Sustaining Connectivity of the Greater Sage-Grouse Ecosystem in Increasing Warming Scenarios

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Skills for Undergraduate Participation in Ecological Research

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Research Summary

The transboundary corridor between northern Montana and southern Saskatchewan provides a significant and important ecosystem for migration of the Greater Sage-Grouse. Ecological habitat connectivity of the species is of great importance as well, and different parcels of protected areas are expected to change in importance of this connectivity in different warming scenarios. This project answers the question of if greater protection of conserved parcels of land, as denoted by IUCN categorization, are associated with greater connectivity of sage grouse as warming increases in the Saskatchewan-Montana corridor. Spatial data of protected areas, species suitability requirements, and habitat suitability data was used in order to process and analyze data. The software Graphab was used in this process to calculate key metrics for connectivity, which was then analyzed using QGIS to assess importance of nodes, links, as well as allowing the data to be visualized through mapping processes. It was concluded that natural monuments as well as habitat or species management areas, associated with IUCN categories of three and four, provided the greatest increase of connectivity for the species. This leads to recommendations for an increase of protected areas within these categories in order to preserve connectivity as much as possible throughout this transboundary ecosystem.

Introduction

The Greater sage-grouse (Figure 1) is denoted as a sensitive species in the United States, and their winter food source, sagebrush, is significantly decreasing in amount and connectivity over time (Tack et al., 2011). Because of such, and their identified decreasing populations over time, they have been of high priority and concern for conservation, and efforts to do so have also been of recent focus.

It is important to understand terms such as ecological connectivity, as well as the difference between structural and functional connectivity. Connectivity within ecosystems is defined as, “the unimpeded movement of species and the flow of natural processes that sustain life on Earth,” and includes both structural and functional connectivity, in terms of species, within it (CMS, 2020). Functional connectivity describes the ability of genes or individuals to move through an ecosystem, while structural connectivity measures physical features, patches of habitats, and disturbances (Hilty et al., 2020). Both of these aspects of connectivity are important to consider for overarching connectivity and conservation of a species.

Sagebrush, the main food source for sage-grouse, are largely found in the western United States, and patterns of its structural connectivity have been assessed in order to prioritize areas for conservation, as shown in Figure 2 (Buchholtz et al., 2024). One area in particular, a transboundary corridor existing on the northern border of Montana and the southern border of Saskatchewan, can be seen to be of particular importance as assessed in numerous studies for areas necessary to ensure connectivity of sage-grouse due to its importance for migratory pathways of sage-grouse (Belote et al., 2016; Tack et al., 2019). This area, Figure 3, along with the important migratory pathways which exist within it, also is situated between Grasslands National Park in Saskatchewan and the Glaciated Sage-Steppe region in Montana and is an important ecosystem for many other species which also rely on sage brush.

Currently, there is a lack of a more detailed qualitative analysis which would identify possible critical areas for conservation, as well as possible links, within the corridor of interest for this research. Along with this, research which highlights the possible increasing importance of certain areas for conservation in increasing warming scenarios in the future also has not been done. Yet, there has been a call for this to be done, especially in transboundary corridors such as that for this research, as often policy does not align (Beazley et al., 2021; Thornton et al., 2019). The purpose of this study is to begin to address these gaps, with a research question specifically asking if greater protection of spaces, as denoted by IUCN categorization, is associated with greater connectivity of sage grouse as warming increases in the Saskatchewan-Montana corridor.

Figure 1. Male greater sage-grouse performing a lek, a mating ritual, standing upon sagebrush. Photo credit: S.J. Krasemann

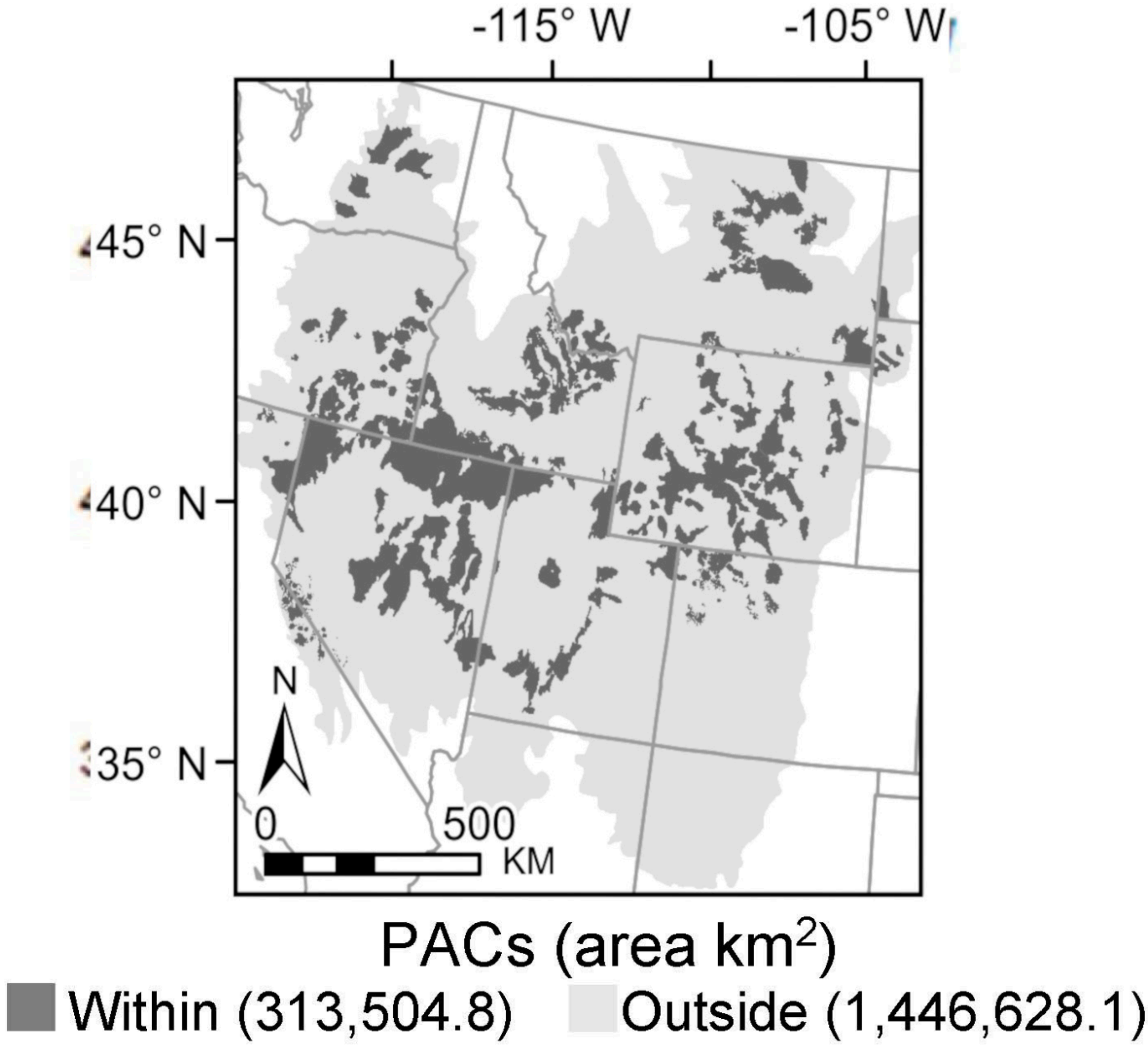

Figure 2. Priority areas for conservation of sagebrush in the western United States, denoted as within or outside conservation areas, from Buchholtz et al., 2024.

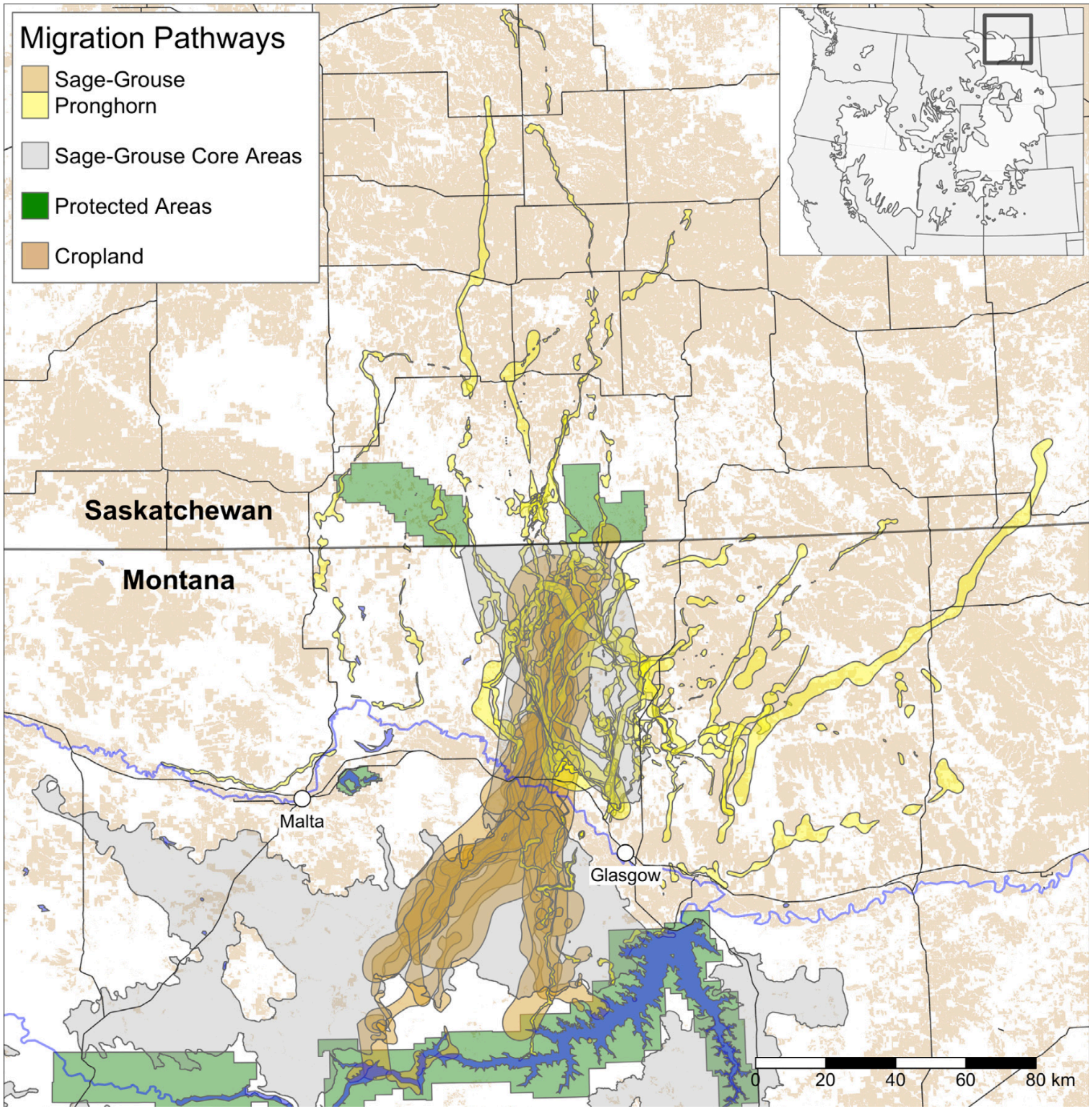

Figure 3. Study area of Montana-Saskatchewan corridor, showing migratory pathways of sage-grouse as well as pronghorn, and some of the assessed protected areas in this project, from Tack et al., 2019.

Research Questions and Hypotheses

Research Question:

Is greater protection of spaces, as denoted by IUCN categorization, associated with greater connectivity of sage grouse as warming increases in the Saskatchewan-Montana corridor?

Research Hypothesis:

As areas are under greater protection status, sage grouse have greater connectivity, exasperated as warming increases in the Saskatchewan-Montana corridor. Greater sage-grouse will prefer to migrate through these areas with increased protection and travel further to do so.

Null Hypothesis:

As areas are under greater protection status, the connectivity of sage-grouse does not change, and exasperation of such does not increase with warming in the Saskatchewan-Montana corridor.

Explanation:

If areas or patches are greater protected, they are more likely to most closely resemble a habitat preference to sage grouse. Sagebrush would be expected to be present in greater amounts, and anthropogenic disturbances would be lessened with greater conservation measures.

Methods

The methods of this project can be categorized into three distinct parts, data collection which occurred prior to the start of this project specifically, processing in Graphab, and analysis in QGIS (Figure 4).

Data Collection

Data used within this project was collected and pre-processed by Dr. Sergio Nicasio-Arzeta and Dr. Julie Heinrichs or publicly accessible through various databases. All data is spatial in form, in order to be analyzed in that way as well. As this project is transboundary in nature, crossing the border of the United States and Canada, both USGS data as well as Parks Canada data was utilized as well as data from the World Database on Protected Areas, which provided the shapefiles for protected areas in both countries. In order to assess habitats for the greater sage-grouse, it is necessary to see which areas are suitable, as well as their median dispersal distance data. These are essential to assess connectivity and sourced from Rangeland Condition Monitoring Assessment and Projection data.

Data Processing

Data processing occurred using Graphab, an open source software program. Importing spatial data provided into Graphab, following further processing, produces the equivalent connected area. The equivalent connected area provides a key metric to understanding connectivity over time, and in this project in the different warming scenarios tested. Probability of connectivity is also calculated using Graphab, in order to assess protected areas which may or may not be in connectivity with each other. The integral index of connectivity, again calculated in Graphab, looks at how well areas are connected with one another. This assesses which areas in particular are of greater importance than others in terms of sustaining connectivity, giving each a value of how significant their connectivity is.

Data Analysis

In analyzing the data, the key metrics provided using calculations in Graphab will be looked at both spatially, as well as graphically. Using the three prior specific metrics, nodes and links of the study area will be assessed for importance, to answer the hypothesis regarding the significance of varying status of protected areas. Metrics are further processed using Excel in order to create the assessed percentage change of each within the IUCN categories. With this, visualization and mapping processes are especially important to analyze as well, occurring using QGIS. These maps also aid in visualizing the implications of what connectivity may look like as it continues across the border.

Methods Diagram

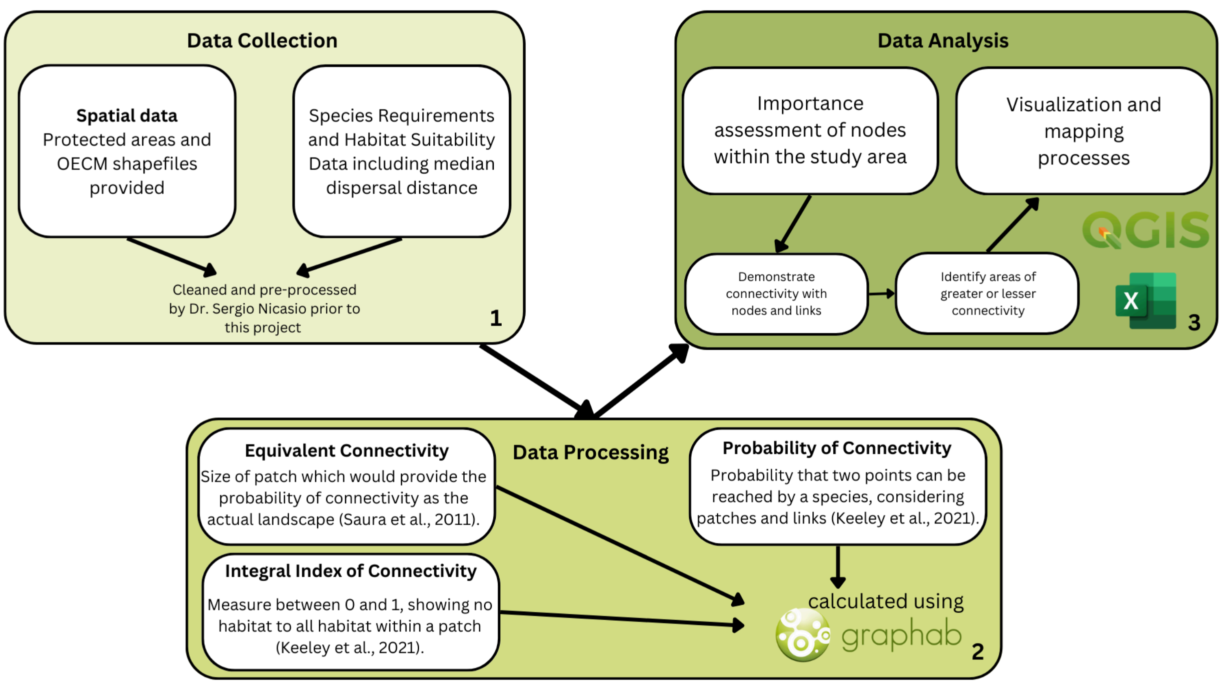

Figure 4. Diagram of the three phases of the methods used to answer the research questions, of data collection, data processing using Graphab, and data analysis using QGIS and Excel.

Results

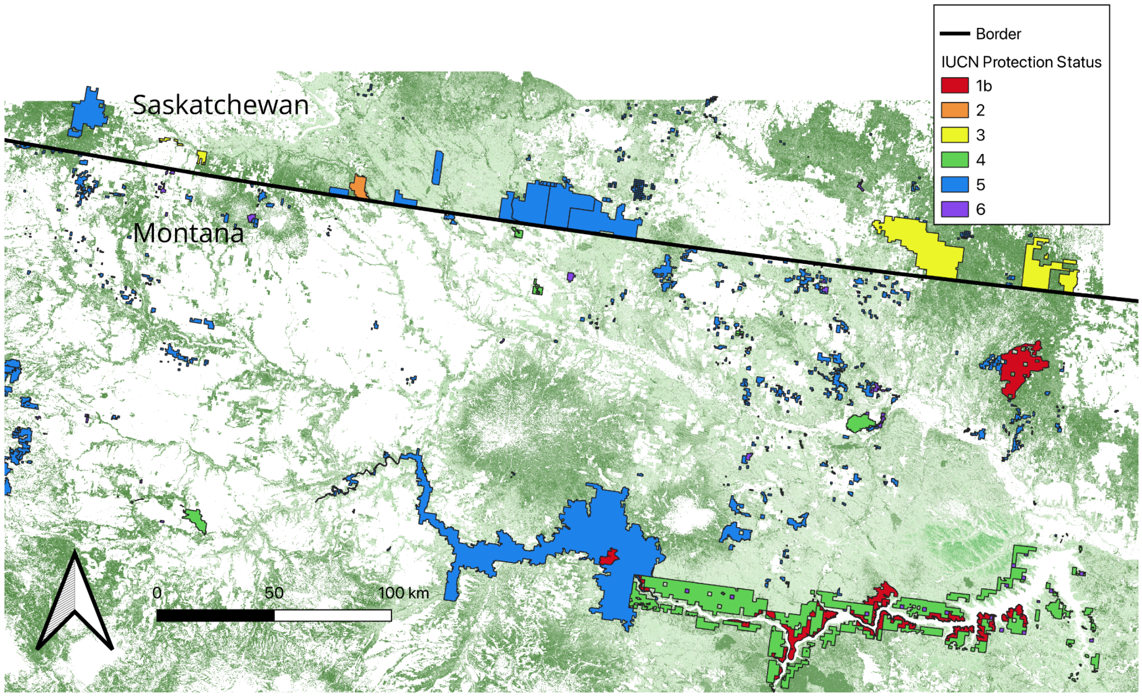

Figure 5. Map of the study area and assessed protected areas, showing IUCN categorization of protection status and border between Canada and the United States.

Table 1. Percent change of three connectivity metrics in two climatic scenarios in five different categories of protected areas within the study area.

Metric / IUCN Categorization	Probability of Connectivity RCP 4.5	Probability of Connectivity RCP 8.5	Equivalent Connectivity RCP 4.5	Equivalent Connectivity RCP 8.5	Integral Index of Connectivity RCP 4.5	Integral Index of Connectivity RCP 8.5
Ib - Wilderness Area	-4.26%	-4.80%	-4.27%	-4.81%	-1.99%	-1.99%
II - National Park	-1.62%	-2.18%	-1.62%	-2.18%	-1.71%	-1.71%
III - Natural Monument	14.72%	14.27%	14.72%	14.26%	11.18%	11.18%
IV - Habitat or Species Management Area	18.03%	17.82%	18.03%	17.83%	16.07%	16.07%
V - Protected Landscape	0.00%	0.84%	2.85%	2.93%	3.53%	3.38%
VI - Managed Resource Protected Area	-1.74%	-2.23%	-1.74%	-2.23%	-1.67%	-1.66%

Results indicate that protected areas designated as natural monuments, habitat or species management areas, and protected landscapes in the study area will provide increased connectivity in both climatic scenarios assessed (Table 1). Along with this, areas designated as wilderness areas, national parks, and managed resource protected areas in the study area will have lessened connectivity for the sage-grouse in the two scenarios assessed (Table 1).

Discussion

The results show that in the climatic warming scenarios analyzed, areas of more median protected measures are associated with greater connectivity of the Greater Sage-Grouse. Habitat or species management areas provided the most increase of connectivity, followed by natural monuments, and then protected landscape which provided lesser, but still evident increased connectivity in the scenarios assessed. The metrics analyzed in order to understand this demonstrate that connectivity is significantly determined by the factors of how an area is protected.. The proposed hypothesis was not supported by these findings as they did not prove that connectivity increased in areas of higher protection, designated by IUCN categorization. Figure 5 shows the IUCN categorizations of the different protected areas within the study area, with all represented but 1a, strict nature reserve, and 2, national park. Figure 6 shows the different scenarios and the change of connectivity which occurs in each.

Limitations of this research lie in the relatively small area which this study encompasses. Thus, the applications of the findings may be difficult to apply to all migratory pathways of Greater Sage-Grouse of the Western United States. Along with this, although models provide a start to predicting connectivity, a number of currently unpredictable variables may impact this in the future. Still, these findings begin to fill a gap in knowledge to identify critical areas for conservation within transboundary corridors in order to begin to align policy between the United States and Canada to conserve the species.

The next steps in order to further this research may include to conduct an assessment for a broader study area which encompassess all of the IUCN protected area categories, or an assessment which includes other species beyond the Greater Sage-Grouse. This would ensure that stakeholders have the full picture of the conservation of other important keystone species in areas of concern to make a well-informed management decision.

Conclusions

It was found that in the area analyzed, as well as within the three particular scenarios, that areas of median protection are associated with greater connectivity of the Greater Sage-Grouse, as in greatest increase of connectivity for category four, habitat or species management areas, second in natural monuments, and third as in the only other category with an increase being protected landscapes. These findings can be applied to policy, prioritizing an increase of areas dedicated to habitat and species management in order to ensure connectivity of the Greater Sage-Grouse in the future. Future work may continue to create models based on any change within this area, as well as consider other species in the area, such as Pronghorn Antelope, in order for prioritization of conservation to occur in consideration of the connectivity of other species as well.

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