GREATER SAGE-GROUSE HABITAT SUITABILITY ANALYSIS IN GRAND TETON NATIONAL PARK, WYOMING, USA

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INTRODUCTION AND PURPOSE

The greater sage-grouse (*Centrocercus urophasianus)* is a large game bird and is the largest grouse in North America. The sage-grouse range varies from the western to north central United States to southern Canada. Sage-grouse have long been present in the Grand Teton National Park (GTNP) area in northwestern Wyoming. The numbers of sage-grouse, as well as quality and distribution of their sagebrush habitat, has declined over the past 50 years in the Grand Teton area and North America as a whole. Conservation efforts to increase sage-grouse populations are an important aspect of GTNP management and ecosystem protection (USRBSG LWGM, 2007).

The sage-grouse is very dependent on sagebrush habitats for its survival. Ideal habitat consists of sagebrush dominated plant communities with an understory of grass and forbs. Sagebrush is mainly located in the valley floors and foothills. Sage-grouse have various seasonal habitats, so it is essential these habitats occur in patches of the right vegetation types (Fish and Wildlife Service, 2010). For the purpose of this study, only breeding and nesting habitat for sage-grouse is considered. Breeding and nesting habitats are interrelated and it is thought that if all components of their habitat are in one area, sage-grouse might not migrate and mortality rate will decrease (USRBSG LWGM, 2007). In early spring, breeding occurs on leks, which are open mating areas such as meadows, roadsides, burns, and areas with a relatively low sagebrush cover. Large patches of sagebrush surround leks and are used for foraging and shelter. Leks are located in close proximity to nesting sites. In late spring, hens nest under mid-height, denser sagebrush with diverse forb understory and thick lateral cover (Fish and Wildlife Service, 2010; USRBSG LWGM, 2007). Sage-grouse typically benefit from an increase in precipitation. Wet climatic cycles increase the amount of grass and forb production, however, too much precipitation could physically stress and kill young chicks and have a negative impact on insects, a prime sage-grouse food source. The presence of hiking trails and roads can also negatively impact sage-grouse populations. Infrastructure-related disturbances from dust or noise have the potential to cause sage-grouse leks to become inactive over time, mask breeding related sounds, and adversely affect plants and insects (USRBSG LWGM, 2007).

This study involves a weighted habitat suitability analysis using ArcGIS software to identify ideal sage-grouse breeding and nesting habitats. Factors used in determining suitability include available food and shelter from sagebrush, annual precipitation, slope, and presence of trails and roads. To do so, relevant datasets will be obtained, converted to raster format, reclassified based on a ranking scheme relevant to each attribute, and combined to create a map depicting a rank of suitable sage-grouse breeding and nesting habitats in GTNP. I hypothesize that the most suitable habitat will consist of a medium amount of sagebrush, be relatively flat, experience a medium to high amount of annual precipitation, and will be relatively far away from trails and roads.

METHODS

Data Collection:

To begin the data collection process, raster and vector data from a variety of online resources was acquired. This habitat suitability analysis required a Digital Elevation Model (DEM) for the state of Wyoming, two geodatabase feature classes for precipitation ranges and waterbodies, and six shapefiles including data for Wyoming county boundaries, National Park

Service boundaries, the state of Wyoming boundary, Grand Teton National Park roads, Grand Teton National Park trails, and Grand Teton National Park vegetation (Table 1). After collecting the various zipped files, I extracted each of them to their own folder in my "Gathered_Data" folder (Figure 1). Some files contained their relevant metadata. For files that did not contain it, metadata was available in ArcCatalog (Figure 2).

Table 1: File name, file type, online source, original spatial reference, description, and use for each data layer used in the study

File Name	File Type	Source/Link	Original Spatial Reference	Description
Counties_OpenData	Shapefile	http://pathfinder.geospatialhub.org/datasets/3c649815e6ce4536a451555131e2fa6d_0	GCS_WGS_1984	Shapefile of Wyoming county boundaries. This will be used in creating the inset map showing the relation of GTNP to the rest of Wyoming and protected areas.
nps_boundary	Shapefile	https://irma.nps.gov/DataStore/Reference/Profile/2225713	North_American_Datum_1983	Shapefile of boundaries for all protected areas managed by the National Park Service (NPS). The GTNP boundary will be exported as its own shapefile and will be used for the boundary of the study area. Wyoming protected areas will be clipped and used in the inset map showing the relation of GTNP to the rest of Wyoming and protected areas.
state	shapefile	http://www.blm.gov/wy/st/en/resources/public_room/gis/datagis/state/state.html	NAD_1983_UTM_Zone_12N	Shapefile of the boundary of Wyoming. This will be used in creating the inset map of where GTNP is located in relation to the rest of Wyoming.

GRTEJOD R_TRANS_ Roads_In	Shapefile	https://irma.n ps.gov/DataS tore/Referenc e/Profile/2218 685	NAD_1983_U TM_Zone_12 N	Shapefile of roads in GTNP and the John D. Rockefeller, Jr. Memorial Parkway. This is a comprehensive feature class for all roads with class, access, Federal Highway, and Facility Management System attributes. This will be used to help determine sage-grouse habitat suitability
grte_veg	Shapefile	https://irma.n ps.gov/DataS tore/Referenc e/Profile/2168 721	NAD_19183_ UTM_Zone_1 2N	Shapefile of vegetation in GTNP as a part of the USGS/NPS Vegetation Mapping Project created by the Biological Resources Division (BRD) of the USGS and the NPS Inventory and Monitoring Program. This is a comprehensive feature class for all vegetative classes including ecological and physical characteristics. This will be used to help determine sage-grouse habitat suitability.
GRTEJOD R_TRANS_ Trails_In	Shapefile	https://irma.n ps.gov/DataS tore/Referenc e/Profile/2220 518	NAD_1983_U TM_Zone_12 N	Shapefile of trails in GTNP and the John D. Rockefeller, Jr. Memorial Parkway. This is a comprehensive feature class for all trails with trail name, intensity use, status, and physical attributes. This will be used to help determine sage-grouse habitat suitability.
Precip_Ran ge	Personal Geodataba se	https://irma.n ps.gov/DataS tore/Referenc e/Profile/1036 860	NAD_1983_U TM_Zone_12 N	Shapefile of precipitation data for 1971-2002 in GTNP and surrounding areas created by the NPS. This will be used to help determine sage-grouse habitat suitability

NHDWater body	Personal Geodatabase	https://irma.nps.gov/DataStore/Reference/Profile/2221114	GCS_North_American_1983	Geodatabase of GTNP water bodies and types by the Hydrographic and impairment Statistics (HIS) of the NPS Water Resource Division. This will be used in the presentation of the final map.
grdn45w111_1	Raster	http://viewer.nationalmap.gov/basic/#productSearch	GCS_North_American_1983	Raster of digital elevation data from the National Map. It will be combined with another digital elevation model to form a mosaic and will then be used to calculate slope
grdn44w111_1	Raster	http://viewer.nationalmap.gov/basic/#productSearch	GCS_North_American_1983	Raster of digital elevation data from the National Map. It will be combined with another digital elevation model to form a mosaic and will then be used to calculate slope

Figure 1: Data extraction of zipped files using digital elevation data as an example.

grteveg_nad83
Shapefile

Thumbnail Not Available

Tags
Grand Teton National Park, Wyoming, Vegetation, Land Cover and Land Use, USGS-NPS National Vegetation Mapping Program, NVCS Plant Associations, NVCS Plant Alliances

Summary
The NPS Inventory and Management goals are, among others, to consistently map and document the vegetation of all National Park Service units with a resource component, thereby creating a baseline vegetation inventory.

The purposes of this specfic mapping effort are varied and include the following: 1) provide support for NPS Resource Management, 2) promote vegetation-related research, 3) provide support for NPS Planning and Compliance, 4) add to the information base for NPS Interpretation, 5) provide a vegetation baseline inventory for the Park, 6) provide information needed for NPS Fire Program, and 7) assist in overall NPS Operations.

Description
This metadata is for the vegetation and land-use geo-spatial database for Grand Teton National Park and surrounding areas. This project is authorized as part of the USGS/NPS Vegetation Mapping Program. The program is being administered by the Biological Resources Division (BRD) of the United States Geological Survey (USGS) in conjunction with the National Park Service (NPS) Inventory and Monitoring Program. The USGS/BRD is responsible for overall management and oversight of all ongoing mapping efforts. This mapping effort was performed by the U.S. Bureau of Reclamation's (USBR) Remote Sensing and GIS Group, Technical Service Center, Denver, Colorado and NatureServe (formally The Nature Conservancy).

Credits
USBR Remote Sensing and GIS Group: David Salas,Trudy Meyer, and Mike Pucherelli. Others: Dan Cogan (Cogan Technology Inc.) and Gwen Kittle (Nature Serve).

Figure 2: Metadata stored in ArcCatalog using vegetation data as an example.

Data preprocessing:
DEM Processing
      Two DEM mosaics ("grdn44w111_1" and "grdn45w111_1") with 1 degree by 1 degree resolution were downloaded from the National Map. These two DEMs cover the total study area. They were combined using "Data Management" → "Mosaic to New Raster", creating one new raster named "DEM_mosaic" (Figure 3). This new raster has the same characteristics as the original file, including a floating point pixel type, 32 bit depth, cell size of 0.00027777778 by 0.00027777778, and 1 number of bands. "DEM_mosaic" was then projected using "Data Management → Project Raster" to NAD 1983 UTM Zone 14N using the nearest neighbor technique.
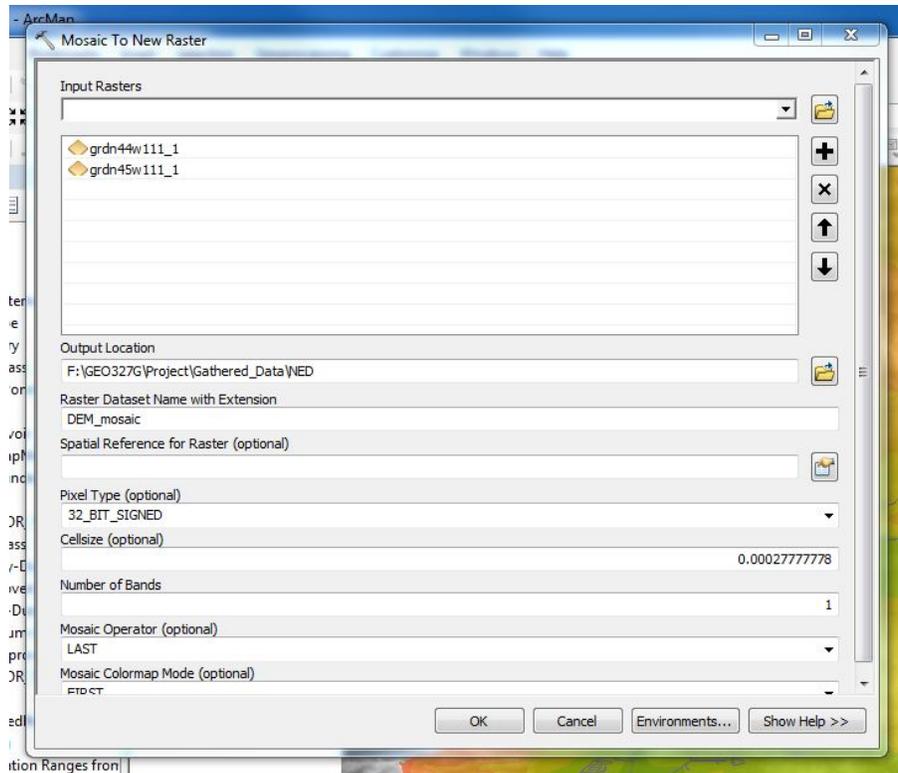
Figure 3: Mosaic to raster for digital elevation model

Assigning a spatial reference and creating a personal geodatabase

Table 1 illustrates the inconsistencies in spatial reference between data files. They must have the same spatial reference in order for the data to be accurate in relation to one another and appear in their true geographic position. Wyoming is part of both UTM Zone 12N and UTM Zone 13N. Because the region of analysis lies in northwestern Wyoming, NAD 1983 UTM Zone 12N was chosen as the new spatial reference. A personal geodatabase was then created to ease file accessibility. The Wyoming border, NPS boundary, waterbodies, rivers, trails, roads, vegetation, and precipitation files were imported using "Import" → "Feature classes (multiple) and the DEM mosaic was imported using "Import" → "Raster Datasets".

Rasterization and reclassification preparation

The "nps_boundary" is a shapefile of all National Park Service managed land. In order to obtain the border for the study area, the boundary for GTNP was selected and imported as a new shapefile "GTNP_boundary" using "Selection → Create Layer from Selected Features " then "Data" → "Export Data" (Figure 4). Precipitation, vegetation, trails, roads, and waterbodies were then clipped to the "GTNP_boundary".

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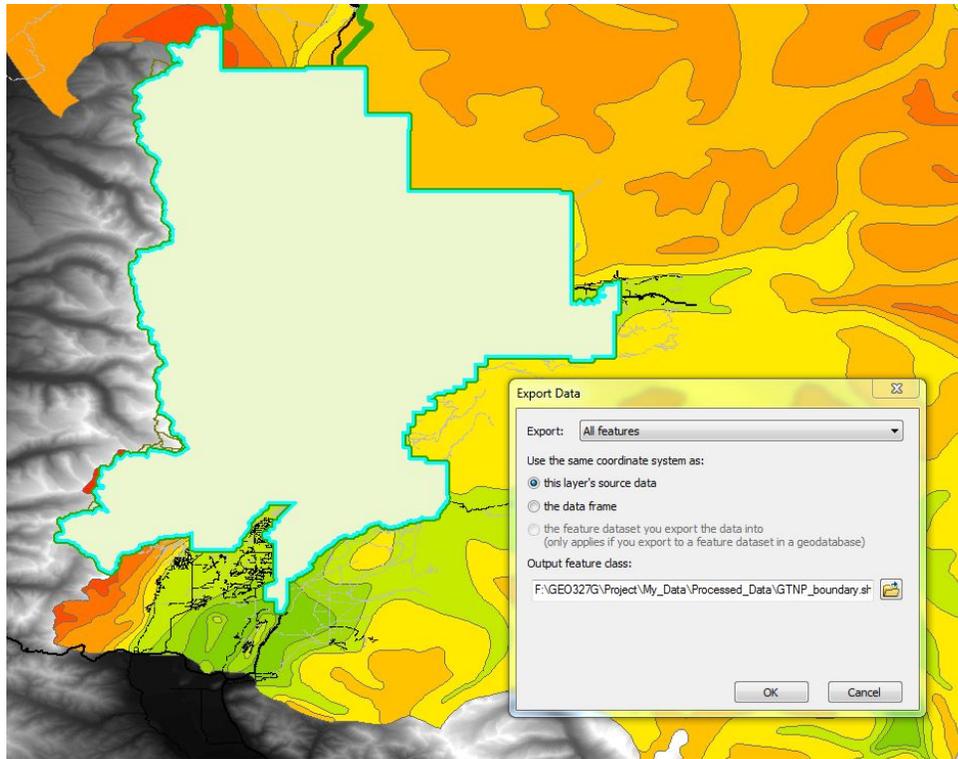
Figure 4: Export of GTNP boundary from selected features

The vegetation file attribute table was disorganized, repetitive, and contained many different types of vegetation, with most entries being very similar and specific (ex – Spruce Forest, Coniferous Woodland, Coniferous Forest, Sparse Vegetation, Herbaceous Vegetation). General descriptors such as "Woodland", "Shrubland", "Herbaceous Grassland", "Sagebrush", and "Sparse Vegetation" would be sufficient, reduce redundancy, and increase data processing speed. The attribute table contained over 25,000 FIDs. Because the amount of editing was limited from the large file size and resulted in an ArcMap crash the majority of the time, only three vegetation types, "Shrubland", "Sagebrush", and "Herbaceous Grassland", were used in this study. They were selected by attribute and exported as a new layer (Figure 5).

Figure 5: Vegetation attribute table and selection of sagebrush

Because proximity to trails and roads negatively impacts sage-grouse populations, buffers for the "GRTEJODR_TRANS_Trails_In" and "GRTEJODR_TRANS_Roads_In" were created. Because roads are used more frequently and have greater negative effects than trails, different buffers were created for each file. Two buffer distances were also created to better analyze habitat suitability (Table 2). To create the trail buffer, the "Multiple Ring Buffer" tool was used, setting the "Input Features" to "Trails_clipped", "Distances" to distances specified in Table 2, "Buffer Unit" as meters, and "Dissolve Type" to "All" (Figure 6). This process was repeated for the roads file, setting "Roads_clipped" as the "Input Features" (Figure 7) (Figure 8). Because some regions in the new buffered trails and roads file lie outside of the GTNP boundary, these files were also clipped (Figure 9).

Table 2: Buffer descriptions for trail and road files

File Description/Name	Buffer Width [m]
Trails - GRTEJODR_TRANS_Trails_In	100 m
	200 m
Roads - GRTEJODR_TRANS_Roads_In	500 m
	1000 m
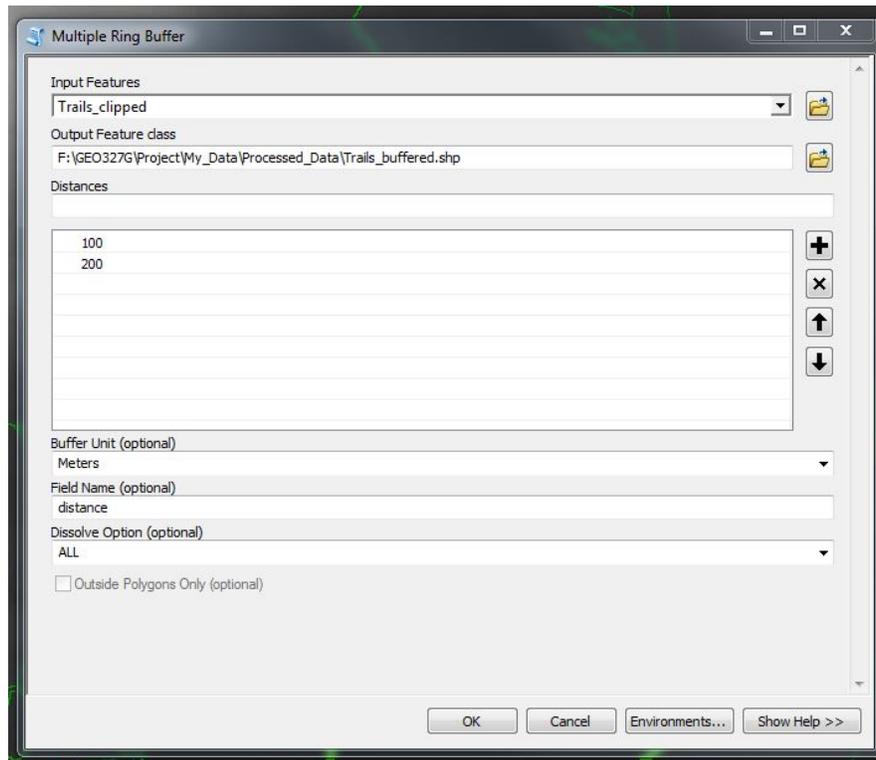
Figure 6: Multiple ring buffer creation for clipped trails file
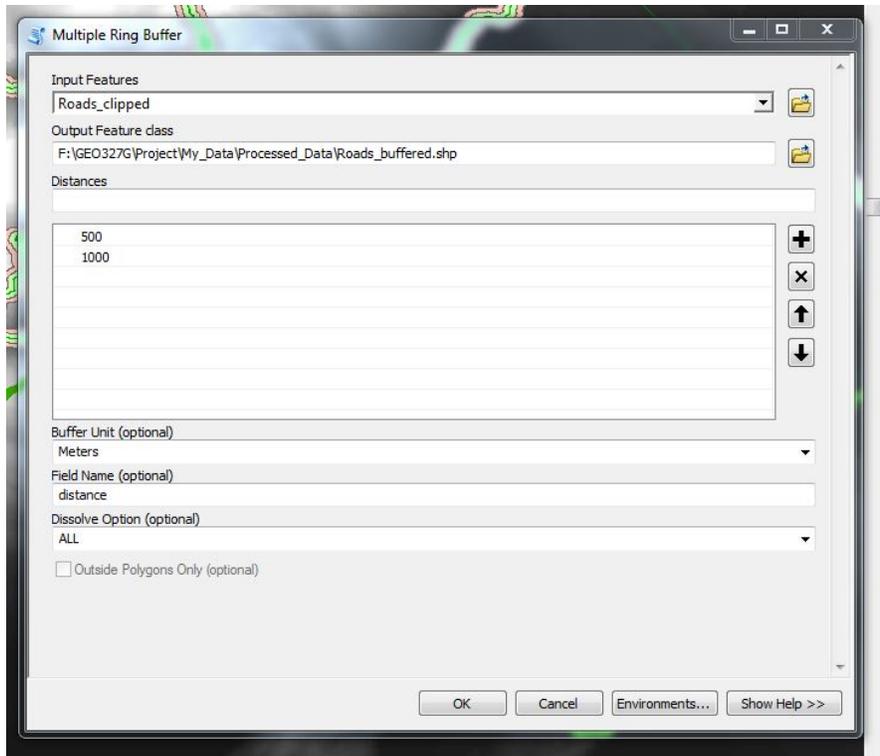
Figure 7: Multiple ring buffer creation for clipped roads file
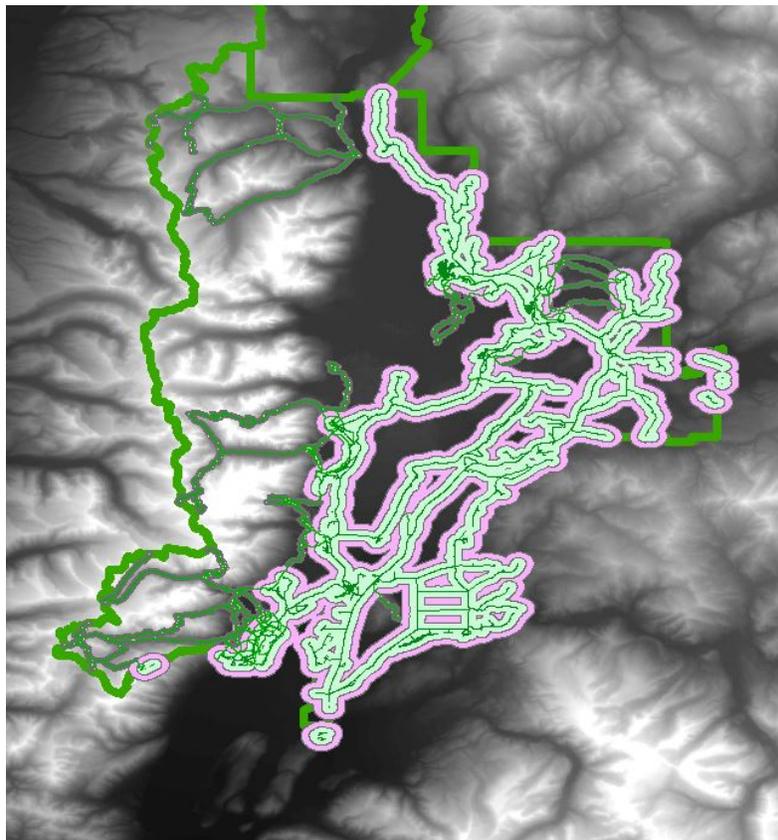
Figure 8: Buffered regions for trails and roads
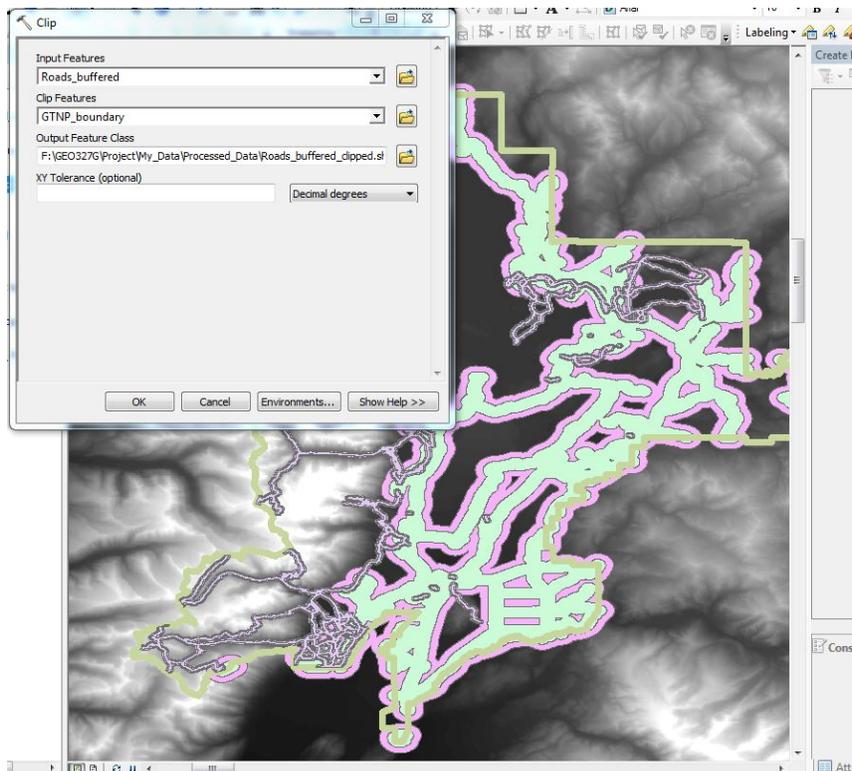
Figure 9: Clipping of buffered roads file

Data processing:
Generating raster datasets

      To prepare data for rasterization, I created a "New_Grids" folder. Using the "Environment" tab, "New_Grids" was set as the working directory and the "GTNP_boundary" was set as a mask. The clipped vegetation, clipped precipitation, clipped buffered trail, and clipped buffered road vector layers were converted to rasters using the "Convert" → "Features to Raster" tool in the "Conversion" toolbox (Figure 10).

      As stated earlier, the clipped vegetation file now only contains data regarding "Sagebrush", "Herbaceous Grassland", and "Shrubland". A similar situation occurred with the buffered trails and roads files. The only regions with data were the buffered regions, leaving a majority of GTNP without data. This will create problems during the reclassification step. Therefore, the "Raster Calculator" was used to assign cells with "NoData" a numerical value of 0 (Figure 11). This was done for the vegetation, buffered trails, and buffered roads files.

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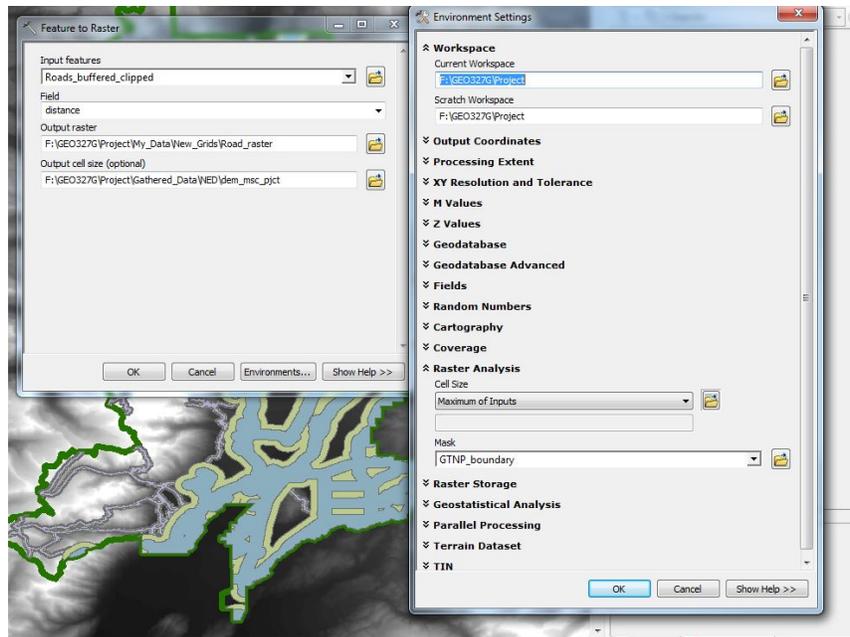
Figure 10: Feature to raster conversion of buffered road file
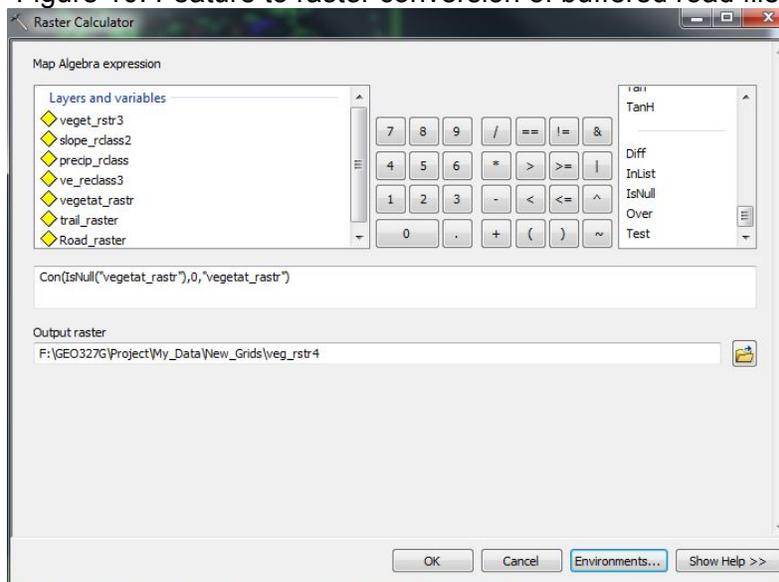
Figure 11: Raster calculation to assign value to "NoData" cells

Slope calculation

In order to quantitatively asses slope, the DEM mosaic needs to be analyzed. Slope calculation involved the "Slope" tool under the "Surface" tool of "Spatial Analyst". Slope is calculated using a degree output measurement. Setting the mask to the "GTNP_boundary" clips the new raster to the boundary. This produced a new raster depicting the various degrees of slope in GTNP (Figure 11) (Figure 12).
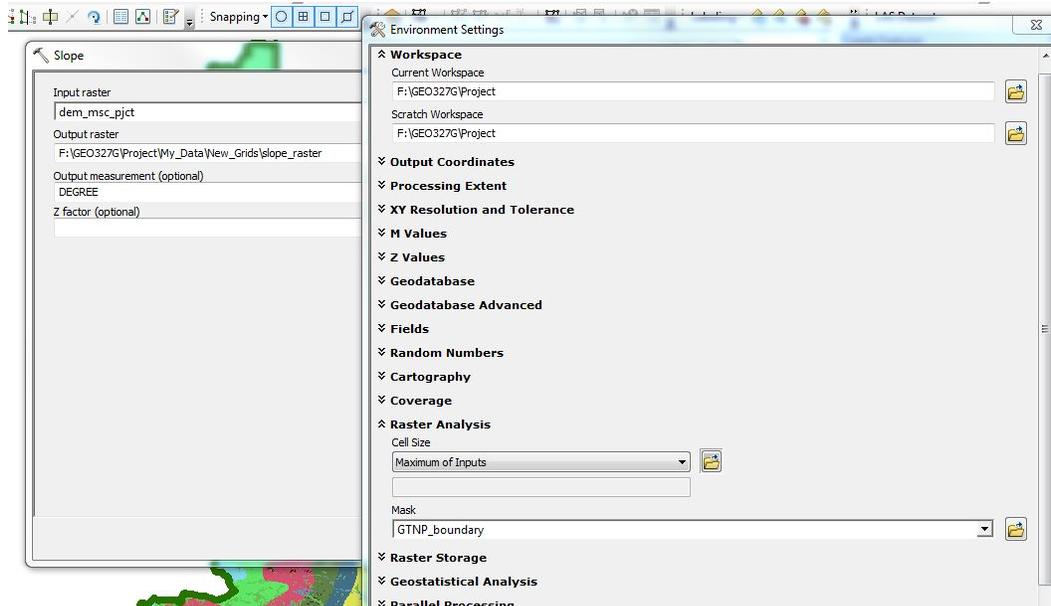
Figure 12: Slope calculation
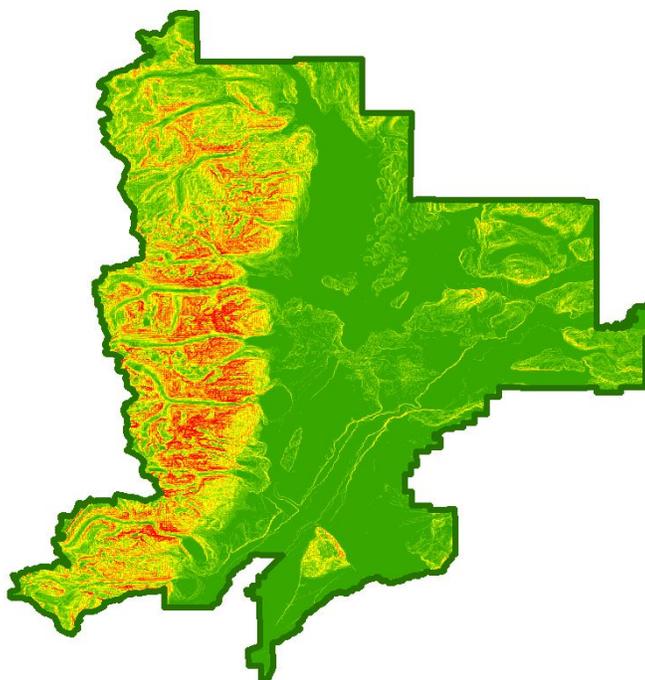
Figure 12: Results of slope calculation illustrating slope in GTNP.

Development of ranking scheme and reclassification

A ranking scheme for each of the new rasters was produced using general knowledge obtained from publications (USRBSG LWGM, 2007) (Table 3). The ranking of each raster is not dependent nor affected by one another. The highest rank (generally a 5) corresponds to the most habitable attribute.

- Slope: Sage-grouse generally occupy habitats with minimal slope. Therefore, optimal sage-grouse habitat was assigned a slope of less than 5 degrees
- Vegetation type: Vegetation is a key factor impacting sage-grouse distribution. Sage-grouse depend on sage-brush, as well as a fresh herb understory for food and shelter. This is why sagebrush received the highest rank (5) and herbaceous grassland received the middle rank (3). Shrubland is also relatively important, but received a lower rank (1) because it is not vital to sage-grouse success.
- Precipitation: Sage-grouse rely on large amounts of rain, however too much can be detrimental. There was some ambiguity when assigning rank. Precipitation of 40 – 60 in/yr received the highest rank (5), while less than 20 in/yr received the lowest rank (0).
- Distance to trail: Proximity to disturbances, such as trails, can be detrimental to sage-grouse populations. The distance greater than the largest buffer received the highest rank (5), while the distance of the smallest buffer received the lowest rank (0).
- Distance to road: Proximity to disturbances, such as roads, can be detrimental to sage-grouse populations. The distance greater than the largest buffer received the highest rank (5), while the distance of the smallest buffer received the lowest rank (0).

The "Reclassify" tool within the "Spatial Analyst" toolbar was used to assign ranks and reclassify datasets (Figure 13).

Table 3: Reclassification scheme for slope, vegetation type, precipitation, distance to trail, and distance to road.

Rank	Slope	Vegetation Type	Precipitation [in/yr]	Distance to Trail [m]	Distance to Road [m]
0	>25	-	<20	<100	<500
1	20 - 25	Shrubland	-	-	-
2	15 - 20	-	20 – 40	100 - 200	500 - 1000
3	10 - 15	Herbaceous Grassland	60 – 80	-	-
4	5 - 10	-	-	-	-
5	<5	Sagebrush	40 – 60	>200	>1000
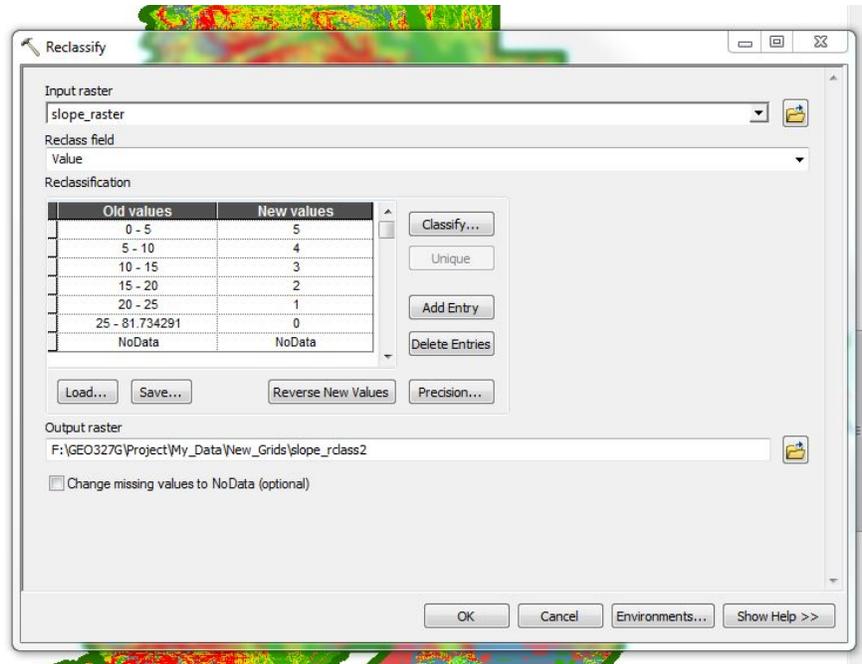
Figure 13: Reclassification regarding slope intensity

Assessing suitable habitats

      All five factors were treated with equal weight to attempt to reduce error when ranking and relatively limited knowledge of sage-grouse habitat. "Raster Calculator" was used to add the five rasters, resulting in the final raster depicting sage-grouse habitat suitability (Figure 14).
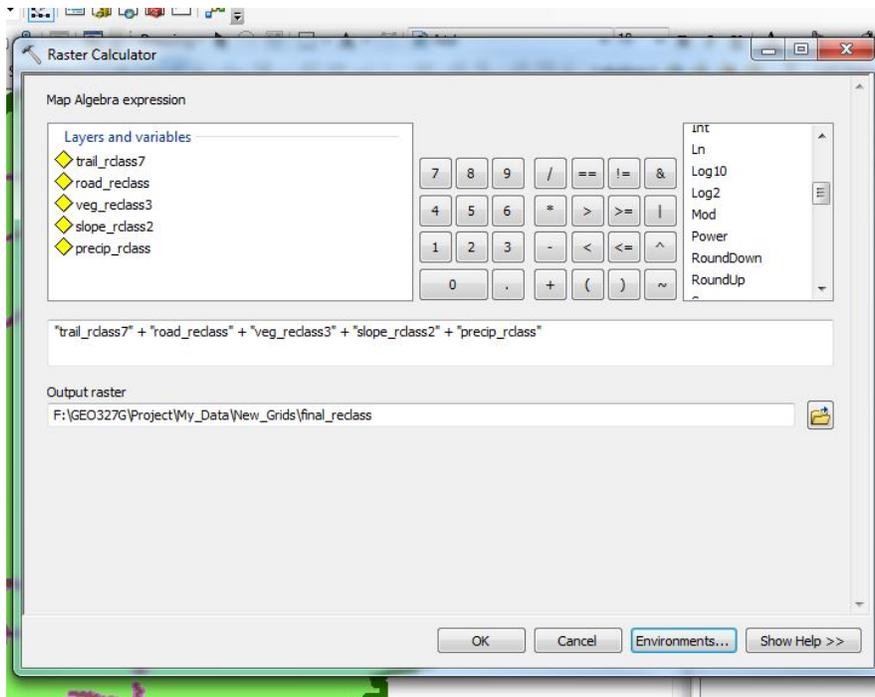
Figure 14: Adding the five reclassified rasters into a single raster

RESULTS AND CONCLUSION

Suitable areas for sage-grouse breeding and nesting in GTNP are relatively fragmented. A large highly suitable area is located in the southeast corner of the park. This large area is in close proximity to another relatively large area. More fragmented areas are located in the northeast, southwest, and eastern sections of the park. It is interesting to note that the most suitable areas are in close proximity to infrastructure and therefore a large number of visitors, possibly suggesting the increase likelihood of sage-grouse in areas that are separated from, but not isolated from human development. The two largest and most connected areas occur in areas where sagebrush is the most prominent. There is a strong correlation between vegetation distribution and suitable areas, especially in regards to sagebrush and herbaceous grasslands. It is also interesting to note that highly suitable, but fragmented areas occur in the western portion of the park. This is actually where the highly steep Grand Teton Mountains occur, therefore preventing sage-grouse occupation. This is the area that receives the majority of precipitation and contains the most land far away from human intervention. Although this analysis simplified a highly complex process, vegetation, slope, precipitation, distance from trails, and distance from roads are necessary to consider when predicting and studying sage-grouse habitat. This study could be improved through a better knowledge of sage-grouse habitat, a better developed ranking scheme, and the inclusion of previous fire disturbances, human disturbances, and predator distribution within GTNP.

Habtiat Suitability Analysis for Greater Sage-Grouse
in Grand Teton National Park, Wyoming, USA

0   5   10   20
Km
Scale: 1:350,000

N

Legend
Sage-Grouse Habitat Suitability

2 - Lowest	10	18	Lake
3	11	19	Trail
4	12	20	Road
5	13	21	GTNP Boundary
6	14	22	NPS Boundary
7	15	23	
8	16	24	
9	17	25 - Highest	

0   150   300
Km
Scale: 1:1,350,000

N
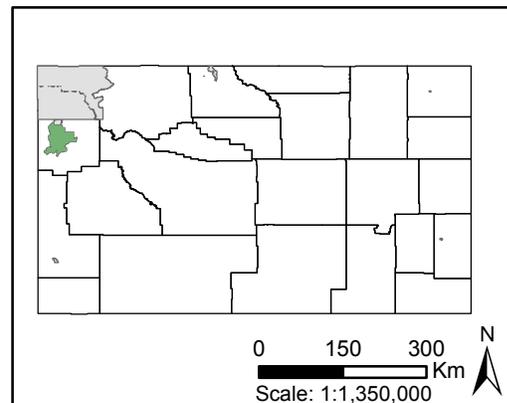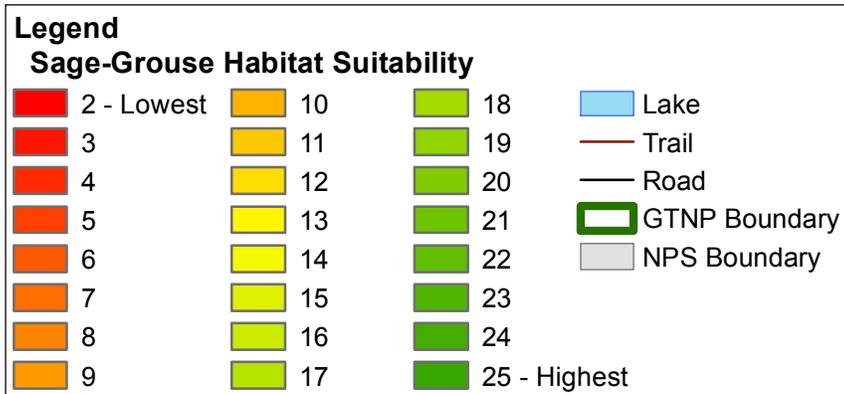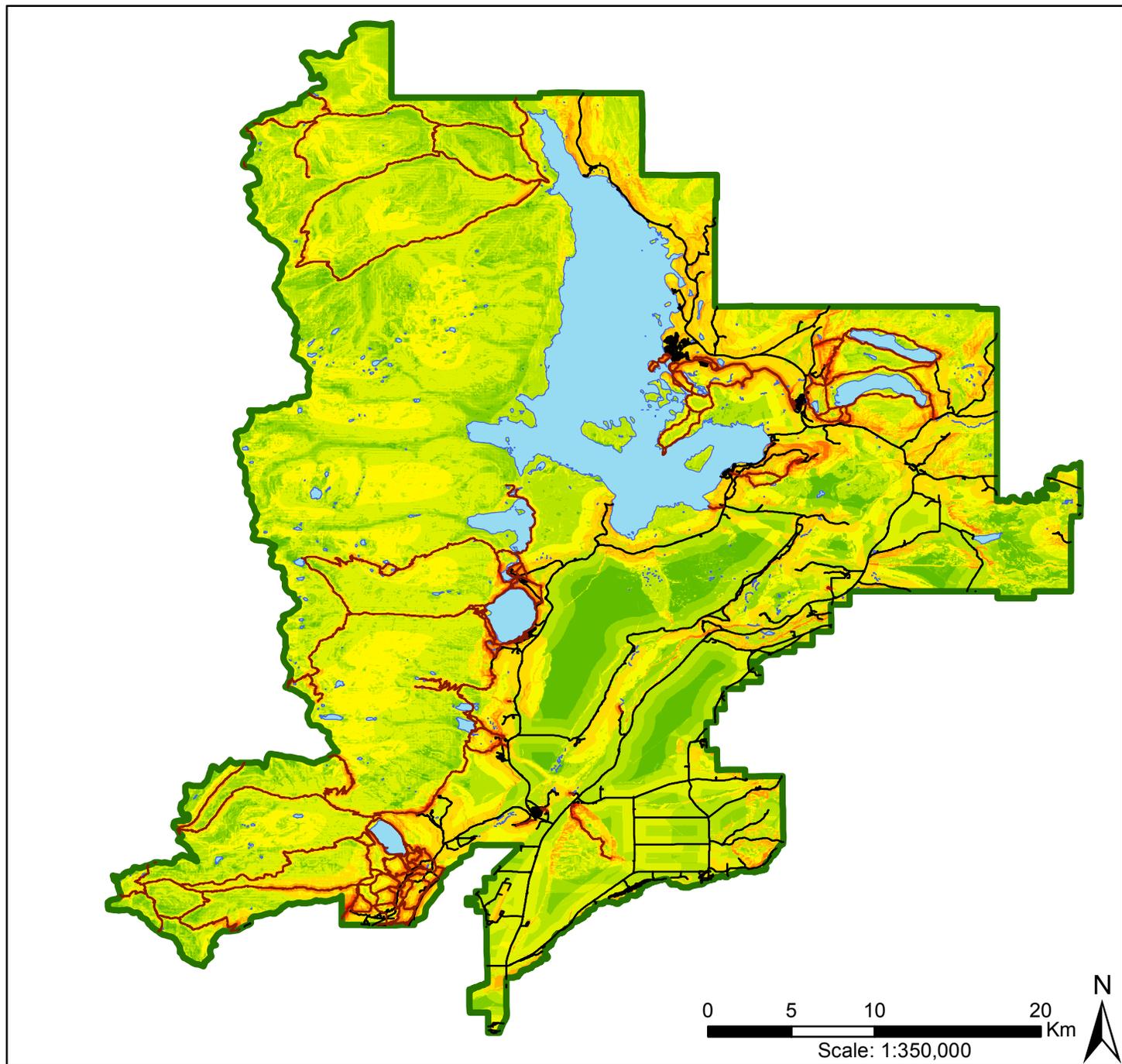
* Habitat suitability for the sage-grouse in Grand Teton National
Park was determined based on equal weights of vegetation type,
annual precipitation, slope, distance to trails, and distance to roads

Projection: Transverse Mercator
Coordinate System: NAD 1983 UTM Zone 12N

REFERENCES

USRBSG LWGM, 2007: Upper Snake River Basin sage-grouse conservation plan. Upper Snake River Basin Sage-Grouse Local Working Group Members, 1-156.

Fish and Wildlife Service, 2010: Endangered and threatened wildlife and plants; 12-month findings for petitions to list the greater sage-grouse (*Centrocercus urophasianus*) as threatened or endangered. Department of the Interior, 1-103.