Development of statewide 30 meter winter sage-grouse habitat models for Utah

Ben Crabb, Remote Sensing and Geographic Information System Laboratory, Department of Wildland Resources, Utah State University

Todd Black, USU Extension

BACKGROUND

The Utah Department of Wildland Resources (UDWR) current map of sage-grouse occupied territory in the state identifies 3.04 million hectares as occupied by sage-grouse, representing 13.8% of all state lands (Fig. 1; UDWR 2011a). However, this map is of limited utility for guiding sage-grouse management, especially with respect to winter habitat use, for which limited field data is available. In this paper, we use existing geospatial datasets of topographic, vegetation, and climatic variables in a delphi modeling approach to model and map 'general' and 'critical' sage-grouse winter habitat at a 30 meter spatial resolution across all areas identified by UDWR as sage-grouse occupied. The general winter model indicates areas of suitable winter habitat, and the critical winter habitat model indicates areas within the general habitat model which would be accessible to sage-grouse in the event that 3 feet of snow covered portions of the landscape. All analysis was performed using ArcGIS 10 software (ESRI, Redlands, CA).

METHODS

General Winter Habitat model

The general winter habitat model was created using a decision tree approach to determine which map pixels to classify as suitable winter habitat. Beginning with all UDWR-identified sage-grouse occupied areas, the decision tree used the variables of vegetation, elevation, slope and aspect to identify suitable winter habitat (Fig. 2).

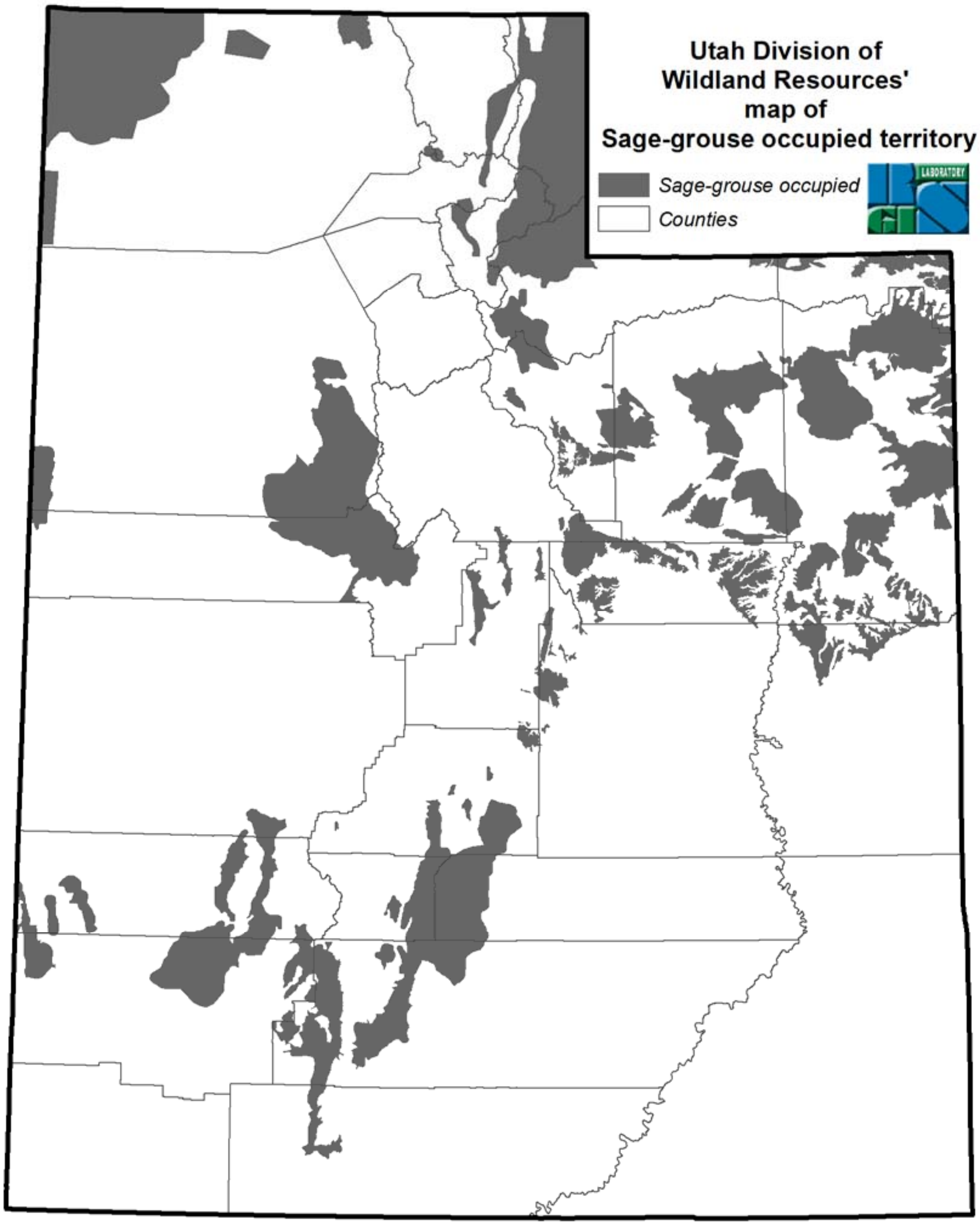

Figure 1 – UDWR map of sage-grouse occupied territory, current as of January 2011 (UDWR 2011a). This paper describes a methodology for identifying suitable sage-grouse winter habitat within areas identified by the UDWR as sage-grouse occupied (gray areas in this map).

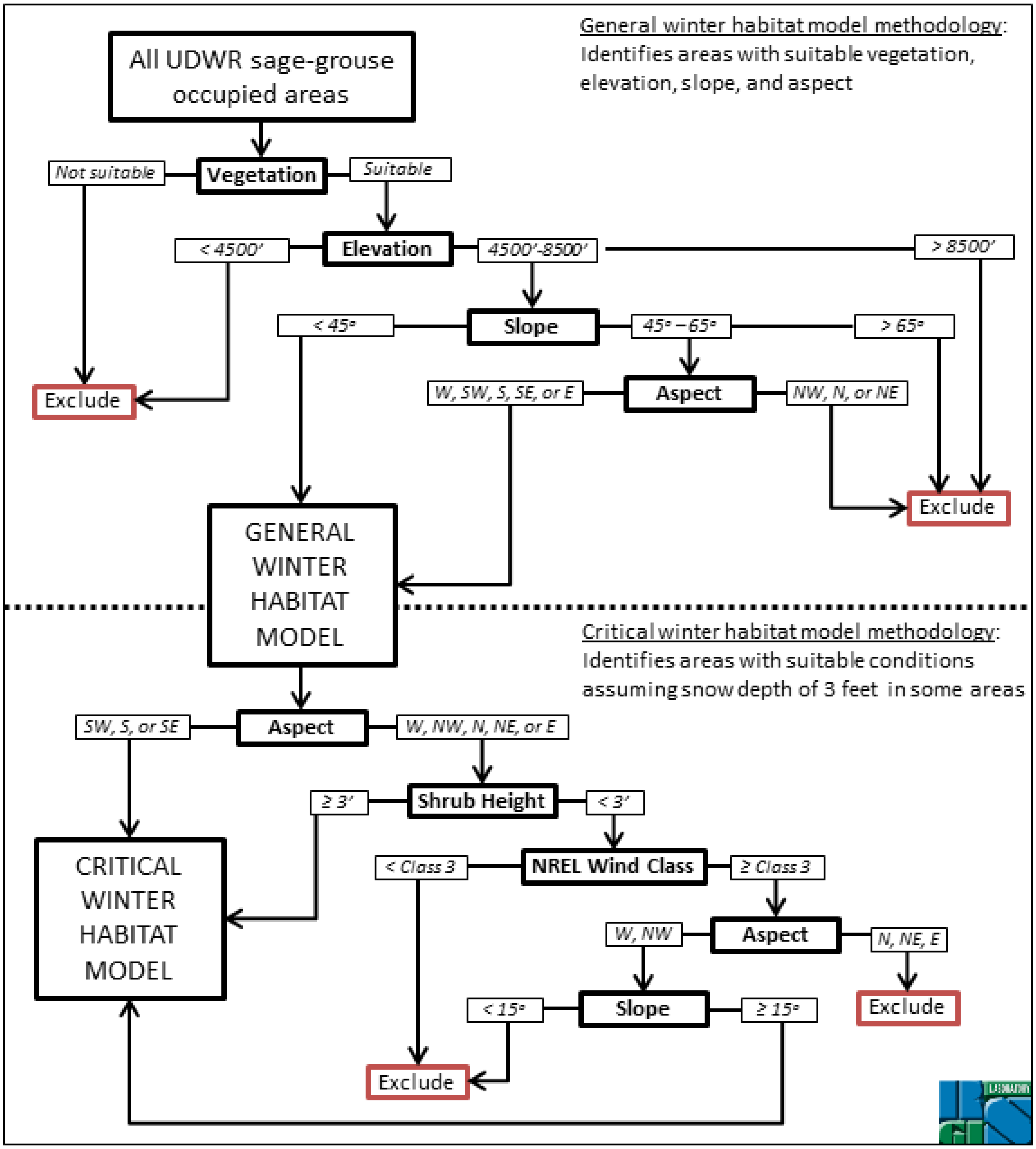

Figure 2 – Methodology for developing the general and critical winter habitat models. The models identify suitable habitat within areas identified by UDWR as sage-grouse occupied using vegetation, topographic, and climatic variables. The "Vegetation" and "Shrub Height" variables are based on LANDFIRE Existing Vegetation Type (EVT) (USGS 2010b) and Existing Vegetation Height (EVH) (USGS 2010a) datasets, respectively; the methodology used to develop these variables is explained in the text. Elevation, slope, and aspect variables were taken or derived from a 30-m digital elevation model (DEM) from the National Elevation Dataset (Gesch et al. 2002; Gesch 2007). The "NREL Wind Class" variable is a geospatial model of average wind speed at a height of 50 meters above ground surface and was developed by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL 2009) at an original raster resolution of 200 meters.

Vegetation Component

We used the LANDFIRE Existing Vegetation Types (EVT) 1.0.5 layer to identify areas with suitable vegetation conditions for sage-grouse (USGS 2010b). USU Extension's Todd Black identified seven shrub vegetation types ("shrub-type EVTs") as suitable sage-grouse habitat (Table 1).

Table 1–Shrub-type EVTs identified as suitable sage-grouse habitat, and their spatial prevalence (hectares) within UDWR sage-grouse occupied areas. The "VALUE" field indicates the LANDFIRE code associated with each EVT.

VALUE	EVT_NAME	Hectares
2064	Colorado Plateau Mixed Low Sagebrush Shrubland	260973
2072	Wyoming Basins Dwarf Sagebrush Shrubland and Steppe	13378
2079	Great Basin Xeric Mixed Sagebrush Shrubland	119911
2080	Inter-Mountain Basins Big Sagebrush Shrubland	736938
2125	Inter-Mountain Basins Big Sagebrush Steppe	59715
2126	Inter-Mountain Basins Montane Sagebrush Steppe	64751
2220	*Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance	283401

In addition, Todd Black identified four forested EVTs present within UDWR-identified sage-grouse occupied areas which represent marginal sage-grouse habitat if located near the shrub-type EVTs (Table 2). Most of these EVTs represent pinyon-juniper (PJ) vegetation types, so we call these EVTs "PJ-type EVTs" (Table 2). We treated pixels associated with PJ-type EVTs as marginally suitable sage-grouse habitat if they fell within 90 meters of a shrub-type EVT pixel.

Table 2–PJ-type EVTs identified as marginal sage-grouse habitat if located near shrub-type EVTs (Table 1).

VALUE	EVT_NAME	Hectares
2011	Rocky Mountain Aspen Forest and Woodland	118498
2016	Colorado Plateau Pinyon-Juniper Woodland	333920
2049	Rocky Mountain Foothill Limber Pine-Juniper Woodland	3916
2115	Inter-Mountain Basins Juniper Savanna	7824

Processing steps for the vegetation component of the general winter habitat model:

1. Clip the LANDFIRE EVT layer to the UDWR sage-grouse occupied areas layer, plus a 90-m buffer (left side of Fig. 3). Assign a value of 1 to all SB-type pixels, a value of 0.5 to PJ-type pixels within 90-m of SB-type pixels, and a value of zero to all other pixels. This renders a raster with values of 0, 0.5 and 1 (right side of Fig. 3).

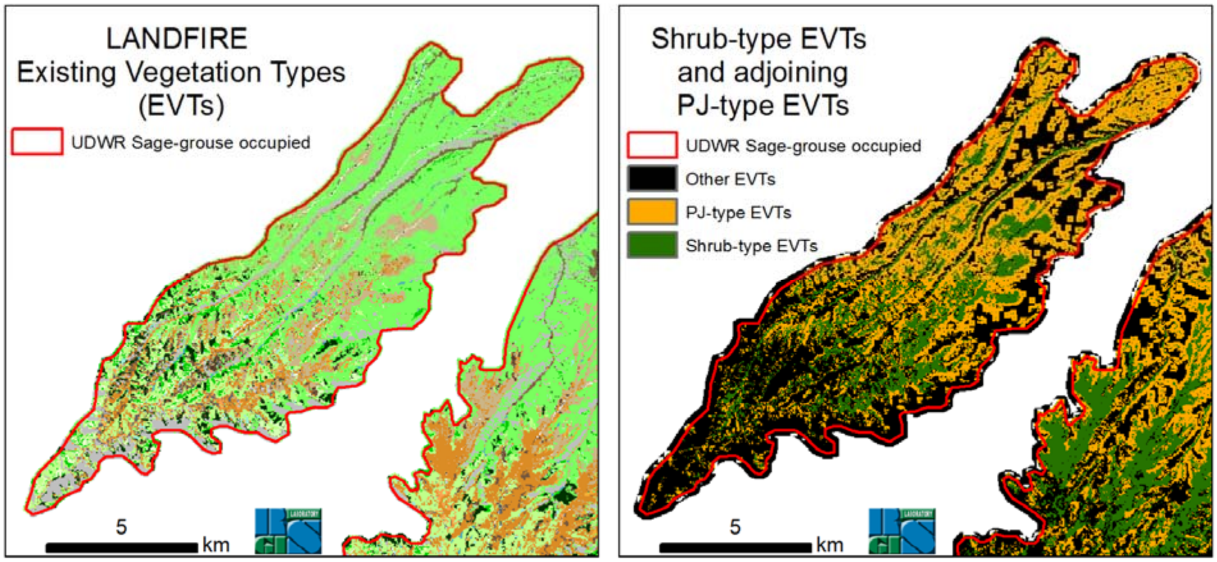

Figure 3 – Detail of original LANDFIRE EVT data (left side) and shrub-type EVTs and adjoining PJ-type EVT pixels (right side). The boundary of the area identified by UDWR as sage-grouse occupied is shown as a red line. Areas associated with shrub-type EVTs (Table 1; areas in green in right image) were treated as having suitable vegetation characteristics for sage-grouse winter habitat and were assigned values of 1. Areas in yellow in the right image indicate pixels associated with PJ-type EVTs (Table 2) which were within 90 meters of shrub-type EVT pixels. These pixels were treated as marginally suitable sage-grouse winter habitat and were assigned values of 0.5. All other pixels were assigned a value of zero.

2. Move a 7x7 pixel window over the raster created in step 1 (right side of Figure 3), assigning the mean value over the window to each center pixel (left side of Fig. 4). Reclassify mean values ≥0.5 to 1, indicating suitable neighborhood vegetation for sage grouse habitat. Reclassify values <0.5 to 0 (right side of fig. 4). The moving window was used to account for the preference of sage-grouse for relatively large expanses of suitable habitat.

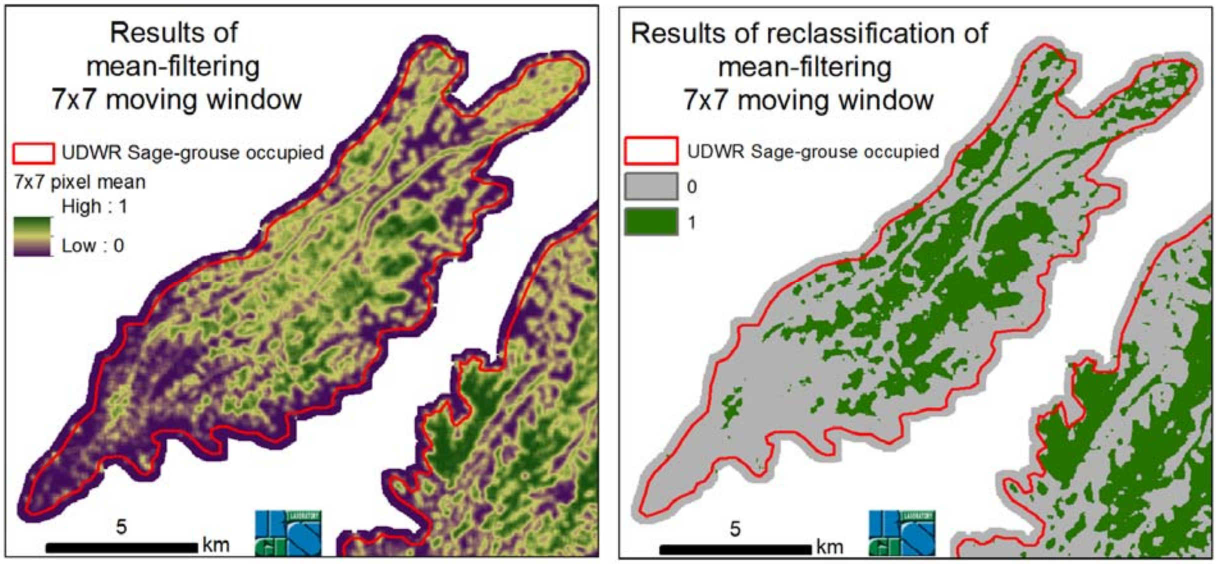

Figure 4 – Detail of the moving window processing step of the vegetation component of the general winter habitat model. The image on the left was created by moving a mean-filtering 7x7 pixel window over the raster containing values of 1 (shrub-type EVT pixels), 0.5 (PJ-type pixels near shrub-type pixels), and 0 (all other pixels) (right side of figure 3). The image on the right was created by reclassifying the image on the left such that pixel values ≥ 0.5 were assigned values of 1 (shown in green) and all other pixels were assigned values of zero (shown in gray).

3. Ensure that pixels associated with shrub-type EVTs have not been discarded by re-assigning these pixels a value of 1 (left side of Fig. 5).

4. Identify and retain only those spatially contiguous patches of suitable habitat larger than or equal to 5 hectares. We defined spatial contiguity based on each pixel's 8 neighboring pixels (i.e. those pixels to the right, left, above, below, and along the diagonals to each target pixel). Each LANDFIRE pixel is 30m x 30m (900m^2), so 56 pixels = 50,400m^2 = 5.04 hectares. Therefore, pixels associated with patches composed of ≥56 pixels were assigned a value of 1, while all other pixels were assigned a value of zero (right side of Fig. 5).

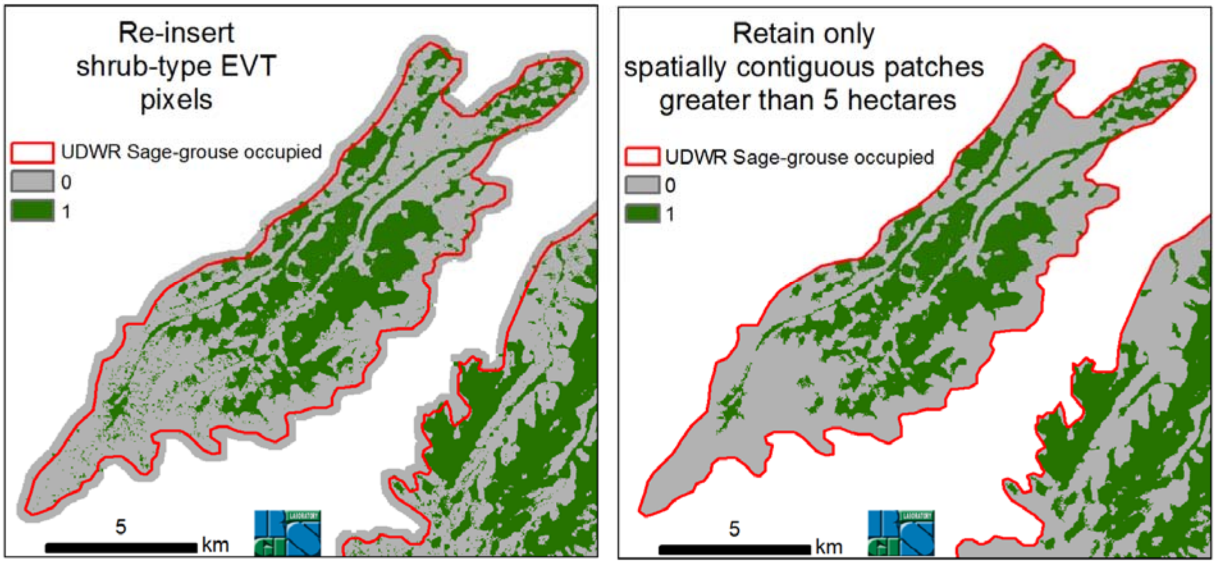

Figure 5 – Detail of the final processing steps for the vegetation component of the general winter habitat model. The image on the left shows the results of processing step 3, and was created by re-inserting pixels associated with shrub-type EVTs into the map created in processing step 2 (right side of Figure 4). The image on the right shows the results of processing step 4, and was created by eliminating all patches of suitable habitat smaller than 5 hectares. This image represents the final vegetation component of the general winter habitat model.

Elevation component

USU Extension experts determined that suitable sage-grouse winter habitat in Utah falls between 4500 feet and 8500 feet in elevation. We therefore eliminated all areas with elevation higher than 8500 feet (>=2591 m) or lower than 4500 feet (<=1371 m) from the vegetation component map. We used a 1 arc-second digital elevation model (DEM) from the National Elevation Dataset (Gesch et al. 2002; Gesch 2007), resampled to 30-m resolution, to identify these areas.

Slope and Aspect component

We used a slope raster derived from the 30-m DEM to eliminate areas with slope >65°. We also used an aspect raster derived from the DEM to eliminate areas with slope ≥45° which were also on N, NE, or NW aspects. These aspects retain more snow in the winter and would be inaccessible to sage-grouse.

Final general winter habitat model summary

The final general winter habitat model was composed of ones (suitable habitat) and zeros (not suitable habitat) (Figure 6). The model indicated suitable habitat where all of these conditions were satisfied:

- vegetation criteria were met;

- slope on all aspects is ≤65°;
- slope on N, NE, and NW aspects is <45°; and
- elevation is between 4500 feet (1371 meters) and 8500 feet (2591 meters).

Critical Winter Habitat Model

The general winter habitat model described above identifies areas of suitable winter sage-grouse habitat based on vegetation types and the topographic variables of elevation, slope, and aspect. We also created a 'critical' winter habitat model to identify areas within this general model which would be critical to sage-grouse survival during a harsh winter characterized by the presence of 3 feet of snow on portions of the landscape. This model incorporated the additional variables of shrub height and mean wind speed and imposed more restrictive constraints on suitable habitat based on slope and aspect criteria.

The following criteria were applied to develop the critical winter habitat model:

- Retain areas identified in the general winter habitat model with S, SW, and SE facing aspects. We assumed these areas will remain relatively snow-free.
- Retain all areas with shrub height ≥3 feet.
- Discard areas with W, NW, N, NE, or E facing aspects *and* shrub height <3 feet, assuming that these shrubs would be inaccessible due to snow, *except*:
    - Retain areas where we can assume that prevailing winds will blow away snow. We assume this would occur in areas with W or NW-facing aspects with high wind speeds *and* slope >15°.

Shrub height component

We used the LANDFIRE Existing Vegetation Height (EVH) layer (USGS 2010a) to identify areas with shrub height ≥ 3 feet. We did this in three steps:

1. Reclassify the EVH layer from ordinal categories defined by ranges of height values, to integer values (in cm) at the central value of each range (Table 3).

Table 3 – Reclassification of LANDFIRE Existing Vegetation Height (EVH) (USGS 2010a) data. The first two columns, *VALUE* and *CLASSNAMES*, are taken from the original LANDFIRE EVH data. The third column, *NEW VALUE (cm)*, represents the new value assigned.

VALUE	CLASSNAMES	NEW VALUE (cm)
104	Shrub Height 0 to 0.5 meters	25
105	Shrub Height 0.5 to 1 meters	75
106	Shrub Height 1 to 3 meters	200
107	Shrub Height > 3 meters	300

2. Move a mean-filtering 3x3 window over the reclassified EVH layer. The resulting values represent our estimates of shrub height for each pixel.
3. Reclassify the raster created in step 2 such that values less than 91.44 (91.44 cm = 3 feet) are assigned values of zero and values greater than or equal to 91.44 are assigned a value of one.

Wind speed component

The wind speed component of the critical winter habitat model identifies areas with average wind speeds we assume are sufficient to keep an area relatively snow-free. The dataset used in this model component is distributed by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) as polygons; the original raster data was at a 200-m resolution (NREL 2009). We converted the polygon data to raster data at 30-m resolution. The dataset models seven classes of wind speeds at a height of 50 meters above the ground surface (Table 4) (NREL 2011). We assumed that wind power classes of 3 or greater, corresponding to wind speeds at a 50-m height ≥ 14.3 mph, would be sufficient to keep an area relatively snow free.

Table 4 – NREL wind power classes and associated average wind speeds at a height of 50-m above ground surface (NREL 2011).

Wind Power Class	Speed (b) m/s (mph)
1	0(0) - 5.6 (12.5)
2	5.6 (12.5) - 6.4 (14.3)
3	6.4 (14.3) - 7.0 (15.7)
4	7.0 (15.7) - 7.5 (16.8)
5	7.5 (16.8) - 8.0 (17.9)
6	8.0 (17.9) - 8.8 (19.7)
7	8.8 (19.7) - 11.9 (26.6)

RESULTS

The general and critical winter habitat models identify areas with suitable vegetation, topographic, and climatic conditions for sage-grouse winter habitat at much finer spatial resolution than does the existing UDWR map of sage-grouse occupied areas (Figs. 6, 7).

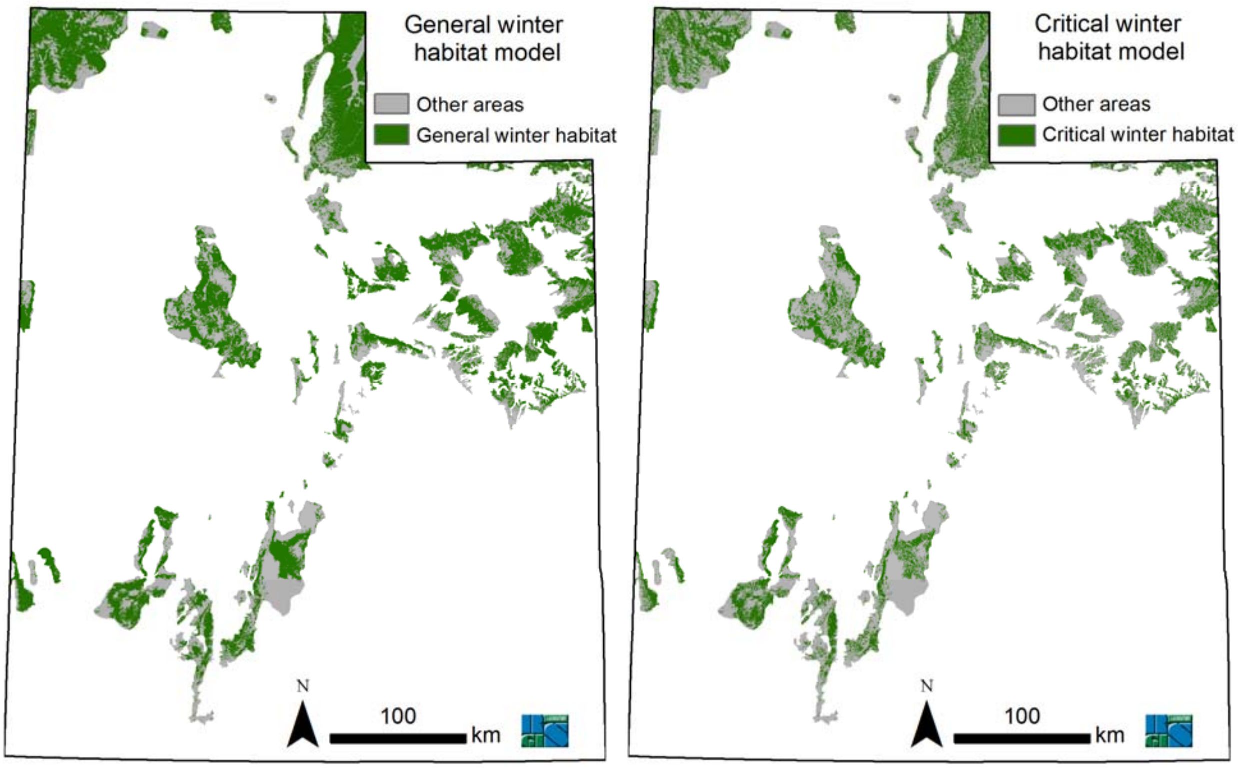

Figure 6: Comparison of the general (left side) and critical (right side) winter habitat models for UDWR-identified sage-grouse occupied areas. The general winter habitat model indicates that large amounts of land within the UDWR map of sage-grouse occupied areas may not be suitable winter habitat. The critical winter habitat model identifies those areas that would be critical for sage-grouse survival during a harsh winter in which 3 feet of snow covered large areas of the landscape.

The UDWR has 3.04 million hectares of land in Utah identified as being occupied by sage-grouse, representing 13.8% of all the state's total area. Of these 3.04 million hectares, the general winter habitat model identified 1.74 million hectares, or 57% of occupied areas, as suitable winter habitat for sage-grouse. The critical winter habitat model identified 1.22 million hectares, or 40% of occupied areas, as critical winter habitat accessible to grouse when three feet of snow cover portions of the landscape.

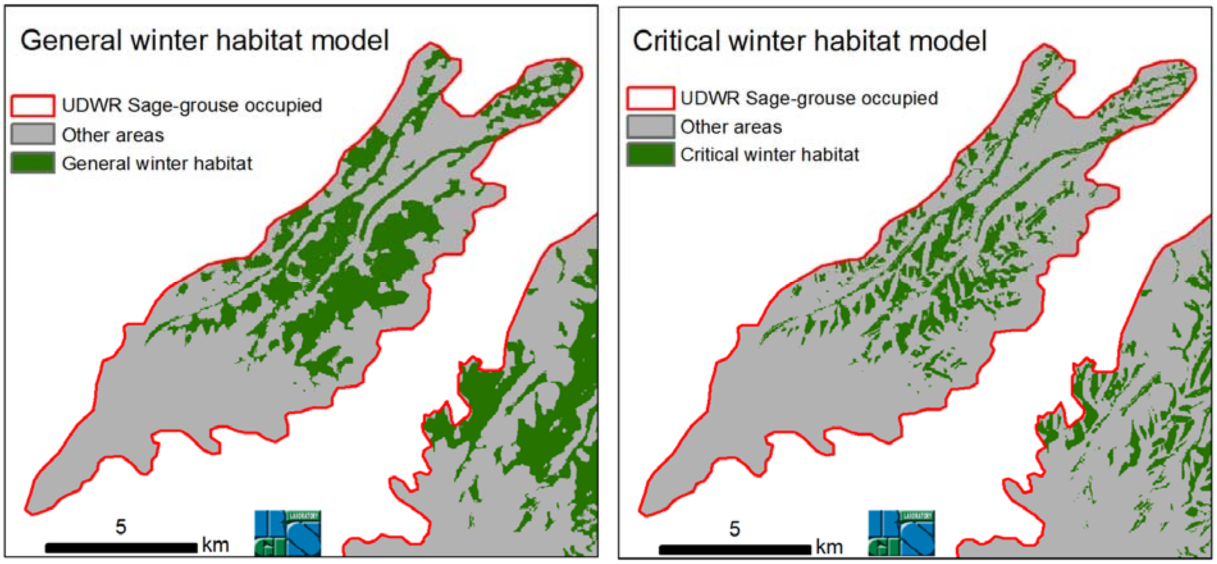

Figure 7 – Detail of comparison between the general winter habitat model (left side) and the critical winter habitat model (right side). Both models identify sage-grouse winter habitat within areas identified by UDWR as sage-grouse occupied. The general winter habitat model (left side) identifies suitable habitat based on vegetation types, elevation, slope, and aspect. The critical winter habitat model (right side) identifies critical winter habitat within areas identified by the general winter habitat model using more restrictive vegetation, aspect, slope, and wind speed criteria.

The modeling approach outlined in this paper represents an easy to implement methodology which relies on readily available and freely distributed geospatial datasets. The methodology could be refined by incorporating the knowledge of additional sage-grouse experts. The models should also be developed across the entire state of Utah and compared to the UDWR map of sage-grouse occupied areas and the UDWR map of sage-grouse winter habitat (UDWR 2011b). Model validation could be accomplished using spatially referenced field data on sage-grouse winter habitat use.

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