HABITAT SUITABILITY FOR GREATER SAGE-GROUSE IN OIL AND GAS DEVELOPED AREAS IN NORTH DAKOTA AND MONTANA

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INTRODUCTION

The historical range of greater sage-grouse has been dramatically reduced since European settlement (Connelly and Braun 1997, Schroeder et al. 2004). The range of greater sage-grouse (sage-grouse hereafter) has been reduced by 45% across North America (Schroeder et al. 2004) with an estimated range-wide population decline of 45-80% and local declines of 17-92% (Aldridge and Brigham 2002, Aldridge 1998). The distribution of sage-grouse is clearly associated with the distribution of sagebrush (*Artemisia* spp.) and sage-grouse are year-round obligates of sagebrush communities (Paige and Ritter 1999, Schroeder et al.2004). Reduced sage-grouse populations are intimately linked to widespread degradation of sagebrush vegetation communities. The direct and indirect causes of habitat degradation for sage-grouse are associated with altered fire regimes (Wrobleski and Kauffman 2003), grazing and agriculture, urbanization, and oil and gas extraction (Connelly et al. 2004). Oil and gas development is the most recent and least understood impact on sage-grouse and their habitat. Since economic production of oil and gas are predicted to continue for 20 – 100 years (Connelly et al. 2004), it is important to understand these impacts. Once understood, it will be possible to plan future resource development in ways that least impact sage-grouse populations.

There are several factors related to oil and gas development that negatively impact sage-grouse populations. Development of oil and gas industry requires construction of roads, well pads, disturbance during drilling, short term storage, and transporting the material off site. Typical well pads require 0.8-1.9 ha and compressor stations along pipelines require 5-7 ha (Connelly et al.2004). Construction of roads is a direct loss of habitat. The placement of these physical structures has varying impacts on wildlife. Soil disturbance along roads and near wells, facilitates spread of exotic plants species, and power lines and communication structures provide nest and perch sites for raptors (Connelly et al. 2004).

Direct effects of oil and gas development and long-term effects of pumping stations, refineries, and other permanent facilities are largely unknown. However, if more than 40% of the area within 0.8 km or a lek is within 350 m of a coal bed methane well, the number of male sage-grouse displaying and the total number of active leks are reduced (Walker et al. 2007). Female sage-grouse are also less likely to select areas for nesting and brooding in areas with coal bed methane wells (Doherty et al. 2008). Roads related to oil and gas can reduce nest success, and increased disturbance during lekking and brood-rearing periods (Braun 1998, Lyon and Anderson 2003). The negative effects of oil and gas development are further exasperated by increased extraction technology enabling development of oil and gas fields. In 2002, 99% of 4,279 permit applications were approved (Connelly et al.2004). Thus the effects of all factors related to oil and gas development need to be understood so that accurate management recommendations can be made.

Previous research on sage-grouse in southwestern North Dakota (Herman-Brunson 2007, Swanson 2009) identified an area of the Cedar Creek Anticline in Bowman County, ND and Fallon County, MT with an obvious lack of sage-grouse use. This area (Figure 1) also has considerable oil and gas development and infrastructure. Before attributing the dispersion patterns of sage-grouse in this region to oil and gas development, the suitability of the habitat must be ascertained. The objective of this study is to further develop brood habitat models for sage-grouse and use these models to assess habitat suitability for sage-grouse in the Cedar Creek Anticline area.

STUDY AREA

Historically, the study area was sagebrush steppe ecosystem. Populations of sage-grouse have been declining. Population indices for sage-grouse in North Dakota suggest declining populations since about 1960 (Smith et al. 2004). Habitat alteration primarily through grazing, agricultural activities, altered fire regimes, and urbanization has fragmented much of the contiguous sagebrush communities. The landscape is currently a mixture of crop land, grazed pasture, and sagebrush communities.

METHODS

Radio-marking and monitoring

Female sage-grouse will be captured via night spotlighting beginning mid-March and continuing through April (Giesen et al. 1982). Age, sex, and weight of sage-grouse captured was recorded and female sage-grouse were marked with leg-bands and a necklace-mounted, 20-g radio transmitter with activity switch attached to each bird. Female sage-grouse were located using standard telemetry procedures to determine nest locations and if the nest was successful, locations were obtained bi-weekly for hens with broods. Locations of sage-grouse locations were recorded in handheld GPS (NAD 1927 CONUS, UTM Zone 13 Projection).

Habitat Measurements

Vegetation characteristics important to resource selection by hens with broods in the Dakotas included height of sagebrush, percent herbaceous vegetation cover, grass height, and percent forb cover (Kaczor et al. in press). Vegetation measurement described below include only those measurements that were collected as part of this study and as supplemental data for developing resource selection models. Original and extensive descriptions of the sampling designs are described by Herman-Brunson et al. (2009) and Kaczor et al. (in press). We characterized vegetation at sites used by females with broods about 14 ± 2 SE days after recording the location. Two 50-m transects were established in the north-south cardinal directions, each starting at the marked brood location and terminating at their respective north-south ends. A modified Robel pole was used to quantify visual obstruction readings (VOR) and maximum grass height at 10 m intervals (N = 11; Robel et al. 1970, Benkobi et al. 2000). We estimated sagebrush (*A. tridentata* spp. and *A. cana* spp.) density and height at 10-m intervals (N = 11) using the point-centered quarter method (Cottam and Curtis 1956). Canopy coverage was estimated using a 0.10 m^2 quadrat (Daubenmire 1959). At each 10-m interval, four 0.1 m^2 quadrats were placed in an H-shape with each leg of the H being 1 m long (N = 44 per site). We recorded percent cover in six categories for total vegetation, grass, forb, shrub, litter, bare ground, shrub species, grass species, and forb species cover in each quadrat (Daubenmire 1959). In addition, we characterized vegetation at an equal number of random sites during the same period. Random sites were generated within a 10 km buffer of capture leks with a Geographic Information System (GIS) with Hawth's Analysis Tool (Beyer 2004). Random points were reselected if they were on a road, in a road ditch, or on private lands where we could not obtain permission for access. Measurements were recorded in the field using a CMT MC-IV (Corvallis Microtechnology) data entry device.

Vegetation in the Cedar Creek Anticline

We digitized an approximate boundary of the Cedar Creek Anticline in ArcMap (ESRI 2005) geographic information system. We then used Hawth's tools in ArcMap version 8 to select approximately 100 random sites within the boundary of the anticline area (hereafter referred to as oil random sites). Oil random sites in the anticline <30 m from a road were discarded and another set of coordinates selected. Data collected at oil random sites were the same as those at used and random sites described above.

Analytical Methods

Data characterizing vegetation at nest and brood sites and the associated random sites were summarized to a value for each site. These data were then pooled with data collected in 2005-2006 at sites used by hens with broods (Kaczor et al. in press). For shrub height measurements we entered 0 for measurements when no shrubs were present in the quarter plots of the point-centered-quarter method. Prior to developing resource selection models we evaluated the form each variable that best accounted for the variation in used and random sites using a log-ratio test. We standardized the values from each site as a z-score and evaluated the linear, quadratic, exponential, and pseudo-threshold (Franklin et al. 2000) forms of each variable. A set of candidate resource selection models incorporating variables from those publications were evaluated using logistic regression in an Information Theoretic framework (Burnham and Anderson 2002) with small sample size correction. We evaluated the post-hoc predictive ability of the model using receiver operating curve (ROC) in which ROC values > 0.7 were considered to have good predictive ability.

We then estimated habitat suitability for sage-grouse in the anticline by classifying probability of oil random sites being used as brood habitat. Habitat suitability is a relative scale from 0 – 1.0 with 1.0 being ideal habitat. We included 3 estimates of habitat suitability for sage-grouse nesting and broods: 1) proportion of sites each with a posterior probability of being used >0.5, 2) calculated average probability of use and nonuse, 3) and qualitative evaluation of number of sites with posterior probability of being used in the following categories >0.7, 0.6 – 0.7, 0.5 -<0.6, 0.4 - 0.5, and >0.4. Analyses were completed using SAS 9.2 (SAS Institute 2008).

RESULTS

Brood Habitat

We measured 169 locations from 27 individual sage-grouse broods and 161 random sites from 2005-2007. A resource selection model for sage-grouse brood habitat was developed from these data (see below). In 2007, we measured 45 oil random sites in the southwestern portion of the Cedar Creek Anticline (Figure 2).

We evaluated 17 candidate models (Table 1, 2) using variables from resource selection models for sage-grouse broods from 2005 – 2006 (Kaczor et al. in press). Of the models considered, the model that included percent herbaceous cover, grass height, and shrub height was the most supported model (AIC_{wi}.= 0.76). A second model with some support (AIC_{wi}. = 0.16) included visual obstruction in place of grass height in that occurred in the most supported model, but was not within 2 ΔAIC_c units of the other model. Combined these models received 91% of the AIC weights. A third model, included percent cover of bunch grasses with variables in the most supported model but had essentially the same log-likelihood and was dismissed from further consideration. We average coefficients from supported models because support for the "best" model was >4 times greater than the next model, there was little support for any other models.

The odds ratios for percent herbaceous cover and shrub height indicated these were the primary variables determining resource selection by sage-grouse broods in this area (Table 3). The odds ratio for grass height suggested that this variable was the least important variable in the model. However, the model without grass height was substantially less supported.

Probability of the oil random sites being classified as used by sage-grouse broods was averaged 0.29, whereas the averaged probability of sites being classified as unused was 0.71 (Table 4). Proportion of these sites being classified as used and unused was 0.26 and 0.74, respectively. Finally, the highest posterior probability of a random sites in the Cedar Creek Anticline being use was 0.8 only one sites while the highest posterior probability of sites being unused was 0.96. The posterior classifications based on the resources selection function suggest that habitat in the portion of the Cedar Creek Anticline evaluated was largely unsuitable as brood habitat for sage-grouse. Figure 2 shows that of the sites classified as suitable for sage-grouse broods most only were moderate or weakly classified as suitable habitat. Finally, Figure 3 show that those sites classified as suitable habitat for sage-grouse broods were mostly located outside or along the edge of the area of the Cedar Creek Anticline with few sage-grouse locations.

CONCLUSIONS

The areas of the Cedar Creek Anticline that we studied and for which the use by sage-grouse was absent or minimal is probably because the habitat was unsuitable. Vegetative conditions in this area did not provide adequate height or abundance of herbaceous vegetation for sage-grouse broods. Several metrics of habitat suitability based on posterior probabilities from the resource selection function for the area we evaluated were less than 0.3. The Cedar Creek Anticline extends well beyond the area we evaluated and this study should not be interpreted to suggest that those areas are not suitable sage-grouse habitat.

This study was designed to evaluate the habitat suitability for both nesting and brood rearing by greater sage-grouse, but these objectives were not attainable because the graduate student left the project after the first year. Another graduate student took over the project, but the study design was compromised by a combination of weather factors prohibiting the capture and radio-collaring of additional birds, and habitat data collection protocols that were incomplete.

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Table 1. Evaluation of candidate models of resource selection for sage-grouse broods in southwestern North Dakota and southeastern Montana using an information theoretic approach.

Model[1]	-2LL	N variables + intercept	AICc	Delta AICc	Model weight
Grass height	451.070	2	455.1067	73.6546	0.0000
Shrub height	447.035	2	451.0717	69.6196	0.0000
Visual obstruction	439.620	2	443.6567	62.2046	0.0000
Percent cover bunch grasses	448.476	2	452.5127	71.0606	0.0000
Percent herbaceous cover	388.870	2	392.9067	11.4546	0.0025
Percent herbaceous cover + Grass height	386.181	3	392.2546	10.8025	0.0034
Percent herbaceous cover + Shrub height	380.226	3	386.2996	4.8475	0.0669
Grass height + percent cover bunch grasses	441.683	3	447.7566	66.3045	0.0000
Shrub height + Percent cover bunch grasses	440.779	3	446.8526	65.4005	0.0000
Percent herbaceous cover + Percent cover bunch grasses.	388.733	3	394.8066	13.3545	0.0010
Percent herbaceous cover + Visual obstruction	385.934	3	392.0076	10.5555	0.0039
Percent herbaceous cover + Grass height + Percent cover bunch grasses	385.927	4	394.0501	12.5980	0.0014
Percent herbaceous cover + Shrub height + Percent cover bunch grasses	428.123	4	436.2461	54.7940	0.0000
Percent herbaceous cover + Cover + Percent cover bunch grasses	385.853	4	393.9761	12.5240	0.0014

Percent herbaceous cover + Grass height + Shrub height	373.329	4	381.4521	0.0000	0.7557
Percent herbaceous cover + Visual obstruction + Shrub height	376.387	4	384.5101	3.0580	0.1638

[1] Visual obstruction, percent cover bunch grasses, percent herbaceous cover, visual obstruction, and shrub height with 0 if absent were all pseudo threshold transformation of the variable; grass height was an exponential transformation of the variable.

Table 2. Parameter estimates for the most supported model predicting resource selection by sage-grouse broods in southwestern North Dakota and southeastern Montana, 2005-2007.

Model component	β	SE of β	Chi square
Intercept	-9.91	1.24	<0.01
Percent herbaceous cover	4.90	0.71	<0.01
Grass height	0.02	0.02	0.49
Shrub height with 0 if absent	1.23	0.36	<0.01

Table 3. Odds ratios and 95% confidence intervals for odds ratio for the most supported model predicting resource selection by sage-grouse broods in southwestern North Dakota and southeastern Montana, 2005-2007.

Model component	Estimate	95% Confidence interval	
		Lower	Upper
Percent herbaceous cover	134.24	33.42	539.17
Grass height	1.02	0.97	1.06
Shrub height with 0 if absent	3.43	1.70	6.89

Table 4. Summary statistics of predicted habitat suitability for sage-grouse broods of 46 random sites in the Cedar Creek Anticline using logistic regression model developed southwestern North Dakota and southeastern Montana.

Habitat suitability estimate	Classified as used	Classified as unused
Average probability	0.29	0.71
Proportion classified	0.26	0.74
Largest probability in category	0.80	0.96

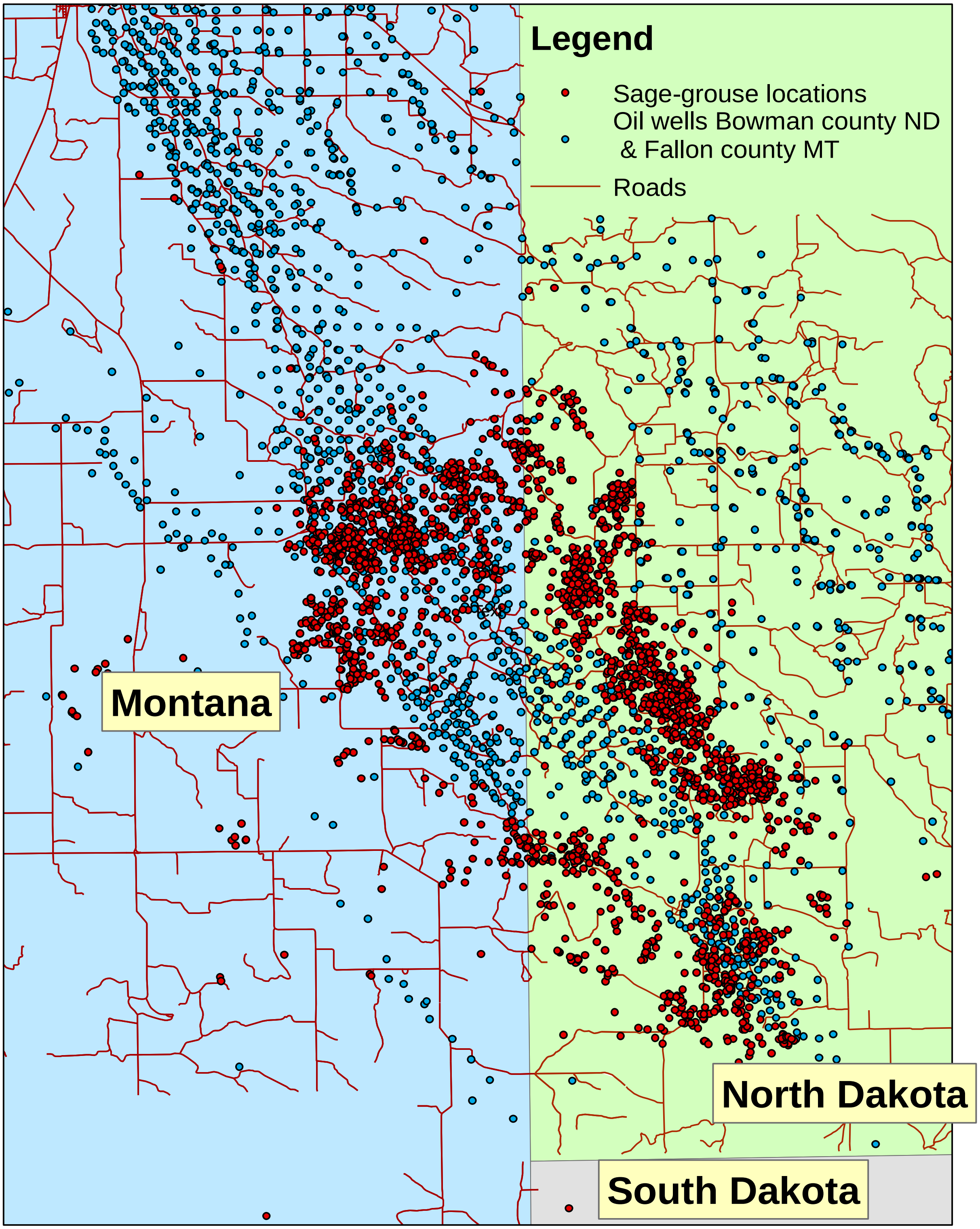

Figure 1. Map of depicting sage-grouse locations and roads and oil pads in North Dakota and Montana associated with the Cedar Creek Anticline.

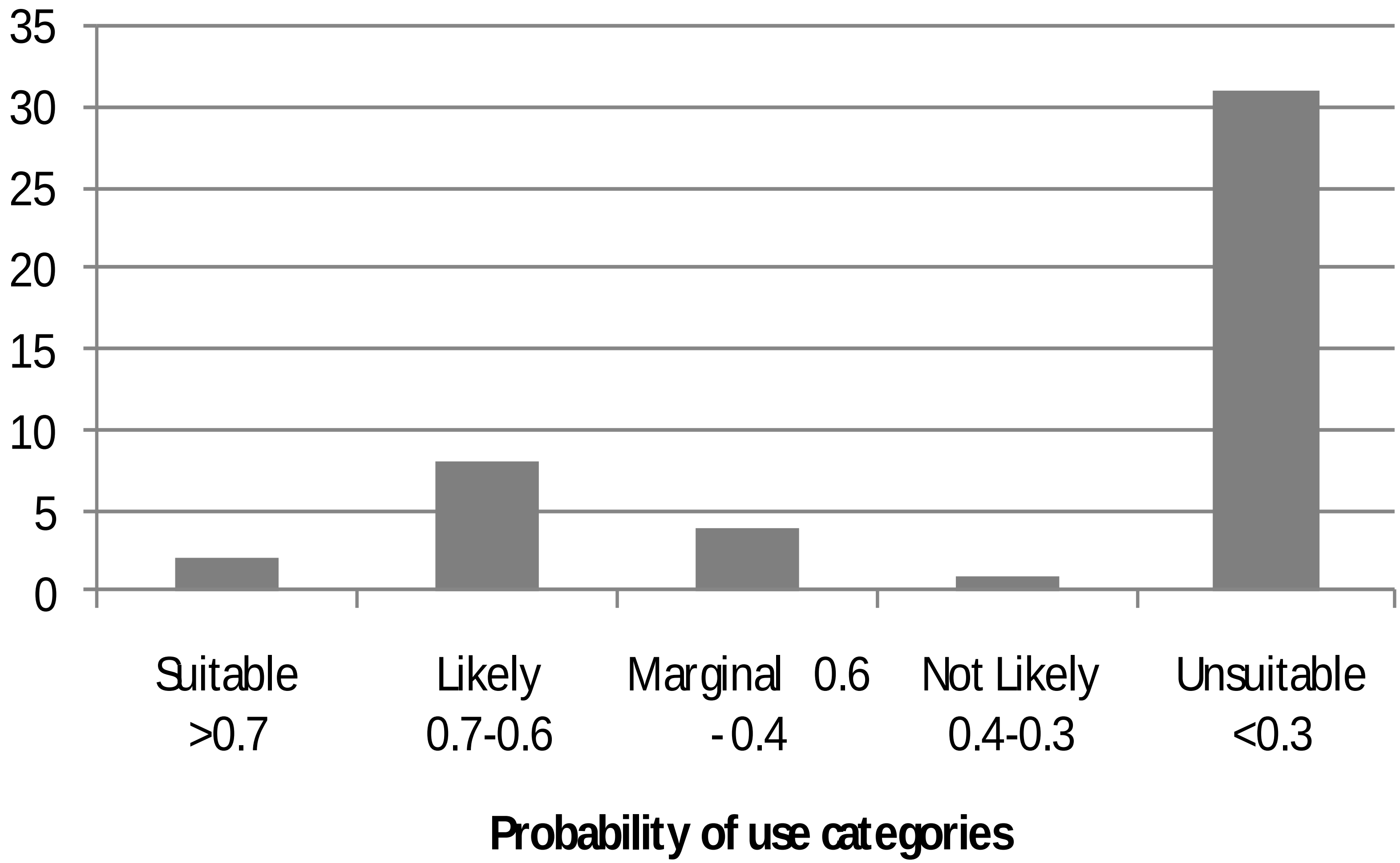

Figure 2. Number of oil random sites with posterior classification probabilities depicted in categories.

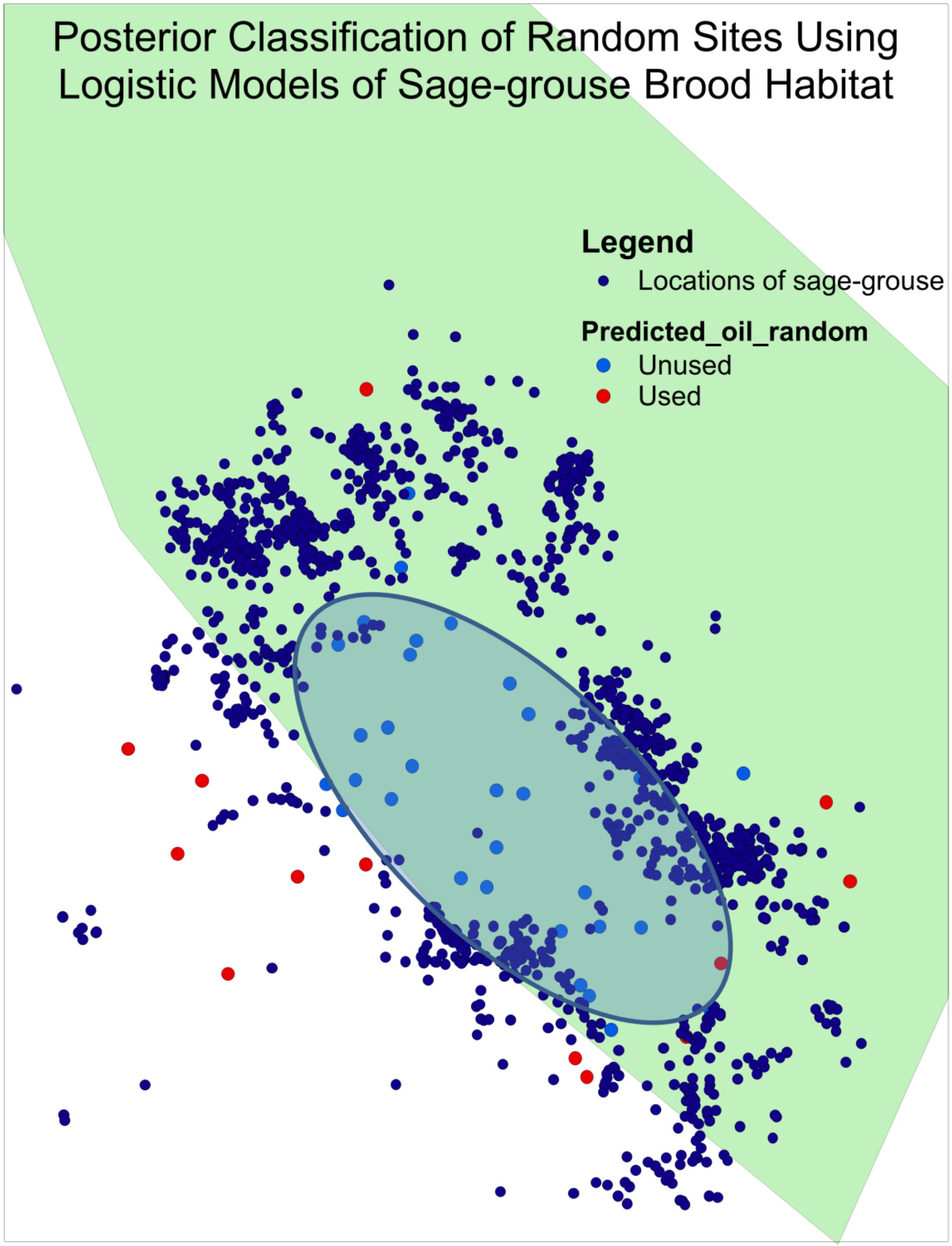

Figure 3. Boundary of the Cedar Creek Anticline with sage-grouse locations and coordinates of 45 oil random sites classified as used or unused by resource selection funtion.