Montana Connectivity Project

A Statewide Analysis

Executive Summary

Montana Fish, Wildlife and Parks

August 2011

Implementation Update January 2014

The connectivity project was started following the initial work on the Crucial Areas Planning System (CAPS), Montana's Crucial Habitat Assessment Tool (CHAT). As one of the first states to begin working on the Western Governors Association's (WGA) Crucial Habitat and Corridors Initiative, Montana began examining species and habitat connectivity at the landscape level in 2008. As documented in the following Executive Summary and documentation, work was largely completed in 2011. Since that time, continual improvement and efforts have been made by the western states participating in expanding the work of the pilot states to the west-wide CHAT system. That work followed the same trend as Montana's efforts which eventually reflected a broad level evaluation of connectivity as a function of the landscape over the focus on individual species.

Much of the following documentation outlines the project process and analytical methodology based upon the approach of evaluating connectivity at the species level. Generally the species level process involved identifying core habitat blocks and the most likely pathways of movement between those blocks using habitat suitability models. Most of these models were developed during the initial work on CAPS. The primary limitation with these models is that many species lack sufficient data to inform modeling efforts, and little biological experience exists to evaluate them. These limitations are more pronounced when examining lesser known migration and movement behaviors. While some species models seemed reasonable based upon biologist review, they are difficult to interpret without the biological understanding of the species, movement behavior and model assumption. Thus the recommendation from the FWP wildlife management staff was that species specific data be an internal product to be used by FWP biologists when determined to be beneficial to specific conservation efforts.

Broad scale models of landscape connectivity based upon general habitat characteristics are the publicly available final products from the connectivity project. These large landscape block ecotype models (Section 3.3.3) are provided in the CAPS application for All General habitat, Alpine, Grass/Shrub, Forest Generalist and Forest Specialist classifications. These models selected habitats that could be grouped into the classifications and then evaluated the level of anthropogenic disturbance to derive core habitat blocks. It is assumed species within these classifications select for suitable habitats and avoid anthropogenic disturbance as well when moving between core blocks as a measure of connectivity. These models eliminate the requirement to model specific species behaviors in favor of the assumption that native habitats within an ecotype class are selected for and habitats not in the class, or any habitats that have been disturbed, are not selected for. These models are much simpler, more useful and understandable in the context of the conservation discussion.

Regardless of the final results presented, the effort to understand and explore connectivity as a conservation priority is important and will continue. The connectivity project documentation is provided so that other entities exploring the connectivity discussion can learn from these efforts and build upon what has been done to date.

Executive Summary

Conserving and maintaining terrestrial and aquatic habitat connectivity is essential for a variety of fish and wildlife species' life histories, including movements to food or shelter, reproduction requirements, seasonal movements, and/or dispersal to maintain healthy populations. In addition, access to suitable habitat in response to changing weather patterns and shifts in vegetation communities will help ensure the potential long-term viability of wildlife populations.

In November 2008, Montana Fish, Wildlife and Parks (MFWP) launched a Crucial Areas and Connectivity Assessment (Assessment), aimed at producing a planning and information tool. Referred to as the Crucial Areas Planning System (CAPS), it is designed to assist in assessing fish and wildlife values during the early planning stages of conservation and development projects. In addition, MFWP focused their efforts on the integration of final products with the Western Governors' Association's Wildlife Corridor Initiative.

The Connectivity Project of MFWP's Assessment was intended to provide the greatest habitat conservation benefit to support the greatest number of species. The goal was to identify priority geographic areas in order to maintain wildlife connectivity between important habitats in Montana. There were three phases to the Connectivity Project beginning in the fall of 2008.

Phase I developed a process to select focal species to be used in the Connectivity Project. Phase I work was conducted by the Connectivity Working Group (CWG), a multi-disciplinary team made up of agency staff, NGO representatives, state and federal government agencies and university staff.

The initial list of species consisted of Montana Species of Concern with a State Rank of S1-S3 and species identified by NatureServe with a Global Rank of G1 and G2; species having greater than 10% of their breeding range in Montana; species chosen for their socioeconomic value; and species sensitive to habitat connectivity loss that were not already included. These species were placed in a matrix that was sent to species experts for characterization of ecological processes and vulnerability to threats. In order to assure that connectivity between all ecotypes were included, we used the general ecological associations developed by NatureServe with a geographic component that distinguished western Montana ecotypes from eastern Montana ecotypes. For each ecotype combination, species were sorted first by their process score (total number of connectivity processes they depend upon) and then by their total threat score (their vulnerability to loss of those processes). Each species was then ranked based on these two scores.

The top five ranked species for each primary ecotype combination were selected as candidate focal species. After a final review by the CWG, a final focal species list was designated with the assumptions that:

- satisfying the connectivity needs of these species will satisfy the connectivity needs of most vertebrate species in Montana;
- there is redundancy in the list relative to connectivity on the landscape which will become apparent as mapping proceeds;

- every effort will be made to model/map connectivity for all species, even where data is limited;
- it may be necessary to map species in separate groups based on scale and
- the list will be adjusted in the future as more information becomes available and as conditions in Montana change.

Due to their unique connectivity needs, semi-aquatic species were identified differently than terrestrial mammals and amphibians. The initial process assigned each species a watershed rather than an ecoregion. Processes and threats were then scored and summed by the same approach used for the terrestrial species. The top ranked species for each watershed were selected as the candidate semi-aquatic focal species.

Bird species also have unique connectivity needs and thus were selected by avian experts in the state through a separate process. The initial list included all birds commonly occurring in Montana and was revised several times to develop the final list. Habitat and potential threats were associated with all species on the list to determine if there were threats to connectivity that were not captured.

Mammals	**Birds**	**Semi-Aquatics Guild**	**Raptor Guild**
Black Bear	Baird's Sparrow	Beaver	Ferruginous Hawk
Black-tailed Prairie Dog	Black Rosy-Finch	Northern River Otter	Rough-legged Hawk
Elk	Cassin's Finch	Spiny Soft-shelled Turtle	Swainson's Hawk
Grizzly Bear	Clark's Nutcracker	**Waterbird Guild**	**Shorebird Guild**
Lynx	Ferruginous Hawk	American White Pelican	Long-billed Curlew
Moose	Greater Sage-grouse	Black Tern	Long-billed
Mountain Lion	Long-billed Curlew	Common Loon	Dowitcher
Mule Deer	Mountain Plover	Common Tern	Mountain Plover
Pronghorn Antelope	Piping Plover	Franklin's Gull	Piping Plover
Pygmy Rabbit	Rufous Hummingbird	Northern Pintail	
Swift Fox	Trumpeter Swan	Trumpeter Swan	
Townsend's Big-eared Bat	**Amphibian**	Tundra Swan	
Wolverine	Northern Leopard Frog	Wilson's Phalarope	

Species/Species Guilds included in the Montana Connectivity Project – Color coded by habitat type: Forest Specialist; Forest Generalist; Grassland/Shrub; Shrub-steppe; Riparian/Wetland; Alpine)

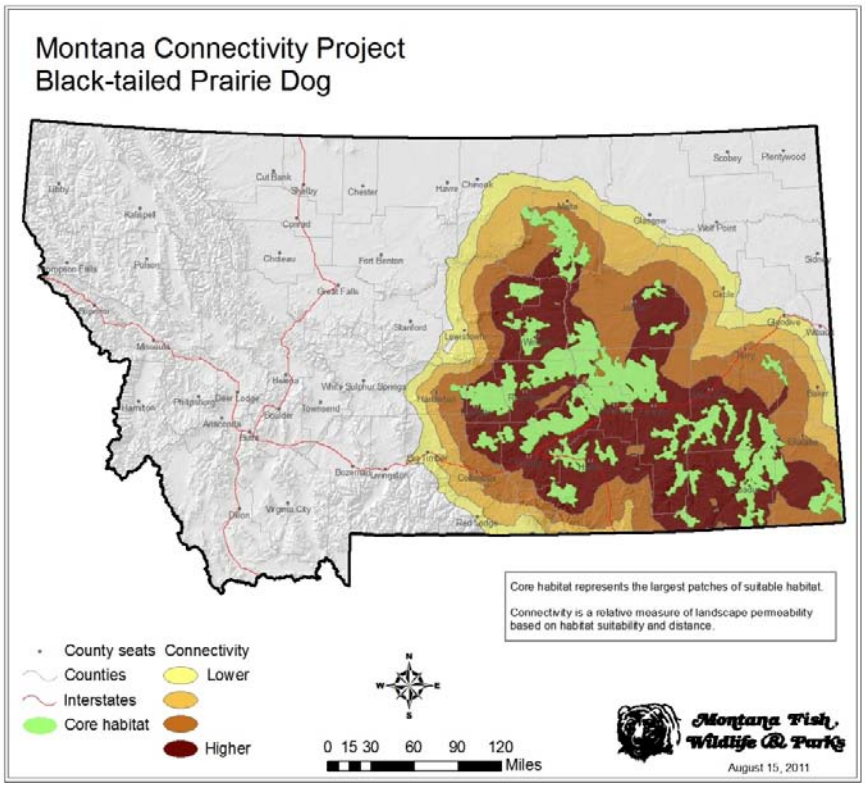
Phase II began in November 2009 supported by grants from the Wildlife Conservation Society (WCS) with a match provided by a grant from the National Fish and Wildlife Foundation. A project charter was developed and endorsed by MFWP's Fish and Wildlife Division. The goals of the Project Charter included: 1) Develop wildlife connectivity layers that identify wildlife corridors and linkage zones for selected focal species; 2) Identify effective scales for source data and display purposes; 3) Create definitions for four categories ranking connectivity and rank each linkage; 4) Create management recommendations for corridors and linkage zones as appropriate; and 5) Integrate resulting connectivity layer(s) into CAPS. Goal 1 was completed in Phase II.

For the purpose of this analysis, connectivity was operationally defined as *a process-oriented property of a landscape that permits movement of organisms.* Such movement may help to maintain and/or increase population persistence and resiliency, species and genetic diversity, and ecosystem processes,

including the interchange of genetic information. The connectivity analysis result for a species may be one of several types: linkages, stepping stones and patches/connectivity.

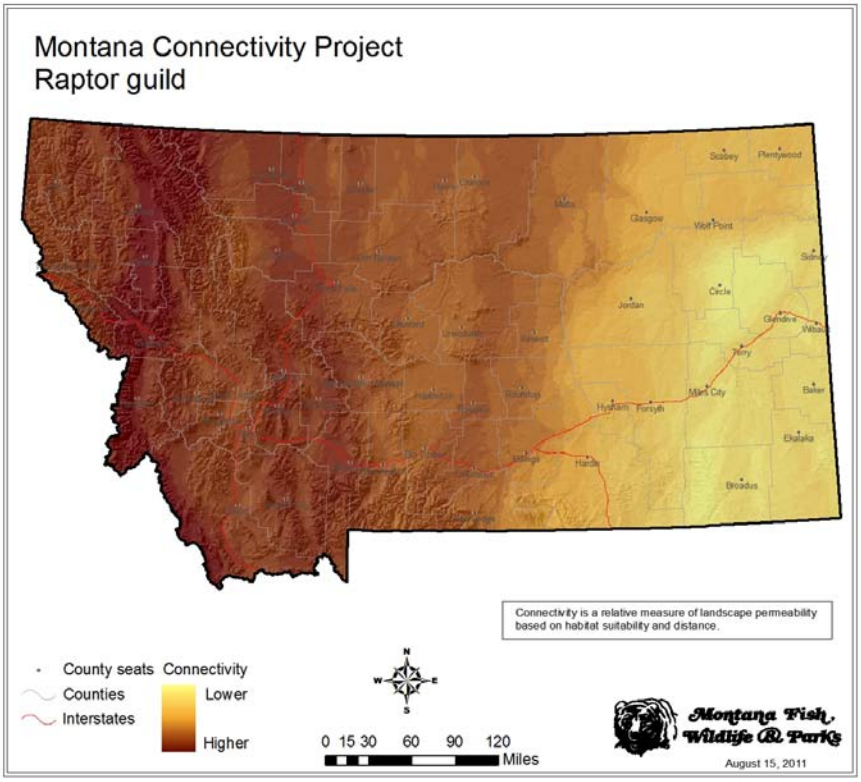
The approach for building connectivity layers followed the same pattern for all focal species.. Variability in the specific parameters used was dependent upon the species or species group. In general, mapping habitat connectivity for species consisted of identifying core habitat patches, generating a representation of cost for the movement of species between those core habitat patches, and modeling the connectivity between these patches to obtain a representation of the permeability of the landscape. We employed three general approaches to accommodate the different methods used to model a species, a guild of species, and a species using landscape blocks.

Species specific models were used when there was an existing model of habitat suitability for the species, represented through MaxEnt models. MaxEnt is a machine learning technique that uses presence-only data to develop a niche-based model to predict a species' realized ecological niche, and by extension, the geographic space the species occupies. These habitat suitability models are based upon characteristics at known locations and background characteristics based upon data from randomly selected pseudo-absence points. Core habitat patches were generated based on areas that exceeded a minimum suitability threshold, combining those areas within a specified perception distance, and then selecting areas that met a minimum breeding and population patch size. We first identified all potential core habitat patches and then selected the 20 largest core habitat patches to run the connectivity analyses.



Black-tailed Prairie Dog Core habitat and the minimum number of permeability slices needed to connect all core habitat.

Species guild models were used to represent suites of prioritized focal species with similar habitat and movement requirements. The guild approach was used to group individual species where ecological requirements and movement behavior did not differ greatly from one species to another. This approach was used for: waterbird, raptor, shorebird and semi-aquatics guilds. This technique followed the same process as individual species by identifying core habitat patches and running connectivity models between them.

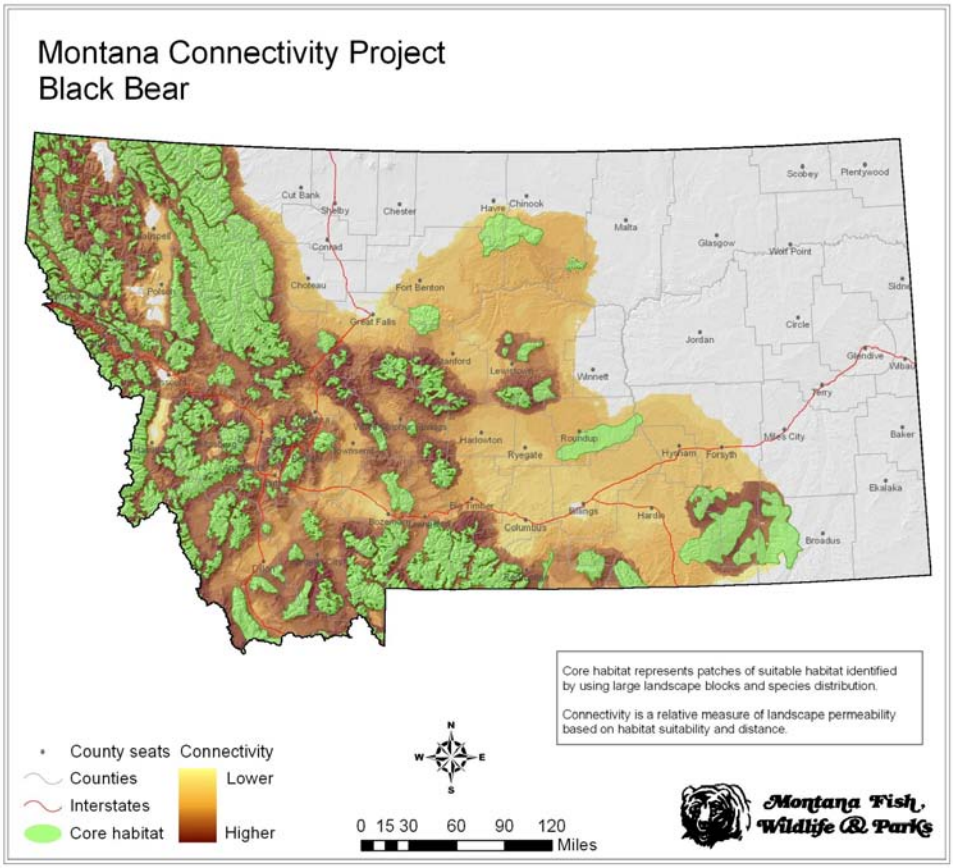


Raptor guild potential range/statewide landscape connectivity.

Landscape Block Species Models were used to identify core habitat patches and movement areas for species without habitat suitability models. This suite of species included terrestrial game and Lynx and Grizzly Bear. Initially, expert knowledge was used to identify movement areas, however the completeness of this information varied and was not comprehensive at a statewide level.

Alternatively, MFWP used a landscape integrity approach to identify large areas of native habitat to serve core habitat patches. This technique identified native habitat, removed areas that had been anthropogenically altered and selected the largest remaining intact areas. We termed these areas "Large Landscape Blocks (LLB)".

The LLBs were categorized by their general ecotypes including forest, sparse forest, alpine and grassland/shrub. Once a LLB was categorized by ecotype, it was used to represent core habitat patches for species associated with that ecotype. Movement cost were generated using the same habitat and anthropogenic factors that went into the formation of LLBs. Costs varied depending upon the general habitat ecotype being modeled. The resulting connectivity model was developed following the same technique described for the species specific models.



Black Bear core habitat patches and potential range/statewide landscape connectivity.

Connectivity Modeling Technique. We examined three approaches for modeling connectivity which included circuit theory using Circuitscape, graph theory using Funconn, and cost-distance analysis. Considering the number of species to be modeled, our experience and expertise and available data, we ultimately chose cost-distance analysis. As well, we were experienced with this method; models are relatively intuitive to parameterize, explain or evaluate; and the resulting maps are relatively easy to interpret. Because we made no assumptions about the location or strength of linkages and relied on the models to identify areas of potential linkage, we opted for an advanced cost-distance modeling technique that computes multiple pair-wise comparisons of least-cost corridors between core habitat patches. These corridor surfaces were then combined to produce a composite map of linkages between all pair-wise combinations. To automate this process, we developed a suite of tools called "Linkage Assistant" which loops through a list of user-determined core habitat patch combinations and generates pair-wise corridors, a composite linkage layer, and a layer representing percentile slices of the full range of connectivity modeling values. For species specific and guild models we generated 5th percentile slices, whereas we used 1 percent slices for landscape block models.

Data Review and Refinement. All modeling efforts required making assumptions about the response of species to habitat which influenced the resulting core habitat patch delineations and connectivity models. To ensure that the models generated were an adequate representation of on the ground conditions, species experts were asked to provide feedback as the results became available. A "Data

Review" mapping application and a Survey Monkey questionnaire were used to collect specific comments.

Phase III began in August 2011 and overlapped with the completion of Phase II. The focus is to explore analyses and display options for the Connectivity Project products, explore composite species layers, and integrate products into the CAPS. Development of additional data, tools and products will occur as necessary.

Interpreting Connectivity Maps. The connectivity maps generated for this project resulted from a modeling exercise that illustrated the lowest cumulative cost-distance associated with an individual of the focal species moving between/among core habitat patches. Output of the connectivity modeling is a raster data set that provides a continuous representation of the lowest cumulative cost-distance values between all core habitat patches analyzed. This raw output, however, is difficult to interpret. To aid in interpretation, the raw data were processed one more time to take the continuously represented data and generate 20 discrete bands, representing 5 % of the values. The resulting pattern shows bands radiating out from core habitat patches. Bands closest to core habitat patches generally represent lower cost-distance values, whereas bands further away from cores represent higher cost-distance values. Bands with the lower cost-distance values can be viewed as being easier to move through as a function of distance and landscape characteristics, representing higher relative landscape permeability for the focal species. These bands *do not* imply frequency of use or indicate how important particular areas might be in terms of connectivity for the focal species. Just because a band or group of bands represents low cost-distance values, that does not mean it is used most often or is the most important. For example, the outer bands may be the most important for facilitating a once in a century dispersal event that connects two isolated populations.

Future Integration and Interpretation. The first three objectives of the Charter to conduct a statewide assessment for 25 species and 4 species guilds for connectivity were accomplished in July 2011. All species, with the exception of wolverine, required developing new models/products because of the scattered geographic nature of existing data.

The remainder of the Montana Connectivity Charter's goals focus on integration of the connectivity products into the operations of local, state and federal government, and private and public entities through a publicly available mapping application and other mapping services.

The first step in this process is to recognize the complexity of what MFWP has created and the need to explore visually simplifying a product(s) to be used as a useful interpretation of connectivity. This approach has been taken in other data types in CAPS because it reduces visual confusion and interpretation when comparing individual species; broadens and expands the number of species and habitats considered during project review; and allows data to be compared with other data layers more easily. In order to address what approach should be taken in creating a composite of connectivity, it is important to understand how our constituents would use the products created. The questions of what is needed and how it will be used will influence the final product development. The evaluation will include addressing the issue of scale (coarse scale/fine scale) and determining what is

the appropriate scale for Montana connectivity data, how using finer scale existing connectivity products would be incorporated, and/or provide guidance for their use.

We will initially explore follow a "coarse filter/fine filter" approach. The Large Landscape Blocks will serve as core habitat patches by general habitat type which will serve for the coarse filter. Individual species will then be considered at the fine filter scale.

The final goal in the Charter is to address how connectivity layers will be included in the prioritization process outlined in the Western Governors' Association's Wildlife Council's White Paper, *"Western Regional Wildlife Decision Support System: Definitions and guidance for State Systems"* (WGA 2011). Questions to explore include:

- What do we use to categorize locations on the landscape that are most important for maintaining/improving population connectivity?
    - More use by more species = more value?
    - More permeability= higher value? More resistance= higher value?

These and other questions will be explored over the remainder of 2011, and the report to WCS will be updated at that time. The integration of the final products into CAPS will occur prior to the prioritization process.

Several areas needing improvements were noted during the Montana Connectivity Project. A full list of these are provided in the full document and include: 1) the "edge effects" from modeling solely within the boundaries of Montana; 2) the need to improve Maxent habitat suitability models, which are the foundation to all subsequent analysis; 3) a recognition of lack of knowledge concerning connectivity; 4) a clearer understanding of avian and bat movement and migration behaviors; and 5) a better understanding of species movement through field validation, GPS locations and genetics.