1.27, -0.94)	Avoidance
Distance to spring	Expon. decay	-0.77 (-0.95, -0.59)	Avoidance
Distance to water body	Linear	-0.24 (-0.27, -0.21)	Selection
Elevation	Linear	-0.86 (-1.10, -0.62)	Selection for lower elevation
Topographic position index	510 m	0.009 (0.005, 0.01)	Selected ridges / Avoided valleys

Table A3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Buffalo-Skedaddle subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California."

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Bare ground	61.5 ha	0.510	0.0019	0.527	0.0034
Big sagebrush	661.4 ha	0.049	0.0003	0.042	0.0007
Forest	661.4 ha	0.014	0.0009	0.000	0.0001
Herbaceous	661.4 ha	0.169	0.0007	0.187	0.0014
Non-sagebrush shrub	61.5 ha	0.043	0.0004	0.034	0.0008
Riparian	661.4 ha	0.003	0.0001	0.001	0.0001
Wet meadow	661.4 ha	0.005	0.0003	0.001	0.0002
Distance to cropland	Km	2.93	0.0270	3.61	0.0614
Variety of land cover types	61.5 ha	3.80	0.0247	2.56	0.0399
Distance to perennial stream	Km	4.58	0.0457	5.45	0.0846
Distance to spring	Km	2.78	0.0249	3.37	0.0570
Distance to water body	Km	2.07	0.0190	1.82	0.0309
Elevation	Km	1.62	0.0024	1.57	0.0037
Topographic position index	510 m	0.07	0.1714	1.11	0.2168

Appendix B. Supplemental material for Buffalo-Skedaddle summer season RSF modeling

Table B1. Variable selection results from the "proposal set" of variables from the Buffalo-Skedaddle subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-10,184.2	0.0	1.0
		61.5 ha	4	-10,224.1	79.8	0.0
		8.7 ha	4	-10,235.7	103.0	0.0
		Null	3	-10,237.8	105.2	0.0
	Bare ground	661.4 ha	4	-9,436.9	0.0	1.0
		61.5 ha	4	-9,551.3	228.9	0.0
		8.7 ha	4	-9,656.5	439.2	0.0
		Null	3	-10,237.8	1,599.8	0.0
	Big sagebrush	661.4 ha	4	-9,993.4	0.0	1.0
		61.5 ha	4	-10,095.8	204.9	0.0
		8.7 ha	4	-10,109.9	233.1	0.0
		Null	3	-10,237.8	486.8	0.0
	Cropland	661.4 ha	4	-10,131.6	0.0	1.0
		61.5 ha	4	-10,229.6	196.1	0.0
		8.7 ha	4	-10,235.7	208.2	0.0
		Null	3	-10,237.8	210.4	0.0
	Forest	661.4 ha	4	-10,035.0	0.0	1.0
		61.5 ha	4	-10,068.8	67.6	0.0
		8.7 ha	4	-10,107.0	144.1	0.0
		Null	3	-10,237.8	403.6	0.0
	Herbaceous	61.5 ha	4	-9,887.0	0.0	1.0
		8.7 ha	4	-9,925.8	77.4	0.0
		661.4 ha	4	-9,948.6	123.1	0.0
		Null	3	-10,237.8	699.5	0.0
	Non-sagebrush shrub	Null	3	-10,237.8	0.0	0.46
		8.7 ha	4	-10,237.7	1.8	0.19
		61.5 ha	4	-10,237.7	1.9	0.18
		661.4 ha	4	-10,237.8	1.9	0.17
	Other sagebrush	661.4 ha	4	-10,231.9	0.0	0.99
		Null	3	-10,237.8	9.8	0.01
		61.5 ha	4	-10,237.4	11.1	0.00
		8.7 ha	4	-10,237.6	11.4	0.00
	Riparian	661.4 ha	4	-9,964.1	0.0	1.0
		61.5 ha	4	-10,108.9	289.5	0.0
		8.7 ha	4	-10,171.1	414.1	0.0
		Null	3	-10,237.8	545.4	0.0
Land cover	Wet meadow	661.4 ha	4	-10,209.1	0.0	1.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		61.5 ha	4	-10,226.7	35.2	0.0
		8.7 ha	4	-10,234.4	50.5	0.0
		Null	3	-10,237.8	55.3	0.0
Sagebrush height	Sagebrush height	61.5 ha	4	-10,152.3	0.0	1.0
		661.4 ha	4	-10,171.6	38.5	0.0
		8.7 ha	4	-10,234.5	164.3	0.0
		Null	3	-10,237.8	168.9	0.0
Agriculture	Distance to cropland	Expon. decay	4	-10,219.1	0.0	1.0
		Null	3	-10,237.8	35.4	0.0
		Linear	4	-10,236.8	35.4	0.0
Edge	Variety of edge types	61.5 ha	4	-9,857.7	0.0	1.0
		661.4 ha	4	-9,876.6	37.9	0.0
		8.7 ha	4	-9,897.8	80.3	0.0
		Null	3	-10,237.8	758.2	0.0
Landscape variation	Variety of land cover types	61.5 ha	4	-9,774.3	0.0	1.0
		8.7 ha	4	-9,855.0	161.5	0.0
		661.4 ha	4	-10,054.3	560.1	0.0
		Null	3	-10,237.8	925.0	0.0
Water sources	Distance to spring	Expon. decay	4	-8,869.7	0.0	1.0
	Distance to spring	Linear	4	-8,908.6	77.8	0.0
	Distance to perennial stream	Expon. decay	4	-9,760.9	1,782.5	0.0
	Distance to intermittent stream	Expon. decay	4	-9,778.3	1,817.2	0.0
	Distance to water body	Linear	4	-9,826.2	1,913.1	0.0
	Distance to intermittent stream	Linear	4	-9,846.2	1,953.0	0.0
	Distance to perennial stream	Linear	4	-9,884.4	2,029.4	0.0
	Distance to water body	Expon. decay	4	-10,055.7	2,372.1	0.0
	Distance to nearest stream	Expon. decay	4	-10,102.9	2,466.3	0.0
	Distance to nearest stream	Linear	4	-10,149.0	2,558.6	0.0
	Distance wet meadow	Linear	4	-10,228.6	2,717.8	0.0
	Null	Null	3	-10,237.8	2,734.2	0.0
	Distance to wet meadow	Expon. decay	4	-10,237.5	2,735.6	0.0
Topography	Roughness index	1 ha	4	-8,222.9	0.0	1.0
	Elevation	Linear	4	-9,926.6	3,407.3	0.0
	Topographic position index	2010 m	4	-10,228.2	4,010.5	0.0
	Null		3	-10,237.8	4,027.7	0.0
	Topographic position index	510 m	4	-10,237.3	4,028.7	0.0

Table B2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Buffalo-Skedaddle summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	0.26 (-0.91, 1.44)	None
Bare ground	661.4 ha	-4.25 (-4.59, -3.92)	Avoidance
Big sagebrush	661.4 ha	-10.97 (-12.69, -9.25)	Avoidance
Cropland	661.4 ha	0.48 (-0.26, 1.22)	None
Forest	661.4 ha	-4.46 (-6.25, -2.67)	Avoidance
Herbaceous	61.5 ha	9.98 (9.36, 10.60)	Selection
Other sagebrush	661.4 ha	-8.12 (-9.86, -6.38)	Avoidance
Riparian	661.4 ha	-16.84 (-23.68, -10.01)	Avoidance
Wet meadow	661.4 ha	-14.96 (-17.70, -12.21)	Avoidance
Variety of land cover types	61.5 ha	-0.19 (-0.22, -0.17)	Avoidance
Distance to perennial stream	Expon. decay	-1.46 (-1.64, -1.29)	Avoidance
Distance to spring	Expon. decay	-2.70 (-2.93, -2.47)	Avoidance
Distance to water body	Linear	-0.29 (-0.33, -0.25)	Selection
Elevation	Linear	-0.25 (-0.53, 0.02)	None
Roughness index	1 ha	-17.91 (-18.59, -17.24)	Avoidance
Topographic position index	2010 m	0.005 (0.004, 0.007)	Selected ridges / Avoided valleys

Table B3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Buffalo-Skedaddle subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California."

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.015	0.0004	0.021	0.0009
Bare ground	661.4 ha	0.508	0.0015	0.418	0.0039
Big sagebrush	661.4 ha	0.050	0.0003	0.041	0.0006
Cropland	661.4 ha	0.010	0.0005	0.024	0.0019
Forest	661.4 ha	0.014	0.0009	0.001	0.0003
Herbaceous	61.5 ha	0.171	0.0007	0.201	0.0020
Other sagebrush	661.4 ha	0.041	0.0003	0.040	0.0006
Riparian	661.4 ha	0.003	0.0001	0.001	0.0001
Wet meadow	661.4 ha	0.005	0.0003	0.003	0.0003
Variety of land cover types	61.5 ha	3.85	0.0235	2.88	0.0464
Distance to perennial stream	Km	4.55	0.0427	6.08	0.0841
Distance to spring	Km	2.76	0.0232	4.48	0.0531
Distance to water body	Km	2.05	0.0177	1.47	0.0224
Elevation	Km	1.62	0.0022	1.55	0.0035
Roughness index	1 ha	0.14	0.0010	0.06	0.0016
Topographic position index	2010 m	-0.37	0.4441	-2.43	0.3348

Appendix C. Supplemental material for Buffalo-Skedaddle winter RSF modeling

Table C1. Variable selection results from the "proposal set" of variables from the Buffalo-Skedaddle subregion during the winter season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-2,415.8	0.0	0.97
		61.5 ha	4	-2,419.5	7.3	0.02
		8.7 ha	4	-2,422.3	13.0	0.00
		Null	3	-2,426.0	18.4	0.00
	Bare ground	8.7 ha	4	-2,422.1	0.0	0.89
		Null	3	-2,426.0	5.9	0.05
		61.5 ha	4	-2,425.1	6.1	0.04
		661.4 ha	4	-2,425.7	7.2	0.02
	Big sagebrush	661.4 ha	4	-2,355.3	0.0	1.0
		61.5 ha	4	-2,406.9	103.3	0.0
		8.7 ha	4	-2,415.9	121.2	0.0
		Null	3	-2,426.0	139.5	0.0
	Cropland	661.4 ha	4	-2,390.7	0.0	1.0
		61.5 ha	4	-2,420.2	59.0	0.0
		Null	3	-2,426.0	68.6	0.0
		8.7 ha	4	-2,425.7	70.0	0.0
	Herbaceous	8.7 ha	4	-2,419.6	0.0	0.98
		661.4 ha	4	-2,424.4	9.7	0.01
		61.5 ha	4	-2,424.8	10.4	0.01
		Null	3	-2,426.0	10.9	0.00
	Non-sagebrush shrub	661.4 ha	4	-2,315.7	0.0	1.0
		61.5 ha	4	-2,373.1	114.8	0.0
		8.7 ha	4	-2,400.9	170.4	0.0
		Null	3	-2,426.0	218.6	0.0
	Other sagebrush	661.4 ha	4	-2,416.6	0.0	1.0
		Null	3	-2,426.0	16.8	0.0
		61.5 ha	4	-2,425.4	17.5	0.0
		8.7 ha	4	-2,425.8	18.4	0.0
Sagebrush height	Sagebrush height	Null	3	-2,426.0	0.0	0.36
		661.4 ha	4	-2,425.3	0.5	0.27
		8.7 ha	4	-2,425.5	0.9	0.23
		61.5 ha	4	-2,425.9	1.8	0.14
Agriculture	Distance to cropland	Linear	4	-2,417.6	0.0	1.0
		Expon. Decay	4	-2,424.2	13.2	0.0
		Null	3	-2,426.0	14.9	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Edge	Variety of edge types	61.5 ha	4	-2,336.6	0.0	0.95
		8.7 ha	4	-2,339.5	5.8	0.05
		661.4 ha	4	-2,354.4	35.6	0.00
		Null	3	-2,426.0	176.9	0.00
Landscape variation	Variety of land cover types	61.5 ha	4	-2,254.0	0.0	1.0
		8.7 ha	4	-2,319.8	131.6	0.0
		661.4 ha	4	-2,349.8	191.7	0.0
		Null	3	-2,426.0	342.1	0.0
Water sources	Distance to spring	Expon. decay	4	-2,321.4	0.0	0.96
	Distance to spring	Linear	4	-2,324.7	6.6	0.04
	Distance to perennial stream	Expon. decay	4	-2,326.8	10.8	0.00
	Distance to perennial stream	Linear	4	-2,376.0	109.2	0.00
	Distance to intermittent stream	Expon. decay	4	-2,416.5	190.2	0.00
	Distance to intermittent stream	Linear	4	-2,421.7	200.6	0.00
	Distance to nearest stream	Expon. decay	4	-2,422.5	202.1	0.00
	Distance to nearest stream	Linear	4	-2,424.3	205.7	0.00
	Distance to water body	Expon. decay	4	-2,424.9	206.9	0.00
	Null	Null	3	-2,426.0	207.2	0.00
	Distance to wet meadow	Expon. decay	4	-2,425.1	207.3	0.00
	Distance to water body	Linear	4	-2,425.9	208.8	0.00
	Distance to wet meadow	Linear	4	-2,426.0	209.1	0.00
Topography	Roughness index	1 ha	4	-2,226.6	0.0	1.0
	Elevation	Linear	4	-2,421.9	390.6	0.0
	Topographic position index	510 m	4	-2,422.9	392.6	0.0
	Null		3	-2,426.0	396.9	0.0
	Topographic position index	2010 m	4	-2,426.0	398.9	0.0

Table C2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Buffalo-Skedaddle winter season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	11.37 (9.04, 13.69)	Selection
Bare ground	8.7 ha	0.02 (0.01, 0.03)	Selection
Big sagebrush	661.4 ha	-0.21 (-0.25, -0.18)	Avoidance
Cropland	661.4 ha	7.98 (6.56, 9.40)	Selection
Herbaceous	8.7 ha	0.01 (0.002, 0.02)	Selection
Non-sagebrush shrub	661.4 ha	-0.25 (-0.28, -0.21)	Avoidance
Other sagebrush	661.4 ha	-0.12 (-0.16, -0.09)	Avoidance
Variety of land cover types	61.5 ha	-0.34 (-0.39, -0.29)	Avoidance
Distance to perennial stream	Expon. decay	-1.69 (-2.00, -1.38)	Avoidance
Distance to spring	Expon. decay	-2.64 (-2.98, -2.30)	Avoidance
Elevation	Linear	0.62 (0.14, 1.10)	Selection for higher elevation
Roughness index	1 ha	-8.49 (-9.72, -7.26)	Avoidance
Topographic position index	510 m	0.008 (0.001, 0.015)	Selected ridges / Avoided valleys

Table C3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Buffalo-Skedaddle subregion, and found important in resource selection function (RSF) modeling during the winter season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.016	0.0009	0.021	0.0021
Bare ground	8.7 ha	0.511	0.0037	0.526	0.0085
Big sagebrush	661.4 ha	0.049	0.0006	0.040	0.0011
Cropland	661.4 ha	0.011	0.0011	0.032	0.0053
Herbaceous	8.7 ha	0.172	0.0017	0.181	0.0043
Non-sagebrush shrub	661.4 ha	0.042	0.0007	0.029	0.0013
Other sagebrush	661.4 ha	0.041	0.0006	0.037	0.0012
Variety of land cover types	61.5 ha	3.77	0.0484	2.62	0.0814
Distance to perennial stream	Km	4.65	0.0890	5.77	0.1511
Distance to spring	Km	2.82	0.0487	3.84	0.1152
Elevation	Km	1.61	0.0047	1.60	0.0054
Roughness index	1 ha	0.14	0.0021	0.08	0.0035
Topographic position index	510 m	-0.20	0.3324	0.75	0.4093

Appendix D. Supplemental material for Cortez spring RSF modeling

Table D1. Variable selection results from the "proposal set" of variables from the Cortez subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	8.7 ha	4	-22,460.3	0.0	1.0
		61.5 ha	4	-22,470.3	19.9	0.0
		661.4 ha	4	-22,476.3	32.0	0.0
		Null	3	-22,478.8	34.9	0.0
	Bare ground	8.7 ha	4	-21,898.1	0.0	1.0
		61.5 ha	4	-21,911.0	25.9	0.0
		661.4 ha	4	-22,043.7	291.3	0.0
		Null	3	-22,478.8	1,159.4	0.0
	Big sagebrush	661.4 ha	4	-21,933.3	0.0	1.0
		61.5 ha	4	-21,974.0	81.4	0.0
		8.7 ha	4	-22,069.0	271.4	0.0
		Null	3	-22,478.8	1,088.9	0.0
	Cropland	661.4 ha	4	-22,101.3	0.0	1.0
		61.5 ha	4	-22,227.3	251.9	0.0
		8.7 ha	4	-22,258.4	314.2	0.0
		Null	3	-22,478.8	752.9	0.0
	Herbaceous	8.7 ha	4	-22,365.0	0.0	0.96
		661.4 ha	4	-22,368.3	6.5	0.04
		61.5 ha	4	-22,372.0	14.0	0.00
		Null	3	-22,478.8	225.5	0.00
	Non-sagebrush shrub	661.4 ha	4	-22,455.3	0.0	0.90
		8.7 ha	4	-22,458.1	5.8	0.05
		61.5 ha	4	-22,458.2	5.9	0.05
		Null	3	-22,478.8	45.0	0.00
	Other sagebrush	661.4 ha	4	-20,183.6	0.0	1.0
		61.5 ha	4	-20,427.4	487.6	0.0
		8.7 ha	4	-20,748.2	1,129.2	0.0
		Null	3	-22,478.8	4,588.4	0.0
	Pinyon-juniper	8.7 ha	4	-21,444.5	0.0	1.0
		61.5 ha	4	-21,485.4	81.8	0.0
		661.4 ha	4	-21,910.2	931.3	0.0
		Null	3	-22,478.8	2,066.5	0.0
	Riparian	661.4 ha	4	-21,914.3	0.0	1.0
		61.5 ha	4	-22,111.0	393.4	0.0
		8.7 ha	4	-22,215.3	602.0	0.0
		Null	3	-22,478.8	1,126.9	0.0
Sagebrush	Sagebrush height	661.4 ha	4	-22,470.6	0.0	0.88

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
height						
		61.5 ha	4	-22,472.6	4.0	0.12
		Null	3	-22,478.8	14.4	0.00
		8.7 ha	4	-22,477.8	14.4	0.00
Agriculture	Distance to cropland	Expon. decay	4	-22,093.6	0.0	1.0
		Linear	4	-22,264.2	341.1	0.0
		Null	3	-22,478.8	768.3	0.0
Edge	Variety of edge types	8.7 ha	4	-22,340.8	0.0	1.0
		61.5 ha	4	-22,371.8	61.9	0.0
		661.4 ha	4	-22,419.2	156.9	0.0
		Null	3	-22,478.8	273.9	0.0
Landscape variation	Variety of land cover types	61.5 ha	4	-22,221.6	0.0	1.0
		8.7 ha	4	-22,227.6	12.0	0.0
		661.4 ha	4	-22,443.3	443.5	0.0
		Null	3	-22,478.8	512.4	0.0
Water sources	Distance to intermittent stream	Linear	4	-22,147.6	0.0	1.0
	Distance to perennial stream	Linear	4	-22,183.2	71.2	0.0
	Distance to perennial stream	Expon. decay	4	-22,229.5	163.8	0.0
	Distance to nearest stream	Linear	4	-22,247.4	199.6	0.0
	Distance to water body	Expon. decay	4	-22,302.9	310.6	0.0
	Distance to water body	Linear	4	-22,371.0	446.9	0.0
	Distance to spring	Linear	4	-22,398.0	500.9	0.0
	Distance to intermittent stream	Expon. decay	4	-22,402.8	510.4	0.0
	Distance to nearest stream	Expon. decay	4	-22,411.1	527.0	0.0
	Distance to spring	Expon. decay	4	-22,430.3	565.4	0.0
	Distance to wet meadow	Expon. decay	4	-22,453.8	612.4	0.0
	Distance to wet meadow	Linear	4	-22,476.9	658.7	0.0
	Null	Null	3	-22,478.8	660.4	0.0
Topography	Topographic position index	510 m	4	-22,292.3	0.0	1.0
	Elevation	Linear	4	-22,367.7	150.7	0.0
	Roughness index	1 ha	4	-22,469.8	355.0	0.0
	Topographic position index	2010 m	4	-22,476.8	369.1	0.0
	Null		3	-22,478.8	370.9	0.0

Table D2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Cortez spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual Grass	8.7 ha	-0.91 (-1.07, -0.74)	Avoidance
Bare ground	8.7 ha	2.38 (2.23, 2.54)	Selection
Big sagebrush	661.4 ha	1.11 (0.34, 1.87)	Selection
Herbaceous	8.7 ha	0.03 (-0.39, 0.45)	None
Non-sagebrush shrub	661.4 ha	13.52 (12.55, 14.49)	Selection
Other sagebrush	661.4 ha	59.01 (57.03, 61.00)	Selection
Pinyon-juniper	8.7 ha	-6.14 (-6.63, -5.66)	Avoidance
Riparian	661.4 ha	-39.33 (-42.37, -36.30)	Avoidance
Sagebrush height	661.4 ha	-2.96 (-3.21, -2.71)	Avoidance
Distance to cropland	Expon. decay	-0.83 (-0.94, -0.71)	Avoidance
Variety of land cover types	61.5 ha	-0.20 (-0.22, -0.19)	Avoidance
Distance to intermittent stream	Linear	-0.40 (-0.47, -0.33)	Selection
Distance to spring	Linear	-0.03 (-0.04, -0.02)	Selection
Distance to water body	Expon. decay	0.43 (0.30, 0.56)	Selection
Distance to wet meadow	Expon. decay	0.72 (0.56, 0.87)	Selection
Elevation	Linear	0.59 (0.46, 0.71)	Selection for higher elevations
Roughness index	1 ha	-1.13 (-1.41, -0.84)	Avoidance
Topographic position index	510 m	0.01 (0.01, 0.01)	Selected ridges / Avoided valleys

Table D3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Cortez subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	8.7 ha	0.037	0.0012	0.028	0.0023
Bare ground	8.7 ha	0.520	0.0018	0.592	0.0024
Big sagebrush	661.4 ha	0.063	0.0003	0.076	0.0007
Herbaceous	8.7 ha	0.078	0.0005	0.088	0.0010
Non-sagebrush shrubs	661.4 ha	0.047	0.0002	0.050	0.0006
Other sagebrush	661.4 ha	0.030	0.0001	0.042	0.0003
Pinyon-juniper	8.7 ha	0.050	0.0009	0.009	0.0007
Riparian	661.4 ha	0.007	0.0001	0.003	0.0001
Sagebrush height	661.4 ha	0.32	0.0010	0.31	0.0017
Distance to cropland	Km	3.07	0.0157	3.51	0.0299
Variety of land cover types	61.5 ha	3.28	0.0135	2.87	0.0272
Distance to intermittent stream	Km	0.43	0.0044	0.31	0.0050
Distance to spring	Km	3.14	0.0184	2.83	0.0359
Distance to water body	Km	4.78	0.0216	5.22	0.0437
Distance to wet meadow	Km	9.68	0.0345	9.78	0.0658
Elevation	Km	1.92	0.0016	1.95	0.0035
Roughness index	1 ha	0.14	0.0008	0.15	0.0013
Topographic position index	510 m	0.02	0.1311	3.33	0.2476

Appendix E. Supplemental material for Cortez summer season RSF modeling

Table E1. Variable selection results from the "proposal set" of variables from the Cortez subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-4,439.3	0.0	1.0
		61.5 ha	4	-4,514.0	149.4	0.0
		8.7 ha	4	-4,539.3	200.1	0.0
		Null	3	-4,567.8	255.2	0.0
	Bare ground	661.4 ha	4	-4,409.7	0.0	1.0
		61.5 ha	4	-4,442.4	65.3	0.0
		8.7 ha	4	-4,446.7	74.0	0.0
		Null	3	-4,567.8	314.2	0.0
	Big sagebrush	661.4 ha	4	-3,738.5	0.0	1.0
		61.5 ha	4	-3,905.7	334.5	0.0
		8.7 ha	4	-3,915.8	354.7	0.0
		Null	3	-4,567.8	1,656.8	0.0
	Cropland	661.4 ha	4	-4,532.2	0.0	1.0
		61.5 ha	4	-4,560.0	55.7	0.0
		8.7 ha	4	-4,564.6	64.9	0.0
		Null	3	-4,567.8	69.4	0.0
	Forest	61.5 ha	4	-4,563.1	0.0	0.64
		8.7 ha	4	-4,564.1	2.1	0.22
		661.4 ha	4	-4,564.7	3.2	0.13
		Null	3	-4,567.8	7.5	0.01
	Herbaceous	661.4 ha	4	-3,468.7	0.0	1.0
		61.5 ha	4	-3,640.0	342.6	0.0
		8.7 ha	4	-3,767.5	597.6	0.0
		Null	3	-4,567.8	2,196.2	0.0
	Non-sagebrush shrub	661.4 ha*	4	-4,234.4	0.0	1.0
		61.5 ha	4	-4,286.8	104.9	0.0
		8.7 ha	4	-4,314.9	160.9	0.0
		Null	3	-4,567.8	664.8	0.0
	Other sagebrush	661.4 ha	4	-3,782.7	0.0	1.0
		61.5 ha	4	-4,028.5	491.6	0.0
		8.7 ha	4	-4,182.2	798.9	0.0
		Null	3	-4,567.8	1,568.3	0.0
	Pinyon-juniper	61.5 ha	4	-4,463.0	0.0	0.9
		8.7 ha	4	-4,465.2	4.3	0.1
		661.4 ha	4	-4,496.2	66.2	0.0
		Null	3	-4,567.8	207.6	0.0
Land cover	Riparian	661.4 ha	4	-4,544.7	0.0	1.0
		61.5 ha	4	-4,563.8	38.2	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		Null	3	-4,567.8	44.2	0.0
		8.7 ha	4	-4,567.6	45.7	0.0
Sagebrush height	Sagebrush height	8.7 ha	4	-4,532.1	0.0	1.0
		661.4 ha	4	-4,546.8	29.5	0.0
		61.5 ha	4	-4,551.9	39.7	0.0
		Null	3	-4,567.8	69.6	0.0
Agriculture	Distance to cropland	Linear	4	-4,520.1	0.0	1.0
		Expon. decay	4	-4,539.5	38.6	0.0
		Null	3	-4,567.8	93.4	0.0
Edge	Variety of edge types	661.4 ha*	4	-3,872.0	0.0	1.0
		61.5 ha	4	-4,282.1	820.3	0.0
		8.7 ha	4	-4,386.9	1,029.9	0.0
		Null	3	-4,567.8	1,389.7	0.0
Landscape Variation	Variety of land cover types	661.4 ha	4	-4,093.7	0.0	1.0
		8.7 ha	4	-4,424.5	661.6	0.0
		61.5 ha	4	-4,429.3	671.2	0.0
		Null	3	-4,567.8	946.2	0.0
Water sources	Distance to spring	Expon. decay	4	-3,511.7	0.0	1.0
	Distance to spring	Linear	4	-3,729.8	436.3	0.0
	Distance to perennial stream	Expon. decay	4	-4,045.7	1,067.9	0.0
	Distance to perennial stream	Linear	4	-4,062.1	1,100.7	0.0
	Distance to nearest stream	Linear	4	-4,357.4	1,691.3	0.0
	Distance to nearest stream	Expon. decay	4	-4,452.7	1,882.0	0.0
	Distance to intermittent stream	Linear	4	-4,471.1	1,918.8	0.0
	Distance to water body	Linear	4	-4,487.3	1,951.2	0.0
	Distance to wet meadow	Expon. decay	4	-4,506.6	1,989.7	0.0
	Distance to intermittent stream	Expon. decay	4	-4,516.0	2,008.5	0.0
	Distance to water body	Expon. decay	4	-4,518.1	2,012.9	0.0
	Distance to wet meadow	Linear	4	-4,533.3	2,043.2	0.0
	Null	Null	3	-4,567.8	2,110.3	0.0
Topography	Elevation	Linear	4	-3,599.0	0.0	1.0
	Roughness index	1 ha	4	-4,224.6	1,251.1	0.0
	Topographic position index	510 m	4	-4,565.1	1,932.1	0.0
	Null		3	-4,567.8	1,935.6	0.0
	Topographic position index	2010 m	4	-4,567.3	1,936.5	0.0

*Model failed to converge. Was not carried forward in the RSF modeling procedure.

Table E2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Cortez summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	5.72 (5.15, 6.28)	Selection
Bare ground	661.4 ha	-0.67 (-1.12, -0.23)	Avoidance
Big sagebrush	661.4 ha	19.98 (18.02, 21.94)	Selection
Forest	61.5 ha	-57.12 (-102.06, -12.18)	Avoidance
Herbaceous	661.4 ha	19.36 (17.89, 20.84)	Selection
Non-sagebrush shrub	61.5 ha	21.36 (19.56, 23.15)	Selection
Other sagebrush	661.4 ha	78.93 (72.96, 84.90)	Selection
Pinyon-juniper	61.5 ha	-10.38 (-11.41, -9.35)	Avoidance
Riparian	661.4 ha	-78.32 (-86.95, -69.70)	Avoidance
Sagebrush height	8.7 ha	0.48 (0.07, 0.89)	Selection
Distance to cropland	Linear	-0.21 (-0.34, -0.09)	Avoidance
Variety of land cover types	661.4 ha	0.41 (0.38, 0.45)	Selection
Distance to perennial stream	Expon. decay	2.46 (2.21, 2.71)	Selection
Distance to spring	Expon. decay	4.86 (4.56, 5.16)	Selection
Distance to water body	Linear	-0.21 (-0.24, -0.18)	Selection
Distance to wet meadow	Expon. decay	-2.16 (-2.57, -1.74)	Avoidance
Elevation	Linear	5.76 (5.39, 6.14)	Selection for higher elevation
Roughness index	1 ha	1.38 (0.62, 2.15)	Selection
Topographic position index	510 m	-0.005 (-0.008, -0.001)	Avoided ridges / Selected valleys

Table E3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Cortez subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.031	0.0017	0.089	0.0073
Bare ground	661.4 ha	52.313	0.3336	45.363	0.4342
Big sagebrush	661.4 ha	6.312	0.0618	10.271	0.1616
Forest	61.5 ha	0.001	0.0002	0.000	0.0001
Herbaceous	661.4 ha	7.878	0.0927	14.049	0.1771
Non-sagebrush shrub	61.5 ha	4.716	0.0566	7.457	0.2322
Other sagebrush	661.4 ha	3.078	0.0265	4.367	0.0349
Pinyon-juniper	61.5 ha	0.048	0.0019	0.018	0.0022
Riparian	661.4 ha	0.007	0.0002	0.005	0.0003
Sagebrush height	8.7 ha	0.30	0.0030	0.34	0.0052
Distance to cropland	Km	3.06	0.0352	2.60	0.0710
Variety of land cover types	661.4 ha	5.69	0.0405	7.21	0.0563
Distance to perennial stream	Km	7.04	0.0808	3.75	0.1374
Distance to spring	Km	3.16	0.0409	1.18	0.0571
Distance to water body	Km	4.81	0.0483	4.00	0.0933
Distance to wet meadow	Km	9.70	0.0758	10.52	0.1394
Elevation	Km	1.92	0.0036	2.17	0.0096
Roughness index	1 ha	0.14	0.0018	0.20	0.0030
Topographic position index	510 m	0.12	0.2901	-0.89	0.7113

Appendix F. Supplemental material for Cortez winter season RSF modeling

Table F1. Variable selection results from the "proposal set" of variables from the Cortez subregion during the winter season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-2,050.9	0.0	1.0
		61.5 ha	4	-2,057.5	13.3	0.0
		8.7 ha	4	-2,058.2	14.7	0.0
		Null	3	-2,065.6	27.4	0.0
	Bare ground	8.7 ha	4	-2,048.6	0.0	0.95
		61.5 ha	4	-2,051.5	5.7	0.05
		661.4 ha	4	-2,056.4	15.6	0.00
		Null	3	-2,065.6	31.9	0.00
	Big sagebrush	661.4 ha	4	-2,029.5	0.0	1.0
		61.5 ha	4	-2,040.2	21.4	0.0
		8.7 ha	4	-2,046.0	33.0	0.0
		Null	3	-2,065.6	70.2	0.0
	Cropland	61.5 ha	4	-2,033.8	0.0	1.0
		8.7 ha	4	-2,042.4	17.3	0.0
		661.4 ha	4	-2,044.9	22.2	0.0
		Null	3	-2,065.6	61.6	0.0
	Herbaceous	661.4 ha	4	-2,039.3	0.0	1.0
		61.5 ha	4	-2,049.1	19.7	0.0
		8.7 ha	4	-2,050.3	22.0	0.0
		Null	3	-2,065.6	50.5	0.0
	Non-sagebrush shrub	661.4 ha	4	-2,032.8	0.0	1.0
		61.5 ha	4	-2,044.5	23.3	0.0
		8.7 ha	4	-2,044.7	23.8	0.0
		Null	3	-2,065.6	63.5	0.0
	Other sagebrush	61.5 ha	4	-1,970.5	0.0	1.0
		661.4 ha	4	-1,976.5	11.9	0.0
		8.7 ha	4	-1,977.3	13.4	0.0
		Null	3	-2,065.6	188.1	0.0
	Pinyon-juniper	61.5 ha	4	-2,049.5	0.0	0.49
		8.7 ha	4	-2,049.6	0.1	0.48
		661.4 ha	4	-2,052.3	5.6	0.03
		Null	3	-2,065.6	30.1	0.00
	Riparian	661.4 ha	4	-2,038.6	0.0	1.0
		8.7 ha	4	-2,047.1	17.0	0.0
		61.5 ha	4	-2,048.3	19.5	0.0
		Null	3	-2,065.6	52.0	0.0
Sagebrush	Sagebrush height	Null	3	-2,065.6	0.0	0.33

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
height						
		61.5 ha	4	-2,064.7	0.3	0.29
		661.4 ha	4	-2,064.8	0.5	0.26
		8.7 ha	4	-2,065.6	2.0	0.13
Agriculture	Distance to cropland	Expon. decay	4	-2,063.7	0.0	0.64
		Null	3	-2,065.6	1.8	0.26
		Linear	4	-2,065.6	3.8	0.10
Edge	Variety of edge types	8.7 ha	4	-2,060.5	0.0	0.95
		661.4 ha	4	-2,064.5	8.0	0.02
		Null	3	-2,065.6	8.2	0.02
		61.5 ha	4	-2,064.7	8.5	0.01
Landscape variation	Variety of land cover types	8.7 ha	4	-2,050.6	0.0	0.95
		61.5 ha	4	-2,053.6	5.9	0.05
		661.4 ha	4	-2,060.9	20.6	0.00
		Null	3	-2,065.6	27.9	0.00
Water sources	Distance to perennial stream	Linear	4	-2,003.3	0.0	1.0
	Distance to perennial stream	Expon. decay	4	-2,014.2	21.7	0.0
	Distance to nearest stream	Linear	4	-2,028.1	49.6	0.0
	Distance to intermittent stream	Linear	4	-2,032.4	58.1	0.0
	Distance to spring	Expon. decay	4	-2,042.4	78.1	0.0
	Distance to spring	Linear	4	-2,047.1	87.5	0.0
	Distance to nearest stream	Expon. decay	4	-2,053.5	100.5	0.0
	Distance to intermittent stream	Expon. decay	4	-2,058.8	110.9	0.0
	Distance to water body	Linear	4	-2,059.3	112.0	0.0
	Distance to wet meadow	Expon. decay	4	-2,062.6	118.5	0.0
	Distance to water body	Expon. decay	4	-2,064.1	121.6	0.0
	Null	Null	3	-2,065.6	122.5	0.0
	Distance to wet meadow	Linear	4	-2,064.9	123.2	0.0
Topography	Elevation	Linear	4	-2,035.9	0.0	1.0
	Roughness index	1 ha	4	-2,055.4	38.9	0.0
	Topographic position index	510 m	4	-2,063.0	54.2	0.0
	Null		3	-2,065.6	57.3	0.0
	Topographic position index	2010 m	4	-2,065.1	58.4	0.0

Table F2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Cortez winter season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	0.82 (0.22, 1.43)	Selection
Bare ground	8.7 ha	3.14 (2.61, 3.66)	Selection
Big sagebrush	661.4 ha	3.24 (1.10, 5.37)	Selection
Cropland	61.5 ha	-6.43 (-10.46, -2.39)	Avoidance
Herbaceous	661.4 ha	2.97 (1.41, 4.53)	Selection
Non-sagebrush shrub	661.4 ha	14.72 (12.05, 17.39)	Selection
Other sagebrush	61.5 ha	36.70 (31.72, 41.68)	Selection
Pinyon-juniper	61.5 ha	-0.79 (-1.67, 0.10)	None
Riparian	661.4 ha	-22.94 (-31.20, -14.68)	Avoidance
Variety of land cover types	8.7 ha	-0.19 (-0.25, -0.12)	Avoidance
Distance to perennial stream	Linear	-0.10 (-0.12, -0.08)	Selection
Distance to spring	Expon. decay	0.76 (0.48, 1.04)	Selection
Distance to water body	Linear	-0.13 (-0.16, -0.10)	Selection
Distance to wet meadow	Expon. decay	0.21 (-0.23, 0.66)	Selection
Elevation	Linear	1.24 (0.20, 2.28)	Selection for higher elevations
Roughness index	1 ha	1.14 (0.34, 1.95)	Selection
Topographic position index	510 m	0.004 (-0.001, 0.009)	Selected ridges / Avoided valleys

Table F3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Cortez subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.033	0.0028	0.060	0.0092
Bare ground	8.7 ha	0.525	0.0059	0.567	0.0094
Big sagebrush	661.4 ha	0.062	0.0009	0.074	0.0023
Cropland	61.5 ha	0.023	0.0034	0.001	0.0006
Herbaceous	661.4 ha	0.079	0.0013	0.092	0.0028
Non-sagebrush shrub	661.4 ha	0.048	0.0007	0.058	0.0022
Other sagebrush	61.5 ha	0.031	0.0005	0.039	0.0010
Pinyon-juniper	61.5 ha	0.046	0.0028	0.028	0.0043
Riparian	661.4 ha	0.007	0.0003	0.004	0.0004
Variety of land cover types	8.7 ha	2.189	0.0308	1.963	0.0615
Distance to perennial stream	Km	7.034	0.1200	5.257	0.2280
Distance to spring	Km	3.103	0.0586	2.613	0.1229
Distance to water body	Km	4.850	0.0738	4.502	0.1450
Distance to wet meadow	Km	9.673	0.1155	9.852	0.2328
Elevation	Km	1.917	0.0053	1.980	0.0138
Roughness index	1 ha	0.144	0.0027	0.159	0.0047
Topographic position index	510 m	-0.399	0.4411	0.841	0.7404

Appendix G. Supplemental material for Gollaher spring season RSF modeling

Table G1. Variable selection results from the "proposal set" of variables from the Gollaher subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Big sagebrush	661.4 ha	4	-7,584.8	0.0	1.0
		61.5 ha	4	-7,697.3	225.1	0.0
		8.7 ha	4	-7,769.6	369.6	0.0
		Null	3	-8,234.6	1,297.7	0.0
	Cropland	661.4 ha	4	-7,929.3	0.0	1.0
		61.5 ha	4	-8,070.8	283.1	0.0
		8.7 ha	4	-8,118.5	378.5	0.0
		Null	3	-8,234.6	608.6	0.0
	Forest	661.4 ha	4	-7,109.6	0.0	1.0
		61.5 ha	4	-7,546.4	873.6	0.0
		8.7 ha	4	-7,842.1	1,465.1	0.0
		Null	3	-8,234.6	2,248.0	0.0
	Herbaceous	661.4 ha	4	-7,796.9	0.0	1.0
		61.5 ha	4	-7,857.3	120.9	0.0
		8.7 ha	4	-7,906.6	219.4	0.0
		Null	3	-8,234.6	873.4	0.0
	Non-sagebrush shrub	661.4 ha	4	-6,354.1	0.0	1.0
		61.5 ha	4	-6,493.9	279.7	0.0
		8.7 ha	4	-6,809.7	911.2	0.0
		Null	3	-8,234.6	3,759.0	0.0
	Other sagebrush	661.4 ha	4	-6,403.6	0.0	1.0
		61.5 ha	4	-6,648.7	490.1	0.0
		8.7 ha	4	-7,012.0	1,216.8	0.0
		Null	3	-8,234.6	3,659.9	0.0
	Riparian	61.5 ha	4	-7,675.7	0.0	1.0
		661.4 ha	4	-7,700.8	50.2	0.0
		8.7 ha	4	-7,891.1	430.7	0.0
		Null	3	-8,234.6	1,115.7	0.0
Sagebrush height	Sagebrush height	661.4 ha	4	-8,049.3	0.0	1.0
		61.5 ha	4	-8,092.5	86.3	0.0
		8.7 ha	4	-8,118.8	138.9	0.0
		Null	3	-8,234.6	368.6	0.0
Agriculture	Distance to cropland	Linear	4	-7,535.9	0.0	1.0
		Expon. decay	4	-8,067.8	1,064.0	0.0
		Null	3	-8,234.6	1,395.5	0.0
Edge	Variety of edge types	661.4 ha	4	-7,079.4	0.0	1.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		61.5 ha	4	-7,223.1	287.5	0.0
		8.7 ha	4	-7,521.0	883.3	0.0
		Null	3	-8,234.6	2,308.4	0.0
Landscape variation	Variety of land cover types	lcvar439orig	4	-7,253.4	0.0	1.0
		lcvar167orig	4	-7,391.1	275.5	0.0
		lcvar1451orig	4	-7,767.7	1,028.8	0.0
		null	3	-8,234.6	1,960.5	0.0
Water sources	Distance to spring	Expon. decay	4	-7,805.0	0.0	1.0
	Distance to spring	Linear	4	-7,863.2	116.3	0.0
	Distance to intermittent stream	Linear	4	-7,870.1	130.1	0.0
	Distance to intermittent stream	Expon. decay	4	-8,029.5	448.9	0.0
	Distance to water body	Expon. decay	4	-8,066.1	522.0	0.0
	Distance to nearest stream	Linear	4	-8,155.5	700.8	0.0
	Distance to nearest stream	Expon. decay	4	-8,164.3	718.6	0.0
	Distance to water body	Linear	4	-8,186.4	762.7	0.0
	Distance to perennial stream	Linear	4	-8,220.4	830.7	0.0
	Null	Null	3	-8,234.6	857.1	0.0
	Distance to perennial stream	Expon. decay	4	-8,233.8	857.4	0.0
Topography	Elevation	Linear	4	-6,884.0	0.0	1.0
	Roughness index	1 ha	4	-8,070.3	2,372.6	0.0
	Topographic position index	2010 m	4	-8,197.2	2,626.5	0.0
	Topographic position index	510 m	4	-8,218.8	2,669.5	0.0
	Null		3	-8,234.6	2,699.2	0.0

Table G2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Gollaher spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Forest	661.4 ha	-133.95 (-149.11, -118.78)	Avoidance
Herbaceous	661.4 ha	3.13 (2.16, 4.10)	Selection
Non-sagebrush shrub	661.4 ha	-41.26 (-43.86, -38.65)	Avoidance
Other sagebrush	661.4 ha	158.88 (152.99, 164.76)	Selection
Riparian	61.5 ha	-19.95 (-22.05, -17.85)	Avoidance
Sagebrush height	661.4 ha	-15.06 (-15.90, -14.22)	Avoidance
Distance to cropland	Linear	-0.51 (-0.55, -0.47)	Selection
Variety of edge types	661.4 ha	-0.33 (-0.35, -0.31)	Avoidance
Variety of land cover types	61.5 ha	-0.47 (-0.51, -0.44)	Avoidance
Distance to intermittent stream	Linear	1.87 (1.71, 2.03)	Avoidance
Distance to spring	Expon. decay	-0.16 (-0.40, 0.08)	None
Distance to water body	Expon. decay	0.26 (0.00, 0.51)	Selection
Roughness index	1 ha	-3.65 (-4.21, -3.09)	Avoidance
Topographic Position Index	2010 m	0.01 (0.01, 0.01)	Selected ridges / Avoided valleys

Table G3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Gollaher subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Forest	661.4 ha	0.034	0.0014	0.0004	0.0001
Herbaceous	661.4 ha	0.175	0.0008	0.143	0.0016
Non-sagebrush shrub	661.4 ha	0.050	0.0005	0.019	0.0005
Other sagebrush	661.4 ha	0.035	0.0001	0.047	0.0004
Riparian	61.5 ha	0.030	0.0009	0.004	0.0005
Sagebrush height	661.4 ha	0.32	0.0013	0.29	0.0015
Distance to cropland	Km	2.74	0.0304	1.58	0.0219
Variety of edge types	661.4 ha	6.19	0.0397	3.86	0.0554
Variety of land cover types	61.5 ha	3.53	0.0213	2.28	0.0381
Distance to intermittent stream	Km	0.25	0.0032	0.42	0.0129
Distance to spring	Km	2.39	0.0217	3.23	0.0493
Distance to water body	Km	2.02	0.0176	2.24	0.0277
Roughness index	1 ha	0.18	0.0011	0.15	0.0022
Topographic position index	2010 m	-0.52	0.5808	5.23	0.7312

Appendix H. Supplemental material for Gollaher summer season RSF modeling

Table H1. Variable selection results from the "proposal set" of variables from the Gollaher subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Big sagebrush	661.4 ha	4	-4,772.4	0.0	0.85
		Null	3	-4,775.8	4.7	0.08
		61.5 ha	4	-4,775.5	6.2	0.04
		8.7 ha	4	-4,775.7	6.5	0.03
	Cropland	661.4 ha	4	-4,724.3	0.0	1.0
		61.5 ha	4	-4,763.7	78.9	0.0
		8.7 ha	4	-4,766.3	84.0	0.0
		Null	3	-4,775.8	101.0	0.0
	Forest	661.4 ha	4	-4,690.5	0.0	1.0
		61.5 ha	4	-4,726.6	72.1	0.0
		8.7 ha	4	-4,746.3	111.5	0.0
		Null	3	-4,775.8	168.5	0.0
	Herbaceous	661.4 ha	4	-4,678.9	0.0	1.0
		8.7 ha	4	-4,694.3	30.9	0.0
		61.5 ha	4	-4,696.8	35.9	0.0
		Null	3	-4,775.8	191.8	0.0
	Non-sagebrush shrub	661.4 ha	4	-4,747.4	0.0	1.0
		61.5 ha	4	-4,759.1	23.4	0.0
		8.7 ha	4	-4,769.8	44.8	0.0
		Null	3	-4,775.8	54.8	0.0
	Other sagebrush	661.4 ha	4	-4,707.3	0.0	1.0
		61.5 ha	4	-4,739.8	65.0	0.0
		8.7 ha	4	-4,767.9	121.3	0.0
		Null	3	-4,775.8	135.0	0.0
	Riparian	661.4 ha	4	-4,670.3	0.0	1.0
		61.5 ha	4	-4,733.3	126.0	0.0
		8.7 ha	4	-4,757.7	174.7	0.0
		Null	3	-4,775.8	208.9	0.0
Sagebrush height	Sagebrush height	61.5 ha	4	-4,773.2	0.0	0.62
		8.7 ha	4	-4,774.3	2.2	0.21
		Null	3	-4,775.8	3.2	0.13
		661.4 ha	4	-4,775.7	5.0	0.05
Agriculture	Distance to cropland	Linear	4	-4,552.6	0.0	1.0
		Expon. decay	4	-4,622.0	138.7	0.0
		Null	3	-4,775.8	444.3	0.0
Edge	Variety of edge types	661.4 ha	4	-4,771.0	0.0	0.71

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		61.5 ha	4	-4,772.0	2.0	0.27
		Null	3	-4,775.8	7.5	0.02
		8.7 ha	4	-4,775.7	9.3	0.01
Landscape variation	Variety of land cover types	661.4 ha	4	-4,742.2	0.0	1.0
		61.5 ha	4	-4,772.9	61.4	0.0
		Null	3	-4,775.8	65.2	0.0
		8.7 ha	4	-4,775.6	66.7	0.0
Water sources	Distance to spring	Linear	4	-4,484.9	0.0	1.0
	Distance to spring	Expon. decay	4	-4,635.1	300.4	0.0
	Distance to water body	Linear	4	-4,656.5	343.2	0.0
	Distance to water body	Expon. decay	4	-4,678.7	387.6	0.0
	Distance to intermittent stream	Expon. decay	4	-4,733.8	497.9	0.0
	Distance to nearest stream	Linear	4	-4,746.9	524.1	0.0
	Distance to intermittent stream	Linear	4	-4,748.0	526.2	0.0
	Distance to nearest stream	Expon. decay	4	-4,748.6	527.4	0.0
	Distance to perennial stream	Linear	4	-4,759.0	548.3	0.0
	Distance to perennial stream	Expon. decay	4	-4,774.3	579.0	0.0
	Null	Null	3	-4,775.8	579.9	0.0
Topography	Roughness index	1 ha	4	-4,707.3	0.0	1.0
	Topographic position index	2010 m	4	-4,726.1	37.7	0.0
	Elevation	Linear	4	-4,761.6	108.6	0.0
	Topographic position index	510 m	4	-4,766.5	118.3	0.0
	Null		3	-4,775.8	135.0	0.0

Table H2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Gollaher summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Forest	661.4 ha	-6.90 (-8.28, -5.52)	Avoidance
Herbaceous	661.4 ha	7.37 (6.42, 8.33)	Selection
Non-sagebrush shrub	661.4 ha	-12.97 (-14.83, -11.10)	Avoidance
Other sagebrush	661.4 ha	39.57 (33.29, 45.85)	Selection
Riparian	661.4 ha	-11.14 (-12.85, -9.44)	Avoidance
Sagebrush height	61.5 ha	-2.14 (-2.67, -1.62)	Avoidance
Distance to cropland	Linear	-0.34 (-0.37, -0.30)	Selection
Variety of edge types	661.4 ha	-0.08 (-0.10, -0.06)	Avoidance
Variety of land cover types	661.4 ha	0.06 (0.03, 0.09)	Selection
Distance to intermittent spring	Expon. decay	-0.91 (-1.10, -0.73)	Avoidance
Distance to spring	Linear	-0.53 (-0.58, -0.48)	Selection
Distance to water body	Linear	-0.39 (-0.44, -0.34)	Selection
Roughness index	1 ha	-5.52 (-6.21, -4.83)	Avoidance
Topographic position index	2010 m	0.005 (0.004, 0.006)	Selected ridges / Avoided valleys

Table H3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Gollaher subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Forest	661.4 ha	0.033	0.0017	0.011	0.0015
Herbaceous	661.4 ha	0.175	0.0011	0.194	0.0018
Non-sagebrush shrub	661.4 ha	0.052	0.0006	0.047	0.0009
Other sagebrush	661.4 ha	0.034	0.0002	0.037	0.0003
Riparian	661.4 ha	0.028	0.0007	0.017	0.0009
Sagebrush height	61.5 ha	0.32	0.0020	0.31	0.0033
Distance to cropland	Km	2.80	0.0395	1.80	0.0591
Variety of edge types	661.4 ha	6.11	0.0524	5.91	0.0765
Variety of land cover types	661.4 ha	6.37	0.0324	6.72	0.0608
Distance to intermittent stream	Km	0.25	0.0042	0.30	0.0094
Distance to spring	Km	2.44	0.0292	1.65	0.0344
Distance to water body	Km	2.04	0.0230	1.59	0.0391
Roughness index	1 ha	0.18	0.0015	0.16	0.0025
Topographic position index	2010 m	1.44	0.7659	11.38	1.4319

Appendix I. Supplemental material for Gollaher winter season RSF modeling

Table I1. Variable selection results from the "proposal set" of variables from the Gollaher subregion during the winter season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Big sagebrush	661.4 ha	4	-1,350.9	0.0	1.0
		61.5 ha	4	-1,375.0	48.1	0.0
		8.7 ha	4	-1,378.1	54.2	0.0
		Null	3	-1,427.9	151.9	0.0
	Cropland	661.4 ha	4	-1,409.9	0.0	1.0
		61.5 ha	4	-1,417.8	15.8	0.0
		8.7 ha	4	-1,419.8	19.8	0.0
		Null	3	-1,427.9	34.0	0.0
	Herbaceous	61.5 ha	4	-1,253.9	0.0	1.0
		661.4 ha	4	-1,262.6	17.5	0.0
		8.7 ha	4	-1,278.2	48.8	0.0
		Null	3	-1,427.9	346.0	0.0
	Non-sagebrush shrub	661.4 ha	4	-1,132.0	0.0	1.0
		61.5 ha	4	-1,139.5	15.0	0.0
		8.7 ha	4	-1,185.0	106.0	0.0
		Null	3	-1,427.9	589.7	0.0
	Other sagebrush	661.4 ha	4	-876.5	0.0	1.0
		61.5 ha	4	-990.0	227.1	0.0
		8.7 ha	4	-1,104.2	455.5	0.0
		Null	3	-1,427.9	1,100.8	0.0
	Forest	661.4 ha	4	-1,321.1	0.0	1.0
		61.5 ha	4	-1,342.4	42.7	0.0
		8.7 ha	4	-1,368.8	95.5	0.0
		Null	3	-1,427.9	211.6	0.0
	Riparian	61.5 ha	4	-1,381.0	0.0	0.91
		8.7 ha	4	-1,383.5	4.8	0.08
		661.4 ha	4	-1,385.4	8.8	0.01
		Null	3	-1,427.9	91.7	0.00
Sagebrush height	Sagebrush height	661.4 ha	4	-1,421.8	0.0	0.92
		8.7 ha	4	-1,424.5	5.5	0.06
		61.5 ha	4	-1,426.0	8.4	0.01
		Null	3	-1,427.9	10.2	0.01
Agriculture	Distance to cropland	Linear	4	-1,315.4	0.0	1.0
		Expon. decay	4	-1,389.8	148.6	0.0
		Null	3	-1,427.9	222.9	0.0
Edge	Variety of edge types	8.7 ha	4	-1,364.4	0.0	1.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		61.5 ha	4	-1,378.6	28.4	0.0
		661.4 ha	4	-1,397.8	66.9	0.0
		Null	3	-1,427.9	125.0	0.0
Landscape variation	Variety of land cover types	8.7 ha	4	-1,344.6	0.0	1.0
		61.5 ha	4	-1,366.3	43.4	0.0
		661.4 ha	4	-1,425.8	162.4	0.0
		Null	3	-1,427.9	164.5	0.0
Water sources	Distance to intermittent stream	Expon. decay	4	-1,197.1	0.0	0.93
	Distance to intermittent stream	Linear	4	-1,199.7	5.2	0.07
	Distance to nearest stream	Linear	4	-1,246.1	97.8	0.00
	Distance to nearest stream	Expon. decay	4	-1,265.4	136.6	0.00
	Distance to spring	Expon. decay	4	-1,365.1	336.0	0.00
	Distance to water body	Linear	4	-1,391.4	388.5	0.00
	Distance to spring	Linear	4	-1,399.3	404.4	0.00
	Distance to water body	Expon. decay	4	-1,409.3	424.3	0.00
	Distance to perennial stream	Linear	4	-1,426.7	459.2	0.00
	Null	Null	3	-1,427.9	459.5	0.00
	Distance to perennial stream	Expon. decay	4	-1,427.5	460.7	0.00
Topography	Elevation	Linear	4	-1,286.3	0.0	1.0
	Roughness index	1 ha	4	-1,360.4	148.2	0.0
	Topographic position index	2010 m	4	-1,423.1	273.6	0.0
	Null		3	-1,427.9	281.2	0.0
	Topographic position index	510 m	4	-1,427.6	282.7	0.0

Table I2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Gollaher winter season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Cropland	661.4 ha	-3.25 (-12.81, 6.32)	Avoidance
Forest	661.4 ha	-10.80 (-18.90, -2.71)	Avoidance
Herbaceous	61.5 ha	-3.17 (-5.59, -0.76)	Avoidance
Non-sagebrush shrub	661.4 ha	-16.85 (-22.40, -11.30)	Avoidance
Other sagebrush	661.4 ha	144.07 (130.08, 158.06)	Selection
Riparian	61.5 ha	-5.64 (-9.18, -2.11)	Avoidance
Sagebrush height	661.4 ha	-3.18 (-4.84, -1.52)	Avoidance
Variety of land cover types	8.7 ha	-0.21 (-0.33, -0.09)	Avoidance
Distance to intermittent stream	Expon. decay	-2.67 (-3.24, -2.10)	Avoidance
Distance to spring	Expon. decay	0.20 (-0.46, 0.86)	None
Distance to water body	Linear	-0.47 (-0.59, -0.36)	Selection
Roughness index	1 ha	-2.78 (-4.34, -1.21)	Avoidance
Topographic position index	2010 m	0.008 (0.005, 0.01)	Selected ridges / Avoided valleys

Table I3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Gollaher subregion, and found important in resource selection function (RSF) modeling during the winter season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Cropland	661.4 ha	0.009	0.0013	0.003	0.0003
Forest	661.4 ha	0.030	0.0029	0.002	0.0005
Herbaceous	61.5 ha	0.174	0.0022	0.125	0.0028
Non-sagebrush shrub	661.4 ha	0.051	0.0011	0.018	0.0015
Other sagebrush	661.4 ha	0.035	0.0003	0.053	0.0007
Riparian	61.5 ha	0.030	0.0024	0.008	0.0017
Sagebrush height	661.4 ha	0.32	0.0032	0.31	0.0037
Variety of land cover types	8.7 ha	2.25	0.0367	1.63	0.0664
Distance to intermittent stream	Km	0.25	0.0079	0.60	0.0307
Distance to spring	Km	2.47	0.0544	2.99	0.0961
Distance to water body	Km	2.05	0.0430	1.61	0.0646
Roughness index	1 ha	0.18	0.0027	0.14	0.0052
Topographic position index	2010 m	1.98	1.4127	7.27	2.1679

Appendix J. Supplemental material for Lincoln spring season RSF modeling

Table J1. Variable selection results from the "proposal set" of variables from the Lincoln subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Bare ground	661.4 ha	4	-1,967.0	0.0	1.0
		8.7 ha	4	-1,988.8	43.6	0.0
		61.5 ha	4	-1,990.5	46.9	0.0
		Null	3	-2,010.1	84.2	0.0
	Big sagebrush	661.4 ha	4	-1,947.9	0.0	0.98
		8.7 ha	4	-1,952.1	8.4	0.01
		61.5 ha	4	-1,954.1	12.3	0.00
		Null	3	-2,010.1	122.4	0.00
	Cropland	661.4 ha	4	-1,769.5	0.0	1.0
		61.5 ha	4	-1,833.6	128.1	0.0
		8.7 ha	4	-1,856.8	174.5	0.0
		Null	3	-2,010.1	479.2	0.0
	Forest	8.7 ha	4	-1,876.2	0.0	1.0
		61.5 ha	4	-1,891.1	29.8	0.0
		661.4 ha	4	-1,896.9	41.5	0.0
		Null	3	-2,010.1	265.9	0.0
	Herbaceous	661.4 ha	4	-1,934.3	0.0	1.0
		8.7 ha	4	-1,967.4	66.2	0.0
		61.5 ha	4	-1,970.1	71.5	0.0
		Null	3	-2,010.1	149.6	0.0
	Non-sagebrush shrub	61.5 ha	4	-2,002.0	0.0	0.96
		8.7 ha	4	-2,005.3	6.5	0.04
		661.4 ha	4	-2,008.9	13.7	0.00
		Null	3	-2,010.1	14.2	0.00
	Other sagebrush	661.4 ha	4	-1,947.5	0.0	1.0
		8.7 ha	4	-1,953.2	11.3	0.0
		61.5 ha	4	-1,965.4	35.7	0.0
		Null	3	-2,010.1	123.2	0.0
	Pinyon-juniper	61.5 ha	4	-1,596.1	0.0	0.99
		8.7 ha	4	-1,600.4	8.6	0.01
		661.4 ha	4	-1,628.0	63.8	0.00
		Null	3	-2,010.1	826.0	0.00
	Riparian	8.7 ha	4	-1,992.3	0.0	1.0
		Null	3	-2,010.1	33.7	0.0
		61.5 ha	4	-2,009.7	34.7	0.0
		661.4 ha	4	-2,010.1	35.7	0.0
Sagebrush	Sagebrush height	Null	3	-2,010.1	0.0	0.37

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
height						
		661.4 ha	4	-2,009.2	0.1	0.35
		61.5 ha	4	-2,010.0	1.8	0.15
		8.7 ha	4	-2,010.1	2.0	0.14
Agriculture	Distance to cropland	Linear	4	-1,627.2	0.0	1.0
		Expon. decay	4	-1,688.5	122.6	0.0
		Null	3	-2,010.1	763.9	0.0
Edge	Variety of edge types	661.4 ha	4	-1,900.4	0.0	1.0
		61.5 ha	4	-1,967.5	134.3	0.0
		8.7 ha	4	-1,998.5	196.2	0.0
		Null	3	-2,010.1	217.5	0.0
Land cover variation	Variety of land cover types	661.4 ha	4	-1,875.4	0.0	1.0
		61.5 ha	4	-1,988.8	226.8	0.0
		8.7 ha	4	-1,994.2	237.5	0.0
		Null	3	-2,010.1	267.4	0.0
Water sources	Distance to water body	Linear	4	-1,643.0	0.0	1.0
	Distance to water body	Expon. decay	4	-1,693.9	102.0	0.0
	Distance to wet meadow	Expon. decay	4	-1,749.4	212.8	0.0
	Distance to wet meadow	Linear	4	-1,804.1	322.2	0.0
	Distance to perennial stream	Linear	4	-1,890.7	495.6	0.0
	Distance to perennial stream	Expon. decay	4	-1,926.0	566.2	0.0
	Distance to spring	Linear	4	-1,932.4	578.8	0.0
	Distance to spring	Expon. decay	4	-1,974.5	663.1	0.0
	Distance to nearest stream	Linear	4	-2,008.5	731.0	0.0
	Distance to intermittent stream	Expon. decay	4	-2,008.7	731.5	0.0
	Null	Null	3	-2,010.1	732.3	0.0
	Distance to intermittent stream	Linear	4	-2,009.7	733.5	0.0
	Distance to nearest stream	Expon. decay	4	-2,009.9	733.8	0.0
Topography	Roughness index	1 ha	4	-1,806.6	0.0	1.0
	Elevation	Linear	4	-1,879.8	146.4	0.0
	Topographic position index	2010 m	4	-2,005.2	397.2	0.0
	Topographic position index	510 m	4	-2,006.8	400.5	0.0
	Null		3	-2,010.1	405.1	0.0

Table J2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Lincoln spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Big sagebrush	661.4 ha	15.43 (12.79, 18.07)	Selection
Forest	8.7 ha	-17.62 (-23.74, -11.51)	Avoidance
Herbaceous	661.4 ha	18.74 (15.57, 21.92)	Selection
Non-sagebrush shrub	61.5 ha	-14.68 (-17.41, -11.96)	Avoidance
Pinyon-juniper	61.5 ha	-13.41 (-15.80, -11.03)	Avoidance
Riparian	8.7 ha	2.11 (0.33, 3.90)	Selection
Distance to cropland	Linear	-0.59 (-0.66, -0.52)	Selection
Variety of land cover types	661.4 ha	0.35 (0.31, 0.39)	Selection
Distance to perennial stream	Linear	-0.31 (-0.35, -0.28)	Selection
Distance to spring	Linear	-0.44 (-0.49, -0.39)	Selection
Distance to water body	Linear	-0.53 (-0.59, -0.47)	Selection
Distance to wet meadow	Expon. decay	3.35 (2.95, 3.74)	Selection
Roughness index	1 ha	-9.05 (-10.23, -7.86)	Avoidance
Topographic position index	2010 m	-0.002 (-0.005, 0.0002)	Avoided ridges / Selected valleys

Table J3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Lincoln subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Big sagebrush	661.4 ha	0.047	0.0010	0.064	0.0026
Forest	8.7 ha	0.083	0.0065	0.001	0.0007
Herbaceous	661.4 ha	0.054	0.0008	0.068	0.0019
Non-sagebrush shrub	61.5 ha	0.056	0.0011	0.050	0.0019
Pinyon-juniper	61.5 ha	0.139	0.0043	0.016	0.0029
Riparian	8.7 ha	0.021	0.0017	0.009	0.0027
Distance to cropland	Km	3.34	0.0574	1.42	0.0767
Variety of land cover types	661.4 ha	5.32	0.0529	6.83	0.1617
Distance to perennial stream	Km	4.87	0.0990	2.98	0.1543
Distance to spring	Km	3.36	0.0752	2.27	0.1023
Distance to water body	Km	4.14	0.0646	1.99	0.0948
Distance to wet meadow	Km	12.12	0.2135	6.52	0.3892
Roughness index	1 ha	0.18	0.0030	0.11	0.0035
Topographic position index	2010 m	-1.94	1.5508	-7.14	1.3457

Appendix K. Supplemental material for Lincoln summer season RSF modeling

Table K1. Variable selection results from the "proposal set" of variables from the Lincoln subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Bare ground	61.5 ha	4	-2,526.3	0.0	1.0
		8.7 ha	4	-2,532.6	12.6	0.0
		661.5 ha	4	-2,588.9	125.3	0.0
		Null	3	-2,634.0	213.3	0.0
	Big sagebrush	661.4 ha	4	-2,576.4	0.0	1.0
		61.5 ha	4	-2,583.1	13.3	0.0
		8.7 ha	4	-2,589.8	26.8	0.0
		Null	3	-2,634.0	113.0	0.0
	Cropland	661.4 ha	4	-1,967.1	0.0	1.0
		61.5 ha	4	-2,068.6	202.9	0.0
		8.7 ha	4	-2,145.4	356.6	0.0
		Null	3	-2,634.0	1,331.7	0.0
	Forest	8.7 ha	4	-2,564.8	0.0	0.67
		61.5 ha	4	-2,565.5	1.4	0.33
		661.4 ha	4	-2,603.2	76.7	0.00
		Null	3	-2,634.0	136.2	0.00
	Herbaceous	661.4 ha	4	-2,328.0	0.0	1.0
		61.5 ha	4	-2,391.8	127.6	0.0
		8.7 ha	4	-2,401.3	146.6	0.0
		Null	3	-2,634.0	609.9	0.0
	Non-sagebrush shrub	661.4 ha	4	-2,410.0	0.0	1.0
		61.5 ha	4	-2,458.0	96.0	0.0
		8.7 ha	4	-2,492.6	165.2	0.0
		Null	3	-2,634.0	445.9	0.0
	Other sagebrush	661.4 ha	4	-2,585.9	0.0	1.0
		8.7 ha	4	-2,607.8	43.7	0.0
		61.5 ha	4	-2,610.5	49.1	0.0
		Null	3	-2,634.0	94.1	0.0
	Pinyon-juniper	61.5 ha	4	-2,079.3	0.0	1.0
		8.7 ha	4	-2,123.5	88.5	0.0
		661.4 ha	4	-2,147.9	137.2	0.0
		Null	3	-2,634.0	1,107.4	0.0
	Riparian	661.4 ha	4	-2,626.6	0.0	0.98
		61.5 ha	4	-2,630.6	8.1	0.02
		Null	3	-2,634.0	12.8	0.00
		8.7 ha	4	-2,633.6	14.0	0.00

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Sagebrush Height	Sagebrush Height	61.5 ha	4	-2,616.8	0.0	1.0
		8.7 ha	4	-2,624.8	15.8	0.0
		661.4 ha	4	-2,626.4	19.1	0.0
		Null	3	-2,634.0	32.2	0.0
Agriculture	Distance to cropland	Linear	4	-1,647.3	0.0	1.0
		Expon. decay	4	-1,803.5	312.5	0.0
		Null	3	-2,634.0	1,971.3	0.0
Edge	Variety of edge types	661.4 ha*	4	-1,828.0	0.0	1.0
		61.5 ha	4	-2,317.9	979.9	0.0
		8.7 ha	4	-2,491.5	1,327.0	0.0
		Null	3	-2,634.0	1,610.0	0.0
Landscape variation	Variety of land cover types	661.4 ha	4	-1,757.2	0.0	1.0
		61.5 ha	4	-2,246.2	977.9	0.0
		8.7 ha	4	-2,460.2	1,406.0	0.0
		Null	3	-2,634.0	1,751.5	0.0
Water sources	Distance to water body	Linear	4	-1,619.5	0.0	1.0
	Distance to water body	Expon. decay	4	-1,741.7	244.3	0.0
	Distance to spring	Linear	4	-2,173.6	1,108.1	0.0
	Distance to spring	Expon. decay	4	-2,307.3	1,375.5	0.0
	Distance to perennial stream	Linear	4	-2,338.2	1,437.3	0.0
	Distance to wet meadow	Expon. decay	4	-2,412.9	1,586.7	0.0
	Distance to wet meadow	Linear	4	-2,470.8	1,702.5	0.0
	Distance to perennial stream	Expon. decay	4	-2,473.0	1,706.8	0.0
	Distance to intermittent stream	Expon. decay	4	-2,571.5	1,904.0	0.0
	Distance to nearest stream	Expon. decay	4	-2,601.5	1,963.9	0.0
	Distance to intermittent stream	Linear	4	-2,617.0	1,994.9	0.0
	Distance to nearest stream	Linear	4	-2,627.9	2,016.7	0.0
	Null	Null	3	-2,634.0	2,026.8	0.0
Topography	Roughness index	1 ha	4	-2,538.7	0.0	1.0
	Topographic position index	510 m	4	-2,626.4	175.5	0.0
	Topographic position index	2010 m	4	-2,630.3	183.4	0.0
	Null		3	-2,634.0	188.6	0.0
	Elevation	Linear	4	-2,633.2	189.1	0.0

*Model failed to converge. Was not carried forward in the RSF modeling procedure.

Table K2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Lincoln summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Big sagebrush	661.4 ha	21.02 (18.08, 23.95)	Selection
Forest	8.7 ha	-1.23 (-1.82, -0.65)	Avoidance
Herbaceous	661.4 ha	42.85 (38.67, 47.03)	Selection
Non-sagebrush shrub	661.4 ha	19.29 (16.42, 22.15)	Selection
Pinyon-juniper	61.5 ha	-15.07 (-16.62, -13.51)	Avoidance
Riparian	661.4 ha	9.30 (4.72, 13.88)	Selection
Sagebrush height	61.5 ha	2.12 (1.08, 3.16)	Selection
Distance to cropland	Linear	-1.01 (-1.12, -0.91)	Selection
Variety of edge types	61.5 ha	0.24 (0.20, 0.28)	Selection
Variety of land cover types	661.4 ha	0.64 (0.58, 0.70)	Selection
Distance to perennial stream	Linear	-0.35 (-0.39, -0.30)	Selection
Distance to spring	Linear	-0.65 (-0.73, -0.57)	Selection
Distance to water body	Linear	-0.87 (-0.96, -0.79)	Selection
Distance to wet meadow	Expon. decay	0.27 (-0.10, 0.65)	None
Roughness index	1 ha	0.03 (-1.37, 1.44)	None
Topographic position index	510 m	0.0009 (-0.004, 0.01)	None

Table K3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Lincoln subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Big sagebrush	661.4 ha	0.048	0.0008	0.061	0.0022
Forest	8.7 ha	0.094	0.0062	0.020	0.0050
Herbaceous	661.4 ha	0.053	0.0007	0.080	0.0021
Non-sagebrush shrub	661.4 ha	0.057	0.0008	0.082	0.0022
Pinyon-juniper	61.5 ha	0.145	0.0039	0.017	0.0023
Riparian	661.4 ha	0.016	0.0006	0.019	0.0012
Sagebrush height	61.5 ha	0.20	0.0025	0.18	0.0042
Distance to cropland	Km	3.26	0.0510	0.80	0.0461
Variety of edge types	61.5 ha	2.21	0.0468	4.41	0.1657
Variety of land cover types	661.4 ha	5.45	0.0473	8.24	0.0859
Distance to perennial stream	Km	4.78	0.0875	2.42	0.0944
Distance to spring	Km	3.32	0.0647	1.34	0.0498
Distance to water body	Km	3.95	0.0562	1.06	0.0547
Distance to wet meadow	Km	11.65	0.1815	7.45	0.3472
Roughness index	1 ha	0.18	0.0026	0.13	0.0046
Topographic position index	510 m	0.05	0.5010	2.40	0.7613

Appendix L. Supplemental material for Lincoln winter season RSF modeling

Table L1. Variable selection results from the "proposal set" of variables from the Lincoln subregion during the winter season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Bare ground	8.7 ha	4	-1,563.8	0.0	0.99
		61.5 ha	4	-1,568.4	9.3	0.01
		661.4 ha	4	-1,612.6	97.6	0.00
		Null	3	-1,892.3	655.0	0.00
	Big sagebrush	661.4 ha	4	-1,808.0	0.0	1.0
		61.5 ha	4	-1,833.3	50.6	0.0
		8.7 ha	4	-1,839.6	63.2	0.0
		Null	3	-1,892.3	166.7	0.0
	Cropland	8.7 ha	4	-1,875.3	0.0	1.0
		661.4 ha	4	-1,886.5	22.4	0.0
		61.5 ha	4	-1,888.0	25.4	0.0
		Null	3	-1,892.3	31.9	0.0
	Forest	661.4 ha	4	-1,810.7	0.0	1.0
		61.5 ha	4	-1,823.3	25.2	0.0
		8.7 ha	4	-1,836.5	51.5	0.0
		Null	3	-1,892.3	161.1	0.0
	Herbaceous	661.4 ha	4	-1,720.2	0.0	1.0
		61.5 ha	4	-1,753.8	67.1	0.0
		8.7 ha	4	-1,772.5	104.5	0.0
		Null	3	-1,892.3	342.2	0.0
	Non-sagebrush shrub	61.5 ha	4	-1,888.0	0.0	0.56
		8.7 ha	4	-1,888.7	1.4	0.28
		661.4 ha	4	-1,889.4	2.7	0.14
		Null	3	-1,892.3	6.6	0.02
	Other sagebrush	661.4 ha	4	-1,614.6	0.0	1.0
		61.5 ha	4	-1,696.0	162.8	0.0
		8.7 ha	4	-1,735.1	241.0	0.0
		Null	3	-1,892.3	553.3	0.0
	Pinyon-juniper	661.4 ha	4	-1,443.2	0.0	1.0
		61.5 ha	4	-1,463.2	40.0	0.0
		8.7 ha	4	-1,498.0	109.5	0.0
		Null	3	-1,892.3	896.2	0.0
	Riparian	61.5 ha	4	-1,736.4	0.0	1.0
		661.4 ha	4	-1,745.1	17.4	0.0
		8.7 ha	4	-1,793.4	114.0	0.0
		Null	3	-1,892.3	309.9	0.0
Sagebrush	Sagebrush height	661.4 ha	4	-1,842.3	0.0	0.82

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
height						
		61.5 ha	4	-1,843.8	3.0	0.18
		8.7 ha	4	-1,874.2	63.7	0.00
		Null	3	-1,892.3	97.9	0.00
Agriculture	Distance to cropland	Linear	4	-1,786.7	0.0	1.0
		Expon. decay	4	-1,824.7	75.9	0.0
		Null	3	-1,892.3	209.2	0.0
Edge	Variety of edge types	8.7 ha	4	-1,840.1	0.0	1.0
		61.5 ha	4	-1,867.6	55.0	0.0
		Null	3	-1,892.3	102.5	0.0
		661.4 ha	4	-1,892.3	104.4	0.0
Landscape variation	Variety of land cover types	8.7 ha	4	-1,810.6	0.0	1.0
		61.5 ha	4	-1,834.8	48.4	0.0
		Null	3	-1,892.3	161.5	0.0
		661.4 ha	4	-1,891.3	161.6	0.0
Water sources	Distance to water body	Linear	4	-1,811.4	0.0	1.0
	Distance to nearest stream	Linear	4	-1,841.9	60.9	0.0
	Distance to water body	Expon. decay	4	-1,844.2	65.6	0.0
	Distance to intermittent stream	Linear	4	-1,854.7	86.6	0.0
	Distance to nearest stream	Expon. decay	4	-1,865.6	108.4	0.0
	Distance to wet meadow	Linear	4	-1,873.0	123.2	0.0
	Distance to intermittent stream	Expon. decay	4	-1,873.1	123.5	0.0
	Distance to wet meadow	Expon. decay	4	-1,875.4	128.0	0.0
	Distance to perennial stream	Linear	4	-1,877.1	131.4	0.0
	Distance to perennial stream	Expon. decay	4	-1,879.7	136.7	0.0
	Distance to spring	Expon. decay	4	-1,883.4	144.1	0.0
	Distance to spring	Linear	4	-1,889.6	156.4	0.0
	Null	Null	3	-1,892.3	159.8	0.0
Topography	Roughness index	1 ha	4	-1,676.0	0.0	1.0
	Elevation	Linear	4	-1,791.8	231.5	0.0
	Topographic position index	510 m	4	-1,885.0	418.1	0.0
	Null		3	-1,892.3	430.6	0.0
	Topographic position index	2010 m	4	-1,892.3	432.6	0.0

Table L2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Lincoln winter season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Big sagebrush	661.4 ha	11.58 (9.05, 14.11)	Selection
Forest	661.4 ha	1.43 (0.26, 2.60)	Selection
Non-sagebrush shrub	61.5 ha	-7.60 (-10.53, -4.68)	Avoidance
Other sagebrush	661.4 ha	90.51 (75.34, 105.68)	Selection
Pinyon-juniper	661.4 ha	-15.21 (-17.08, -13.34)	Avoidance
Riparian	61.5 ha	-11.20 (-17.27, -5.13)	Avoidance
Sagebrush height	661.4 ha	2.67 (1.33, 4.01)	Selection
Distance to cropland	Linear	-0.24 (-0.29, -0.19)	Selection
Variety of land cover types	8.7 ha	-0.39 (-0.50, -0.27)	Avoidance
Distance to nearest stream	Linear	-2.15 (-2.57, -1.73)	Selection
Distance to spring	Expon. decay	1.56 (1.17, 1.96)	Selection
Distance to water body	Linear	-0.16 (-0.20, -0.11)	Selection
Distance to wet meadow	Linear	-0.04 (-0.05, -0.03)	Selection
Topographic position index	510 m	0.02 (0.01, 0.03)	Selected ridges / Avoided valleys

Table L3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Lincoln subregion, and found important in resource selection function (RSF) modeling during the winter season, Nevada and northeastern California

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Big sagebrush	661.4 ha	0.048	0.0010	0.067	0.0022
Forest	661.4 ha	0.072	0.0048	0.011	0.0041
Non-sagebrush shrub	61.5 ha	0.056	0.0011	0.060	0.0017
Other sagebrush	661.4 ha	0.014	0.0002	0.021	0.0004
Pinyon-juniper	661.4 ha	0.144	0.0040	0.019	0.0025
Riparian	61.5 ha	0.018	0.0010	0.002	0.0006
Sagebrush height	661.4 ha	0.20	0.0023	0.17	0.0037
Distance to cropland	Km	3.36	0.0589	2.31	0.0922
Variety of land cover types	8.7 ha	2.04	0.0271	1.61	0.0454
Distance to nearest stream	Km	0.27	0.0100	0.17	0.0094
Distance to spring	Km	3.39	0.0765	3.63	0.1567
Distance to water body	Km	4.05	0.0683	2.97	0.1098
Distance to wet meadow	Km	11.97	0.2107	10.24	0.4091
Topographic position index	510 m	-1.49	0.5733	0.81	0.4543

Appendix M. Supplemental material for Midway spring season RSF modeling

Table M1. Variable selection results from the "proposal set" of variables from the Midway subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Bare ground	661.4 ha	4	-8,910.9	0.0	1.0
		61.5 ha	4	-9,023.2	224.5	0.0
		8.7 ha	4	-9,030.3	238.8	0.0
		Null	3	-9,031.7	239.6	0.0
	Big sagebrush	661.4 ha	4	-9,020.7	0.0	1.0
		61.5 ha	4	-9,029.9	18.4	0.0
		Null	3	-9,031.7	20.0	0.0
		8.7 ha	4	-9,031.7	22.0	0.0
	Cropland	61.5 ha	4	-8,203.2	0.0	1.0
		661.4 ha	4	-8,270.0	133.7	0.0
		8.7 ha	4	-8,424.5	442.6	0.0
		Null	3	-9,031.7	1,655.0	0.0
	Forest	61.5 ha	4	-8,931.7	0.0	1.0
		661.4 ha	4	-8,939.5	15.5	0.0
		8.7 ha	4	-8,981.9	100.3	0.0
		Null	3	-9,031.7	198.0	0.0
	Herbaceous	8.7 ha	4	-8,898.8	0.0	1.0
		61.5 ha	4	-8,918.0	38.4	0.0
		661.4 ha	4	-8,931.3	65.0	0.0
		Null	3	-9,031.7	263.8	0.0
	Non-sagebrush shrub	8.7 ha	4	-8,974.7	0.0	1.0
		61.5 ha	4	-8,994.0	38.7	0.0
		661.4 ha	4	-9,030.3	111.2	0.0
		Null	3	-9,031.7	112.1	0.0
	Other sagebrush	661.4 ha*	4	-8,945.3	0.0	0.96
		61.5 ha	4	-8,948.6	6.6	0.04
		8.7 ha	4	-8,965.8	40.9	0.00
		Null	3	-9,031.7	170.8	0.00
	Pinyon-juniper	61.5 ha	4	-7,427.7	0.0	1.0
		8.7 ha	4	-7,471.5	87.6	0.0
		661.5 ha	4	-7,601.4	347.3	0.0
		Null	3	-9,031.7	3,206.0	0.0
Sagebrush height	Sagebrush height	661.4 ha	4	-8,864.9	0.0	1.0
		61.5 ha	4	-8,964.0	198.3	0.0
		8.7 ha	4	-8,989.4	249.0	0.0
		Null	3	-9,031.7	331.6	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Agriculture	Distance to cropland	Expon. decay	4	-8,314.8	0.0	1.0
		Linear	4	-8,687.5	745.5	0.0
		Null	3	-9,031.7	1,431.8	0.0
Edge	Variety of edge types	8.7 ha	4	-8,956.8	0.0	1.0
		61.5 ha	4	-8,987.0	60.3	0.0
		Null	3	-9,031.7	147.7	0.0
		661.5 ha	4	-9,031.7	149.7	0.0
Landscape variation	Variety of land cover types	661.5 ha	4	-8,787.1	0.0	1.0
		8.7 ha	4	-8,923.7	273.3	0.0
		61.5 ha	4	-8,982.0	389.8	0.0
		Null	3	-9,031.7	487.2	0.0
Water sources	Distance to wet meadow	Expon. decay	4	-8,377.5	0.0	1.0
	Distance to wet meadow	Linear	4	-8,466.6	178.2	0.0
	Distance to nearest stream	Linear	4	-8,788.6	822.2	0.0
	Distance to perennial stream	Expon. decay	4	-8,805.8	856.7	0.0
	Distance to nearest stream	Expon. decay	4	-8,811.2	867.3	0.0
	Distance to water body	Linear	4	-8,853.1	951.1	0.0
	Distance to perennial stream	Linear	4	-8,858.2	961.5	0.0
	Distance to intermittent stream	Expon. decay	4	-8,944.8	1,134.6	0.0
	Distance to intermittent stream	Linear	4	-8,947.0	1,139.1	0.0
	Distance to spring	Linear	4	-8,987.1	1,219.3	0.0
	Distance to spring	Expon. decay	4	-8,994.1	1,233.2	0.0
	Distance to water body	Expon. decay	4	-8,997.0	1,238.9	0.0
	Null	Null	3	-9,031.7	1,306.4	0.0
Topography	Roughness index	1 ha	4	-8,402.1	0.0	1.0
	Elevation	Linear	4	-8,722.7	641.3	0.0
	Topographic position index	2010 m	4	-9,005.5	1,206.8	0.0
	Null		3	-9,031.7	1,257.3	0.0
	Topographic position index	510 m	4	-9,031.7	1,259.3	0.0

*Model failed to converge. Was not carried forward in the RSF modeling procedure.

Table M2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Midway spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Cropland	61.5 ha	9.51 (8.60, 10.42)	Selection
Forest	61.5 ha	-2.10 (-5.33, 1.14)	None
Herbaceous	8.7 ha	15.76 (14.38, 17.13)	Selection
Non-sagebrush shrub	8.7 ha	3.91 (3.10, 4.72)	Selection
Other sagebrush	61.5 ha	48.26 (44.24, 52.29)	Selection
Pinyon-juniper	61.5 ha	-29.56 (-31.80, -27.32)	Avoidance
Sagebrush height	661.4 ha	4.30 (3.69, 4.90)	Selection
Variety of edge types	8.7 ha	0.24 (0.21, 0.28)	Selection
Variety of land cover types	661.4 ha	0.27 (0.24, 0.29)	Selection
Distance to nearest stream	Linear	-1.82 (-2.01, -1.62)	Selection
Distance to spring	Linear	-0.16 (-0.18, -0.15)	Selection
Distance to water body	Linear	0.16 (0.15, 0.17)	Avoidance
Distance to wet meadow	Expon. decay	2.68 (2.48, 2.89)	Selection
Roughness index	1 ha	-1.09 (-1.72, -0.45)	Avoidance
Topographic position index	2010 m	-0.002 (-0.004, -0.001)	Avoided ridges / Selected valleys

Table M3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Midway subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Cropland	61.5 ha	0.003	0.0005	0.074	0.0044
Forest	61.5 ha	0.009	0.0007	0.001	0.0001
Herbaceous	8.7 ha	0.065	0.0005	0.077	0.0012
Non-sagebrush shrub	8.7 ha	0.060	0.0004	0.071	0.0021
Other sagebrush	61.5 ha	0.019	0.0001	0.022	0.0004
Pinyon-juniper	61.5 ha	0.082	0.0017	0.004	0.0004
Sagebrush height	661.4 ha	0.19	0.0012	0.16	0.0019
Variety of edge types	8.7 ha	1.09	0.0131	1.37	0.0419
Variety of land cover types	661.4 ha	5.02	0.0210	5.82	0.0643
Distance to nearest stream	Km	0.25	0.0032	0.17	0.0048
Distance to spring	Km	5.13	0.0360	4.67	0.0744
Distance to water body	Km	4.33	0.0365	5.48	0.1177
Distance to wet meadow	Km	12.18	0.0707	8.87	0.1647
Roughness index	1 ha	0.15	0.0011	0.10	0.0017
Topographic position index	2010 ha	-0.70	0.5204	-4.86	0.5577

Appendix N. Supplemental material for Midway summer season RSF modeling

Table N1. Variable selection results from the "proposal set" of variables from the Midway subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Bare ground	8.7 ha	4	-9,440.9	0.0	0.71
		61.5 ha	4	-9,441.8	1.8	0.29
		661.4 ha	4	-9,500.9	120.0	0.00
		Null	3	-9,503.0	122.3	0.00
	Big sagebrush	661.4 ha	4	-9,472.9	0.0	1.0
		61.5 ha	4	-9,499.2	52.6	0.0
		8.7 ha	4	-9,501.4	56.9	0.0
		Null	3	-9,503.0	58.3	0.0
	Cropland	661.4 ha	4	-8,125.4	0.0	1.0
		61.5 ha	4	-8,444.4	637.9	0.0
		Null	3	-9,503.0	2,753.3	0.0
		8.7 ha	4	-8,880.8	1,510.8	0.0
	Forest	8.7 ha	4	-9,443.8	0.0	1.0
		61.5 ha	4	-9,451.3	14.9	0.0
		661.4 ha	4	-9,500.6	113.5	0.0
		Null	3	-9,503.0	116.4	0.0
	Herbaceous	661.4 ha	4	-8,710.9	0.0	1.0
		61.5 ha	4	-9,033.3	644.8	0.0
		8.7 ha	4	-9,053.1	684.5	0.0
		Null	3	-9,503.0	1,582.3	0.0
	Non-sagebrush shrub	661.4 ha	4	-7,623.2	0.0	1.0
		Null	3	-9,503.0	3,757.7	0.0
		61.5 ha	4	-8,408.9	1,571.5	0.0
		8.7 ha	4	-8,758.0	2,269.5	0.0
	Other sagebrush	61.5 ha	4	-9,498.8	0.0	0.53
		661.4 ha	4	-9,499.0	0.5	0.41
		8.7 ha	4	-9,501.4	5.4	0.04
		null	3	-9,503.0	6.6	0.02
	Pinyon-juniper	661.4 ha	4	-7,979.3	0.0	1.0
		8.7 ha	4	-7,988.2	17.8	0.0
		61.5 ha	4	-7,995.7	32.8	0.0
		Null	3	-9,503.0	3,045.4	0.0
	Riparian	61.5 ha	4	-9,312.4	0.0	1.0
		661.4 ha	4	-9,336.8	48.8	0.0
		8.7 ha	4	-9,406.2	187.6	0.0
		Null	3	-9,503.0	379.3	0.0
Sagebrush	Sagebrush Height	661.4 ha	4	-8,665.1	0.0	1.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
height						
		61.5 ha	4	-8,921.2	512.1	0.0
		8.7 ha	4	-9,029.2	728.1	0.0
		Null	3	-9,503.0	1,673.9	0.0
Agriculture	Distance to cropland	Expon. decay	4	-7,145.6	0.0	1.0
		Null	3	-9,503.0	4,712.8	0.0
		Linear	4	-8,210.5	2,129.7	0.0
Edge	Variety of edge types	661.4 ha	4	-8,010.7	0.0	1.0
		Null	3	-9,503.0	2,982.7	0.0
		61.5 ha	4	-8,962.0	1,902.6	0.0
		8.7 ha	4	-9,041.6	2,061.7	0.0
Landscape variation	Variety of land cover types	661.4 ha	4	-7,793.1	0.0	1.0
		Null	3	-9,503.0	3,417.8	0.0
		61.5 ha	4	-8,788.3	1,990.3	0.0
		8.7 ha	4	-8,852.1	2,117.9	0.0
Water sources	Distance to wet meadow	Linear	4	-4,909.1	0.0	1.0
	Distance to perennial stream	Linear	4	-4,942.8	67.4	0.0
	Distance to wet meadow	Expon. decay	4	-5,065.5	312.7	0.0
	Distance to perennial stream	Expon. decay	4	-5,874.3	1,930.3	0.0
	Distance to water body	Expon. decay	4	-7,312.5	4,806.8	0.0
	Distance to water body	Linear	4	-7,457.1	5,095.9	0.0
	Distance to spring	Expon. decay	4	-8,213.7	6,609.2	0.0
	Distance to spring	Linear	4	-8,400.7	6,983.2	0.0
	Distance to nearest stream	Linear	4	-9,400.9	8,983.7	0.0
	Distance to nearest stream	Expon. decay	4	-9,443.9	9,069.6	0.0
	Distance to intermittent stream	Expon. decay	4	-9,501.8	9,185.3	0.0
	Null	Null	3	-9,503.0	9,185.9	0.0
	Distance to intermittent stream	Linear	4	-9,503.0	9,187.8	0.0
Topography	Roughness index	1 ha	4	-8,924.9	0.0	1.0
	Elevation	Linear	4	-9,286.5	723.1	0.0
	Topographic position index	2010 m	4	-9,315.0	780.0	0.0
	Topographic position index	510 m	4	-9,478.7	1,107.5	0.0
	Null		3	-9,503.0	1,154.2	0.0

Table N2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Midway summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Forest	8.7 ha	-10.00 (-11.89, -8.11)	Avoidance
Herbaceous	661.4 ha	36.25 (33.90, 38.60)	Selection
Non-sagebrush shrub	661.4 ha	44.87 (41.44, 48.31)	Selection
Other sagebrush	61.5 ha	57.77 (52.74, 62.80)	Selection
Pinyon-juniper	661.4 ha	-18.52 (-19.99, -17.06)	Avoidance
Riparian	61.5 ha	-0.10 (-2.22, 2.01)	None
Sagebrush height	661.4 ha	-2.56 (-3.17, -1.95)	Avoidance
Distance to cropland	Expon. decay	1.36 (1.12, 1.59)	Selection
Variety of edge types	661.4 ha	0.22 (0.20, 0.24)	Selection
Variety of land cover types	661.4 ha	-0.22 (-0.19, -0.25)	Avoidance
Distance to spring	Expon. decay	2.75 (2.52, 2.99)	Selection
Distance to water body	Expon. decay	3.68 (3.41, 3.95)	Selection
Distance to wet meadow	Linear	-0.58 (-0.60, -0.56)	Selection
Topographic position index	2010 m	-0.015 (-0.017, -0.013)	Avoided ridges / Selected valleys

Table N3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Midway subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Forest	8.7 ha	0.011	0.0010	0.001	0.0003
Herbaceous	661.4 ha	0.066	0.0003	0.084	0.0008
Non-sagebrush shrub	661.4 ha	0.059	0.0002	0.082	0.0007
Other sagebrush	61.5 ha	0.019	0.0001	0.019	0.0004
Pinyon-juniper	661.4 ha	0.082	0.0015	0.010	0.0007
Riparian	61.5 ha	0.005	0.0002	0.014	0.0011
Sagebrush height	661.4 ha	0.19	0.0012	0.13	0.0026
Distance to cropland	Km	6.31	0.0420	3.29	0.1112
Variety of edge types	661.4 ha	6.97	0.0397	10.11	0.0862
Variety of land cover types	661.4 ha	5.02	0.0201	7.31	0.0704
Distance to spring	Km	5.09	0.0362	2.94	0.0678
Distance to water body	Km	4.32	0.0359	1.79	0.0427
Distance to wet meadow	Km	11.99	0.0684	3.59	0.0941
Topographic position index	2010 m	-0.56	0.5095	-11.91	0.7052

Appendix O. Supplemental material for North SWIP spring season RSF modeling

Table O1. Variable selection results from the "proposal set" of variables from the North SWIP subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-7,322.2	0.0	1.0
		61.5 ha	4	-7,346.0	47.6	0.0
		8.7 ha	4	-7,356.6	68.9	0.0
		Null	3	-7,368.2	89.9	0.0
	Bare ground	661.4 ha	4	-7,340.5	0.0	1.0
		61.5 ha	4	-7,359.1	37.1	0.0
		8.7 ha	4	-7,362.6	44.1	0.0
		Null	3	-7,368.2	53.3	0.0
	Big sagebrush	661.4 ha	4	-6,047.1	0.0	1.0
		61.5 ha	4	-6,165.6	237.0	0.0
		8.7 ha	4	-6,298.2	502.2	0.0
		Null	3	-7,368.2	2,640.1	0.0
	Cropland	661.4 ha	4	-7,282.0	0.0	0.84
		61.5 ha	4	-7,283.6	3.3	0.16
		8.7 ha	4	-7,320.3	76.6	0.00
		Null	3	-7,368.2	170.3	0.00
	Forest	661.4 ha	4	-7,321.9	0.0	1.0
		61.5 ha	4	-7,359.4	75.1	0.0
		Null	3	-7,368.2	90.6	0.0
		8.7 ha	4	-7,367.4	91.1	0.0
	Herbaceous	661.4 ha	4	-5,760.1	0.0	1.0
		61.5 ha	4	-5,909.7	299.3	0.0
		8.7 ha	4	-6,115.2	710.3	0.0
		Null	3	-7,368.2	3,214.2	0.0
	Non-sagebrush shrub	661.4 ha	4	-7,083.5	0.0	1.0
		61.5 ha	4	-7,168.6	170.2	0.0
		8.7 ha	4	-7,208.3	249.6	0.0
		Null	3	-7,368.2	567.3	0.0
	Other sagebrush	661.4 ha	4	-6,330.0	0.0	1.0
		61.5 ha	4	-6,374.0	87.9	0.0
		8.7 ha	4	-6,484.2	308.3	0.0
		Null	3	-7,368.2	2,074.2	0.0
	Pinyon-juniper	8.7 ha	4	-6,851.0	0.0	1.0
		61.5 ha	4	-6,928.2	154.3	0.0
		661.4 ha	4	-7,157.8	613.5	0.0
		Null	3	-7,368.2	1,032.3	0.0
	Riparian	661.4 ha	4	-7,348.0	0.0	1.0
		61.5 ha	4	-7,357.1	18.3	0.0
		8.7 ha	4	-7,366.5	37.1	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		Null	3	-7,368.2	38.4	0.0
	Wet meadow	661.4 ha	4	-7,294.5	0.0	1.0
		61.5 ha	4	-7,339.3	89.6	0.0
		8.7 ha	4	-7,355.4	121.9	0.0
		Null	3	-7,368.2	145.4	0.0
Sagebrush height	Sagebrush height	661.4 ha	4	-7,235.8	0.0	1.0
		8.7 ha	4	-7,263.9	56.3	0.0
		61.5 ha	4	-7,278.4	85.3	0.0
		Null	3	-7,368.2	262.7	0.0
Agriculture	Distance to cropland	Linear	4	-7,345.7	0.0	1.0
		Expon. decay	4	-7,356.9	22.4	0.0
		Null	3	-7,368.2	42.9	0.0
Edge	Variety of edge types	661.4 ha	4	-7,042.6	0.0	1.0
		61.5 ha	4	-7,089.5	93.8	0.0
		8.7 ha	4	-7,237.7	390.1	0.0
		Null	3	-7,368.2	649.0	0.0
Landscape variation	Variety of land cover types	8.7 ha	4	-7,247.5	0.0	1.0
		61.5 ha	4	-7,294.9	94.7	0.0
		661.4 ha	4	-7,300.8	106.5	0.0
		Null	3	-7,368.2	239.2	0.0
Water sources	Distance to spring	Expon. decay	4	-7,029.3	0.0	1.0
	Distance to nearest stream	Linear	4	-7,135.0	211.5	0.0
	Distance to perennial stream	Expon. decay	4	-7,156.3	254.1	0.0
	Distance to intermittent stream	Linear	4	-7,163.2	267.9	0.0
	Distance to wet meadow	Linear	4	-7,182.6	306.6	0.0
	Distance to water body	Expon. decay	4	-7,198.0	337.4	0.0
	Distance to perennial stream	Linear	4	-7,250.9	443.3	0.0
	Distance to spring	Linear	4	-7,283.5	508.5	0.0
	Distance to nearest stream	Expon. decay	4	-7,321.2	583.9	0.0
	Distance to intermittent stream	Expon. decay	4	-7,325.9	593.2	0.0
	Distance to water body	Linear	4	-7,331.8	605.1	0.0
	Distance to water body	Expon. decay	4	-7,360.5	662.5	0.0
	Null	Null	3	-7,368.2	675.8	0.0
Topography	Elevation	linear	4	-6,724.1	0.0	1.0
	Topographic position index	2010 m	4	-7,216.5	984.8	0.0
	Topographic position index	510 m	4	-7,329.8	1,211.5	0.0
	Roughness index	1 ha	4	-7,356.3	1,264.5	0.0
	Null		3	-7,368.2	1,286.2	0.0

Table O2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the North SWIP spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	-93.41 (-153.57, -33.25)	Avoidance
Big sagebrush	661.4 ha	13.83 (12.74, 14.91)	Selection
Cropland	661.4 ha	18.25 (16.80, 19.69)	Selection
Forest	661.4 ha	-10.08 (-12.25, -7.91)	Avoidance
Herbaceous	661.4 ha	31.48 (25.96, 37.00)	Selection
Non-sagebrush shrub	661.4 ha	-11.47 (-13.10, -9.85)	Avoidance
Other sagebrush	661.4 ha	63.96 (58.99, 68.93)	Selection
Pinyon-juniper	8.7 ha	-3.42 (-3.90, -2.94)	Avoidance
Riparian	661.4 ha	-12.75 (-16.10, -9.40)	Avoidance
Variety of edge types	661.4 ha	-0.004 (-0.02, 0.01)	None
Variety of land cover types	8.7 ha	-0.11 (-0.15, -0.07)	Avoidance
Distance to nearest stream	Linear	-1.44 (-1.63, -1.25)	Selection
Distance to spring	Expon. decay	-0.21 (-0.38, -0.03)	Avoidance
Distance to water body	Linear	0.01 (-0.001, 0.03)	Avoidance
Distance to wet meadow	Linear	0.10 (0.09, 0.103)	Avoidance
Elevation	Linear	0.25 (0.04, 0.46)	Selection for higher elevations
Topographic position index	2010 m	0.001 (-0.0003, 0.002)	None

Table O3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the North SWIP subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.003	0.0004	0.0001	0.0000
Big sagebrush	661.4 ha	0.064	0.0006	0.116	0.0019
Cropland	661.4 ha	0.007	0.0004	0.017	0.0016
Forest	661.4 ha	0.010	0.0006	0.016	0.0007
Herbaceous	661.4 ha	0.064	0.0003	0.102	0.0013
Non-sagebrush shrub	661.4 ha	0.058	0.0004	0.074	0.0012
Other sagebrush	661.4 ha	0.022	0.0001	0.035	0.0007
Pinyon-juniper	8.7 ha	0.111	0.0027	0.026	0.0022
Riparian	661.4 ha	0.009	0.0003	0.007	0.0004
Variety of edge types	661.4 ha	7.26	0.0532	9.23	0.1222
Variety of land cover types	8.7 ha	2.17	0.0160	2.55	0.0406
Distance to nearest stream	Km	0.31	0.0059	0.18	0.0054
Distance to spring	Km	5.38	0.0568	4.26	0.1461
Distance to water body	Km	4.45	0.0434	3.98	0.0769
Distance to wet meadow	Km	9.97	0.0950	12.57	0.2174
Elevation	Km	2.04	0.0033	2.24	0.0112
Topographic position index	2010 m	0.66	0.7447	19.33	1.7399

Appendix P. Supplemental material for North SWIP summer season RSF modeling

Table P1. Variable selection results from the "proposal set" of variables from the North SWIP subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha*	4	-8,570.6	0.0	1.0
		61.5 ha	4	-8,678.7	216.3	0.0
		8.7 ha	4	-8,723.7	306.2	0.0
		Null	3	-8,747.5	351.9	0.0
	Bare ground	661.4 ha	4	-8,210.7	0.0	1.0
		8.7 ha	4	-8,250.3	79.1	0.0
		61.5 ha	4	-8,251.1	80.6	0.0
		Null	3	-8,747.5	1,071.6	0.0
	Big sagebrush	661.4 ha	4	-5,815.5	0.0	1.0
		61.5 ha	4	-5,993.3	355.7	0.0
		8.7 ha	4	-6,448.1	1,265.1	0.0
		Null	3	-8,747.5	5,862.1	0.0
	Cropland	61.5 ha	4	-8,634.9	0.0	1.0
		8.7 ha	4	-8,673.0	76.1	0.0
		661.4 ha	4	-8,675.4	81.1	0.0
		Null	3	-8,747.5	223.2	0.0
	Forest	661.4 ha	4	-8,319.8	0.0	1.0
		61.5 ha	4	-8,699.2	759.0	0.0
		8.7 ha	4	-8,741.6	843.8	0.0
		Null	3	-8,747.5	853.5	0.0
	Herbaceous	661.4 ha	4	-4,170.6	0.0	1.0
		61.5 ha	4	-4,899.8	1,458.5	0.0
		Null	3	-8,747.5	9,151.9	0.0
		8.7 ha	4	-5,727.5	3,113.8	0.0
	Non-sagebrush shrub	661.4 ha	4	-6,271.5	0.0	1.0
		Null	3	-8,747.5	4,950.1	0.0
		61.5 ha	4	-7,165.6	1,788.3	0.0
		8.7 ha	4	-7,691.8	2,840.6	0.0
	Other sagebrush	661.4 ha*	4	-6,087.3	0.0	1.0
		61.5 ha	4	-6,122.0	69.4	0.0
		8.7 ha	4	-6,641.4	1,108.2	0.0
		Null	3	-8,747.5	5,318.4	0.0
	Pinyon-juniper	8.7 ha	4	-7,858.9	0.0	1.0
		61.5 ha	4	-7,932.4	147.1	0.0
		661.4 ha	4	-8,445.4	1,173.0	0.0
		Null	3	-8,747.5	1,775.3	0.0
	Riparian	8.7 ha	4	-8,655.1	0.0	1.0
		61.5 ha	4	-8,677.3	44.4	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		Null	3	-8,747.5	182.8	0.0
		661.4 ha	4	-8,747.5	184.8	0.0
	Wet meadow	661.4 ha	4	-8,694.0	0.0	1.0
		61.5 ha	4	-8,729.6	71.2	0.0
		8.7 ha	4	-8,734.1	80.1	0.0
		Null	3	-8,747.5	105.0	0.0
Sagebrush height	Sagebrush height	661.4 ha	4	-8,448.3	0.0	1.0
		8.7 ha	4	-8,512.0	127.3	0.0
		61.5 ha	4	-8,542.1	187.6	0.0
		Null	3	-8,747.5	596.3	0.0
Agriculture	Distance to cropland	Linear	4	-7,782.1	0.0	1.0
		Expon. decay	4	-8,033.5	502.8	0.0
		Null	3	-8,747.5	1,928.9	0.0
Edge	Variety of edge types	661.4 ha	4	-6,752.0	0.0	1.0
		Null	3	-8,747.5	3,989.0	0.0
		61.5 ha	4	-7,809.0	2,114.0	0.0
		8.7 ha	4	-8,155.9	2,807.8	0.0
Landscape variation	Variety of land cover types	8.7 ha	4	-7,997.5	0.0	1.0
		61.5 ha	4	-8,151.2	307.5	0.0
		661.4 ha	4	-8,328.6	662.1	0.0
		Null	3	-8,747.5	1,498.0	0.0
Water sources	Distance to spring	Expon. decay	4	-5,350.3	0.0	1.0
	Distance to perennial stream	Expon. decay	4	-6,088.3	1,476.1	0.0
	Distance to spring	Linear	4	-6,692.7	2,684.8	0.0
	Distance to perennial stream	Linear	4	-7,344.7	3,989.0	0.0
	Distance to water body	Linear	4	-8,408.8	6,117.0	0.0
	Distance to water body	Expon. decay	4	-8,542.0	6,383.5	0.0
	Distance to nearest stream	Linear	4	-8,602.8	6,505.0	0.0
	Distance to intermittent stream	Linear	4	-8,637.5	6,574.5	0.0
	Distance to wet meadow	Expon. decay	4	-8,674.9	6,649.2	0.0
	Distance to nearest stream	Expon. decay	4	-8,732.8	6,765.1	0.0
	Distance to wet meadow	Linear	4	-8,743.4	6,786.3	0.0
	Distance to intermittent stream	Expon. decay	4	-8,746.4	6,792.2	0.0
	Null	Null	3	-8,747.5	6,792.5	0.0
Topography	Elevation	Linear	4	-5,993.8	0.0	1.0
	Roughness Index	1 ha	4	-8,450.1	4,912.6	0.0
	Topographic position index	2010 m	4	-8,705.5	5,423.3	0.0
	Topographic position index	510 m	4	-8,746.3	5,504.9	0.0
	Null		3	-8,747.5	5,505.4	0.0

*Model failed to converge. Was not carried forward in the RSF modeling procedure.

Table P2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the North SWIP summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	8.7 ha	-39.76 (-66.51, -13.01)	Avoidance
Big sagebrush	661.4 ha	12.57 (11.26, 13.88)	Selection
Forest	661.4 ha	-5.43 (-7.54, -3.32)	Avoidance
Herbaceous	661.4 ha	59.36 (56.58, 62.14)	Selection
Non-sagebrush shrub	661.4 ha	11.53 (9.75, 13.31)	Selection
Other sagebrush	61.5 ha	14.43 (10.37, 18.49)	Selection
Pinyon-juniper	8.7 ha	-4.53 (-5.29, -3.77)	Avoidance
Riparian	8.7 ha	6.32 (5.22, 7.42)	Selection
Sagebrush height	661.4 ha	3.29 (2.49, 4.08)	Selection
Distance to cropland	Linear	0.09 (0.07, 0.10)	Avoidance
Variety of edge types	661.4 ha	0.13 (0.11, 0.14)	Selection
Variety of land cover types	8.7 ha	0.28 (0.24, 0.32)	Selection
Distance to spring	Expon. decay	3.39 (3.15, 3.62)	Selection
Distance to water body	Linear	-0.06 (-0.08, -0.04)	Selection
Distance to wet meadow	Expon. decay	-0.97 (-1.23, -0.72)	Avoidance
Elevation	Linear	1.74 (1.48, 2.00)	Selection for higher elevation
Topographic position index	2010 m	-0.007 (-0.008, -0.006)	Avoided ridges / Selected valleys

Table P3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the North SWIP subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	8.7 ha	0.003	0.0007	0.000	0.0000
Big sagebrush	661.4 ha	0.063	0.0005	0.136	0.0017
Forest	661.4 ha	0.010	0.0005	0.026	0.0008
Herbaceous	661.4 ha	0.064	0.0003	0.126	0.0011
Non-sagebrush shrub	661.4 ha	0.057	0.0004	0.101	0.0012
Other sagebrush	61.5 ha	0.022	0.0002	0.040	0.0005
Pinyon-juniper	8.7 ha	0.098	0.0020	0.016	0.0016
Riparian	8.7 ha	0.010	0.0006	0.026	0.0024
Sagebrush height	661.4 ha	0.25	0.0011	0.28	0.0017
Distance to cropland	Km	4.11	0.0393	6.65	0.1019
Variety of edge types	661.4 ha	7.32	0.0491	11.42	0.0759
Variety of land cover types	8.7 ha	2.16	0.0145	3.01	0.0354
Distance to spring	Km	5.36	0.0521	1.47	0.0698
Distance to water body	Km	4.50	0.0402	3.26	0.0614
Distance to wet meadow	Km	10.00	0.0874	10.30	0.1334
Elevation	Km	2.04	0.0029	2.44	0.0095
Topographic position index	2010 m	0.25	0.6471	10.36	1.9948

Appendix Q. Supplemental material for North SWIP winter season RSF modeling

Table Q1. Variable selection results from the "proposal set" of variables from the North SWIP subregion during the winter season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Bare ground	61.5 ha	4	-5,905.1	0.0	1.0
		661.4 ha	4	-5,971.6	132.8	0.0
		8.7 ha	4	-5,974.3	138.4	0.0
		Null	3	-6,986.9	2,161.6	0.0
	Big sagebrush	661.4 ha	4	-6,889.3	0.0	1.0
		61.5 ha	4	-6,905.8	33.0	0.0
		8.7 ha	4	-6,918.2	57.8	0.0
		Null	3	-6,986.9	193.2	0.0
	Cropland	661.4 ha	4	-6,920.2	0.0	1.0
		61.5 ha	4	-6,928.1	15.8	0.0
		8.7 ha	4	-6,945.1	49.7	0.0
		Null	3	-6,986.9	131.4	0.0
	Forest	661.4 ha	4	-6,866.1	0.0	1.0
		8.7 ha	4	-6,916.9	101.8	0.0
		61.5 ha	4	-6,919.1	106.0	0.0
		Null	3	-6,986.9	239.7	0.0
	Herbaceous	661.4 ha	4	-6,848.2	0.0	1.0
		61.5 ha	4	-6,900.5	104.6	0.0
		8.7 ha	4	-6,934.1	171.8	0.0
		Null	3	-6,986.9	275.5	0.0
	Non-sagebrush shrub	661.4 ha	4	-6,755.9	0.0	1.0
		61.5 ha	4	-6,842.9	174.0	0.0
		8.7 ha	4	-6,885.1	258.3	0.0
		Null	3	-6,986.9	460.0	0.0
	Other sagebrush	661.4 ha	4	-5,888.1	0.0	1.0
		61.5 ha	4	-6,215.4	654.6	0.0
		8.7 ha	4	-6,371.6	967.1	0.0
		Null	3	-6,986.9	2,195.7	0.0
	Pinyon-juniper	61.5 ha	4	-5,908.9	0.0	1.0
		8.7 ha	4	-5,916.8	15.7	0.0
		661.4 ha	4	-6,190.0	562.1	0.0
		Null	3	-6,986.9	2,154.0	0.0
	Riparian	661.4 ha	4	-6,022.0	0.0	1.0
		61.5 ha	4	-6,577.3	1,110.6	0.0
		Null	3	-6,986.9	1,927.8	0.0
		8.7 ha	4	-6,854.2	1,664.3	0.0
	Wet meadow	661.4 ha	4	-6,952.1	0.0	1.0
		61.5 ha	4	-6,971.9	39.7	0.0
		8.7 ha	4	-6,980.1	56.2	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		Null	3	-6,986.9	67.7	0.0
Sagebrush height	Sagebrush height	8.7 ha	4	-6,970.3	0.0	1.0
		Null	3	-6,986.9	31.3	0.0
		61.5 ha	4	-6,986.2	31.9	0.0
		661.4 ha	4	-6,986.6	32.6	0.0
Agriculture	Distance to cropland	Linear	4	-6,900.5	0.0	1.0
		Expon. decay	4	-6,955.4	109.8	0.0
		Null	3	-6,986.9	170.8	0.0
Edge	Variety of edge types	661.4 ha	4	-6,324.2	0.0	1.0
		61.5 ha	4	-6,624.1	599.7	0.0
		8.7 ha	4	-6,809.6	970.7	0.0
		Null	3	-6,986.9	1,323.4	0.0
Landscape variation	Variety of land cover types	61.5 ha	4	-6,530.3	0.0	1.0
		661.4 ha	4	-6,666.8	272.9	0.0
		8.7 ha	4	-6,708.0	355.4	0.0
		Null	3	-6,986.9	911.2	0.0
Water sources	Distance to wet meadow	Expon. decay	4	-5,337.8	0.0	0.99
	Distance to wet meadow	Linear	4	-5,343.0	10.3	0.01
	Distance to water body	Expon. decay	4	-5,888.0	1,100.3	0.00
	Distance to water body	Linear	4	-6,067.4	1,459.2	0.00
	Distance to perennial stream	Expon. decay	4	-6,380.1	2,084.6	0.00
	Distance to perennial stream	Linear	4	-6,480.7	2,285.7	0.00
	Distance to spring	Expon. decay	4	-6,516.9	2,358.1	0.00
	Distance to spring	Linear	4	-6,621.5	2,567.3	0.00
	Distance to intermittent stream	Linear	4	-6,757.7	2,839.8	0.00
	Distance to nearest stream	Linear	4	-6,799.2	2,922.7	0.00
	Distance to intermittent stream	Expon. decay	4	-6,843.1	3,010.5	0.00
	Distance to intermittent stream	Expon. decay	4	-6,875.0	3,074.4	0.00
	Null	Null	3	-6,986.9	3,296.2	0.00
Topography	Roughness index	1 ha	4	-6,511.5	0.0	1.0
	Elevation	Linear	4	-6,918.2	813.3	0.0
	Topographic position index	2010 m	4	-6,963.6	904.3	0.0
	Null		3	-6,986.9	948.8	0.0
	Topographic position index	510 m	4	-6,986.8	950.5	0.0

Table Q2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the North SWIP winter season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Bare ground	61.5 ha	6.65 (6.23, 7.06)	Selection
Big sagebrush	661.4 ha	4.50 (3.43, 5.56)	Selection
Forest	661.4 ha	-8.19 (-11.09, -5.29)	Avoidance
Herbaceous	661.4 ha	27.88 (25.30, 30.46)	Selection
Non-sagebrush shrub	661.4 ha	-8.37 (-10.82, -5.92)	Avoidance
Other sagebrush	661.4 ha	90.93 (85.25, 96.60)	Selection
Riparian	661.4 ha	-158.90 (-171.11, -146.69)	Avoidance
Sagebrush height	8.7 ha	-0.30 (-0.72, 0.12)	None
Distance to cropland	Linear	-0.30 (-0.32, -0.27)	Selection
Variety of edge types	661.4 ha	-0.17 (-0.18, -0.15)	Avoidance
Distance to water body	Expon. decay	-4.84 (-5.12, -4.56)	Avoidance
Distance to wet meadow	Expon. decay	-7.63 (-7.99, -7.28)	Avoidance
Topographic position index	2010 m	-0.004 (-0.005, -0.002)	Avoided ridges / Selected valleys

Table Q3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the North SWIP subregion, and found important in resource selection function (RSF) modeling during the winter season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Bare ground	61.5 ha	0.501	0.0035	0.673	0.0026
Big sagebrush	661.4 ha	0.063	0.0006	0.076	0.0016
Forest	661.4 ha	0.010	0.0006	0.002	0.0003
Herbaceous	661.4 ha	0.064	0.0003	0.071	0.0005
Non-sagebrush shrub	661.4 ha	0.057	0.0004	0.047	0.0005
Other sagebrush	661.4 ha	0.022	0.0002	0.031	0.0003
Riparian	661.4 ha	0.009	0.0003	0.001	0.0001
Sagebrush height	8.7 ha	0.24	0.0018	0.25	0.0034
Distance to cropland	Km	4.08	0.0435	3.37	0.0729
Variety of edge types	661.4 ha	7.22	0.0552	4.70	0.0881
Distance to water body	Km	4.43	0.0449	7.05	0.0932
Distance to wet meadow	Km	9.98	0.0978	17.51	0.1807
Topographic position index	2010 m	-0.93	0.7401	-6.34	0.6721

Appendix R. Supplemental material for South SWIP spring season RSF modeling

Table R1. Variable selection results from the "proposal set" of variables from the South SWIP subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Big sagebrush	661.4 ha	4	-7,624.7	0.0	1.0
		61.5 ha	4	-7,743.8	238.3	0.0
		8.7 ha	4	-7,744.9	240.5	0.0
		Null	3	-7,749.4	247.4	0.0
	Cropland	661.4 ha	4	-7,199.7	0.0	1.0
		61.5 ha	4	-7,346.8	294.1	0.0
		8.7 ha	4	-7,485.1	570.8	0.0
		Null	3	-7,749.4	1,097.3	0.0
	Forest	661.4 ha	4	-7,633.0	0.0	1.0
		61.5 ha	4	-7,664.6	63.2	0.0
		8.7 ha	4	-7,684.3	102.6	0.0
		Null	3	-7,749.4	230.9	0.0
	Herbaceous	661.4 ha	4	-7,217.3	0.0	1.0
		61.5 ha	4	-7,501.6	568.6	0.0
		8.7 ha	4	-7,584.4	734.1	0.0
		Null	3	-7,749.4	1,062.1	0.0
	Non-sagebrush shrub	661.4 ha	4	-7,736.2	0.0	0.99
		61.5 ha	4	-7,741.2	9.8	0.01
		8.7 ha	4	-7,745.4	18.3	0.00
		Null	3	-7,749.4	24.3	0.00
	Other sagebrush	661.4 ha	4	-7,367.9	0.0	1.0
		61.5 ha	4	-7,456.5	177.2	0.0
		8.7 ha	4	-7,490.2	244.6	0.0
		Null	3	-7,749.4	761.0	0.0
	Pinyon-juniper	61.5 ha	4	-6,351.5	0.0	1.0
		8.7 ha	4	-6,415.2	127.3	0.0
		661.4 ha	4	-6,493.3	283.7	0.0
		Null	3	-7,749.4	2,793.8	0.0
	Riparian	8.7 ha	4	-7,724.1	0.0	1.0
		61.5 ha	4	-7,733.5	18.9	0.0
		661.4 ha	4	-7,739.2	30.2	0.0
		Null	3	-7,749.4	48.6	0.0
Sagebrush height	Sagebrush height	661.4 ha	4	-7,728.4	0.0	0.99
		8.7 ha	4	-7,733.5	10.1	0.01
		61.5 ha	4	-7,743.0	29.1	0.00
		Null	3	-7,749.4	39.9	0.00
Agriculture	Distance to cropland	Expon. decay	4	-5,996.0	0.0	1.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		Null	3	-7,749.4	3,504.7	0.0
		Linear	4	-6,901.8	1,811.6	0.0
Edge	Variety of edge types	661.4 ha	4	-7,735.8	0.0	0.93
		61.5 ha	4	-7,738.3	5.1	0.07
		Null	3	-7,749.4	25.2	0.00
		8.7 ha	4	-7,749.1	26.5	0.00
Landscape variation	Variety of land cover types	661.4 ha	4	-7,104.8	0.0	1.0
		61.5 ha	4	-7,657.9	1,106.1	0.0
		Null	3	-7,749.4	1,287.1	0.0
		8.7 ha	4	-7,748.5	1,287.3	0.0
Water sources	Distance to wet meadow	Expon. decay	4	-7,215.4	0.0	1.0
	Distance to intermittent stream	Expon. decay	4	-7,242.7	54.5	0.0
	Distance to nearest stream	Expon. decay	4	-7,270.3	109.7	0.0
	Distance to wet meadow	Linear	4	-7,318.6	206.3	0.0
	Distance to intermittent stream	Linear	4	-7,363.5	296.1	0.0
	Distance to nearest stream	Linear	4	-7,377.6	324.4	0.0
	Distance to water body	Linear	4	-7,444.1	457.3	0.0
	Distance to water body	Expon. decay	4	-7,575.8	720.8	0.0
	Distance to spring	Expon. decay	4	-7,621.8	812.8	0.0
	Distance to perennial stream	Expon. decay	4	-7,642.3	853.8	0.0
	Distance to spring	Linear	4	-7,644.6	858.4	0.0
	Distance to perennial stream	Linear	4	-7,647.8	864.7	0.0
	Null	Null	3	-7,749.4	1,065.9	0.0
Elevation	Roughness index	1 ha	4	-6,804.8	0.0	1.0
	Elevation	Linear	4	-6,888.8	167.8	0.0
	Topographic position index	2010 m	4	-7,725.2	1,840.7	0.0
	Null		3	-7,749.4	1,887.1	0.0
	Topographic position index	510 m	4	-7,749.2	1,888.7	0.0

Table R2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the South SWIP spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Big sagebrush	661.4 ha	8.13 (6.94, 9.31)	Selection
Forest	661.4 ha	1.03 (-1.22, 3.29)	None
Herbaceous	661.4 ha	-38.62 (-40.89, -36.36)	Avoidance
Non-sagebrush shrubs	661.4 ha	-7.51 (-10.20, -4.81)	Avoidance
Pinyon-juniper	61.5 ha	-9.60 (-10.27, -8.93)	Avoidance
Riparian	8.7 ha	-6.14 (-7.39, -4.88)	Avoidance
Distance to cropland	Expon. decay	3.89 (3.70, 4.08)	Selection
Variety of edge types	661.4 ha	-0.18 (-0.20, -0.16)	Avoidance
Variety of land cover types	661.4 ha	0.58 (0.55, 0.61)	Selection
Distance to intermittent stream	Expon. decay	1.19 (1.04, 1.33)	Selection
Distance to spring	Expon. decay	-0.33 (-0.53, -0.13)	Avoidance
Distance to water body	Linear	-0.11 (-0.14, -0.08)	Selection
Roughness index	1 ha	-9.95 (-10.71, -9.20)	Avoidance
Topographic position index	2010 m	0.0002 (-0.001, 0.002)	Selected ridges / Avoided valleys

Table R3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the South SWIP subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Big sagebrush	661.4 ha	0.069	0.0006	0.080	0.0009
Forest	661.4 ha	0.008	0.0004	0.002	0.0004
Herbaceous	661.4 ha	0.070	0.0004	0.054	0.0007
Non-sagebrush shrub	661.4 ha	0.059	0.0003	0.057	0.0005
Pinyon-juniper	61.5 ha	0.151	0.0022	0.031	0.0014
Riparian	8.7 ha	0.012	0.0006	0.007	0.0011
Distance to cropland	Km	7.63	0.0588	4.09	0.1532
Variety of edge types	661.4 ha	6.73	0.0418	6.44	0.0821
Variety of land cover types	661.4 ha	5.06	0.0228	6.33	0.0618
Distance to intermittent stream	Km	0.30	0.0044	0.16	0.0059
Distance to spring	Km	5.69	0.0565	4.56	0.1247
Distance to water body	Km	3.37	0.0252	2.60	0.0407
Roughness index	1 ha	0.16	0.0012	0.10	0.0014
Topographic position index	2010 m	-0.59	0.5354	-4.57	0.4634

Appendix S. Supplemental material for South SWIP summer season RSF modeling

Table S1. Variable selection results from the "proposal set" of variables from the South SWIP subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Big sagebrush	661.4 ha	4	-6,640.2	0.0	1.0
		61.5 ha	4	-7,015.3	750.2	0.0
		Null	3	-7,028.5	774.7	0.0
		8.7 ha	4	-7,028.5	776.7	0.0
	Cropland	661.4 ha	4	-4,581.6	0.0	1.0
		61.5 ha	4	-5,609.6	2,056.0	0.0
		8.7 ha	4	-6,037.7	2,912.1	0.0
		Null	3	-7,028.5	4,891.8	0.0
	Forest[1]	61.5 ha	4	-6,703.2	0.0	1.0
		661.4 ha	4	-6,821.3	236.2	0.0
		8.7 ha	4	-6,872.1	337.9	0.0
		Null	3	-7,028.5	648.6	0.0
	Herbaceous	661.4 ha	4	-5,228.8	0.0	1.0
		61.5 ha	4	-5,764.5	1,071.3	0.0
		8.7 ha	4	-6,025.7	1,593.6	0.0
		Null	3	-7,028.5	3,597.3	0.0
	Non-sagebrush shrub	661.4 ha	4	-6,799.9	0.0	1.0
		61.5 ha	4	-6,822.5	45.2	0.0
		8.7 ha	4	-6,923.0	246.2	0.0
		Null	3	-7,028.5	455.2	0.0
	Other sagebrush	661.4 ha	4	-5,437.5	0.0	1.0
		61.5 ha	4	-5,909.4	943.8	0.0
		8.7 ha	4	-6,078.4	1,281.8	0.0
		Null	3	-7,028.5	3,180.0	0.0
	Pinyon-juniper	61.5 ha	4	-5,065.3	0.0	1.0
		8.7 ha	4	-5,215.8	301.0	0.0
		661.4 ha	4	-5,343.1	555.7	0.0
		Null	3	-7,028.5	3,924.4	0.0
	Riparian	661.4 ha	4	-6,915.7	0.0	1.0
		61.5 ha	4	-6,998.5	165.5	0.0
		8.7 ha	4	-7,007.5	183.5	0.0
		Null	3	-7,028.5	223.6	0.0
Sagebrush height	Sagebrush height	661.4 ha	4	-6,773.8	0.0	1.0
		8.7 ha	4	-6,993.1	438.5	0.0
		61.5 ha	4	-7,013.6	479.6	0.0
		Null	3	-7,028.5	507.4	0.0
Agriculture	Distance to cropland	Expon. decay	4	-3,249.2	0.0	1.0

		Linear	4	-3,679.9	861.5	0.0
		Null	3	-7,028.5	7,556.6	0.0
Edge	Variety of edge types	61.5 ha	4	-6,700.8	0.0	1.0
		661.4 ha	4	-6,757.4	113.1	0.0
		8.7 ha	4	-6,955.3	508.9	0.0
		Null	3	-7,028.5	653.4	0.0
Landscape variation	Variety of land cover types	661.4 ha	4	-4,940.8	0.0	1.0
		61.5 ha	4	-6,174.6	2,467.6	0.0
		8.7 ha	4	-6,914.9	3,948.2	0.0
		Null	3	-7,028.5	4,173.4	0.0
	Distance to wet meadow	Linear	4	-4,803.9	0.0	1.0
	Distance to wet meadow	Expon. decay	4	-5,242.5	877.1	0.0
	Distance to spring	Linear	4	-5,550.2	1,492.5	0.0
	Distance to nearest stream	Linear	4	-6,013.0	2,418.1	0.0
	Distance to intermittent stream	Linear	4	-6,013.0	2,418.2	0.0
	Distance to spring	Expon. decay	4	-6,053.0	2,498.2	0.0
	Distance to intermittent stream	Expon. decay	4	-6,215.7	2,823.6	0.0
	Distance to perennial stream	Linear	4	-6,252.1	2,896.3	0.0
	Distance to nearest stream	Expon. decay	4	-6,286.0	2,964.1	0.0
	Distance to water body	Linear	4	-6,428.2	3,248.6	0.0
	Distance to water body	Expon. decay	4	-6,787.3	3,966.8	0.0
	Distance to perennial stream	Expon. decay	4	-6,788.4	3,969.0	0.0
	Null	Null	3	-7,028.5	4,447.2	0.0
Topography	Elevation	Linear	4	-5,554.2	0.0	1.0
	Roughness index	1 ha	4	-6,095.2	1,082.1	0.0
	Topographic position index	2010 m	4	-6,892.1	2,675.9	0.0
	Topographic position index	510 m	4	-7,023.1	2,937.9	0.0
	Null		3	-7,028.5	2,946.7	0.0

[1]Top model within group failed to converge. Next best model was carried forward in the analyses.

Table S2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the South SWIP summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Big sagebrush	661.4 ha	19.83 (18.08, 21.57)	Selection
Forest	661.4 ha	-1.19 (-4.57, 2.18)	None
Herbaceous	661.4 ha	-26.51 (-29.99, -23.03)	Avoidance
Non-sagebrush shrub	661.4 ha	0.27 (-3.44, 3.98)	None
Pinyon-juniper	61.5 ha	-12.28 (-13.66, -10.90)	Avoidance
Riparian	661.4 ha	-27.41 (-33.97, -20.86)	Avoidance
Distance to cropland	Expon. decay	7.50 (7.16, 7.84)	Selection
Variety of edge types	61.5 ha	-0.42 (-0.46, -0.37)	Avoidance
Distance to nearest stream	Linear	-3.25 (-3.67, -2.83)	Selection
Distance to spring	Linear	-0.19 (-0.22, -0.16)	Selection
Distance to water body	Linear	-0.31 (-0.36, -0.26)	Selection
Distance to wet meadow	Linear	-0.11 (-0.13, -0.09)	Selection
Elevation	Linear	-1.55 (-2.00, -1.10)	Selection for lower elevations
Topographic position index	2010 m	-0.009 (-0.012, -0.007)	Avoided ridges / Selected valleys

Table S3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the South SWIP subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Big sagebrush	661.4 ha	0.068	0.0004	0.087	0.0002
Forest	661.4 ha	0.008	0.0003	0.001	0.0001
Herbaceous	661.4 ha	0.070	0.0003	0.043	0.0002
Non-sagebrush shrub	661.4 ha	0.059	0.0002	0.052	0.0002
Pinyon-juniper	61.5 ha	0.151	0.0017	0.014	0.0003
Riparian	661.4 ha	0.010	0.0001	0.014	0.0001
Distance to cropland	Km	7.49	0.0437	1.26	0.0221
Variety of edge types	61.5 ha	2.38	0.0188	3.50	0.0256
Distance to nearest stream	Km	0.28	0.0031	0.10	0.0011
Distance to spring	Km	5.72	0.0418	2.26	0.0164
Distance to water body	Km	3.40	0.0189	2.38	0.0090
Distance to wet meadow	Km	11.30	0.0563	4.94	0.0270
Elevation	Km	2.09	0.0022	1.92	0.0010
Topographic position index	2010 m	-0.38	0.4041	-10.59	0.1937

Appendix T. Supplemental material for Toiyabe spring season RSF modeling

Table T1. Variable selection results from the "proposal set" of variables from the Toiyabe subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-12,497.2	0.0	1.0
		8.7 ha	4	-12,510.9	27.3	0.0
		61.5 ha	4	-12,515.1	35.9	0.0
		Null	3	-12,518.2	40.1	0.0
	Big sagebrush	661.4 ha	4	-11,183.1	0.0	1.0
		61.5 ha	4	-11,457.0	547.9	0.0
		8.7 ha	4	-11,658.5	950.8	0.0
		Null	3	-12,518.2	2,668.3	0.0
	Cropland	61.5 ha	4	-12,349.7	0.0	0.93
		8.7 ha	4	-12,352.3	5.3	0.07
		661.4 ha	4	-12,448.3	197.3	0.00
		Null	3	-12,518.2	335.1	0.00
	Herbaceous	661.4 ha	4	-11,264.8	0.0	1.0
		61.5 ha	4	-11,563.1	596.6	0.0
		8.7 ha	4	-11,616.1	702.6	0.0
		Null	3	-12,518.2	2,504.8	0.0
	Non-sagebrush shrub	8.7 ha	4	-12,474.8	0.0	1.0
		661.4 ha	4	-12,515.2	81.0	0.0
		Null	3	-12,518.2	85.0	0.0
		61.5 ha	4	-12,518.2	86.9	0.0
	Other sagebrush	661.4 ha	4	-10,428.8	0.0	1.0
		61.5 ha	4	-10,908.4	959.3	0.0
		8.7 ha	4	-11,396.2	1,934.8	0.0
		Null	3	-12,518.2	4,176.9	0.0
	Pinyon-juniper	61.5 ha	4	-11,028.5	0.0	1.0
		8.7 ha	4	-11,049.4	41.7	0.0
		661.4 ha	4	-11,467.4	877.7	0.0
		Null	3	-12,518.2	2,977.4	0.0
	Riparian	661.4 ha	4	-12,329.3	0.0	1.0
		61.5 ha	4	-12,435.6	212.7	0.0
		8.7 ha	4	-12,454.2	249.8	0.0
		Null	3	-12,518.2	375.9	0.0
Sagebrush height	Sagebrush height	661.4 ha	4	-11,157.4	0.0	1.0
		61.5 ha	4	-11,509.5	704.1	0.0
		8.7 ha	4	-11,802.2	1,289.6	0.0
		Null	3	-12,518.2	2,719.6	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Agriculture	Distance to cropland	Linear	4	-11,584.6	0.0	1.0
		Expon. decay	4	-12,138.0	1,106.9	0.0
		Null	3	-12,518.2	1,865.4	0.0
Edge	Variety of edge types	661.4 ha	4	-12,197.4	0.0	1.0
		61.5 ha	4	-12,321.4	248.0	0.0
		8.7 ha	4	-12,432.6	470.5	0.0
		Null	3	-12,518.2	639.8	0.0
Landscape variation[1]	Variety of land cover types	661.4 ha	4	-12,199.8	0.0	1.0
		61.5 ha	4	-12,301.4	203.3	0.0
		8.7 ha	4	-12,395.0	390.5	0.0
		Null	3	-12,518.2	634.9	0.0
Water sources	Distance to spring	Linear	4	-11,228.5	0.0	1.0
	Distance to perennial stream	Linear	4	-11,501.1	545.0	0.0
	Distance to wet meadow	Linear	4	-11,860.7	1,264.3	0.0
	Distance to water body	Linear	4	-11,878.4	1,299.8	0.0
	Distance to spring	Expon. decay	4	-12,073.4	1,689.7	0.0
	Distance to water body	Expon. decay	4	-12,139.3	1,821.6	0.0
	Distance to wet meadow	Expon. decay	4	-12,237.4	2,017.7	0.0
	Distance to perennial stream	Expon. decay	4	-12,332.7	2,208.3	0.0
	Distance to intermittent stream	Linear	4	-12,349.0	2,240.9	0.0
	Distance to nearest stream	Linear	4	-12,393.3	2,329.6	0.0
	Distance to intermittent stream	Expon. decay	4	-12,432.5	2,407.9	0.0
	Distance to nearest stream	Expon. decay	4	-12,453.1	2,449.2	0.0
	Null	Null	3	-12,518.2	2,577.4	0.0
Topography	Elevation	Linear	4	-11,512.9	0.0	1.0
	Roughness index	1 ha	4	-12,069.3	1,112.9	0.0
	Topographic position index	2010 m	4	-12,250.6	1,475.5	0.0
	Null		3	-12,518.2	2,008.8	0.0
	Topographic position index	510 m	4	-12,473.7	1,921.8	0.0

[1]Top model within group failed to converge. Next best model was carried forward in the analyses.

Table T2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Toiyabe spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	5.95 (4.59, 7.32)	Selection
Herbaceous	661.4 ha	20.54 (19.50, 21.58)	Selection
Non-sagebrush shrub	8.7 ha	14.39 (13.36, 15.43)	Selection
Other sagebrush	661.4 ha	101.10 (97.66, 104.54)	Selection
Pinyon-juniper	61.5 ha	-55.50 (-59.87, -51.14)	Avoidance
Riparian	661.4 ha	27.20 (25.07, 29.32)	Selection
Sagebrush height	661.4 ha	10.67 (10.26, 11.08)	Selection
Distance to cropland	Linear	-0.26 (-0.28, -0.25)	Selection
Variety of edge types	661.4 ha	0.14 (0.13, 0.15)	Selection
Distance to spring	Linear	-0.55 (-0.58, -0.53)	Selection
Distance to water body	Linear	-0.15 (-0.16, -0.14)	Selection
Distance to wet meadow	Linear	-0.18 (-0.19, -0.18)	Selection

Table T3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Toiyabe subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.003	0.0003	0.006	0.0006
Herbaceous	661.4 ha	0.055	0.0003	0.083	0.0010
Non-sagebrush shrub	8.7 ha	0.043	0.0003	0.048	0.0011
Other sagebrush	661.4 ha	0.033	0.0001	0.045	0.0003
Pinyon-juniper	61.5 ha	0.049	0.0011	0.001	0.0002
Riparian	661.4 ha	0.013	0.0002	0.020	0.0007
Sagebrush height	661.4 ha	0.37	0.0014	0.46	0.0018
Distance to cropland	Km	4.53	0.0331	2.95	0.0364
Variety of edge types	661.4 ha	7.27	0.0432	8.82	0.0965
Distance to spring	Km	3.33	0.0310	1.70	0.0238
Distance to water body	Km	6.58	0.0372	4.95	0.0620
Distance to wet meadow	Km	12.13	0.0649	9.31	0.1004
Annual grass	661.4 ha	0.003	0.0003	0.006	0.0006

Appendix U. Supplemental material for Toiyabe summer season RSF modeling

Table U1. Variable selection results from the "proposal set" of variables from the Toiyabe subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-14,753.1	0.0	0.58
		8.7 ha	4	-14,753.6	1.0	0.36
		61.5 ha	4	-14,756.0	5.7	0.03
		Null	3	-14,757.1	6.0	0.03
	Big sagebrush	661.4 ha	4	-12,461.2	0.0	1.0
		61.5 ha	4	-13,357.3	1,792.1	0.0
		8.7 ha	4	-13,836.9	2,751.4	0.0
		Null	3	-14,757.1	4,589.8	0.0
	Cropland	61.5 ha	4	-14,486.8	0.0	1.0
		8.7 ha	4	-14,540.2	106.8	0.0
		661.4 ha	4	-14,668.8	364.0	0.0
		Null	3	-14,757.1	538.6	0.0
	Herbaceous	661.4 ha	4	-10,286.4	0.0	1.0
		61.5 ha	4	-12,207.3	3,841.8	0.0
		8.7 ha	4	-12,972.3	5,371.9	0.0
		Null	3	-14,757.1	8,939.5	0.0
	Non-sagebrush shrub	661.4 ha	4	-13,629.7	0.0	1.0
		61.5 ha	4	-13,836.8	414.1	0.0
		8.7 ha	4	-13,940.8	622.0	0.0
		Null	3	-14,757.1	2,252.7	0.0
	Other sagebrush	661.4 ha	4	-12,736.2	0.0	1.0
		61.5 ha	4	-13,865.3	2,258.2	0.0
		8.7 ha	4	-14,366.0	3,259.6	0.0
		Null	3	-14,757.1	4,039.9	0.0
	Pinyon-juniper	61.5 ha	4	-13,010.7	0.0	1.0
		8.7 ha	4	-13,083.8	146.2	0.0
		661.4 ha	4	-13,325.0	628.6	0.0
		Null	3	-14,757.1	3,490.8	0.0
	Riparian	661.4 ha	4	-13,501.7	0.0	1.0
		61.5 ha	4	-13,738.2	472.9	0.0
		8.7 ha	4	-14,080.6	1,157.7	0.0
		Null	3	-14,757.1	2,508.8	0.0
Sagebrush height	Sagebrush height	661.4 ha	4	-13,138.9	0.0	1.0
		61.5 ha	4	-13,324.7	371.7	0.0
		8.7 ha	4	-13,639.2	1,000.6	0.0
		Null	3	-14,757.1	3,234.5	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Agriculture	Distance to cropland	Linear	4	-14,334.2	0.0	1.0
		Expon. decay	4	-14,596.0	523.5	0.0
		Null	3	-14,757.1	843.7	0.0
Edge	Variety of edge types	661.4 ha	4	-11,825.6	0.0	1.0
		61.5 ha	4	-13,117.0	2,582.8	0.0
		8.7 ha	4	-13,532.8	3,414.4	0.0
		Null	3	-14,757.1	5,861.0	0.0
Landscape variation	Variety of land cover types	661.4 ha	4	-12,437.8	0.0	1.0
		61.5 ha	4	-12,653.9	432.1	0.0
		8.7 ha	4	-13,407.2	1,938.9	0.0
		Null	3	-14,757.1	4,636.6	0.0
Water sources	Distance to perennial stream	Linear	4	-11,089.3	0.0	1.0
	Distance to spring	Linear	4	-11,704.3	1,230.1	0.0
	Distance to spring	Expon. decay	4	-12,320.9	2,463.3	0.0
	Distance to perennial stream	Expon. decay	4	-12,763.8	3,349.1	0.0
	Distance to wet meadow	Linear	4	-13,194.6	4,210.8	0.0
	Distance to wet meadow	Expon. decay	4	-13,481.3	4,784.2	0.0
	Distance to nearest stream	Expon. decay	4	-14,546.6	6,914.8	0.0
	Distance to water body	Linear	4	-14,551.2	6,924.0	0.0
	Distance to nearest stream	Linear	4	-14,651.8	7,125.1	0.0
	Distance to intermittent stream	Expon. decay	4	-14,667.3	7,156.1	0.0
	Distance to intermittent stream	Linear	4	-14,719.5	7,260.5	0.0
	Distance to water body	Expon. decay	4	-14,744.7	7,310.9	0.0
	Null	Null	3	-14,757.1	7,333.7	0.0
Topography	Elevation	Linear	4	-11,412.7	0.0	1.0
	Roughness index	1 ha	4	-13,978.4	5,131.3	0.0
	Topographic position index	510 m	4	-14,482.7	6,139.9	0.0
	Topographic position index	2010 m	4	-14,736.8	6,648.2	0.0
	Null		3	-14,757.1	6,686.7	0.0

Table U2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Toiyabe summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	-8.50 (-10.02, -6.98)	Avoidance
Big sagebrush	661.4 ha	28.94 (27.56, 30.33)	Selection
Herbaceous	661.4 ha	32.38 (31.16, 33.61)	Selection
Non-sagebrush shrub	661.4 ha	-5.64 (-7.60, -3.69)	Avoidance
Other sagebrush	661.4 ha	57.89 (54.52, 61.27)	Selection
Pinyon-juniper	61.5 ha	-51.83 (-55.73, -47.94)	Avoidance
Riparian	661.4 ha	26.06 (24.44, 27.69)	Selection
Distance to cropland	Linear	-0.34 (-0.36, -0.32)	Selection
Variety of edge types	661.4 ha	0.41 (0.40, 0.42)	Selection
Distance to perennial stream	Linear	-0.35 (-0.37, -0.33)	Selection
Distance to water body	Linear	-0.10 (-0.12, -0.09)	Selection
Distance to wet meadow	Linear	-0.115 (-0.12, -0.11)	Selection
Roughness index	1 ha	-4.41 (-4.93, -3.88)	Avoidance
Topographic position index	510 m	-0.015 (-0.016, -0.013)	Avoided ridges / Selected valleys

Table U3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Toiyabe subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.004	0.0003	0.004	0.0004
Big sagebrush	661.4 ha	7.542	0.0326	10.405	0.0666
Herbaceous	661.4 ha	5.455	0.0310	10.469	0.0989
Non-sagebrush shrub	661.4 ha	4.284	0.0201	5.778	0.0640
Other sagebrush	661.4 ha	3.241	0.0135	4.338	0.0266
Pinyon-juniper	61.5 ha	0.049	0.0010	0.001	0.0001
Riparian	661.4 ha	0.013	0.0002	0.028	0.0008
Distance to cropland	Km	4.54	0.0308	3.52	0.0429
Variety of edge types	661.4 ha	7.23	0.0396	10.87	0.0477
Distance to perennial stream	Km	6.09	0.0481	1.95	0.0291
Distance to water body	Km	6.58	0.0346	5.77	0.0462
Distance to wet meadow	Km	12.12	0.0602	8.01	0.1099
Roughness index	1 ha	0.17	0.0009	0.22	0.0018
Topographic position index	510 m	-0.08	0.1727	-6.39	0.4605

Appendix V. Supplemental material for Toiyabe winter season RSF modeling

Table V1. Variable selection results from the "proposal set" of variables from the Toiyabe subregion during the winter season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-10,450.5	0.0	0.63
		Null	3	-10,452.7	2.3	0.20
		8.7 ha	4	-10,452.5	3.9	0.09
		61.5 ha	4	-10,452.5	4.0	0.09
	Big sagebrush	661.4 ha	4	-10,202.7	0.0	1.0
		61.5 ha	4	-10,290.4	175.4	0.0
		8.7 ha	4	-10,347.0	288.6	0.0
		Null	3	-10,452.7	498.0	0.0
	Cropland	661.4 ha	4	-10,380.2	0.0	0.96
		8.7 ha	4	-10,383.4	6.4	0.04
		61.5 ha	4	-10,393.6	26.8	0.00
		Null	3	-10,452.7	143.0	0.00
	Herbaceous	661.4 ha	4	-10,391.7	0.0	1.0
		61.5 ha	4	-10,421.3	59.2	0.0
		8.7 ha	4	-10,436.9	90.2	0.0
		Null	3	-10,452.7	119.9	0.0
	Non-sagebrush shrub	661.4 ha	4	-9,818.3	0.0	1.0
		61.5 ha	4	-9,910.5	184.5	0.0
		8.7 ha	4	-10,008.7	380.8	0.0
		Null	3	-10,452.7	1,266.8	0.0
	Other sagebrush	661.4 ha	4	-8,265.8	0.0	1.0
		61.5 ha	4	-8,642.7	753.8	0.0
		8.7 ha	4	-8,974.0	1,416.5	0.0
		Null	3	-10,452.7	4,371.7	0.0
	Pinyon-juniper	61.5 ha	4	-9,168.7	0.0	1.0
		661.4 ha	4	-9,211.0	84.5	0.0
		8.7 ha	4	-9,243.7	150.0	0.0
		Null	3	-10,452.7	2,565.9	0.0
	Riparian	661.4 ha	4	-10,397.4	0.0	0.99
		61.5 ha	4	-10,401.7	8.6	0.01
		8.7 ha	4	-10,426.3	57.9	0.00
		Null	3	-10,452.7	108.6	0.00
Sagebrush height	Sagebrush height	661.4 ha	4	-10,338.7	0.0	1.0
		61.5 ha	4	-10,368.0	58.6	0.0
		8.7 ha	4	-10,378.3	79.2	0.0
		Null	3	-10,452.7	225.9	0.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Agriculture	Distance to cropland	Linear	4	-9,260.0	0.0	1.0
		Expon. decay	4	-9,490.7	461.5	0.0
		Null	3	-10,452.7	2,383.4	0.0
Edge	Variety of edge types	661.4 ha	4	-10,445.3	0.0	0.99
		8.7 ha	4	-10,450.1	9.7	0.01
		61.5 ha	4	-10,450.8	11.1	0.00
		Null	3	-10,452.7	12.8	0.00
Landscape variation	Variety of land cover types	661.4 ha	4	-10,208.4	0.0	1.0
		8.7 ha	4	-10,451.5	486.2	0.0
		Null	3	-10,452.7	486.6	0.0
		61.5 ha	4	-10,452.2	487.8	0.0
Water sources	Distance to spring	Linear	4	-8,722.8	0.0	1.0
	Distance to spring	Expon. decay	4	-9,162.2	878.7	0.0
	Distance to water body	Linear	4	-9,241.4	1,037.1	0.0
	Distance to water body	Expon. decay	4	-9,541.1	1,636.6	0.0
	Distance to wet meadow	Linear	4	-10,221.2	2,996.7	0.0
	Distance to perennial stream	Linear	4	-10,223.9	3,002.1	0.0
	Distance to nearest stream	Expon. decay	4	-10,308.9	3,172.2	0.0
	Distance to intermittent stream	Expon. decay	4	-10,359.3	3,272.9	0.0
	Distance to nearest stream	Linear	4	-10,391.3	3,336.9	0.0
	Distance to wet meadow	Expon. decay	4	-10,404.2	3,362.8	0.0
	Distance to intermittent stream	Linear	4	-10,424.9	3,404.2	0.0
	Distance to perennial stream	Expon. decay	4	-10,449.6	3,453.5	0.0
	Null	Null	3	-10,452.7	3,457.7	0.0
Topography	Elevation	Linear	4	-10,383.3	0.0	1.0
	Topographic position index	510 m	4	-10,430.4	94.2	0.0
	Topographic position index	2010 m	4	-10,438.5	110.4	0.0
	Null		3	-10,452.7	136.7	0.0
	Roughness index	1 ha	4	-10,452.2	137.9	0.0

Table V2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Toiyabe winter season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	-2.08 (-3.86, -0.31)	Avoidance
Big sagebrush	661.4 ha	-8.05 (-9.59, -6.51)	Avoidance
Herbaceous	661.4 ha	-6.31 (-7.65, -4.98)	Avoidance
Non-sagebrush shrub	661.4 ha	-13.36 (-15.53, -11.19)	Avoidance
Other sagebrush	661.4 ha	86.04 (82.12, 89.97)	Selection
Pinyon-juniper	61.5 ha	-56.43 (-61.83, -51.02)	Avoidance
Riparian	661.4 ha	-1.41 (-3.26, 0.44)	None
Distance to cropland	Linear	-0.34 (-0.36, -0.32)	Selection
Variety of edge types	661.4 ha	-0.25 (-0.26, -0.24)	Avoidance
Distance to spring	Linear	-0.71 (-0.75, -0.68)	Selection
Distance to water body	Linear	-0.31 (-0.33, -0.30)	Selection
Distance to wet meadow	Linear	-0.12 (-0.13, -0.11)	Selection
Topographic position index	510 m	0.008 (0.006, 0.01)	Selected ridges / Avoided valleys

Table V3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Toiyabe subregion, and found important in resource selection function (RSF) modeling during the winter season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.003	0.0003	0.003	0.0006
Big sagebrush	661.4 ha	0.076	0.0004	0.086	0.0006
Herbaceous	661.4 ha	0.054	0.0004	0.060	0.0007
Non-sagebrush shrub	661.4 ha	0.043	0.0002	0.032	0.0005
Other sagebrush	661.4 ha	0.032	0.0002	0.046	0.0002
Pinyon-juniper	61.5 ha	0.049	0.0012	0.001	0.0002
Riparian	661.4 ha	0.012	0.0002	0.009	0.0005
Distance to cropland	Km	4.53	0.0362	2.52	0.0501
Variety of edge types	661.4 ha	7.19	0.0474	6.95	0.0881
Distance to spring	Km	3.38	0.0340	1.29	0.0312
Distance to water body	Km	6.60	0.0409	4.12	0.0611
Distance to wet meadow	Km	12.05	0.0714	10.23	0.1060
Topographic position index	510 m	0.07	0.2022	1.76	0.3397

Appendix W. Supplemental material for Tuscarora spring season RSF modeling

Table W1. Variable selection results from the "proposal set" of variables from the Tuscarora subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-13,254.6	0.0	1.0
		61.5 ha	4	-13,660.0	811.0	0.0
		8.7 ha	4	-13,736.8	964.5	0.0
		Null	3	-13,828.3	1,145.5	0.0
	Bare ground	661.4 ha	4	-12,376.8	0.0	1.0
		61.5 ha	4	-12,980.8	1,207.9	0.0
		8.7 ha	4	-13,166.2	1,578.8	0.0
		Null	3	-13,828.3	2,900.9	0.0
	Big sagebrush	661.4 ha	4	-13,057.1	0.0	1.0
		61.5 ha	4	-13,425.4	736.5	0.0
		8.7 ha	4	-13,536.6	958.9	0.0
		Null	3	-13,828.3	1,540.3	0.0
	Cropland	661.4 ha	4	-13,481.3	0.0	1.0
		61.5 ha	4	-13,798.2	633.8	0.0
		8.7 ha	4	-13,823.7	684.8	0.0
		Null	3	-13,828.3	692.0	0.0
	Forest	61.5 ha	4	-13,571.0	0.0	1.0
		8.7 ha	4	-13,595.2	48.5	0.0
		661.4 ha	4	-13,664.4	186.9	0.0
		Null	3	-13,828.3	512.7	0.0
	Herbaceous	8.7 ha	4	-13,191.1	0.0	0.89
		61.5 ha	4	-13,193.2	4.1	0.11
		661.4 ha	4	-13,350.0	317.7	0.00
		Null	3	-13,828.3	1,272.3	0.00
	Non-sagebrush shrub	8.7 ha	4	-13,763.5	0.0	1.0
		61.5 ha	4	-13,790.2	53.4	0.0
		661.4 ha	4	-13,817.3	107.7	0.0
		Null	3	-13,828.3	127.7	0.0
	Other sagebrush	61.5 ha	4	-13,609.8	0.0	1.0
		8.7 ha	4	-13,695.1	170.6	0.0
		661.4 ha	4	-13,715.0	210.5	0.0
		Null	3	-13,828.3	435.0	0.0
	Riparian	8.7 ha	4	-13,784.5	0.0	1.0
		61.5 ha	4	-13,792.3	15.5	0.0
		661.4 ha	4	-13,824.4	79.8	0.0
		Null	3	-13,828.3	85.6	0.0
Sagebrush	Sagebrush height	661.4 ha	4	-12,628.2	0.0	1.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
height						
		61.5 ha	4	-13,324.2	1,391.9	0.0
		8.7 ha	4	-13,553.1	1,849.7	0.0
		Null	3	-13,828.3	2,398.1	0.0
Agriculture	Distance to cropland	Expon. decay	4	-13,399.9	0.0	1.0
		Linear	4	-13,613.5	427.3	0.0
		Null	3	-13,828.3	854.9	0.0
Edge	Variety of edge types	661.4 ha	4	-13,744.4	0.0	1.0
		61.5 ha	4	-13,761.5	34.3	0.0
		8.7 ha	4	-13,780.1	71.3	0.0
		Null	3	-13,828.3	165.8	0.0
Landscape variation	Variety of land cover types	8.7 ha	4	-13,772.6	0.0	1.0
		661.4 ha	4	-13,781.6	18.0	0.0
		61.5 ha	4	-13,822.5	99.8	0.0
		Null	3	-13,828.3	109.3	0.0
Water sources	Distance to wet meadow	Linear	4	-11,554.1	0.0	1.0
	Distance to nearest stream	Linear	4	-12,659.6	2,210.9	0.0
	Distance to wet meadow	Expon. decay	4	-12,710.1	2,311.9	0.0
	Distance to nearest stream	Expon. decay	4	-12,838.8	2,569.4	0.0
	Distance to intermittent stream	Expon. decay	4	-13,081.2	3,054.2	0.0
	Distance to intermittent stream	Linear	4	-13,197.6	3,287.0	0.0
	Distance to water body	Expon. decay	4	-13,396.3	3,684.3	0.0
	Distance to water body	Linear	4	-13,719.6	4,330.9	0.0
	Distance to spring	Linear	4	-13,722.1	4,335.9	0.0
	Distance to perennial stream	Linear	4	-13,788.6	4,469.0	0.0
	Distance to perennial stream	Expon. decay	4	-13,794.5	4,480.8	0.0
	Distance to spring	Expon. decay	4	-13,822.2	4,536.1	0.0
	Null	Null	3	-13,828.3	4,546.3	0.0
Topography	Roughness index	1 ha	4	-13,371.4	0.0	1.0
	Topographic position index	510 m	4	-13,697.7	652.5	0.0
	Topographic position index	2010 m	4	-13,771.2	799.6	0.0
	Elevation	Linear	4	-13,795.2	847.5	0.0
	Null		3	-13,828.3	911.7	0.0

Table W2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Tuscarora spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	-21.80 (-25.15, -18.45)	Avoidance
Bare ground	661.4 ha	-6.68 (-7.00, -6.36)	Avoidance
Forest	61.5 ha	-13.32 (-14.92, -11.71)	Avoidance
Herbaceous	8.7 ha	7.77 (7.37, 8.17)	Selection
Non-sagebrush shrub	8.7 ha	-25.41 (-26.44, -24.38)	Avoidance
Other sagebrush	61.5 ha	71.81 (68.70, 74.93)	Selection
Riparian	8.7 ha	-3.18 (-3.68, -2.69)	Avoidance
Distance to cropland	Expon. decay	0.57 (0.45, 0.69)	Selection
Variety of edge types	661.4 ha	0.01 (0.00, 0.02)	Selection
Variety of land cover types	8.7 ha	-0.17 (-0.20, -0.15)	Avoidance
Distance to nearest stream	Linear	3.55 (3.36, 3.73)	Avoidance
Distance to spring	Linear	0.08 (0.05, 0.10)	Avoidance
Distance to water body	Expon. decay	-2.90 (-3.08, -2.73)	Avoidance
Distance to wet meadow	Linear	-0.19 (-0.20, -0.18)	Selection
Elevation	Linear	-6.67 (-6.95, -6.38)	Selection for lower elevations
Roughness index	1 ha	-12.60 (-13.12, -12.09)	Avoidance
Topographic position index	510 m	0.01 (0.01, 0.02)	Selected ridges / Avoided valleys

Table W3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Tuscarora subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.015	0.0004	0.004	0.0001
Bare ground	661.4 ha	0.463	0.0015	0.366	0.0022
Forest	61.5 ha	0.015	0.0006	0.003	0.0003
Herbaceous	8.7 ha	0.179	0.0010	0.225	0.0019
Non-sagebrush shrub	8.7 ha	0.058	0.0005	0.050	0.0011
Other sagebrush	61.5 ha	0.040	0.0001	0.044	0.0003
Riparian	8.7 ha	0.026	0.0008	0.017	0.0012
Distance to cropland	Km	0.40	0.0029	0.52	0.0064
Variety of edge types	661.4 ha	9.98	0.0354	10.57	0.0641
Variety of land cover types	8.7 ha	2.69	0.0129	2.50	0.0286
Distance to nearest stream	Km	0.20	0.0017	0.34	0.0051
Distance to spring	Km	2.00	0.0187	1.70	0.0208
Distance to water body	Km	3.22	0.0236	3.63	0.0328
Distance to wet meadow	Km	13.34	0.0916	6.70	0.0811
Elevation	Km	1.92	0.0021	1.90	0.0035
Roughness index	1 ha	0.19	0.0009	0.16	0.0015
Topographic position index	510 m	0.17	0.2075	4.49	0.3756

Appendix X. Supplemental material for Tuscarora summer season RSF modeling

Table X1. Variable selection results from the "proposal set" of variables from the Tuscarora subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-15,709.2	0.0	1.0
		61.5 ha	4	-16,451.5	1,484.7	0.0
		8.7 ha	4	-16,776.7	2,135.0	0.0
		Null	3	-17,349.5	3,278.6	0.0
	Bare ground	661.4 ha	4	-12,964.8	0.0	1.0
		61.5 ha	4	-13,642.1	1,354.6	0.0
		8.7 ha	4	-13,924.6	1,919.6	0.0
		Null	3	-17,349.5	8,767.4	0.0
	Big sagebrush	661.4 ha	4	-16,881.9	0.0	1.0
		61.5 ha	4	-17,101.0	438.1	0.0
		8.7 ha	4	-17,140.8	517.7	0.0
		Null	3	-17,349.5	933.1	0.0
	Cropland	661.4 ha	4	-15,110.2	0.0	1.0
		61.5 ha	4	-15,746.1	1,271.8	0.0
		8.7 ha	4	-15,908.8	1,597.3	0.0
		Null	3	-17,349.5	4,476.6	0.0
	Forest	61.5 ha	4	-17,218.5	0.0	1.0
		8.7 ha	4	-17,273.0	109.1	0.0
		661.4 ha	4	-17,287.9	139.0	0.0
		Null	3	-17,349.5	260.0	0.0
	Herbaceous	661.4 ha	4	-16,444.4	0.0	1.0
		61.5 ha	4	-16,692.3	495.8	0.0
		8.7 ha	4	-16,740.4	592.0	0.0
		Null	3	-17,349.5	1,808.2	0.0
	Non-sagebrush shrub	661.4 ha	4	-16,972.6	0.0	1.0
		61.5 ha	4	-17,221.6	497.9	0.0
		8.7 ha	4	-17,234.0	522.7	0.0
		Null	3	-17,349.5	751.7	0.0
	Other sagebrush	661.4 ha	4	-16,947.9	0.0	1.0
		61.5 ha	4	-17,010.9	126.0	0.0
		8.7 ha	4	-17,020.1	144.4	0.0
		Null	3	-17,349.5	801.1	0.0
	Riparian	661.4 ha	4	-16,163.1	0.0	1.0
		61.5 ha	4	-17,164.8	2,003.3	0.0
		8.7 ha	4	-17,247.6	2,168.9	0.0
		Null	3	-17,349.5	2,370.7	0.0
Sagebrush	Sagebrush height	661.4 ha	4	-16,422.6	0.0	1.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
height						
		61.5 ha	4	-16,765.7	686.3	0.0
		8.7 ha	4	-17,018.3	1,191.5	0.0
		Null	3	-17,349.5	1,851.8	0.0
Agriculture	Distance to cropland	Expon. decay	4	-16,611.5	0.0	1.0
		Linear	4	-17,237.0	1,251.0	0.0
		Null	3	-17,349.5	1,473.9	0.0
Edge	Variety of edge types	661.4 ha	4	-16,457.3	0.0	1.0
		61.5 ha	4	-17,068.2	1,221.8	0.0
		8.7 ha	4	-17,225.7	1,536.7	0.0
		Null	3	-17,349.5	1,782.4	0.0
Landscape variation	Variety of land cover types	61.5 ha	4	-16,951.0	0.0	1.0
		8.7 ha	4	-17,051.7	201.4	0.0
		661.4 ha	4	-17,341.0	780.0	0.0
		Null	3	-17,349.5	794.9	0.0
Water sources	Distance to wet meadow	Linear	4	-15,145.3	0.0	1.0
	Distance to wet meadow	Expon. decay	4	-16,680.1	3,069.5	0.0
	Distance to perennial stream	Linear	4	-17,048.8	3,807.0	0.0
	Distance to water body	Expon. decay	4	-17,203.7	4,116.9	0.0
	Distance to intermittent stream	Linear	4	-17,279.5	4,268.5	0.0
	Distance to perennial stream	Expon. decay	4	-17,283.4	4,276.3	0.0
	Distance to spring	Linear	4	-17,291.6	4,292.7	0.0
	Distance to nearest stream	Linear	4	-17,296.5	4,302.5	0.0
	Distance to intermittent stream	Expon. decay	4	-17,323.6	4,356.6	0.0
	Distance to spring	Expon. decay	4	-17,331.8	4,372.9	0.0
	Null	Null	3	-17,349.5	4,406.4	0.0
	Distance to nearest stream	Expon. decay	4	-17,349.2	4,407.8	0.0
	Distance to water body	Linear	4	-17,349.5	4,408.4	0.0
Topography	Roughness index	1 ha	4	-16,884.8	0.0	1.0
	Topographic position index	510 m	4	-17,337.4	905.2	0.0
	Topographic position index	2010 m	4	-17,344.5	919.5	0.0
	Null		3	-17,349.5	927.4	0.0
	Elevation	Linear	4	-17,348.9	928.1	0.0

Table X2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Tuscarora summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	-83.20 (-90.05, -76.36)	Avoidance
Bare ground	661.4 ha	-14.93 (-15.31, -14.54)	Avoidance
Cropland	661.4 ha	6.40 (6.05, 6.74)	Selection
Forest	61.5 ha	-22.23 (-23.61, -20.85)	Avoidance
Herbaceous	661.4 ha	-4.21 (-4.80, -3.62)	Avoidance
Other sagebrush	661.4 ha	119.19 (113.65, 124.72)	Selection
Riparian	661.4 ha	-3.34 (-4.35, -2.34)	Avoidance
Variety of edge types	661.4 ha	-0.01 (-0.02, 0.01)	None
Variety of land cover types	61.5 ha	-0.04 (-0.06, -0.01)	Avoidance
Distance to perennial stream	Linear	-0.02 (-0.04, 0.01)	None
Distance to spring	Linear	0.08 (0.05, 0.10)	Avoidance
Distance to water body	Expon. decay	-0.87 (-1.03, -0.71)	Avoidance
Distance to wet meadow	Linear	-0.184 (-0.19, -0.175)	Selection
Roughness index	1 ha	-13.39 (-13.88, -12.91)	Avoidance
Topographic position index	510 m	0.0003 (-0.001, 0.002)	None

Table X3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Tuscarora subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.015	0.0004	0.002	0.0001
Bare ground	661.4 ha	0.462	0.0013	0.308	0.0018
Cropland	661.4 ha	0.026	0.0008	0.127	0.0035
Forest	61.5 ha	0.015	0.0006	0.006	0.0005
Herbaceous	661.4 ha	0.179	0.0007	0.215	0.0012
Other sagebrush	661.4 ha	0.040	0.0001	0.036	0.0002
Riparian	661.4 ha	0.023	0.0003	0.044	0.0007
Variety of edge types	661.4 ha	10.04	0.0316	11.59	0.0425
Variety of land cover types	61.5 ha	4.36	0.0150	4.89	0.0240
Distance to perennial stream	Km	2.08	0.0194	1.53	0.0254
Distance to spring	Km	2.06	0.0170	1.84	0.0219
Distance to water body	Km	3.19	0.0210	3.19	0.0315
Distance to wet meadow	Km	13.23	0.0821	7.52	0.0595
Roughness index	1 ha	0.19	0.0008	0.16	0.0018
Topographic position index	510 m	-0.12	0.1884	1.08	0.3443

Appendix Y. Supplemental material for Tuscarora winter season RSF modeling

Table Y1. Variable selection results from the "proposal set" of variables from the Tuscarora subregion during the winter season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-7,363.6	0.0	1.0
		61.5 ha	4	-7,906.4	1,085.7	0.0
		8.7 ha	4	-8,128.4	1,529.5	0.0
		Null	3	-8,310.8	1,892.5	0.0
	Bare ground	661.4 ha	4	-8,255.0	0.0	1.0
		8.7 ha	4	-8,297.8	85.6	0.0
		61.5 ha	4	-8,307.0	104.0	0.0
		Null	3	-8,310.8	109.7	0.0
	Big sagebrush	661.4 ha	4	-8,247.5	0.0	1.0
		8.7 ha	4	-8,277.2	59.4	0.0
		61.5 ha	4	-8,279.2	63.5	0.0
		Null	3	-8,310.8	124.7	0.0
	Cropland	8.7 ha	4	-8,244.7	0.0	1.0
		61.5 ha	4	-8,282.0	74.7	0.0
		661.4 ha	4	-8,285.9	82.5	0.0
		Null	3	-8,310.8	130.3	0.0
	Forest	661.4 ha	4	-8,128.1	0.0	1.0
		61.5 ha	4	-8,138.1	19.9	0.0
		8.7 ha	4	-8,151.5	46.8	0.0
		Null	3	-8,310.8	363.5	0.0
	Herbaceous	661.4 ha	4	-8,249.4	0.0	1.0
		61.5 ha	4	-8,302.8	106.9	0.0
		8.7 ha	4	-8,308.3	117.8	0.0
		Null	3	-8,310.8	121.0	0.0
	Non-sagebrush shrub	61.5 ha	4	-7,742.8	0.0	1.0
		8.7 ha	4	-7,755.6	25.6	0.0
		661.4 ha	4	-7,903.2	320.9	0.0
		Null	3	-8,310.8	1,134.2	0.0
	Other sagebrush	661.4 ha	4	-7,372.7	0.0	1.0
		61.5 ha	4	-7,471.1	196.7	0.0
		8.7 ha	4	-7,716.4	687.4	0.0
		Null	3	-8,310.8	1,874.3	0.0
	Riparian	61.5 ha	4	-8,199.5	0.0	1.0
		8.7 ha	4	-8,263.3	127.6	0.0
		661.4 ha	4	-8,309.5	220.0	0.0
		Null	3	-8,310.8	220.7	0.0
Sagebrush	Sagebrush height	661.4 ha	4	-8,032.8	0.0	1.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
height						
		61.5 ha	4	-8,191.3	317.0	0.0
		8.7 ha	4	-8,208.2	350.7	0.0
		Null	3	-8,310.8	554.0	0.0
Agriculture	Distance to cropland	Linear	4	-7,943.6	0.0	1.0
		Expon. decay	4	-8,037.3	187.5	0.0
		Null	3	-8,310.8	732.6	0.0
Edge	Variety of edge cover types	61.5 ha	4	-8,002.5	0.0	1.0
		8.7 ha	4	-8,196.4	387.7	0.0
		661.4 ha	4	-8,255.2	505.4	0.0
		Null	3	-8,310.8	614.7	0.0
Landscape variation	Variety of land cover types	61.5 ha	4	-7,900.4	0.0	1.0
		8.7 ha	4	-8,092.6	384.4	0.0
		661.4 ha	4	-8,180.7	560.5	0.0
		Null	3	-8,310.8	818.8	0.0
Water sources	Distance to wet meadow	Linear	4	-7,232.9	0.0	1.0
	Distance to nearest stream	Linear	4	-7,667.8	869.7	0.0
	Distance to nearest stream	Expon. decay	4	-7,793.8	1,121.8	0.0
	Distance to intermittent stream	Expon. decay	4	-7,929.1	1,392.4	0.0
	Distance to wet meadow	Expon. decay	4	-8,043.5	1,621.1	0.0
	Distance to spring	Linear	4	-8,043.9	1,622.0	0.0
	Distance to intermittent stream	Linear	4	-8,046.0	1,626.2	0.0
	Distance to water body	Expon. decay	4	-8,121.7	1,777.5	0.0
	Distance to spring	Expon. decay	4	-8,270.0	2,074.2	0.0
	Distance to perennial stream	Expon. decay	4	-8,289.7	2,113.5	0.0
	Distance to perennial stream	Linear	4	-8,303.8	2,141.8	0.0
	Distance to water body	Linear	4	-8,307.1	2,148.4	0.0
	Null	Null	3	-8,310.8	2,153.8	0.0
Topography	Roughness index	1 ha	4	-7,308.0	0.0	1.0
	Elevation	Linear	4	-8,138.6	1,661.2	0.0
	Topographic position index	2010 m	4	-8,282.5	1,949.0	0.0
	Topographic position index	510 m	4	-8,300.8	1,985.7	0.0
	Null		3	-8,310.8	2,003.7	0.0

Table Y2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Tuscarora winter season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	-106.86 (-115.55, -98.17)	Avoidance
Forest	661.4 ha	-17.70 (-19.96, -15.44)	Avoidance
Herbaceous	661.4 ha	15.62 (14.69, 16.55)	Selection
Non-sagebrush shrub	61.5 ha	-35.58 (-37.16, -34.00)	Avoidance
Other sagebrush	661.4 ha	68.86 (63.08, 74.63)	Selection
Riparian	61.5 ha	-10.51 (-11.71, -9.31)	Avoidance
Sagebrush height	661.4 ha	13.20 (12.54, 13.86)	Selection
Distance to cropland	Linear	-0.26 (-0.28, -0.23)	Selection
Variety of land cover types	61.5 ha	-0.46 (-0.49, -0.43)	Avoidance
Distance to nearest stream	Linear	4.12 (3.89, 4.35)	Avoidance
Distance to spring	Linear	-0.51 (-0.55, -0.47)	Selection
Distance to water body	Expon. decay	-3.25 (-3.49, -3.01)	Avoidance
Distance to wet meadow	Linear	-0.15 (-0.16, -0.14)	Selection
Elevation	Linear	-3.90 (-4.19, -3.61)	Selection of lower elevations
Roughness index	1 ha	-18.73 (-19.50, -17.95)	Avoidance
Topographic position index	2010 m	-0.003 (-0.004, -0.002)	Avoided ridges / Selected valleys

Table Y3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Tuscarora subregion, and found important in resource selection function (RSF) modeling during the winter season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.015	0.0005	0.001	0.0002
Forest	661.4 ha	0.015	0.0006	0.003	0.0005
Herbaceous	661.4 ha	0.180	0.0010	0.193	0.0012
Non-sagebrush shrub	61.5 ha	0.059	0.0006	0.034	0.0010
Other sagebrush	661.4 ha	0.040	0.0002	0.049	0.0003
Riparian	61.5 ha	0.024	0.0007	0.011	0.0011
Sagebrush height	661.4 ha	0.34	0.0014	0.38	0.0016
Distance to cropland	Km	2.33	0.0236	1.53	0.0427
Variety of land cover types	61.5 ha	4.42	0.0215	3.60	0.0402
Distance to nearest stream	Km	0.20	0.0022	0.34	0.0070
Distance to spring	Km	2.02	0.0243	1.42	0.0256
Distance to water body	Km	3.20	0.0309	3.29	0.0346
Distance to wet meadow	Km	13.23	0.1191	7.54	0.0687
Elevation	Km	1.92	0.0028	1.86	0.0041
Roughness index	1 ha	0.20	0.0012	0.13	0.0018
Topographic position index	2010 m	0.13	0.6461	-5.60	0.9056

Appendix Z. Supplemental material for Virginia spring season RSF modeling

Table Z1. Variable selection results from the "proposal set" of variables from the Virginia subregion during the spring season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-2,076.7	0.0	1.0
		61.5 ha	4	-2,578.4	1,003.4	0.0
		8.7 ha	4	-2,949.9	1,746.6	0.0
		Null	3	-4,720.3	5,285.3	0.0
	Bare ground	661.4 ha	4	-4,670.8	0.0	0.60
		8.7 ha	4	-4,671.2	0.9	0.38
		61.5 ha	4	-4,674.2	6.8	0.02
		Null	3	-4,720.3	97.1	0.00
	Big sagebrush	661.4 ha	4	-3,870.9	0.0	1.0
		61.5 ha	4	-4,000.7	259.7	0.0
		8.7 ha	4	-4,036.4	331.1	0.0
		Null	3	-4,720.3	1,696.9	0.0
	Cropland	661.4 ha	4	-4,495.2	0.0	1.0
		61.5 ha	4	-4,567.9	145.5	0.0
		8.7 ha	4	-4,643.2	296.0	0.0
		Null	3	-4,720.3	448.3	0.0
	Forest	661.4 ha	4	-4,712.7	0.0	0.97
		8.7 ha	4	-4,716.2	6.9	0.03
		Null	3	-4,720.3	13.3	0.00
		61.5 ha	4	-4,719.6	13.9	0.00
	Herbaceous	661.4 ha	4	-2,190.0	0.0	1.0
		61.5 ha	4	-2,656.6	933.2	0.0
		8.7 ha	4	-2,912.8	1,445.5	0.0
		Null	3	-4,720.3	5,058.6	0.0
	Non-sagebrush shrub	8.7 ha	4	-4,483.7	0.0	1.0
		61.5 ha	4	-4,490.1	12.7	0.0
		661.4 ha	4	-4,510.2	52.9	0.0
		Null	3	-4,720.3	471.2	0.0
	Other sagebrush	661.4 ha	4	-4,686.5	0.0	1.0
		61.5 ha	4	-4,713.9	54.9	0.0
		8.7 ha	4	-4,717.5	62.1	0.0
		Null	3	-4,720.3	65.7	0.0
	Riparian	61.5 ha	4	-4,714.8	0.0	0.62
		8.7 ha	4	-4,715.4	1.1	0.35
		661.4 ha	4	-4,718.5	7.4	0.02
		Null	3	-4,720.3	9.0	0.01
Sagebrush Height	Sagebrush Height	661.4 ha	4	-4,702.7	0.0	1.0

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
		61.4 ha	4	-4,715.5	25.7	0.0
		Null	3	-4,720.3	33.3	0.0
		8.7 ha	4	-4,720.2	35.1	0.0
Agriculture	Distance to cropland	Expon. decay	4	-4,556.0	0.0	1.0
		Linear	4	-4,675.0	237.9	0.0
		Null	3	-4,720.3	326.6	0.0
Edge	Variety of edge types	661.4 ha	4	-3,016.8	0.0	1.0
		61.5 ha	4	-3,744.8	1,456.0	0.0
		8.7 ha	4	-4,181.0	2,328.3	0.0
		Null	3	-4,720.3	3,405.0	0.0
Landscape variation	Variety of land cover types	8.7 ha	4	-4,308.1	0.0	1.0
		61.5 ha	4	-4,467.9	319.5	0.0
		661.4 ha	4	-4,628.7	641.1	0.0
		Null	3	-4,720.3	822.4	0.0
Water sources	Distance to spring	Linear	4	-3,760.9	0.0	1.0
	Distance to spring	Expon. decay	4	-4,171.8	822.0	0.0
	Distance to wet meadow	Linear	4	-4,475.1	1,428.5	0.0
	Distance to nearest stream	Expon. decay	4	-4,564.8	1,607.8	0.0
	Distance to intermittent stream	Linear	4	-4,633.0	1,744.4	0.0
	Distance to intermittent stream	Expon. decay	4	-4,655.3	1,788.8	0.0
	Distance to wet meadow	Expon. decay	4	-4,665.4	1,809.0	0.0
	Distance to perennial stream	Linear	4	-4,705.7	1,889.6	0.0
	Distance to water body	Linear	4	-4,711.7	1,901.6	0.0
	Distance to water body	Expon. decay	4	-4,717.0	1,912.3	0.0
	Null	null	3	-4,720.3	1,917.0	0.0
	Distance to nearest stream	Linear	4	-4,720.3	1,918.8	0.0
	Distance to perennial stream	Expon. decay	4	-4,720.3	1,918.9	0.0
Topography	Elevation	Linear	4	-3,373.5	0.0	1.0
	Topographic position index	2010 m	4	-4,469.7	2,192.5	0.0
	Roughness index	1 ha	4	-4,627.6	2,508.3	0.0
	Topographic position index	510 m	4	-4,642.0	2,537.1	0.0
	Null		3	-4,720.3	2,691.8	0.0

Table Z2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Virginia spring season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	10.88 (10.06, 11.70)	Selection
Bare ground	661.4 ha	-2.70 (-3.34, -2.07)	Avoidance
Cropland	661.4 ha	-25.17 (-36.85, -13.48)	Avoidance
Forest	661.4 ha	55.25 (46.19, 64.32)	Selection
Herbaceous	661.4 ha	28.32 (25.53, 31.11)	Selection
Non-sagebrush shrub	8.7 ha	22.21 (19.90, 24.51)	Selection
Other sagebrush	661.4 ha	23.07 (18.48, 27.67)	Selection
Riparian	61.5 ha	4.14 (-1.13, 9.40)	None
Sagebrush height	661.4 ha	6.58 (5.29, 7.87)	Selection
Variety of land cover types	8.7 ha	0.32 (0.24, 0.40)	Selection
Distance to nearest stream	Expon. decay	-2.49 (-2.81, -2.14)	Avoidance
Distance to water body	Linear	0.13 (0.07, 0.19)	Avoidance
Distance to wet meadow	Linear	-0.35 (-0.40, -0.30)	Selection
Roughness index	1 ha	3.83 (2.90, 4.76)	Selection
Topographic position index	2010 m	0.011 (0.01, 0.012)	Selected ridges / Avoided valleys

Table Z3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Virginia subregion, and found important in resource selection function (RSF) modeling during the spring season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.040	0.0016	0.330	0.0059
Bare ground	661.4 ha	0.420	0.0031	0.388	0.0017
Cropland	661.4 ha	0.013	0.0010	0.000	0.0002
Forest	661.4 ha	0.001	0.0001	0.002	0.0004
Herbaceous	661.4 ha	0.176	0.0018	0.321	0.0014
Non-sagebrush shrub	8.7 ha	0.034	0.0006	0.056	0.0019
Other sagebrush	661.4 ha	0.028	0.0004	0.032	0.0005
Riparian	61.5 ha	0.005	0.0003	0.003	0.0003
Sagebrush height	661.4 ha	0.25	0.0018	0.24	0.0026
Variety of land cover types	8.7 ha	2.53	0.0205	3.28	0.0331
Distance to nearest stream	Km	0.38	0.0101	0.38	0.0090
Distance to water body	Km	2.59	0.0318	2.42	0.0533
Distance to wet meadow	Km	5.28	0.0572	3.89	0.0562
Roughness index	1 ha	0.19	0.0020	0.22	0.0026
Topographic position index	2010 m	2.54	1.0686	39.90	2.8424

Appendix AA. Supplemental material for Virginia summer season RSF modeling

Table AA1. Variable selection results from the "proposal set" of variables from the Virginia subregion during the summer season, Nevada and northeastern California.

[The top-ranked variable in each set was retained in the suite of candidate variables for resource selection function (RSF) modeling if it performed better than the null model and if confidence intervals around estimated mean effects did not overlap zero]

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
Land cover	Annual grass	661.4 ha	4	-628.1	0.0	1.0
		61.5 ha	4	-829.9	403.5	0.0
		8.7 ha	4	-975.3	694.3	0.0
		Null	3	-1,622.0	1,985.7	0.0
	Bare ground	661.4 ha	4	-932.0	0.0	1.0
		8.7 ha	4	-1,100.7	337.4	0.0
		61.5 ha	4	-1,177.9	491.9	0.0
		Null	3	-1,622.0	1,378.0	0.0
	Big sagebrush	661.4 ha	4	-932.0	0.0	1.0
		61.5 ha	4	-1,100.7	337.4	0.0
		8.7 ha	4	-1,177.9	491.9	0.0
		Null	3	-1,622.0	1,378.0	0.0
	Cropland	661.4 ha	4	-1,431.2	0.0	1.0
		61.5 ha	4	-1,573.8	285.2	0.0
		8.7 ha	4	-1,597.4	332.4	0.0
		Null	3	-1,622.0	379.5	0.0
	Forest	661.4 ha	4	-1,602.6	0.0	1.0
		61.5 ha	4	-1,620.4	35.6	0.0
		Null	3	-1,622.0	36.7	0.0
		8.7 ha	4	-1,621.9	38.5	0.0
	Herbaceous	661.4 ha	4	-463.3	0.0	1.0
		61.5 ha	4	-697.6	468.6	0.0
		8.7 ha	4	-819.8	713.0	0.0
		Null	3	-1,622.0	2,315.3	0.0
	Non-sagebrush shrub	661.4 ha	4	-1,049.9	0.0	1.0
		61.5 ha	4	-1,174.3	248.7	0.0
		8.7 ha	4	-1,239.8	379.7	0.0
		Null	3	-1,622.0	1,142.1	0.0
	Other sagebrush	8.7 ha	4	-1,581.9	0.0	1.0
		61.5 ha	4	-1,600.1	36.4	0.0
		661.4 ha	4	-1,614.7	65.6	0.0
		Null	3	-1,622.0	78.2	0.0
	Riparian	661.4 ha	4	-1,571.7	0.0	1.0
		61.5 ha	4	-1,605.1	66.7	0.0
		Null	3	-1,622.0	98.5	0.0
		8.7 ha	4	-1,621.1	98.8	0.0
Sagebrush	Sagebrush height	8.7 ha	4	-1,620.2	0.0	0.48

Group	Variable	Scale/distance function	K	Log Likelihood	ΔAICc	Model Weight
height						
		Null	3	-1,622.0	1.4	0.24
		661.4 ha	4	-1,621.3	2.0	0.18
		61.5 ha	4	-1,621.8	3.1	0.10
	Distance to cropland	Expon. decay	4	-1,283.0	0.0	1.0
		Linear	4	-1,382.7	199.4	0.0
		Null	3	-1,622.0	675.9	0.0
Edge	Variety of edge cover types	661.4 ha	4	-824.3	0.0	1.0
		61.5 ha	4	-1,083.4	518.2	0.0
		8.7 ha	4	-1,324.9	1,001.1	0.0
		Null	3	-1,622.0	1,593.2	0.0
Landscape variation	Variety of land cover types	8.7 ha	4	-1,382.5	0.0	1.0
		61.5 ha	4	-1,442.8	120.7	0.0
		661.4 ha	4	-1,555.1	345.2	0.0
		Null	3	-1,622.0	476.9	0.0
Water sources	Distance to spring	Linear	4	-1,193.0	0.0	1.0
	Distance to spring	Expon. decay	4	-1,343.4	300.9	0.0
	Distance to wet meadow	Linear	4	-1,505.6	625.3	0.0
	Distance to perennial	Linear	4	-1,554.6	723.4	0.0
	Distance to nearest stream	Expon. decay	4	-1,569.2	752.5	0.0
	Distance to intermittent stream	Linear	4	-1,587.9	790.0	0.0
	Distance to water body	Linear	4	-1,589.8	793.7	0.0
	Distance to wet meadow	Expon. decay	4	-1,592.9	799.8	0.0
	Distance to intermittent stream	Expon. decay	4	-1,599.7	813.4	0.0
	Distance to perennial stream	Expon. decay	4	-1,618.6	851.2	0.0
	Null	Null	3	-1,622.0	856.0	0.0
	Distance to nearest stream	Linear	4	-1,621.3	856.6	0.0
	Distance to water body	Expon. decay	4	-1,621.9	857.9	0.0
Topography	Elevation	Linear	4	-690.0	0.0	1.0
	Topographic position index	2010 m	4	-1,606.3	1,832.5	0.0
	Topographic position index	510 m	4	-1,609.1	1,838.2	0.0
	Roughness index	1 ha	4	-1,615.1	1,850.1	0.0
	Null		3	-1,622.0	1,861.8	0.0

Table AA2. Model averaged parameter estimates and 95-percent confidence intervals for candidate variables included in the Virginia summer season resource selection function (RSF) model, Nevada and northeastern California.

Variable	Scale/distance function	Model averaged estimate (95-percent confidence interval)	Selection/Avoidance
Annual grass	661.4 ha	9.45 (9.448, 9.46)	Selection
Bare ground	661.4 ha	8.69 (3.82, 13.56)	Selection
Forest	661.4 ha	43.36 (27.64, 59.08)	Selection
Herbaceous	661.4 ha	56.38 (56.37, 56.38)	Selection
Non-sagebrush shrubs	661.4 ha	37.30 (28.51, 46.10)	Selection
Other sagebrush	8.7 ha	-22.79 (-32.93, -12.65)	Avoidance
Riparian	661.4 ha	-26.33 (-59.51, 6.85)	None
Distance to cropland	Expon. decay	-6.18 (-6.19, -6.17)	Avoidance
Variety of land cover types	8.7 ha	0.19 (-0.01, 0.40)	None
Distance to perennial stream	Linear	-0.23 (-0.32, -0.13)	Selection
Distance to water body	Linear	-0.66 (-0.81, 0.50)	None
Distance to wet meadow	Linear	-0.12 (-0.23, -0.01)	Selection
Roughness index	1 ha	-8.77 (-11.66, -5.88)	Avoidance
Topographic position index	510 m	0.04 (0.03, 0.05)	Selected ridges / Avoided valleys

Table AA3. Means and standard errors for habitat features available to, and used by, greater sage-grouse (*Centrocercus urophasianus*) in the Virginia subregion, and found important in resource selection function (RSF) modeling during the summer season, Nevada and northeastern California.

Variable	Scale	Available habitats		Used habitats	
		Mean	Standard error	Mean	Standard error
Annual grass	661.4 ha	0.037	0.0026	0.312	0.0084
Bare ground	661.4 ha	0.418	0.0056	0.385	0.0024
Forest	661.4 ha	0.001	0.0002	0.004	0.0011
Herbaceous	661.4 ha	0.169	0.0031	0.342	0.0021
Non-sagebrush shrub	661.4 ha	0.033	0.0007	0.068	0.0018
Other sagebrush	8.7 ha	0.028	0.0008	0.020	0.0010
Riparian	661.4 ha	0.004	0.0003	0.007	0.0003
Distance to cropland	Km	3.70	0.0774	5.66	0.0826
Variety of land cover types	8.7 ha	2.45	0.0350	3.46	0.0594
Distance to perennial stream	Km	5.79	0.1281	4.18	0.1142
Distance to water body	Km	2.52	0.0561	2.00	0.0728
Distance to wet meadow	Km	5.16	0.0955	3.62	0.0775
Roughness index	1 ha	0.19	0.0036	0.20	0.0040
Topographic position index	510 m	-0.46	0.6534	3.71	1.1194

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Director, Western Ecological Research Center
U.S. Geological Survey
3020 State University Drive East
Sacramento, California 95819
http://werc.usgs.gov/

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