Description of Gallatin County Wildlife Connectivity Modeling

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I. Purpose

Landscape connectivity is critical to the health of wildlife populations and facilitates processes such as gene flow, migration, dispersal, and adaptation to climate change. Information is needed on the locations within the landscape that are most important for supporting animal movements to adequately protect and restore wildlife connectivity. Directly observing animal movements is ideal (e.g., tracking of individual animals via GPS collars) but is typically not possible to accomplish across large spatial extents for many species. In such cases, connectivity modeling can fill the information gap by predicting patterns of wildlife movement using algorithms that simulate movement as a function of landscape characteristics.

This document describes a set of wildlife connectivity models created by the Center for Large Landscape Conservation to inform conservation and planning efforts within Gallatin County. Spatial outputs of these models may be helpful in making decisions such as where to pursue conservation easements or other forms of land protection, where to prioritize habitat restoration, or where to construct wildlife crossing structures across roads. We hope these models will complement other available sources of information on wildlife movement including wildlife telemetry data and the expert opinion of biologists.

II. Methods

Gallatin County contains hundreds of wildlife species that are all worthy of consideration and have distinct connectivity needs, but modeling connectivity for each species individually is impractical. We therefore chose to use a generic species approach in which we modeled connectivity for a set of virtual species with ecological requirements designed to reflect the needs of a group of real species. A similar approach was recently used to model wildlife connectivity for the Custer-Gallatin National Forest (Williamson et al. 2020). We considered four generic terrestrial species that represent different habitat preferences: a forest specialist species, a grassland specialist species, a shrubland specialist species, and a generalist species that prefers all three of these vegetation types.

The spatial extent of our connectivity modeling encompassed Gallatin County plus a 50-km buffer, but we clipped the model outputs to a smaller 30-km buffer around the county. This allowed us to eliminate edge effects that would otherwise bias results for grid cells near the study area boundary. All analyses were conducted using spatial data in the NAD 83 Albers Equal Area projection. Model outputs were later reprojected to WG84 UTM Zone 12 for incorporation in the Gallatin Valley Sensitive Lands Modeling Tool.

Connectivity models require as input a resistance surface – a gridded representation of the landscape in which the value of each grid cell reflects how difficult it is for an animal to move through that cell. We used information on the degree of human influence of the landscape (e.g., development, agriculture, energy production, mining, linear infrastructure) to derive a preliminary resistance surface for all generic species. The human modification index (Theobald 2013), H, quantifies modification at 270-m resolution for landscape conditions in 2016 on a scale ranging from 0 to 1. We calculated landscape resistance, R, in each grid cell as:

$$R = (H + 1)^{10}$$

Our preliminary resistance surface therefore assumed that wildlife preferred to move through areas that are less impacted by human development and activities, and that resistance to movement increased exponentially with degree of modification. We then altered this resistance surface to reflect the vegetation preferences associated with each generic species. We used 30-m resolution LANDFIRE version 2.3 Existing Vegetation Type data (LANDFIRE 2022) to classify each grid cell as forest, grassland, shrubland, or non-habitat (all other vegetation types and areas without vegetation) based on the Lifeform attribute. For each generic species, we doubled the resistance value in all grid cells that were a vegetation type other than that preferred by the generic species. For the generalist species, resistance was only doubled in grid cells that were classified as non-habitat.

We considered two scales of movement for each generic species. The first set of connectivity models predicted regional connectivity (movement distances of up to ~300 km). These models were intended to represent long-distance movements that occur infrequently or over long periods, such as seasonal migrations, natal dispersal events, and range shifts in response to climate change. We ran the regional models at a spatial resolution of 270 m using the Circuitscape connectivity algorithm (Shah and McRae 2008). Circuitscape utilizes electronic circuit theory to predict connectivity across a resistance surface between specific source and destination locations (i.e., habitat patches or points) within a landscape. We created a series of 50 evenly spaced points along the perimeter of the 50-km buffer around Gallatin County to serve as source points, then modeled connectivity between from each source point to all 49 other points. When model outputs were summed across all source/destination pairs, the results of this "wall-to-wall" implementation of Circuitscape indicated overall patterns of movement across the study area in all directions.

The second set of models predicted local connectivity (movements up to 5 km), a scale that was intended to represent the regular daily movements of animals (e.g., in search of food, water, and shelter). These connectivity models were run at a finer spatial resolution of 30 m using the Omniscape connectivity algorithm (McRae et al. 2016; Landau et al. 2021). Omniscape uses circuit theory to simulate omni-directional movement across a resistance surface between source grids cells and a set of target grid cells of sufficient habitat quality within a circular radius of the source (5 km in this case). Unlike Circuitscape, Omniscape does not require identification of discrete source and destination locations; rather, it considers all grid cells in the landscape as potential sources and destinations if habitat quality is sufficient. We defined sources and targets as all grid cells in the landscape that were the preferred vegetation type for the generic species of interest and had an H value <0.1, which a previous publication considered the cutoff between low and moderate human impact (Kennedy & Oakleaf 2019).

The outputs of Circuitscape and Omniscape analyses were maps of cumulative current, in which the value for each grid cell represented the predicted amount of animal movement through the cell. We rescaled the values in each output map to range from 0 to 1 for easier interpretation and comparison. Cells with higher values can be interpreted as more important for landscape-level wildlife connectivity.

III. Notes on outputs

The outputs of this analysis are eight GeoTIFF raster files representing connectivity values for all combinations of the four generic species (forest specialist, grassland specialist, shrubland specialist, generalist) and two movement scales (regional and local). File names include the name of the generic species and the movement scale.

We have also created an ArcGIS layer file for each raster to aid in visualization of the results. The large majority of grid cells within each raster have low to moderate connectivity values, so we applied a histogram equalize stretch when symbolizing the layers to provide better contrast across the full range of values from 0 to 1.

We suggest that users of our connectivity model outputs consider both movement scales when making conservation decisions. The coarser-resolution regional model outputs can be used to identify broad areas within the county that are important for wildlife movement. Within these areas, the finer-resolution local model outputs can be used to inform local decisions about conservation, such as where to site a wildlife crossing structure or pursue a conservation easement.

Questions about the connectivity modeling methods or outputs can be directed to Tyler Creech at tyler@largelandscapes.org.

IV. References

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